CORNING

100Gbps MMF Objectives

Steve Swanson
April 9, 2020

Premise

- We have two distinct market needs for the 100G Short Reach MMF SG
  - Interconnects between switches
  - Interconnects between switches and servers

- These two market needs cannot be met with a single PMD operating at 50m on OM4 and 30m on OM3
  - One should be based on supporting the maximum link length MMF 100G switch-to-switch interconnect
    - 100m desired at a cost lower than 100GBASE-DR
  - One should be based on supporting the minimum cost MMF 100G switch-to-server interconnects
    - Cost competitive with AOCs and Copper

Previous contributions considered

- The bulk of the material in this presentation has been taken directly from the IEEE 802.3 100 Gb/s Wavelength Short Reach CFI

- It also considers other contributions in Geneva and our interim calls
  - lewis_100GSR_01_0120.pdf noted that sw-to-svr links are the most cost sensitive part of the data center network and that a lower cost level was needed compared to "traditional" optics
  - ghiasi_100GSR_01_0120.pdf recommended an ultra low cost SR PMD with reach of 15 m addressing TOR to server applications
  - bruckman_100GSR_01_0120.pdf noted
    - 5m within cabinet; a small number of cross-rack interconnects up to 20m for TOR to Server
    - 70m and 100m is preferred depending on cost-efficiency for TOR to T1
  - pimpinella_100GSR_01b_0120.pdf noted a maximum reach of 18m for switch to server channel reach
  - nering_100GSR_01_0120.pdf noted
    - an opportunity to provide alternative to copper for this high-speed application – but cost remains most important criteria. Users will be technology-agnostic
    - Very high volume requiring low total cost of implementation
    - Solution should be a clear winner on the target application
    - Market success will be highly dependent on meeting market expectations for low cost solutions
  - parsons_100GSR_adhoc_01_021320.pdf noted that the 50 m objectives adopted in Geneva will not increase the cost of 30 m switch-to-server links, supporting economic feasibility

What we know

- The first 100G switch-to-switch links for early adopters are short in some regions but not all regions
- Backward compatibility with previous IEEE projects is expected
- All previous IEEE projects to date have had at least one objective supporting “at least 100m on MMF”
- Longer switch-to-server links are needed to address new architectures under consideration
- For switch-to-server links, cost is the most important criteria

Expressed market needs

- Short-reach interconnect between switches
- Low-cost interconnect for 100G serial servers
- Distances:
  - 100 meters desired
  - 50 meters required
  - 30 meters is currently a space for AOCs
- Breakout desired
- Cost < 50%of DR desired
- Power consumption ~ 50% of DR desired

100G MMF SG Objectives adopted in Geneva

- Define a physical layer specification that supports 100 Gb/s operation over 1 pair of MMF with lengths up to at least 50 m
- Define a physical layer specification that supports 200 Gb/s operation over 2 pairs of MMF with lengths up to at least 50 m
- Define a physical layer specification that supports 400 Gb/s operation over 4 pairs of MMF with lengths up to at least 50 m

Will the adopted Objectives support the CSDs?

- Broad Market Potential 
- Compatibility 
- Distinct Identity 
- Technical Feasibility 
- Economic Feasibility 

Other questions

- Is 850nm the right wavelength?
  - For backward compatibility 
  - For maximum length 
  - For lowest cost 
- Is the 50m target sufficient for switch-to-switch
  - For some 
  - But not all 
    - Company A: 80%
    - Company B: 40%
    - Company C: 100%
    - Company D: 100%

Modeled MMF transmission distances

Table 3 – Fiber channel bandwidth and transmission distance of MMF reckoned by the theoretical model used in IEEE

Bit rate	Signal Type	Fiber Type	Fiber channel bandwidth (GHz•km)	Transmission Distance (m)	IEEE standards
50Gbps	PAM4	OM4	2.301	100m	50G-SR, 100G-SR2 200G-SR4, 400G-SR8
50Gbps	PAM4	OM3	1.541	70m	
100Gbps	PAM4	OM4/OM5	2.301/2.377	50m	Defined now
100Gbps	PAM4	OM3	1.541	35m	-

Source: 800G MSA Whitepaper
https://www.800gmsa.com/documents

- Again, all previous IEEE projects to date have had at least one objective supporting “at least 100m on MMF”

Optical module evolution

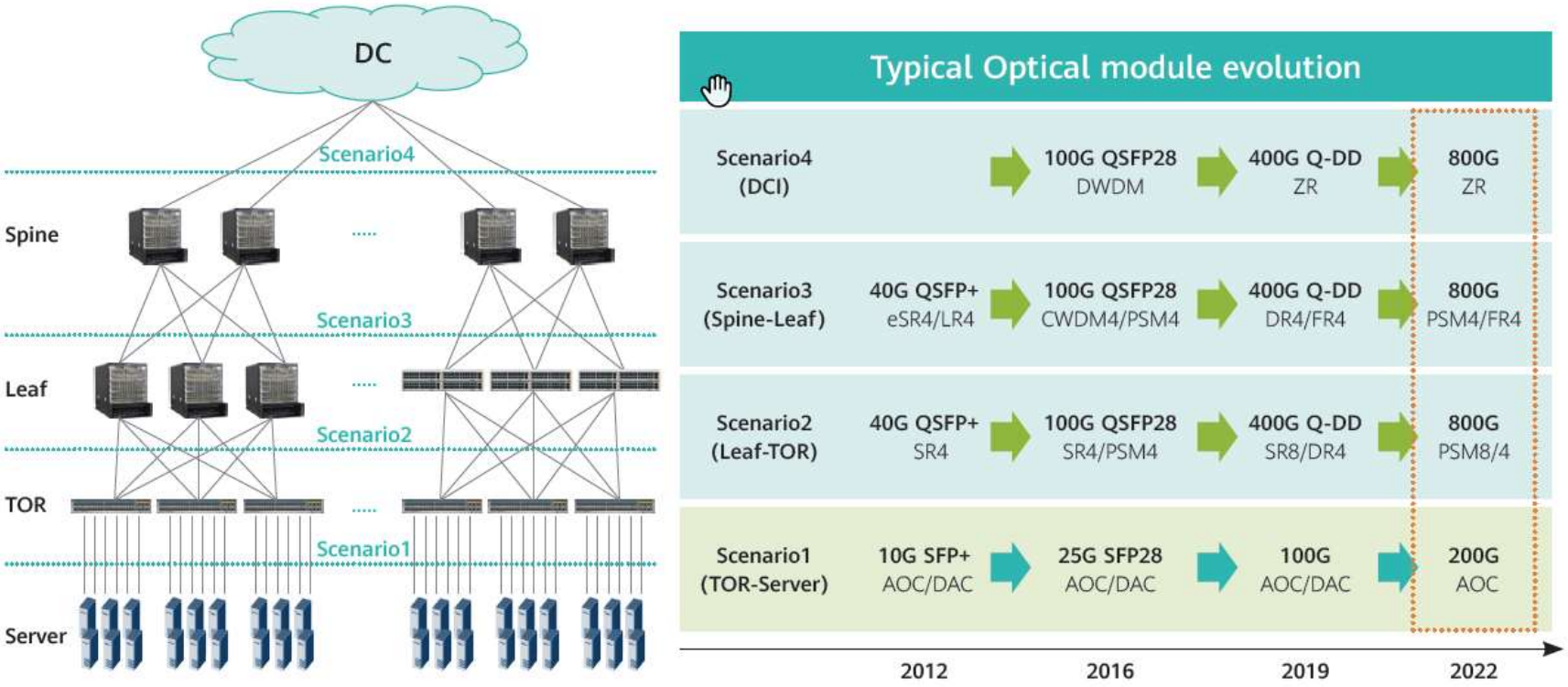

Figure 4 – Typical hyper scale data center interconnect roadmap

Source: 800G MSA Whitepaper
https://www.800gmsa.com/documents

Hyperscale Datacenters distance requirements

Table 1 – Detailed requirements of the typical hyper scale DCN

Scenario	Server to TOR	TOR to Leaf	Leaf to Spine	DCI
Bandwidth	200G	800G	800G	800G
Distance	4m within rack; 20m cross-rack	≥70m 100m is preferred	500m/2km	80km-120km
Module size	QSFP-DD/OSFP	QSFP-DD/OSFP	QSFP-DD/OSFP	QSFP-DD/OSFP

Source: 800G MSA Whitepaper
https://www.800gmsa.com/documents

SR scenario analysis for Hyperscale DCs

- The industry is facing the basic limitations of VCSEL signaling at speeds of 100G/lane
  - Short reaches only partially cover the SR class primarily employed by Chinese hyper scale data center operators
- The 800G MSA targets the development of a low-cost 8x100G module for SR applications, covering the sweet spot of 60-100m
- The MSA is intended to specify a lower cost transmitter technology with the potential to leverage sub-linear cost scaling with a high degree of integration
- A low cost 800G SR8 could also support
  - increasing switch radix and decreasing server count-per-rack
  - Could favor middle-of-the-rack (MoR) and end-of-the-rack (EoR) or top-of-the-rack (ToR) architectures, by providing a low cost serial 100G server interconnect

Source: 800G MSA Whitepaper
https://www.800gmsa.com/documents

Recommendation is to replace current objectives

- **One set of objectives supporting 100m switch-to-switch**
  - Define a physical layer specification that supports 100 Gb/s operation over 1 pair of MMF with lengths up to at least **100 m (TBD)**
  - Define a physical layer specification that supports 200 Gb/s operation over 2 pairs of MMF with lengths up to at least **100 m (TBD)**
  - Define a physical layer specification that supports 400 Gb/s operation over 4 pairs of MMF with lengths up to at least **100 m (TBD)**

- **One set of objectives supporting lowest cost switch-to-server**
  - Define a physical layer specification that supports 100 Gb/s operation over 1 pair of MMF with lengths up to at least **20 m (TBD)**
  - Define a physical layer specification that supports 200 Gb/s operation over 2 pairs of MMF with lengths up to at least **20 m (TBD)**
  - Define a physical layer specification that supports 400 Gb/s operation over 4 pairs of MMF with lengths up to at least **20 m (TBD)**

Summary

- Expressed Market Needs
  - **Short-reach** interconnect between switches
  - **Low-cost** interconnect for 100G serial servers

- Both needs be cannot be fulfilled with the same PMD

- Recommendations
  - **More study needed**
  - Contributions needed on
    - **Technical Feasibility of 100m**
    - BMP of 50m PMDs
    - **Economic feasibility of 20m PMDs**

CORNING