Broadened Consensus for a 200GEL Copper Cable Objective

Sam Kocsis, Amphenol
Nathan Tracy, TE Connectivity

August 26 2021

Proposed Objectives (July-29)

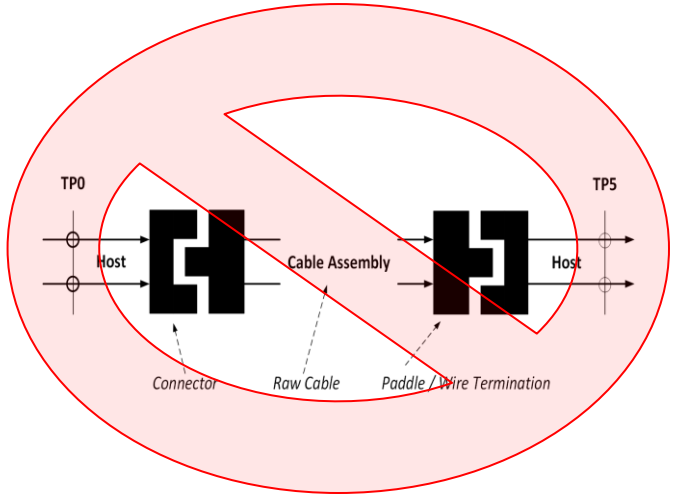
- 800 Gb/s related
  - Define a physical layer specification that supports 800 Gb/s operation over four pairs of copper twinax cable in each direction with a reach of up to at least 1 meter
- 1.6 Tb/s related
  - Define a physical layer specification that supports 1.6 Tb/s operation over eight pairs of copper twinax cable in each direction with a reach of up to at least 1 meter
- 200 Gb/s related
  - Define a physical layer specification that supports 200Gb/s operation over one pair of copper twinax cable in each direction with a reach of up to at least 1 meter
- 400 Gb/s related
  - Define a physical layer specification that supports 400Gb/s operation over two pairs of copper twinax cable in each direction with a reach of up to at least 1 meter

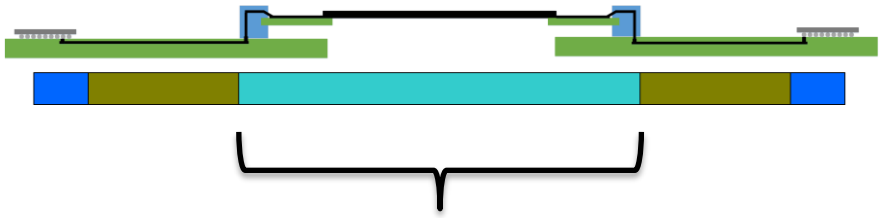
Requests For More Information

- Technical Feasibility
  - "Copper cables would require PAM-6, and can't be done with PAM-4"
- Broad Market Potential
  - "1m doesn't have broad market potential"
- Timing, Effort, Complexity
  - "Divergence of CR and C2M implementations is undeniable, and the added complexity of CR isn't worth pursuing"

Addressing Technical Feasibility – Copper Cables

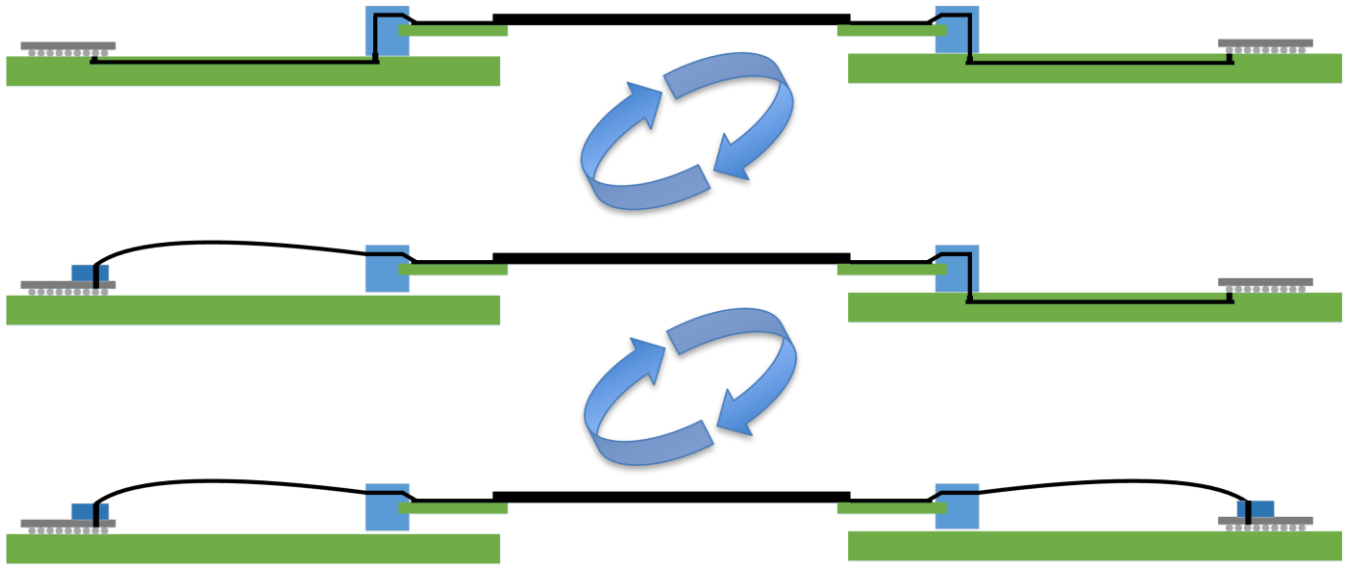
- We may be limiting possibilities by thinking about copper cables TP0-TP5
- Technical feasibility for copper cables should focus on the pluggable IO
- Host implementation decisions and TX/RX characteristics are a topic for the future task force
- For the purposes of this discussion, the data will assess 200GEL technical feasibility with respect to PAM-4





Technical feasibility of the copper cables

Addressing Technical Feasibility – Copper Cables

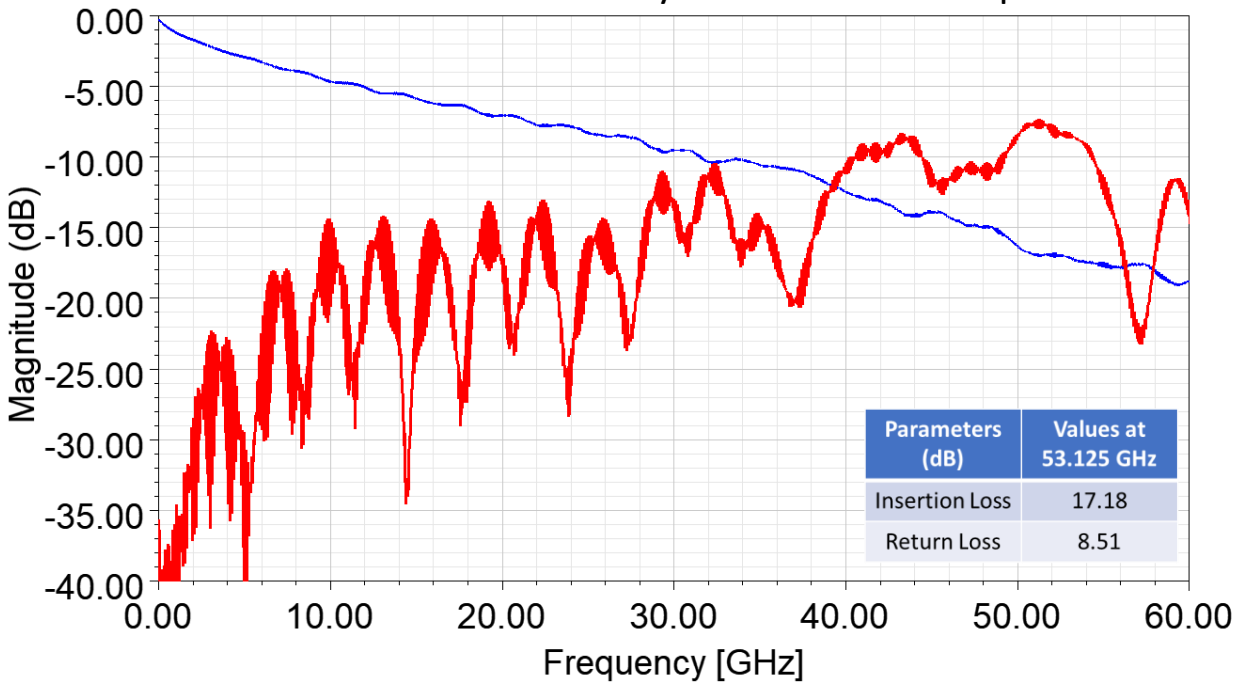


Host implementations are continuing to evolve in several ways that provide a positive future for copper cables

- Systems are being implemented with careful planning to match specific (“known”) port characteristics at both ends of the link
- Users are adapting the CR specification to take advantage of link asymmetries that may provide component benefits
- Traditional PCB-based hosts are giving way to new cabled-host implementations to provide more port flexibility and allocate budget to the copper cable
- Designers are thinking about the copper cable channels “holistically” focused on matching component transitions

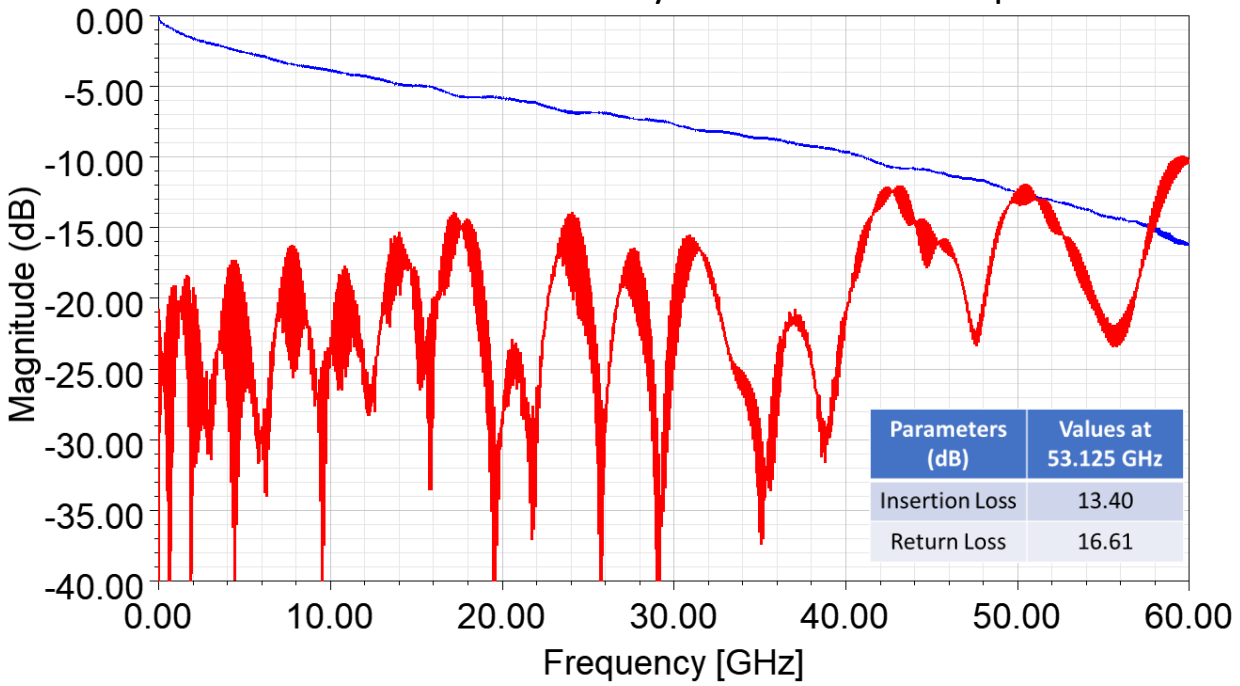
Technical Feasibility – Copper Cables

DAC Solution in 100 Ohm System Reference Impedance



Same data plot as shown on July-29

DAC Solution in 90 Ohm System Reference Impedance

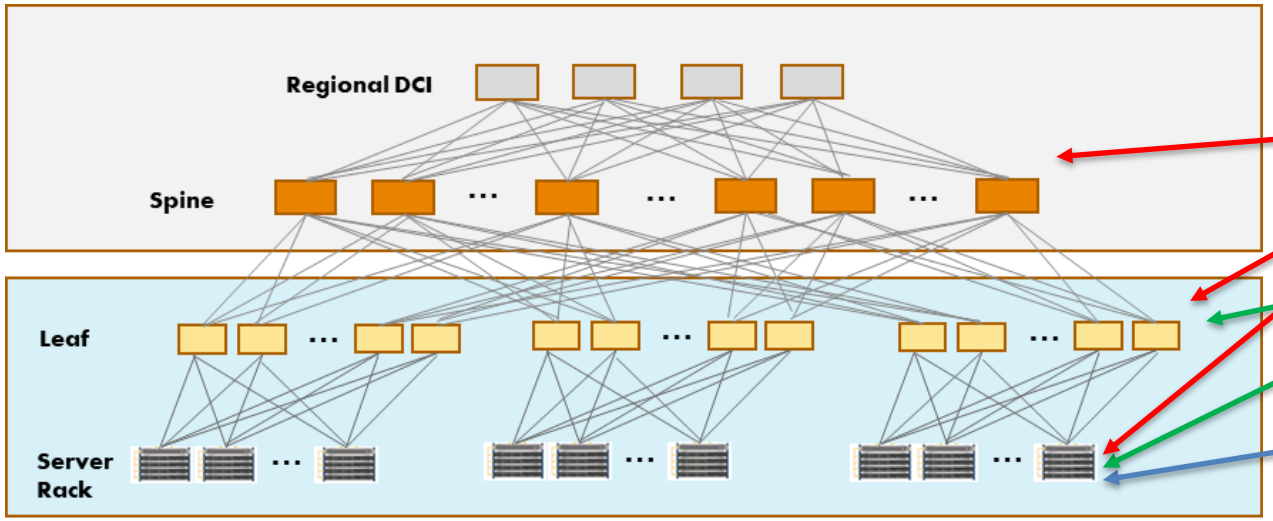


***New data specific example of an implementation improvement ***

Simulated results for host connector footprint to host connector footprint

- The pluggable interconnect has options to extend both the physical reach and the bandwidth to meet potential 200GEL (using PAM-4) targets

Where are DACs broadly deployed?



Based on 100 Gbps
2 m reach

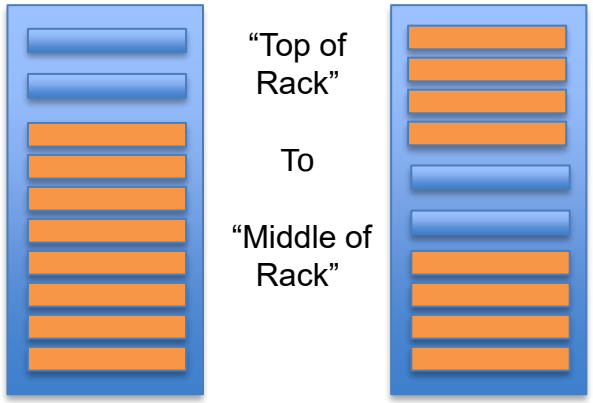
Based on 50 Gbps
3 m reach

Based on 25 Gbps
5 m reach

Although the usage of copper cables within each application varies at each new rate, the net effect is an increase in cable usage

Copper usage is the “constant”, rack design has “evolved” at each generation to enable copper

Examples:



“Top of Rack”

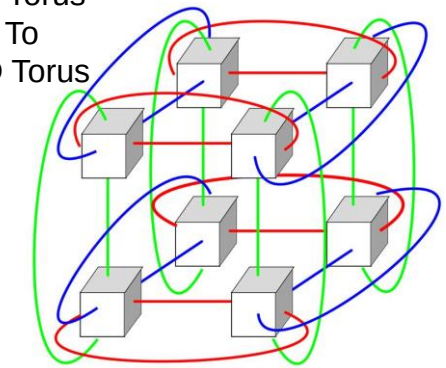
To

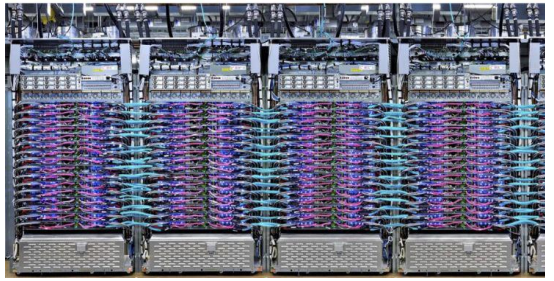
“Middle of Rack”

Modular chassis To Fixed switch rack

https://engineering.fb.com/2018/03/20/data-center-engineering/fabric-aggregator-a-flexible-solution-to-our-traffic-demand/

2D Torus To 3D Torus



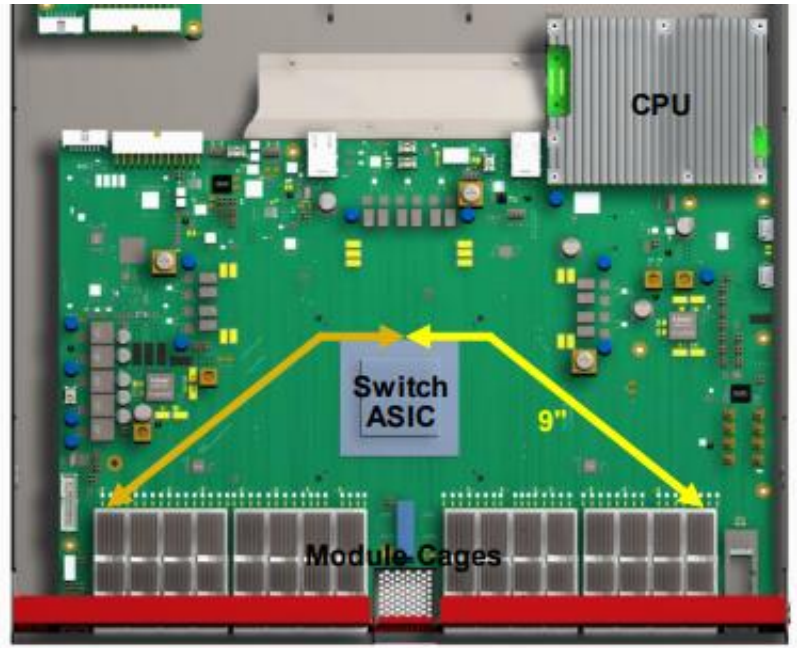


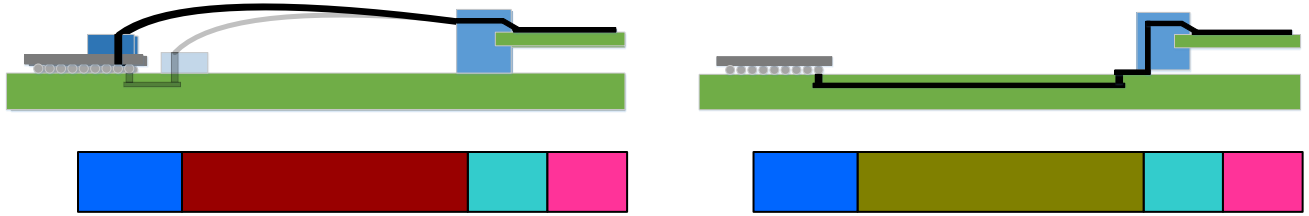
https://www.nextplatform.com/2018/05/10/tearing-apart-googles-tpu-3-0-ai-coprocessor/

Quest for a “Universal Port”

- Differences between the C2M and CR specifications in the 3ck project have been a challenge
- C2M capabilities have advanced significantly
- Trade-offs must focus on creating the optimum implementation for each PHY type

https://www.ieee802.org/3/100GEL/public/18_03/stone_100GEL_01_0318.pdf
https://www.ieee802.org/3/B400G/public/21_05/noujeim_b400g_01_210517.pdf
https://www.ieee802.org/3/ck/public/21_07/dawe_3ck_01_0721.pdf





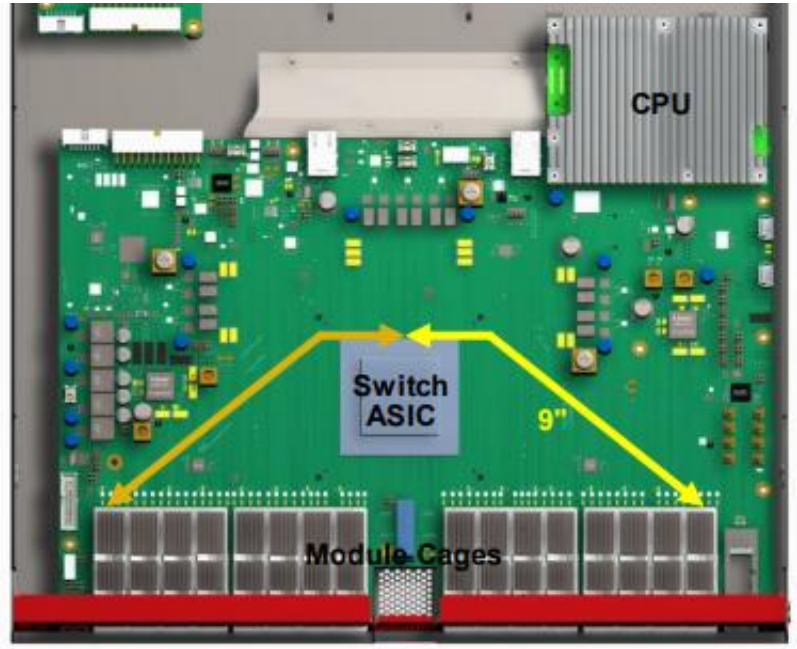
Cabled-Host Implementation

PCB-based Implementation

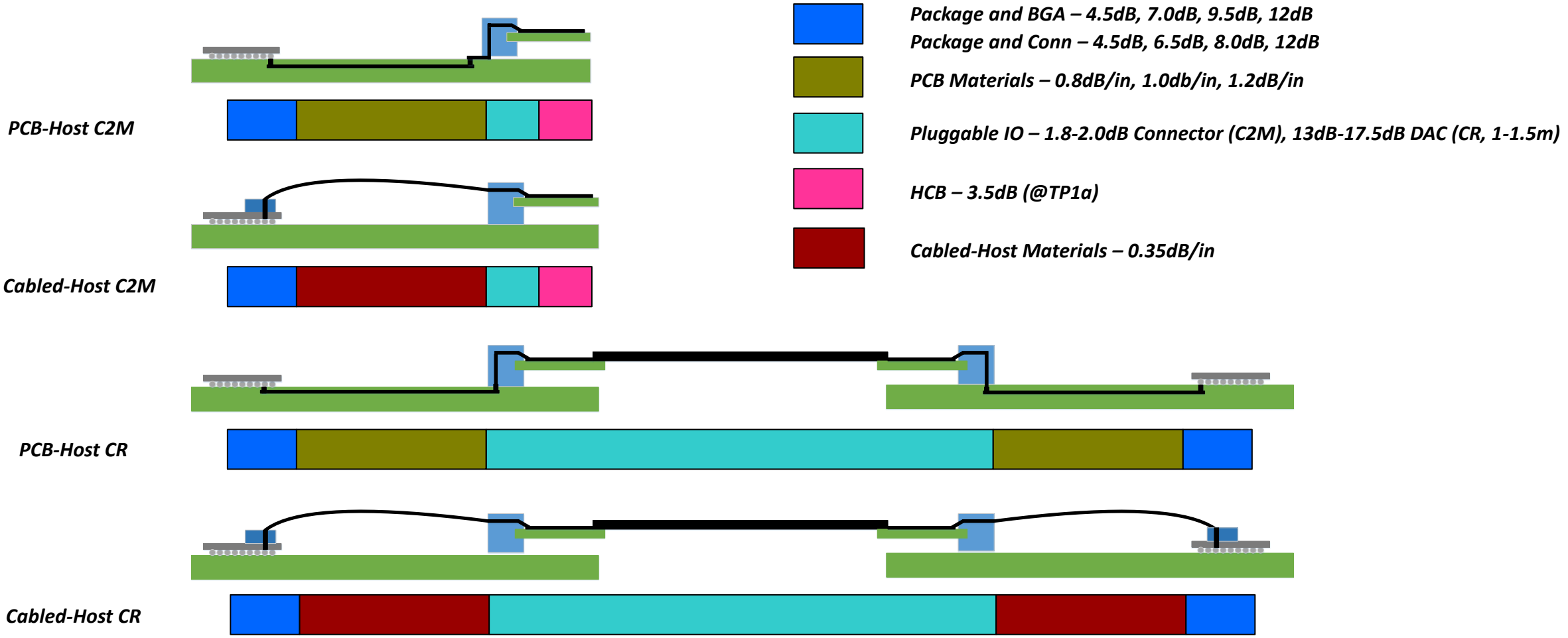
Quest for a “Universal Port”

- Typical physical length for a host
  - 18 out of 32 ports <5”
    - 8 out of 32 ports <3”
  - 6 out of 32 ports 5-7”
  - 8 out of 32 ports 7-9”
- No doubt that a C2M specification can be achieved to cover all these cases
- Minimizing the reach of the C2M channel will save power and enable copper cables
- Goal: A feasible solution space that achieves 9” physical reach for the Host and 1.5m copper reach for the link
- A 35dB bump-to-bump Insertion Loss budget used as reference for channel targets

https://www.ieee802.org/3/B400G/public/21_07/lu_b400g_01b_210729.pdf



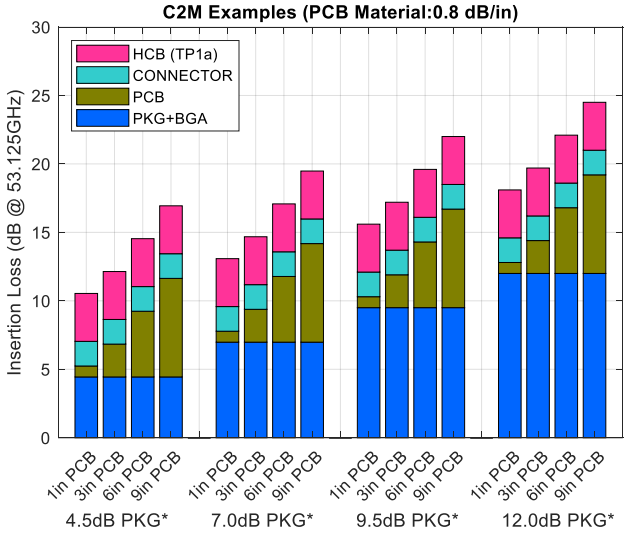
C2M and CR Compatibility

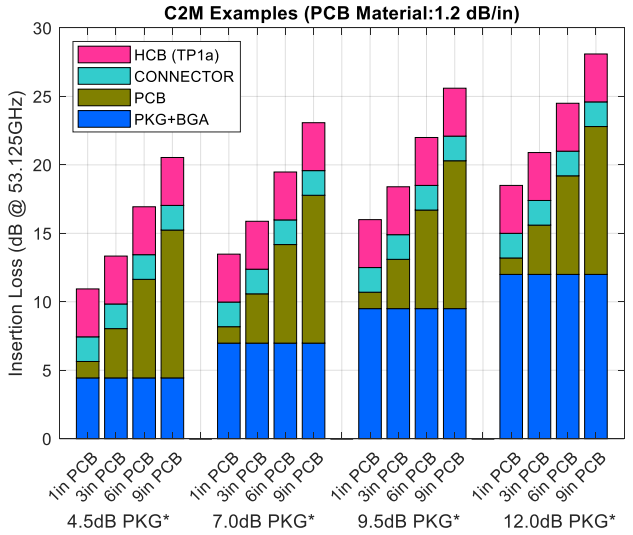


All Insertion Loss numbers @53.125GHz

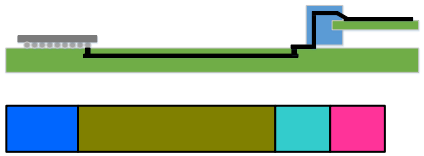
C2M Considerations

0.8 dB/in

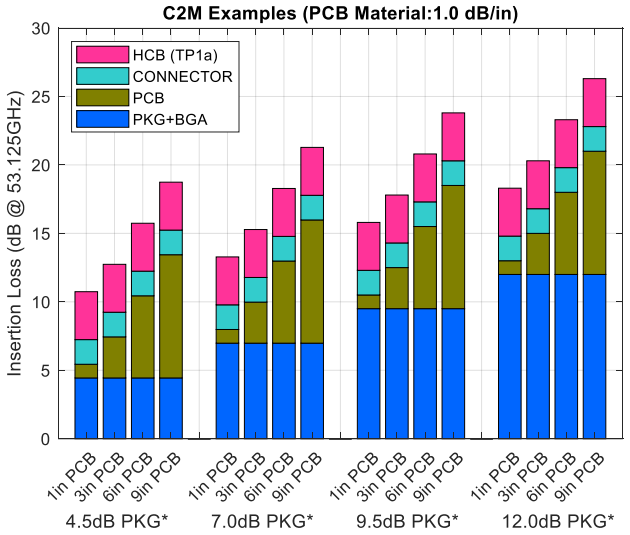


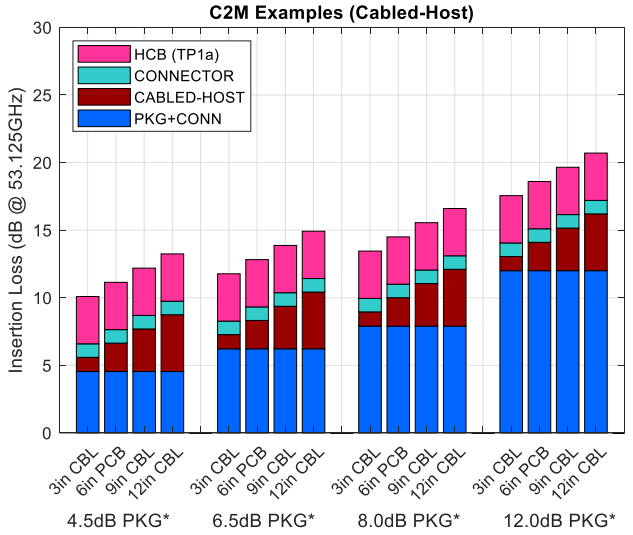


1.2 dB/in



1.0 dB/in

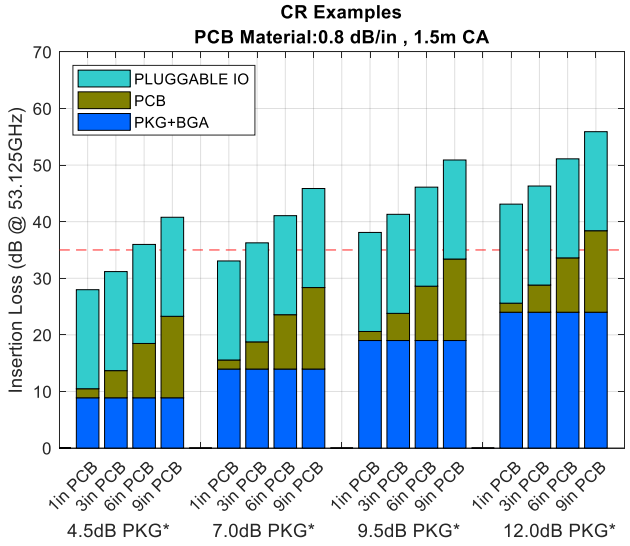


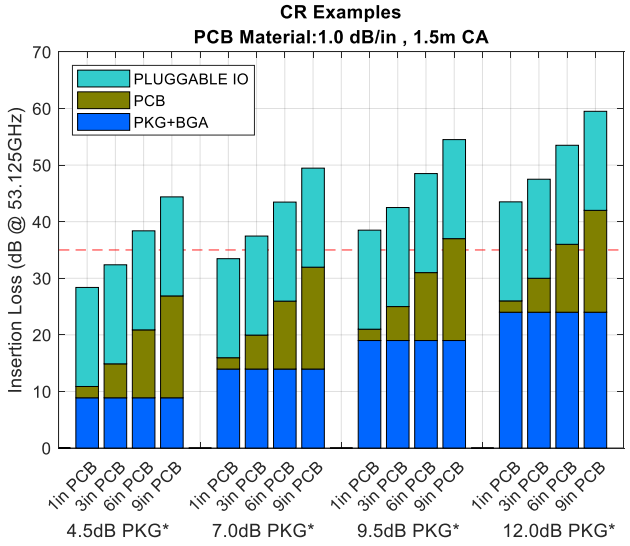


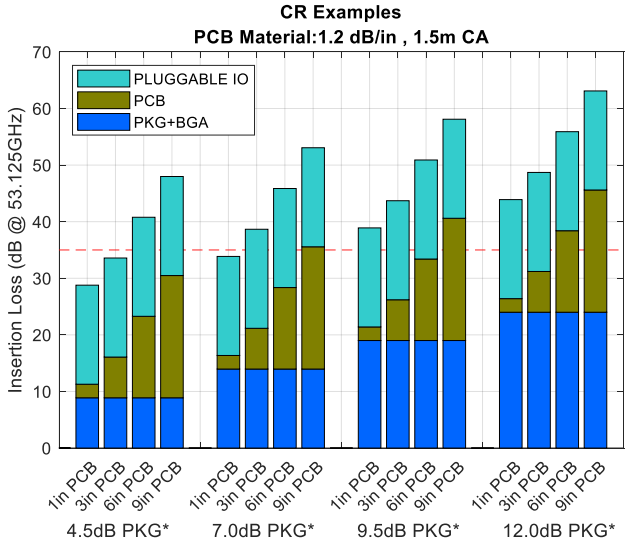
0.35 dB/in

Implementation examples shown for discussion ONLY

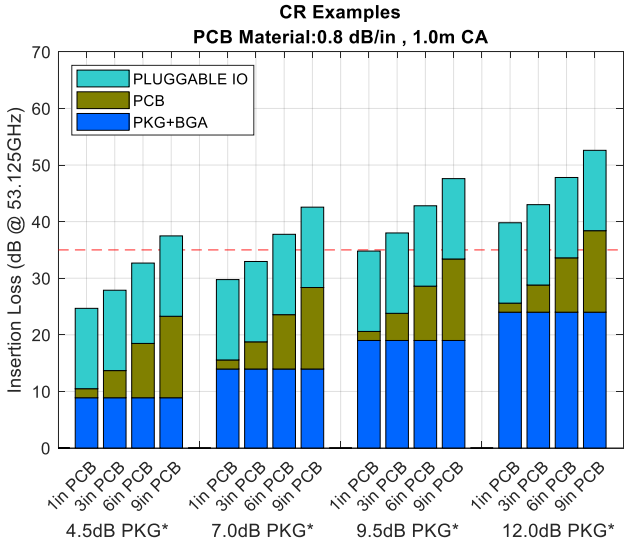
CR Considerations

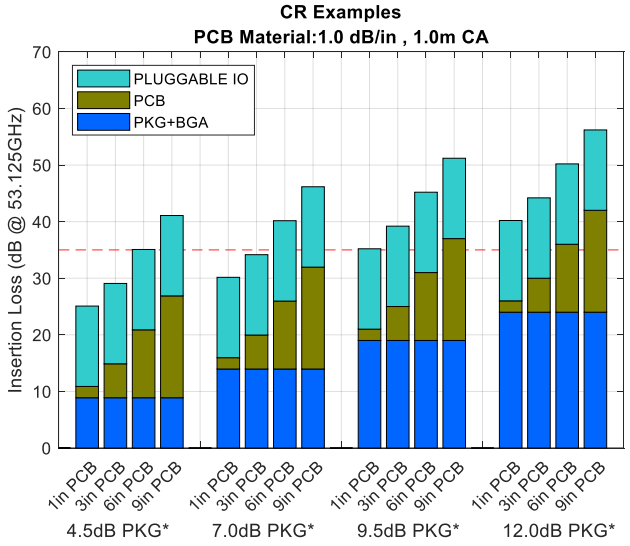


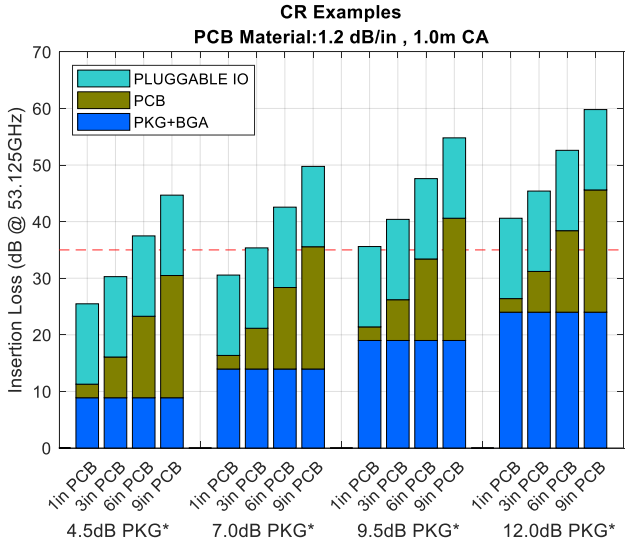




1.5m DACs
Varied host routing with PCB
*Varied Package including BGA



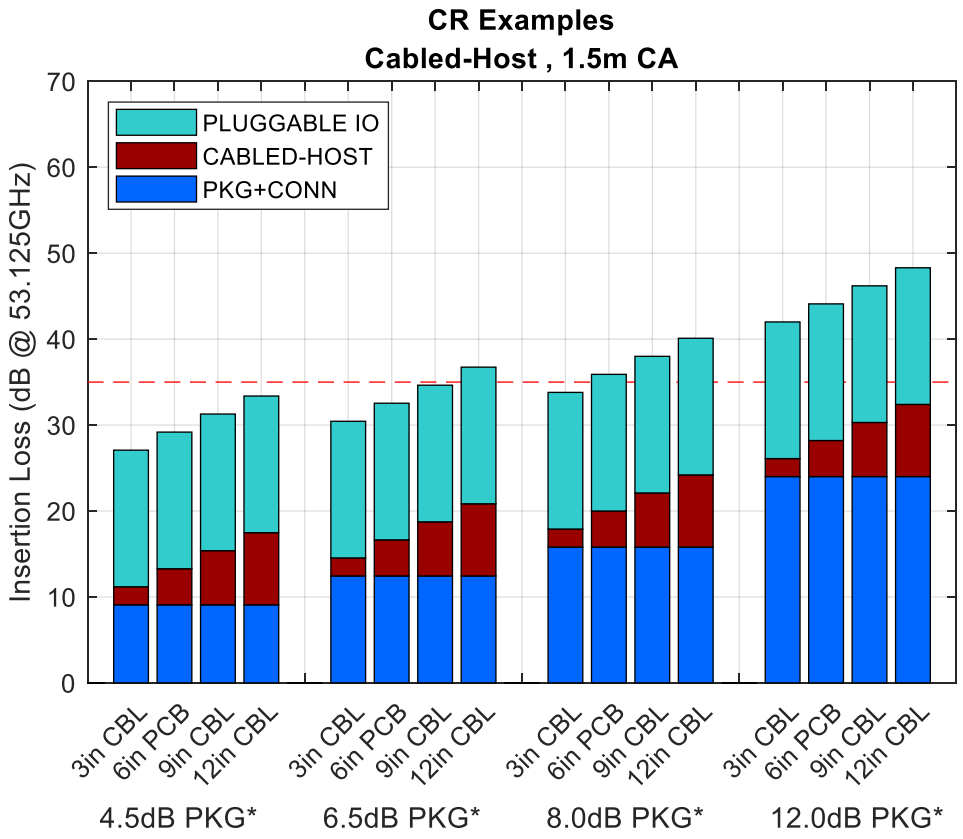


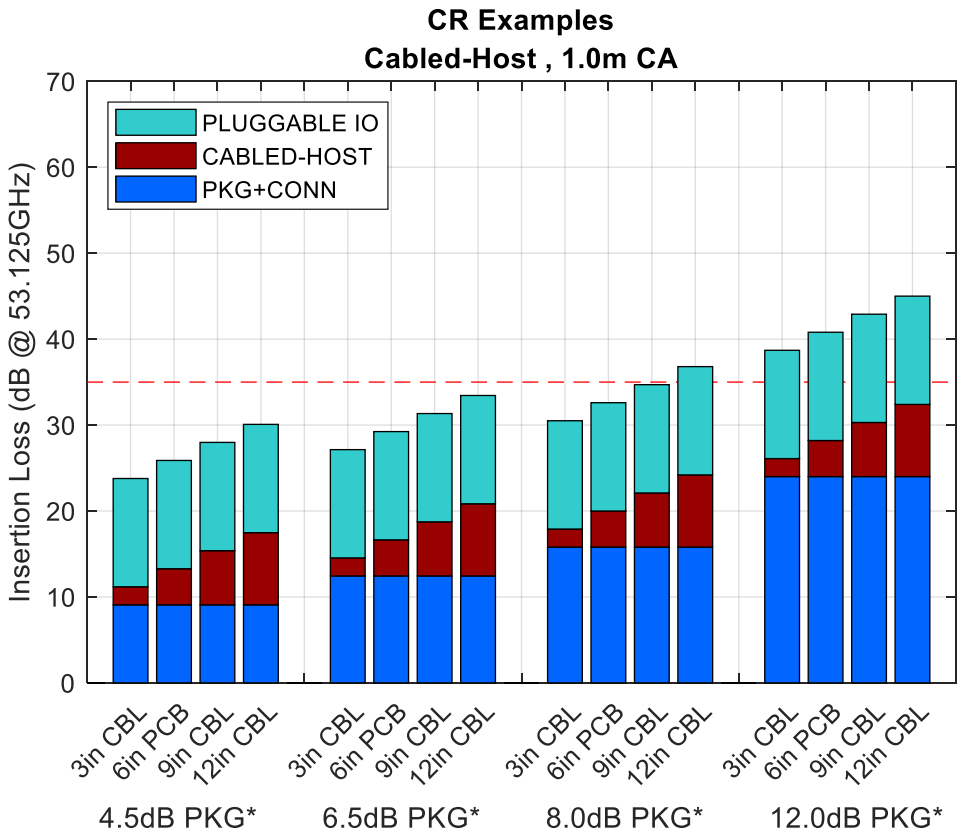


1.0m DACs
Varied host routing with PCB
*Varied Package including BGA

Implementation examples shown for discussion ONLY

CR Considerations

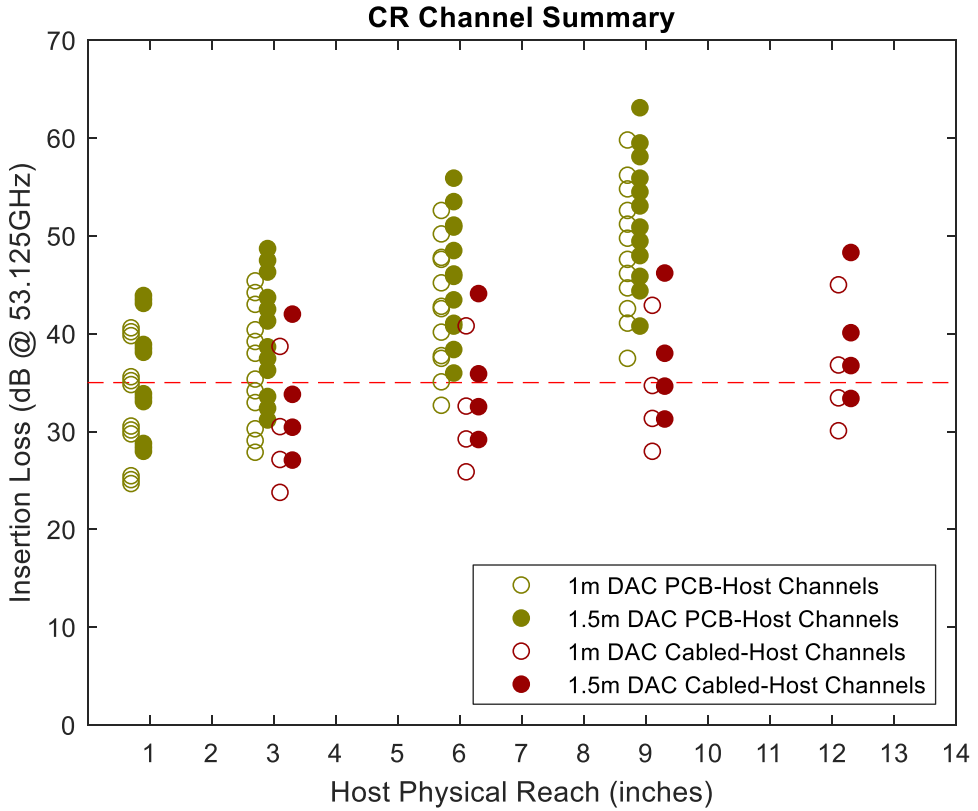




- Cabled-hosts anticipated to provide some improvement in package escape (including on-package or near-package connector) compared to traditional PCB implementations
- Goal of demonstrating path to 9” Host + 1.5m DAC achieved with reasonable package target

Technical Feasibility Summary

- Summary includes only implementations with symmetry on the host
  - Same physical reach and implementation style on both sides of the link
- A significant number of use cases exist within these boundary conditions
  - 35dB IL marker shown for reference only



"Managed Deployment"

- Connecting 2" ports and cabling to 7-9" ports OR matching 5" ports with other 5" ports
- Avoid connecting 7-9" ports to other 7-9" ports
- Limited opportunities to extend cable reach by connecting 2" ports to 2" ports

~33% of ports could support CR with 1m reach using a traditional PCB approach*

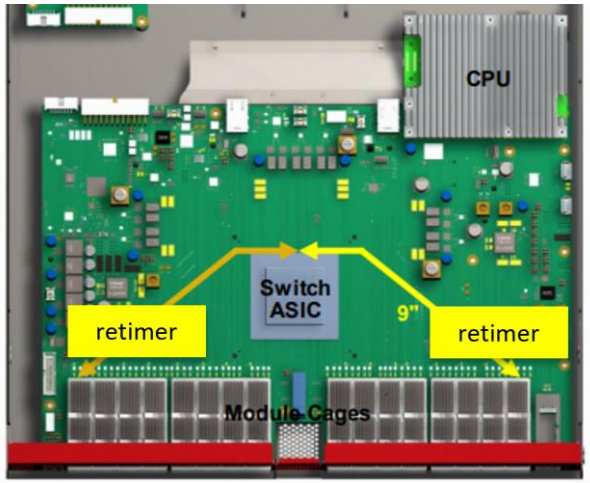
100% of ports could support CR with 1m reach using "Managed Deployment"*

100% of ports could support CR with 1.5m reach using cabled-host implementations*

** Supporting data on previous slides*

Covering All Copper Cable Use-Cases

Number of Ports (per Switch)	Physical Reach (inches)
8	< 3”
10	3-5”
6	5-7”
8	7-9”



What if you can’t use “Managed Deployment” or cabled-hosts?

- Retimer needed

- Retimer on the host doesn’t provide any significant advantage for the additional complexity
- Active Copper Cable (ACC) removes the burden from the host and provides added benefit of increased physical reach >1.5m

Standardizing ACC maximizes the physical reach of the cable with relatively low effort required

Standardizing *only* ACC penalizes use cases that don’t need the extra length
Standardizing *only* ACC may enable design C2M with higher than necessary power

Standardizing ACC is a great complement to passive copper, but not a full replacement

Considerations for the future Task Force

- Importance of truly “Universal Port”?
- Choice of modulation, or use of dual modulation?
- Practical opportunities to employ “Managed Deployment”?
- Relative cost of cabled-host, host retimer, or ACC solution?
- Market opportunity for intra-rack cables <1m, 1m-1.5m, 1.5m-4m?
- Total capabilities of the 200GEL SerDes?

Proposed Objectives

- 800 Gb/s related
  - Define a physical layer specification that supports 800 Gb/s operation over four pairs of copper twinax cable in each direction with a reach of up to at least 1.5 meters
- 1.6 Tb/s related
  - Define a physical layer specification that supports 1.6 Tb/s operation over eight pairs of copper twinax cable in each direction with a reach of up to at least 1.5 meters
- 200 Gb/s related
  - Define a physical layer specification that supports 200Gb/s operation over one pair of copper twinax cable in each direction with a reach of up to at least 1.5 meters
- 400 Gb/s related
  - Define a physical layer specification that supports 400Gb/s operation over two pairs of copper twinax cable in each direction with a reach of up to at least 1.5 meters

Reach target assumes passive copper cable