Reach for 200G per Lane Multimode Links

Ramana Murty and I-Hsing Tan
Broadcom Inc.

IEEE 802.3 200 Gb/s per Wavelength MMF PHYs Study Group
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Supporters

Yu (Helen) Xu, Huawei

Jing Li, YOFC

Adrian Amezcua, Prysmian

Jose Castro, Panduit

Earl Parsons, CommScope

Overview

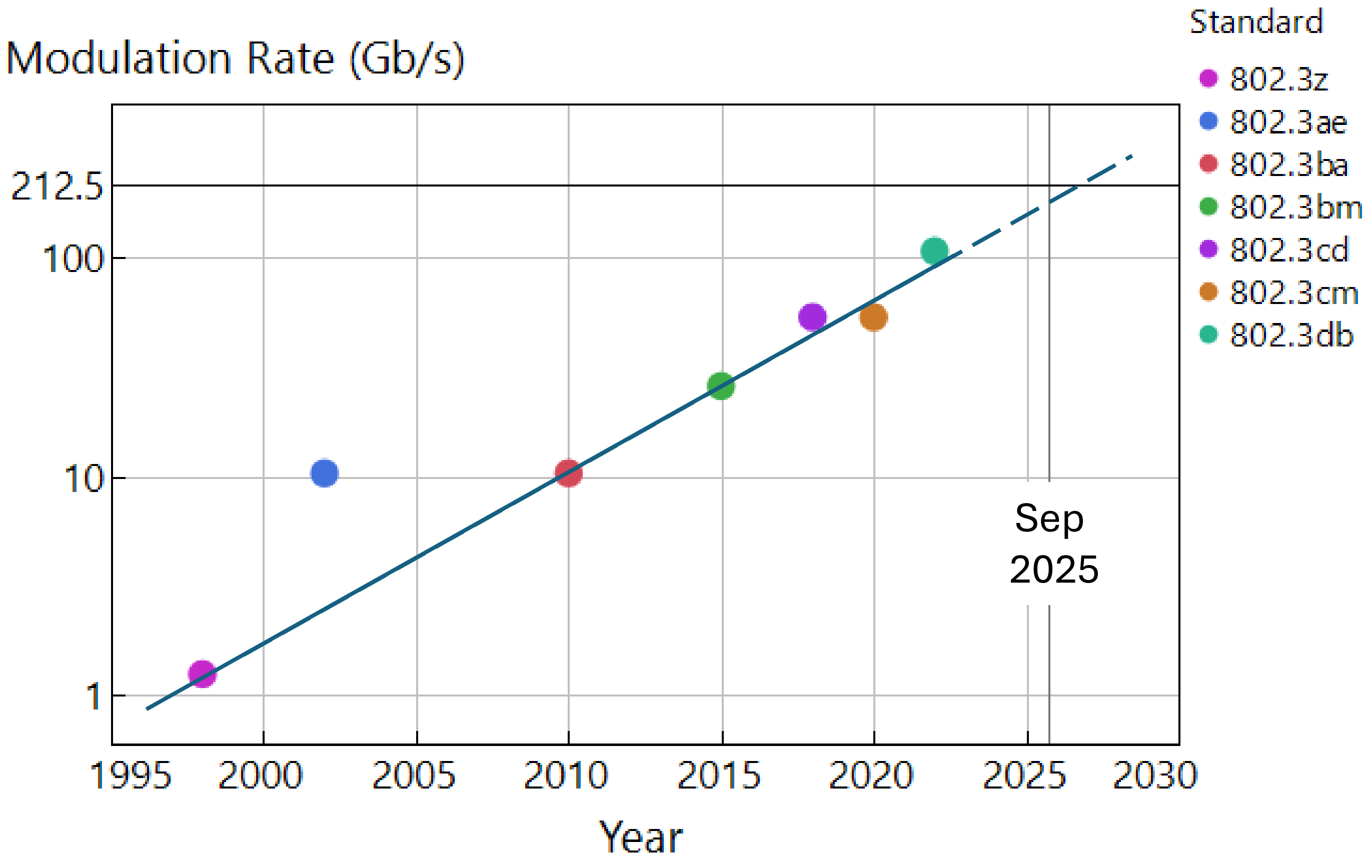
Contribution in support of

- Objectives for 200 Gb/s operation over 30 m and 50 m MMF

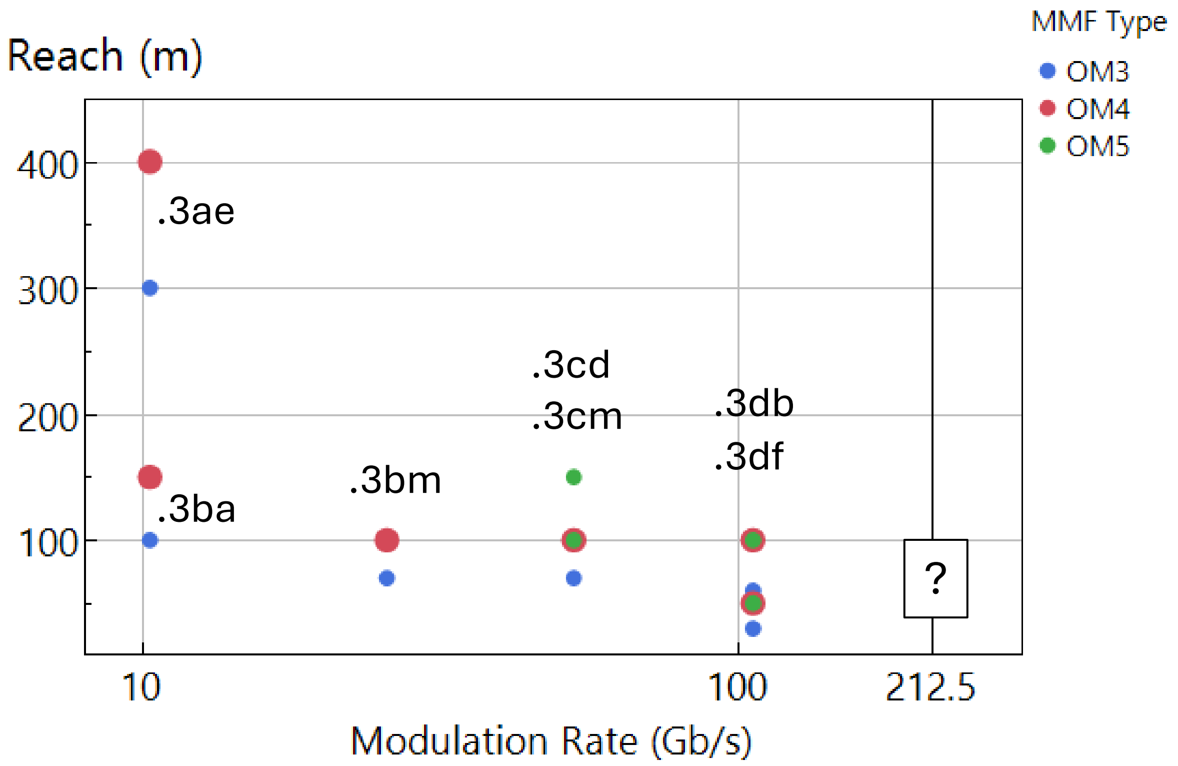
- CSD
  - Broad Market Potential
  - Technical Feasibility
  - Economic Feasibility

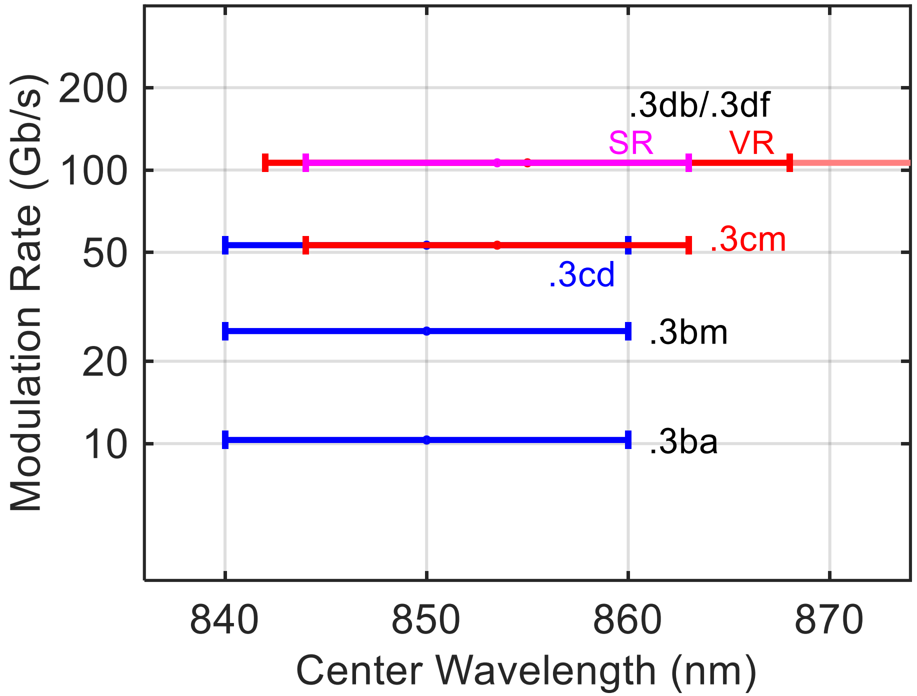
802.3 Multimode Standards

IEEE 802.3 Multimode Standard Publication



Reach and Wavelength





Use of FEC and equalization has helped maintain a reach of 100 m up to 100G per lane

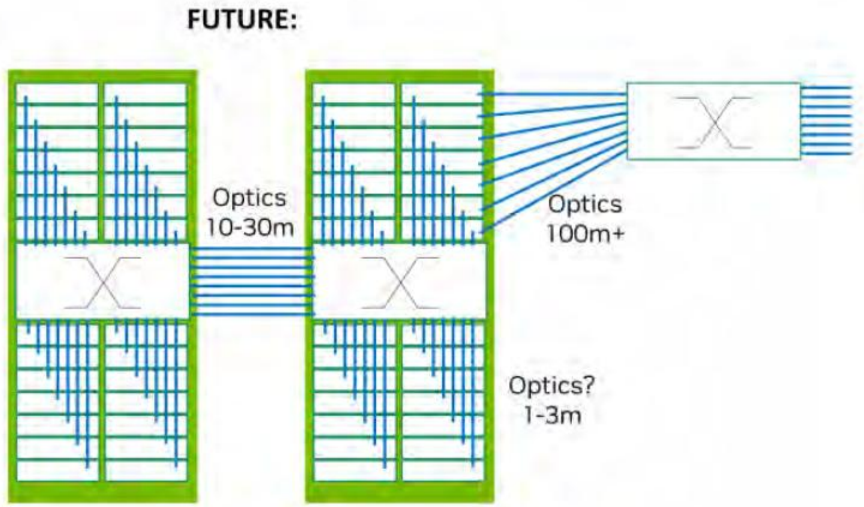
Reach for 200G per lane?

Center wavelength range has shifted toward 860 nm at high modulation rates to benefit from (a) reduced chromatic dispersion, and (b) matching optimized VCSEL performance

Statements on Reach

CFI_200GMMF_R4_250717.pdf

Craig Thompson, Nvidia

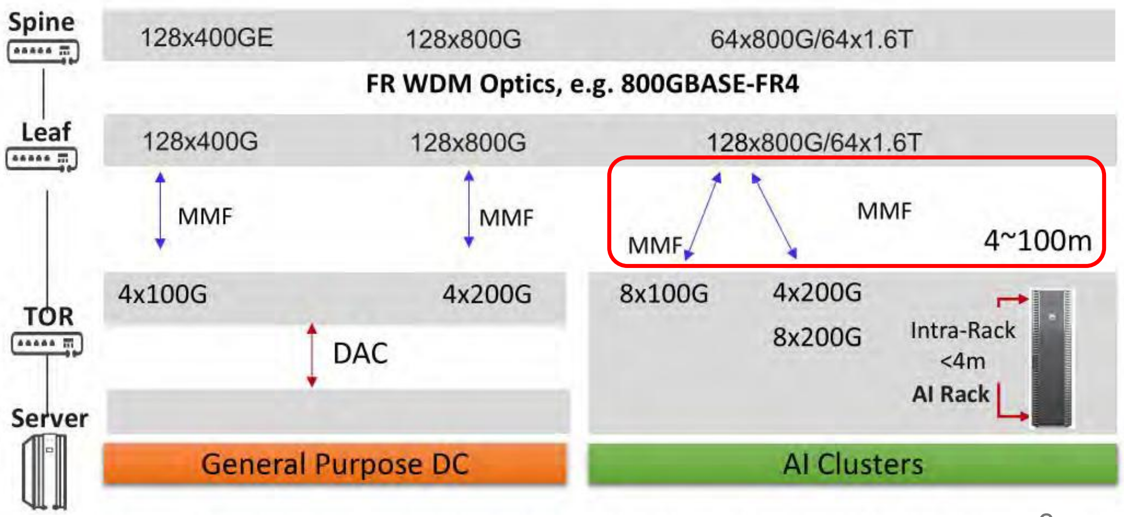


- **Majority of GPU-GPU links will remain <50m**
- **Min 50% of scale-up links must >2m**
- **Need low-cost, reliable, power-efficient optics**
- **Must hit targets:**
  - **30m distance**
  - **Approaching copper-level reliability**
  - **<5pJ/bit (not including PHY)**
  - **1Tbps/mm**

Jerry Chen, Alibaba Cloud and Zhiping Yao, Alibaba Cloud

- Distance
  - 50 meters required for transceivers; covers 60% connections
  - 30 meters is currently a space for AOCs at Alibaba
  - 70 or 100 meters desired for transceivers with inner-FEC enabled

Guangcan Mi, Huawei and Yu (Helen) Xu, Huawei



Reach (1)

λc	center wavelength
Uw	RMS spectral width
EMB	effective modal bandwidth

- Reach of 30 m is a must

  Fiber –3 dBe bandwidth on OM4 (EMB 4700 MHz·km) ≈ 60 GHz (λc = 863 nm, Uw = 0.6 nm)
  ≈ 66 GHz (λc = 863 nm, Uw = 0.5 nm)

  Demonstrations of 200G links so far indicate this can be realized.

- Reach of 50 m has been requested
  - Recent demonstration[a] used a fiber with EMB > 6500 MHz·km
  - ILT and Inner FEC
    - ILT can help extend the range by allowing more overshoot in the launch waveform (which is then attenuated by fiber transmission), but the main benefit will be lower BER across the range of fiber lengths
    - Inner FEC comes with a 6.8% overhead in data rate – FEC gain will be negated by the drop in the VCSEL response
  - 802.3db (100G per lane) defined 100 m link on OM4 (corner λc = 863 nm, Uw = 0.6 nm leads to fiber -3 dBe bandwidth of 18 GHz)

Component bandwidth (relative to Nyquist frequency) / Loss at Nyquist frequency

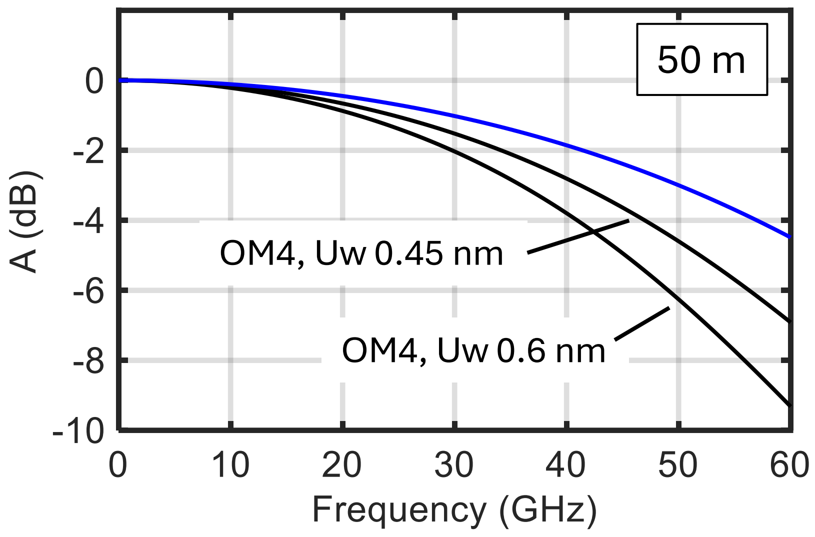
	Component bandwidth: VCSEL	Component bandwidth: MMF (OM4)	Loss: VCSEL	Loss: MMF (OM4)
100G per lane	≈ 1	0.68 (for 100 m)	≈ -3 dB	≈ -7 dB
200G per lane	≈ 0.7[a]	0.68 (for 50 m)	≈ -11 dB	≈ -7 dB

reducing fiber attenuation can help!

a CFI_200GMMF_R4_250717.pdf

Reach (2)

Fiber response (modeled as 4th order BT filter)



EMB 3640 MHz·km (corner OM4)	λc = 863 nm, Uw = 0.6 nm	-3 dBe BW	36 GHz
EMB 3640 MHz·km (corner OM4)	λc = 863 nm, Uw = 0.45 nm	-3 dBe BW	41 GHz
EMB 5200 MHz·km	(λc = 868 nm), Uw = 0.45 nm	-3 dBe BW	50 GHz

- With Uw = 0.45 nm, fiber -3 dBe bandwidth increases to 50 GHz from 41 GHz
- Equivalently, gain of ≈2 dB at 53.1 GHz with the higher EMB fiber

Combination of higher EMB and restricting Uw leads to a fiber contribution of ≈ –3 dB at 53.1 GHz

Loss at Nyquist frequency for 50 m reach

	VCSEL	MMF
100G per lane	≈ -3 dB	≈ -7 dB
200G per lane	≈ -11 dB	≈ -3 dB

Reach (3)

Path to higher EMB MMF:

- Target (fiber bandwidth / Nyquist frequency) $\approx$ 1 with a combination of higher EMB and some restriction on RMS spectral width Uw
- Move λc closer to 860 nm to benefit from (a) reduced chromatic dispersion, and (b) matching optimized VCSEL performance

Chromatic dispersion*	–98.5 ps/(nm·km)	at 850 nm
	–94.2 ps/(nm·km)	at 860 nm

➢ Example: EMB > 5200 MHz·km over a 16 nm window centered at 860 nm
Translates to 6100 MHz·km at 860 nm using OM4 EMB vs. wavelength guidance

* John Abbott *et al.*, abbott_3db_adhoc_01_080620.pdf

Recommended Objectives

Define a physical layer specification that supports 200 Gb/s operation:

- over 1 pair of MMF with lengths up to at least 30 m
- over 1 pair of MMF with lengths up to at least 50 m

Define a physical layer specification that supports 400 Gb/s operation:

- over 2 pairs of MMF with lengths up to at least 30 m
- over 2 pairs of MMF with lengths up to at least 50 m

Define a physical layer specification that supports 800 Gb/s operation:

- over 4 pairs of MMF with lengths up to at least 30 m
- over 4 pairs of MMF with lengths up to at least 50 m

Define a physical layer specification that supports 1.6 Tb/s operation:

- over 8 pairs of MMF with lengths up to at least 30 m
- over 8 pairs of MMF with lengths up to at least 50 m

Summary

Reach for 200G per lane multimode links

- 30 m reach can be attained with OM4
- 50 m reach will benefit from a MMF with higher EMB than OM4