

Beyond 400 GE Speed: End-User Perspective

Dell'Oro Group at IEEE: Beyond 400 Gbps

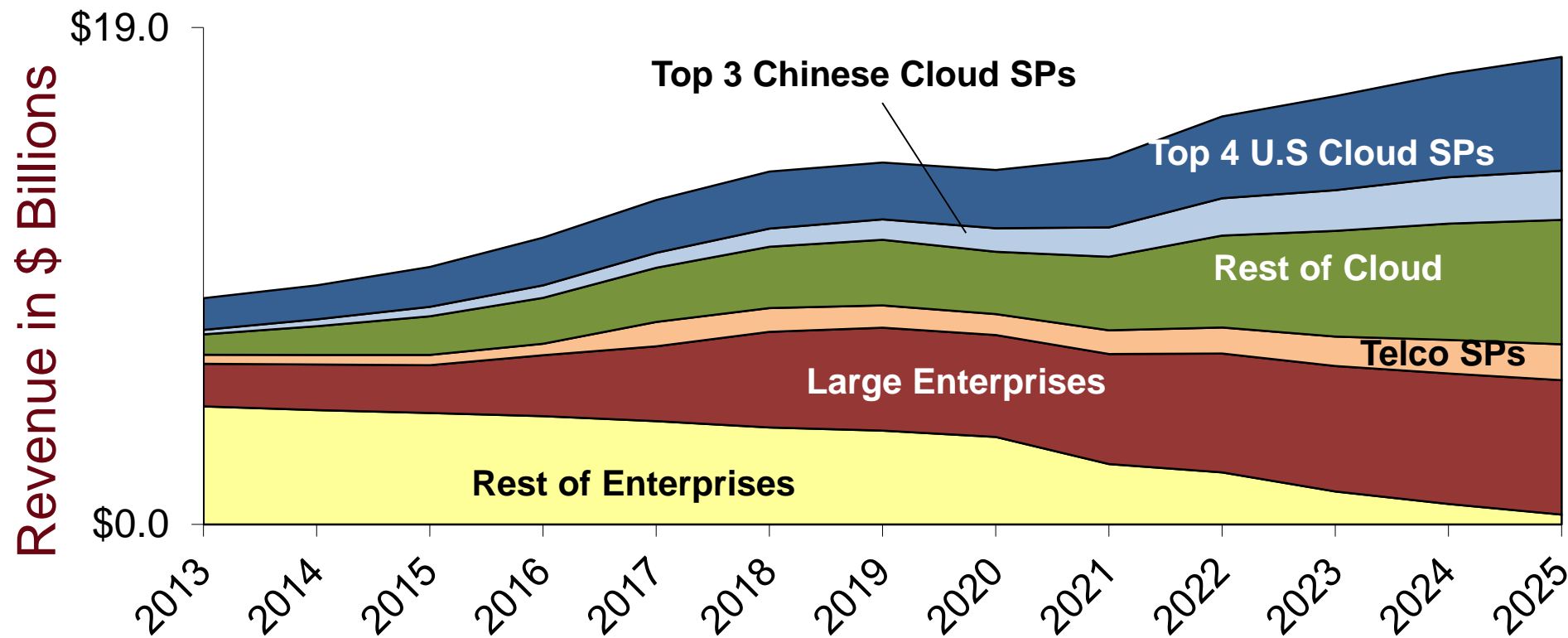
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Topics of Discussion

- ❑ Which market segments are driving the need for higher speeds?
- ❑ How has the 100 GE upgrade cycle unfolded so far?
- ❑ How is the 400 GE upgrade cycle unfolding and what are the major constraints?
- ❑ 800 GE vs. 1.6 TE vs. both?
- ❑ What are the major constraints for speeds beyond 400 GE?

Data Center Switch Revenue by Market Segment



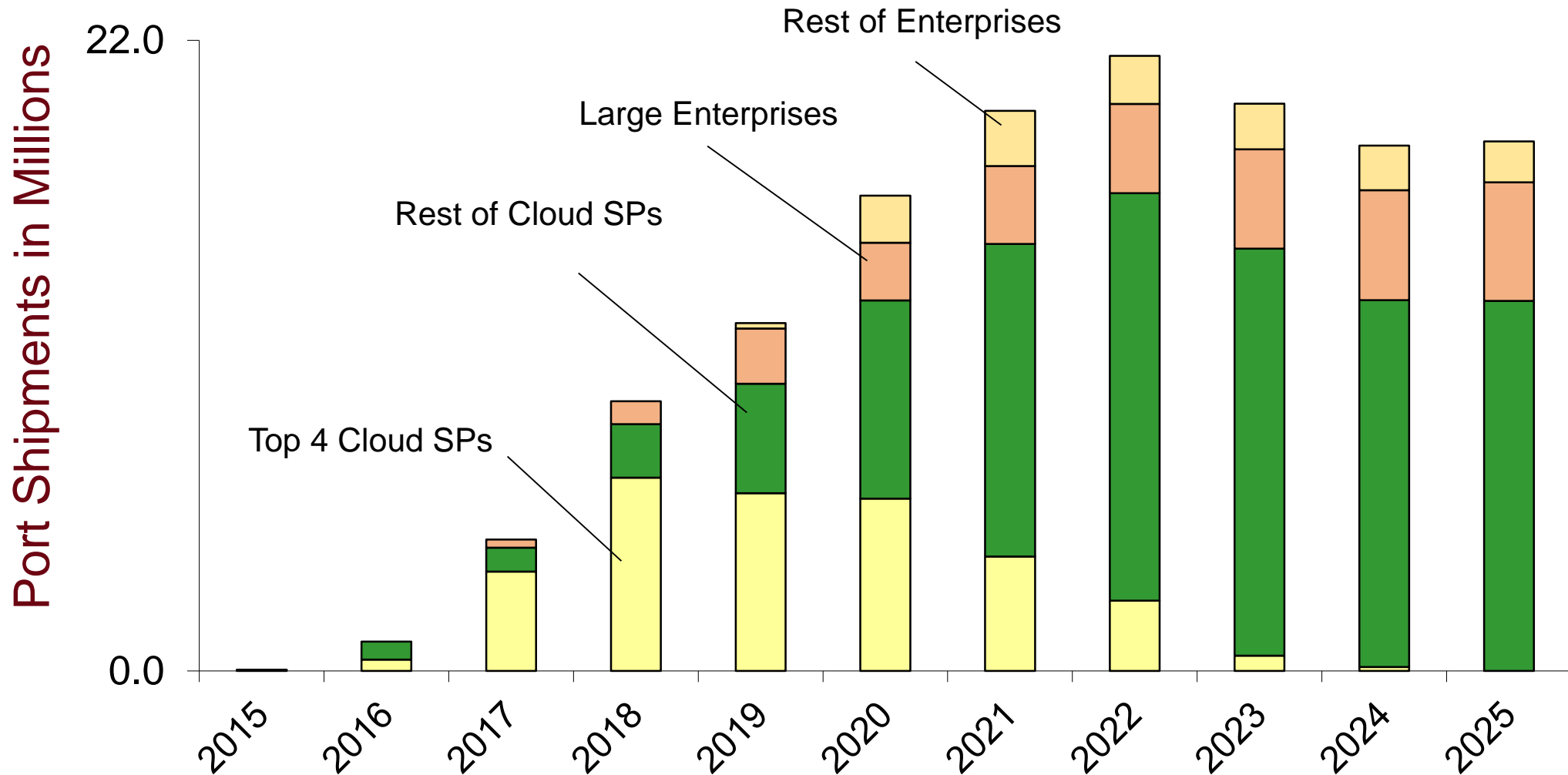
- Our forecast does not reflect increased portion of optics sold by switch system vendors (For example, Cisco selling more optics). We plan to reflect that in a separate forecast to avoid inflating the market size.
- Co-packaged optics (CPO) may start to ramp towards the end of our forecast period. However, the business model is not yet determined (i.e who is going to carry the physical CPO inventory). Hence we did not reflect additional revenue associated with CPO in our current forecast until we have a better view on the business model.

SerDes Roadmap

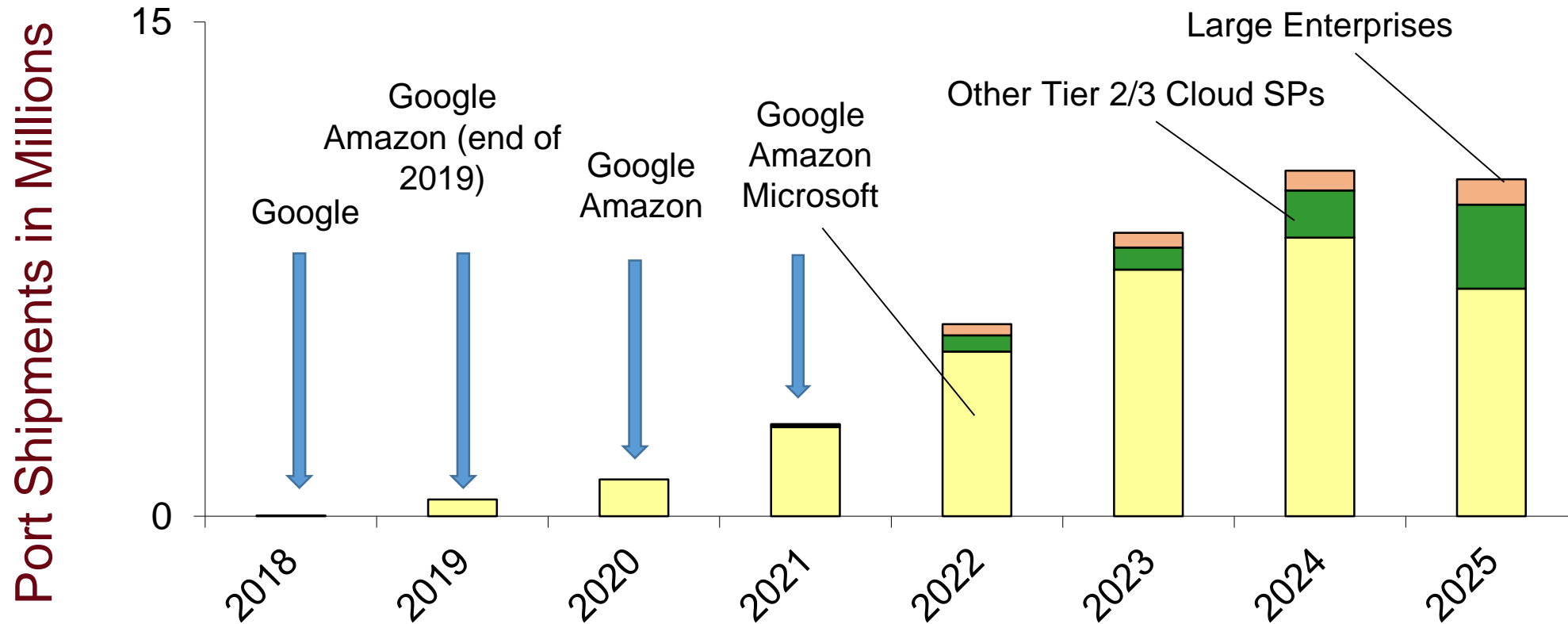
Availability of SerDes	2012 and prior	2016	2019	2021	2024	
SerDes Lanes	10 G-NRZ	25 G-NRZ	50 G-PAM4	100 G-PAM4	200 G-PAMn	
1x	10 GE	25 GE	50 GE	100 GE	200 GE	ToR
2x		50 GE	100 GE	200 GE	400 GE	
4x	40 GE	100 GE	200 GE	400 GE	800 GE	Leaf-Spine
8x			400 GE	800 GE	1.6 TE	

- 40/100/400/800 GE may be also used as ToR @ Tier 1 Cloud SPs

100 GE Switch Port Shipments by Market Segment



400 GE Switch Port Shipments by Market Segment



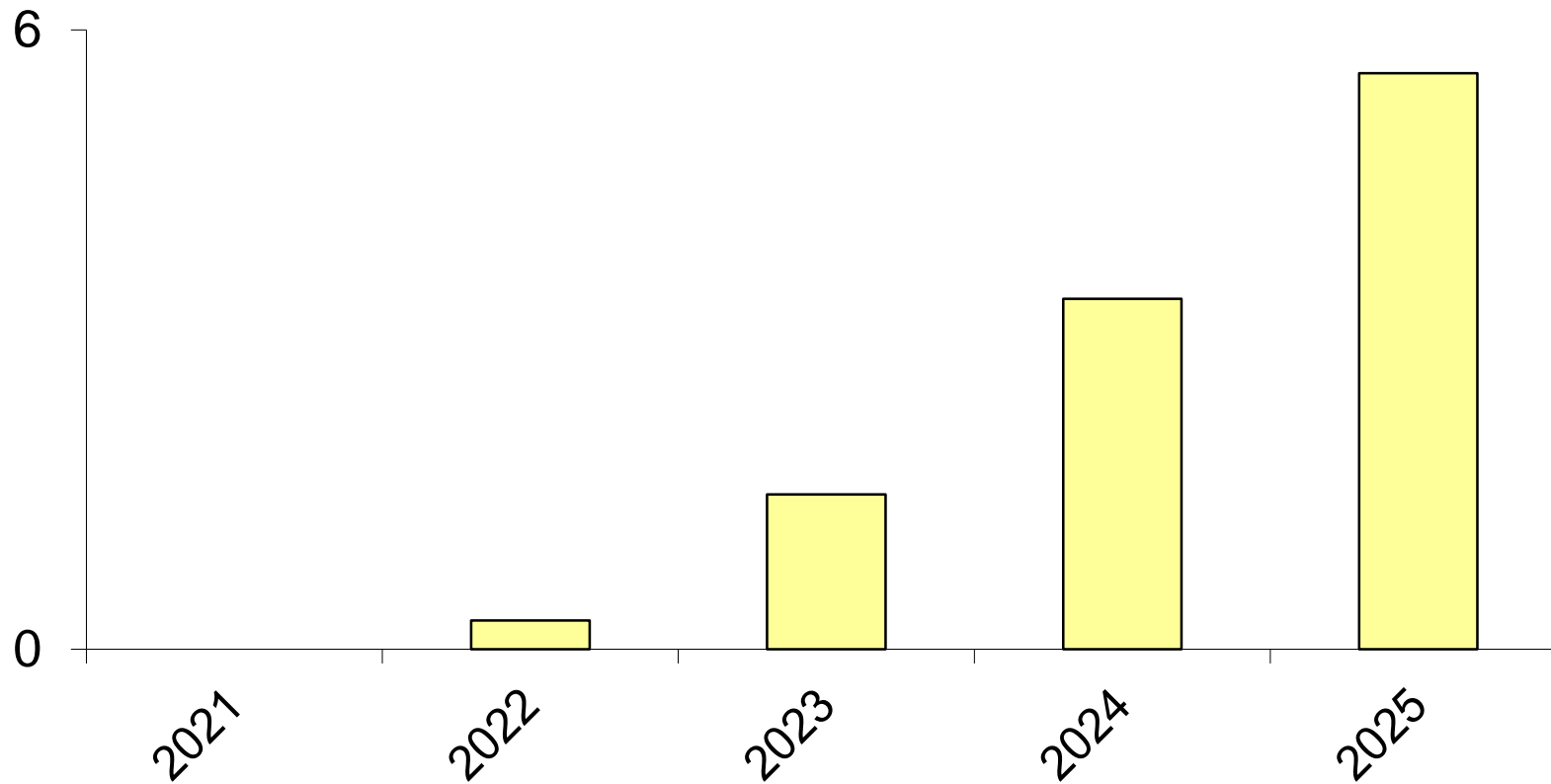
- 400 GE ports can be configured as 1x400 GE, 2x200 GE, 4x100 GE or 8x50 GE. They are all reported under our 400 GE segment
- 400 GE @Microsoft depends on the availability of 400 G ZR optics as well as Jericho 2C+ (due to Power consumption)
- Facebook is adopting 200 GE speed before 400 GE as they need to keep a Radix of 128 ports per switch

Various Switch Implementations @ Top Cloud SPs

Availability of Switch Systems	2019/2020	2021	2021/2022
Switch (Tb/s)	12.8Tbps	25.6Tbps	25.6Tbps
Electrical I/O (Gb/s)	50G-PAM4	50G-PAM4	100G-PAM4
Google	32x400GE (2x200GE)	N/A	32x800G (2x400GE)
Amazon	32x400GE (4x100GE)	N/A	32x800G (8x100GE)
Microsoft	N/A	N/A	64x400GE
Facebook	128x100GE	128x200GE	N/A

800 G vs. 800 GE?

Port Shipments in Millions



- Initial 800 G port shipments will not be using 800 GE MAC and will be used as 2x400 GE or 8x100 GE
- Initial deployment will be driven by Google and Amazon. Microsoft is expected to start 800 G deployment in 2023 (with each port being configured as 2x400 GE)

Potential Need for 800 GE vs. 1.6 TE

Availability of Switch Systems	2019/2020	2021	2021/2022	2023/2024	???
Switch (Tb/s)	12.8Tbps	25.6Tbps	25.6Tbps	51.2Tbps	102.4 Tbps
Electrical I/O (Gb/s)	50G-PAM4	50G-PAM4	100G-PAM4	100G-PAM4	200G-PAMn
Google	32x400GE <i>(2x200GE)</i>	N/A	32x800G <i>(2x400GE)</i>	64x800G? <i>(1x800GE)?</i>	64x1.6 Tbps <i>(1x1.6 TE)?</i>
Amazon	32x400GE <i>(4x100GE)</i>	N/A	32x800G <i>(8x100GE)</i>	64x800G <i>(4x200GE)?</i>	64x1.6 Tbps <i>(4x400 GE)?</i>
Microsoft	N/A	N/A	64x400GE	64x800G <i>(2x400GE)</i>	64x 1.6 Tbps <i>(2x800 GE)? Or (1X1.6 TE)?</i>
Facebook	128x100GE	128x200GE	N/A	128x400GE	128x 800 GE

Potential Need for 800 GE vs. 1.6 TE (Cont.)

□ There's potential need for both 800 GE and 1.6 TE, it's just a matter of timing:

- Potential need for 800 GE @ 51.2 Tbps and 102.4 Tbps
- Potential need for 1.6 TE @ 102.4 Tbps

□ 200 G SerDes and 200 G Lambda are needed for 1.6 TE

- Growing momentum behind 200 G electrical and optical lanes, but volume production and other challenges need to be considered.
- Expect 100 G SerDes with 100 G Lambda to be the main building blocks for next generation speeds over the next five years.

Other Major Considerations for Next Ethernet Speeds

- ❑ Power is one of the major constraints for speeds beyond 400 Gbps
- ❑ Future data center networks may require a combination of photonic innovation (eg. Co-packaged Optics) and optimized network architectures
- ❑ CPO are a viable solution @ 51.2 Tbps but may become inevitable @ 102.4 Tbps for certain hyperscalers
 - Initial solutions will be proprietary but standards are needed to enable a more diverse ecosystem and avoid vertically integrated solutions
- ❑ Different building blocks have to come together in order to enable future speed transitions
 - A lot of work needs to be done, we better get started!

THANK YOU

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