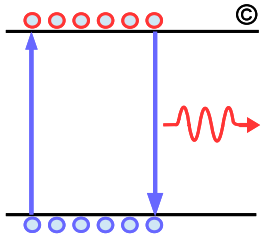


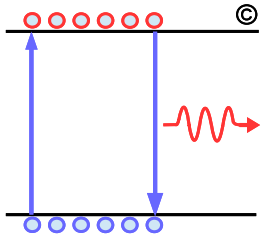
Evolution of Cu Cabling

Ali Ghiasi
Ghiasi Quantum LLC

IEEE Meeting
Rosemount

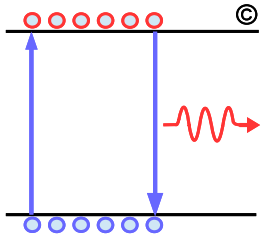
March 7, 2018

Overview



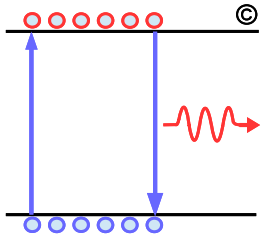
- Cu cabling based on twin-ax started as dedicated Cu port
- SFP+ Cu DAC created the 1st ubiquitous optical and Cu port
- SFP+ Cu DAC did not compromise optical functionality or the host PCB reach
- 802.3 then followed the concept of SFP+ DAC with several follow on standards
- SFP+ Cu DAC with 8 m reach has been a huge success
- But over the last decade with number of server declining per racks, switch radix increasing, and while Cu cable reach declining the success of SFP+ may not extend to future Cu DAC cabling with reach of just 2 m!
- Can we assume a 2 m Cu DAC will have broad market potential with above evolution?

Fiber Channel Help Define Early Twin-ax Cu Cabling



- **Early Cu standards 1997 were based on 150 Ω twin-ax cable for lower loss/weight**
- **With introduction of 1GFC two type of Cu plug were introduced**
  - DB-9
  - HSSDC
- **Cu ports were dedicated but some did offer active-GBIC with Cu ports and some even offered optical MIA (Media Interface Adapter) that plugs into DB-9 connector**
  - Both DB-9 and HSSDC cable assemblies still available on-line from Amphenol
- **Optical ports in this time frame were predominantly based on GBIC.**

10GBASE-CX4 1st Twin-ax Cu Cabling Solution in Ethernet



- **10GBASE-CX4 used XAUI signaling with pre-emphasis to operate over 15 m of cables**
  - The year was 2003
  - IEEE 802.3ak Clause 54 defined Cu Twin-ax cabling
  - Connector based on Fujitsu MicroGigaCN™ SFF-8470
- **In this time frame the dominant module form factor was Xenpak and X2/XPAK were just being introduced.**

MDI Based on Fujitsu MicroGigaCN

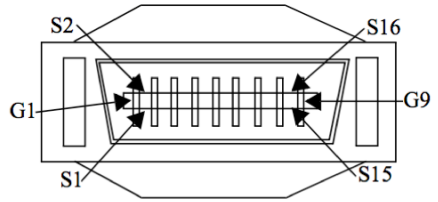


Figure 54–12—Example cable assembly plug (informative)

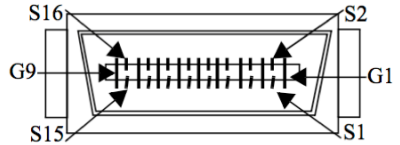
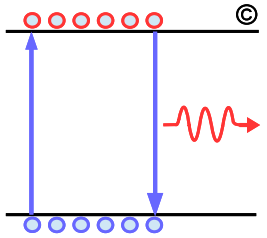


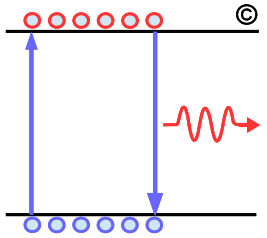
Figure 54–13—Example MDI board receptacle (informative)

SFP+ Delivered the 1st Unified Cu/Optical port for Ethernet



- **I and Tom Lindsay started SFP+ project to define unretime C2M interface for 10 GbE applications**
  - The project started in early 2006 as an SFF
  - The goal of the project was to define an electrical interface in support 10GBASE-SR/LR/LRM
  - The project completed in 2009 and was as complex as any Ethernet project
- **SFP+ help define many of the fundamentals such**
  - PPI interface
  - Compliance methodology for host/module testing
  - Host/module compliance boards
- **Halfway through the project I came up with this crazy idea lets reuse host equalizer for passive Cu Cabling with reach up to 8 m**
  - Many of the optical supplier were unhappy with addition of 10GCu SFP+ but they reluctantly went along based on my argument that by adding Cu SFP+ DAC it will eliminate 10GBASE-T as a datacenter solution therefore creating more volume for optical SFP+ modules
  - Guess what happened after …..
- **SFP+ created ubiquitous port with huge volume shipment!**

SFP+ Channel

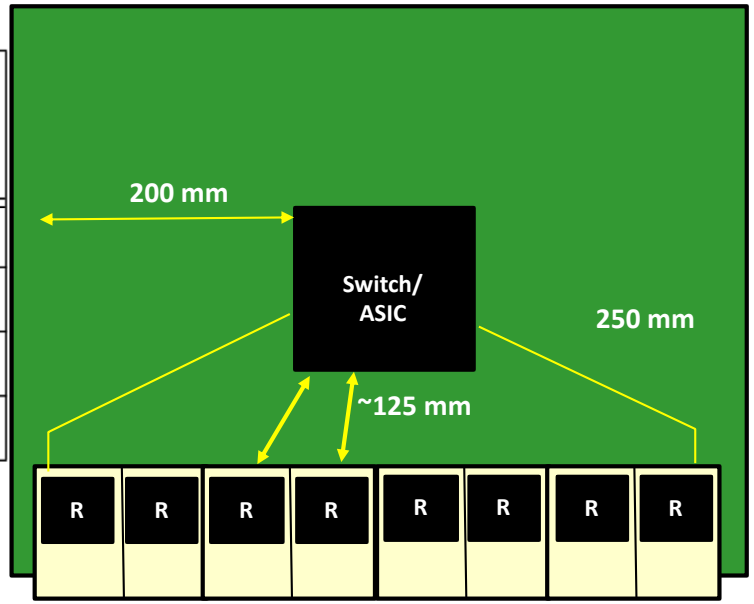


- **SFP+ Ubiquitous port was created by assuming main stream PCB material and supporting 200-300 mm host PCB trace**
  - lim_100GEL_adhoc_01_022618.pdf requires the best of the best material Megtron 7NE just to support 125 mm host trace
  - SFP+ Cu DAC did not burden and reduce the host trace length just to get some meaningful Cu cable reach
  - As the creator of SFP+ Cu DAC it is a bad idea when we start compromising the port in favor of barely getting 2 m Cu cable support

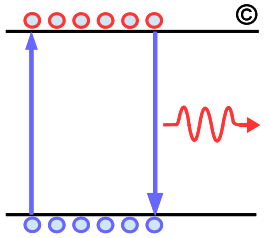
Table 2 Host Board Achievable Trace Length (SFP+)

Type	*Material*	*Trace Width (mm)*	*Loss Tangent*	*Copper Thickness (oz) see 1*	*Copper Thickness (µm)*	*Trace Length (mm)*
Microstrip	FR4-6/8	0.3	0.022	1	35	200
	Nelco 4000-13	0.3	0.016	1	35	300
Stripline	FR4-6/8	0.125	0.022	0.5	17.5	150
	Nelco 4000-13	0.125	0.016	0.5	17.5	200

1. Copper (oz) is defined as an ounce of copper over one square foot of laminate.

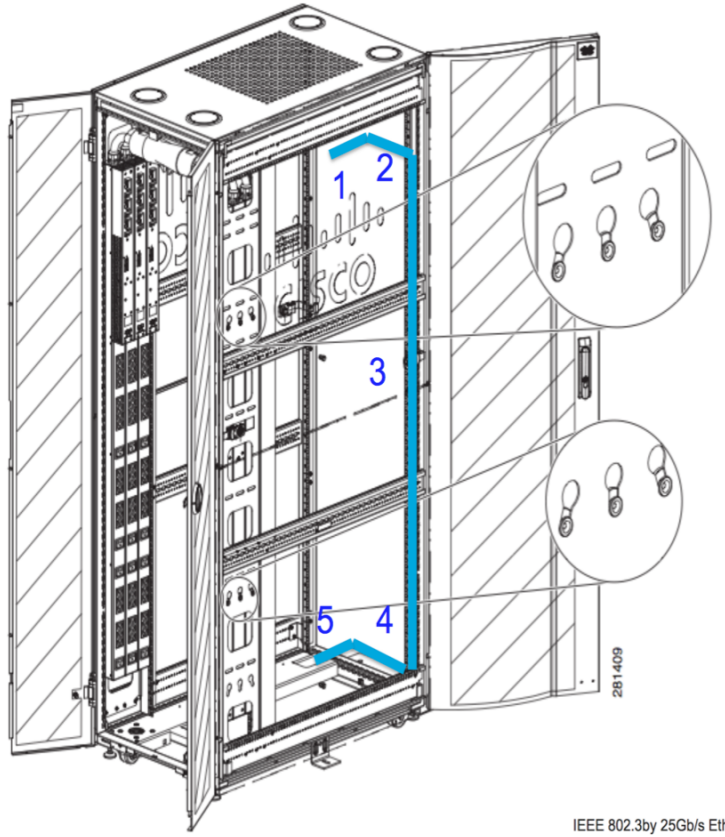


802.3 has since defined several Cu DAC PMDs



- **40GBASE-CR4**
  - Defined in the 802.3ba CL-85 with a reach of 5 m
- **100GBASE-CR4**
  - Defined in the 802.3bj CL-92 with a reach of 3 m
- **25GBASE-CR**
  - Defined in the 802.3by CL110 with a reach of 3 m
- **50GBASE-CR**
  - Defined in 802.3cd CL136 with a reach of 3 m
- **goergen_3by_02a_0715 analysis shows that real life Cu cable needs to be at least 2.69 m!**

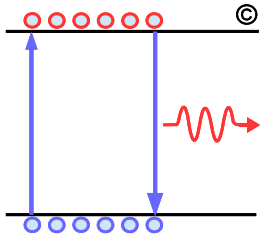
Cabling Installation – Top to Bottom



- Consider this common strategy
  - 1 – 152mm
  - 2 – 304mm
  - 3 – 1778mm
  - 4 – 304mm
  - 5 – 152mm
- This real life case is 2690mm.

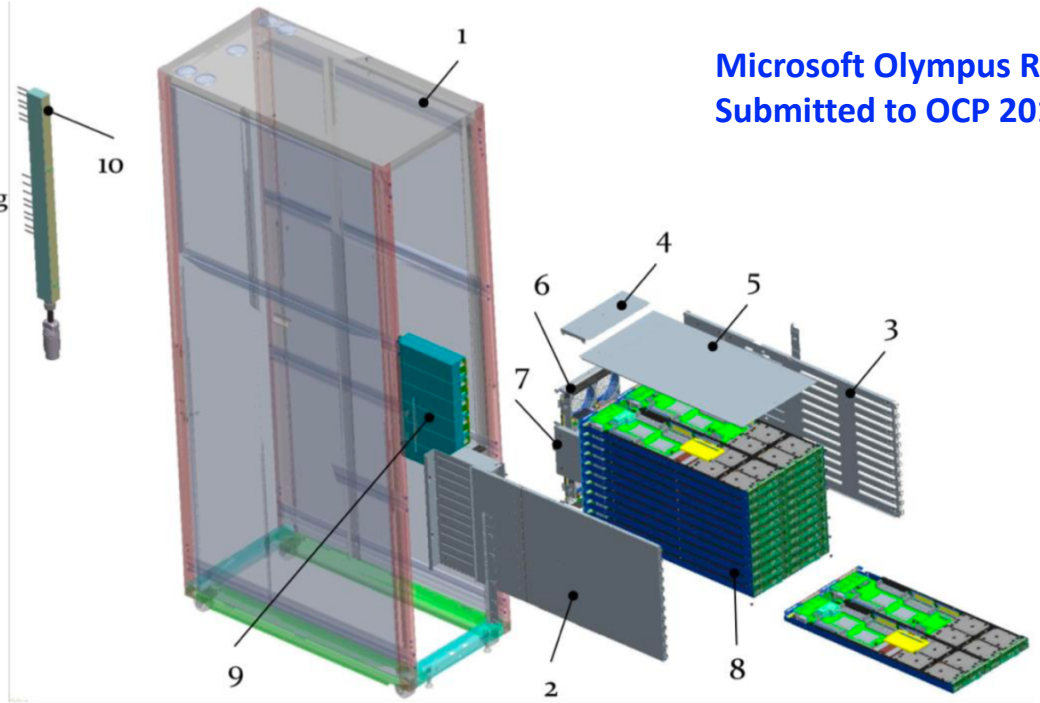
IEEE 802.3by 25Gb/s Ethernet

Number of Server per Rack Has Decressed

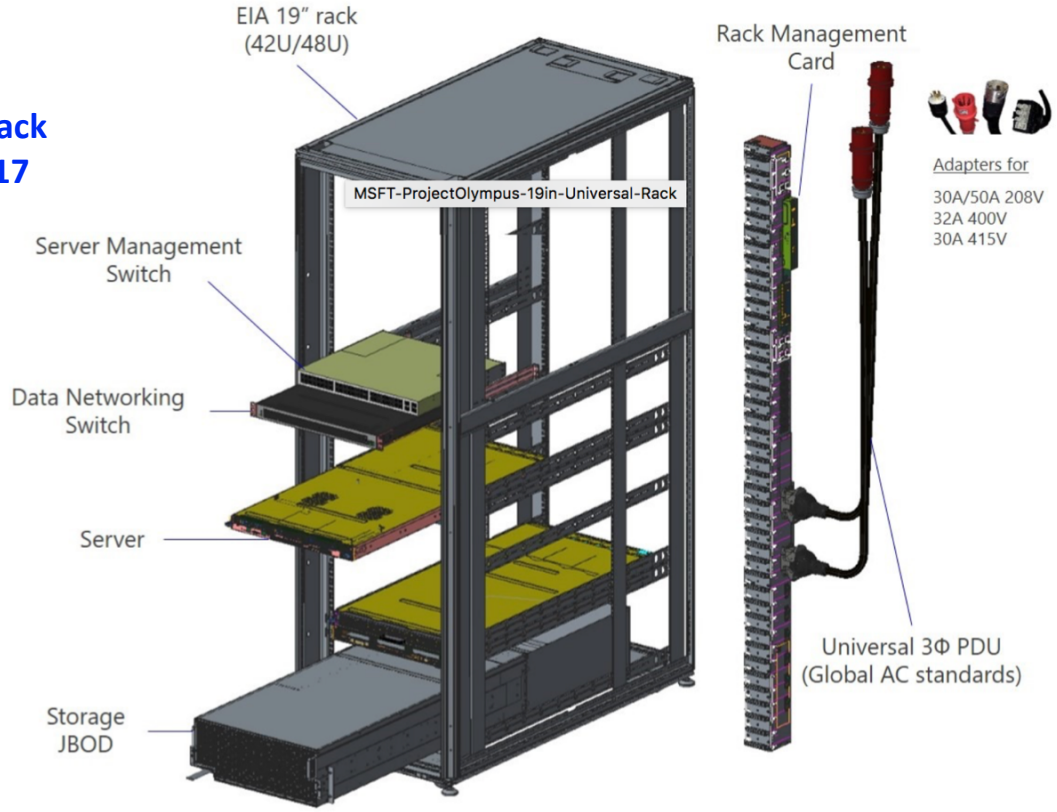


- **A decade ago half-width servers with 96 servers in a rack were common**
- **Today common server rack implementation only have 24-48 servers as result of**
  - Larger CPUs with more cores/memory and racks having JBOD, JBOF, and GPU.

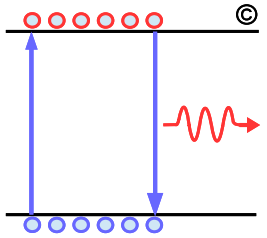
1. Rack
2. Left Side Wall (including Power Dist Board)
3. Right Side Wall
4. Rear Covers
5. Top Cover
6. Fan Door
7. Chassis Manager
8. Trays
9. Power Supplies
10. Power Distribution Unit



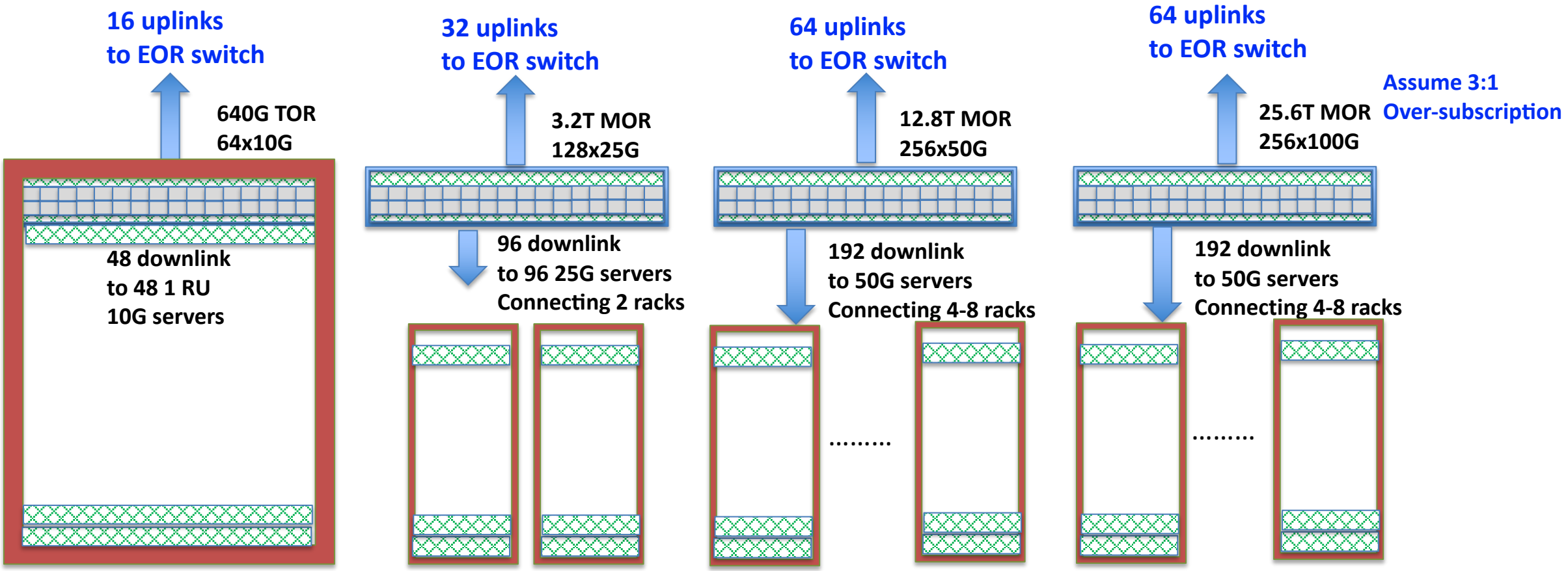
Microsoft Olympus Rack
Submitted to OCP 2017



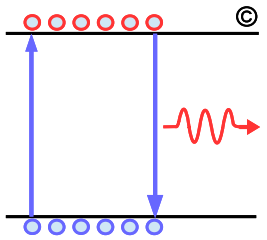
Datacenter Trends



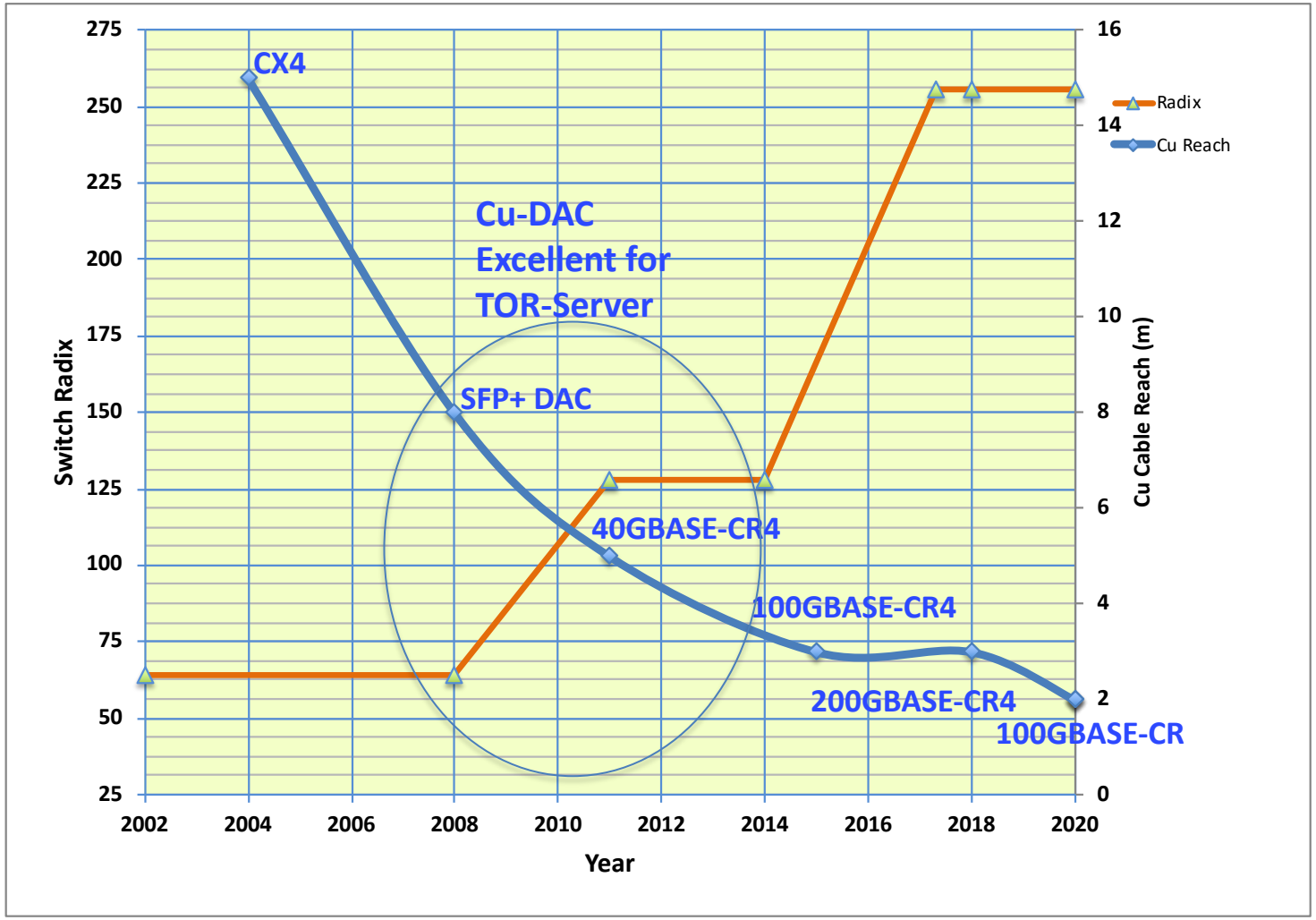
- **Switch radix over the last 9 years has increased from 64x10G, 128x25G, now to 256x50G, and likely to 256x100G by 2019/2020**
  - With this trend a 2 m Cu DAC no-longer will be ubiquitous server-TOR solution.



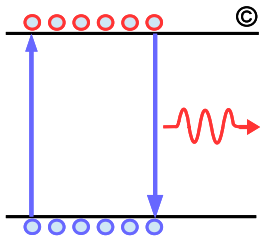
Why Was SFP+ Cu DAC was Such a Perfect Fit



- **SFP+ DAC with 8 m cable reach not only supported TOR but could connect up to 5 racks!**
- **With introduction of 128 radix switches single switch became too large for one rack of servers**
  - Over the last 10 years the number of servers per rack have decreased from ~48 to ~24 while the DAC cable reach decreased from 8 m to 3 m
- **With introduction of 128-256 radix switches Cu DAC with 2-3 m reach no longer is a viable servers to 1st layer switch!**



Summary



- **100GEL study group is rushing to define a sub-optimal 2 m Cu cabling solution by sacrificing C2M**
  - The proposed 2 m Cu cable link budget has no margin
  - With just 11.7 dB loss host PCB limited to just 125 mm on the best PCB material Megtron 7NE
  - C2M is the most important interfaces to enable next generation system, limited host PCB reach will require adding lots of power hungry retimers
- **It is unclear if 2 m Cu DAC even has broad market potential with switch radix increasing to 256 while Cu cable reach reduced to just 2 m**
  - A switch with radix of 256 likely will be placed in the middle of row and will connect to 4-8 racks of servers and require cable reach of at least 10 m
- **The main driver for migration to 100G/lane IO is to enable next generation 12.8/25.6 Tb switches**
  - A low capacity 3.2/6.4 Tb TOR switch can stay with more generous 50GBASE-CR/100GBASE-CR2/200GBASE-CR4 cabling implementation
- **Lets not sacrifice C2M specification for niche 2 m Cu DAC application and instead lets consider the following**
  - Define a Cu port MDI based on 10 dB to provide margin and possibly extending reach to 3
  - A host with 10 dB loss may support both Cu and optical modules
  - See also Ghiasi_100GEL_01_0318.pdf.