200GBASE-SR1.4 technical feasibility

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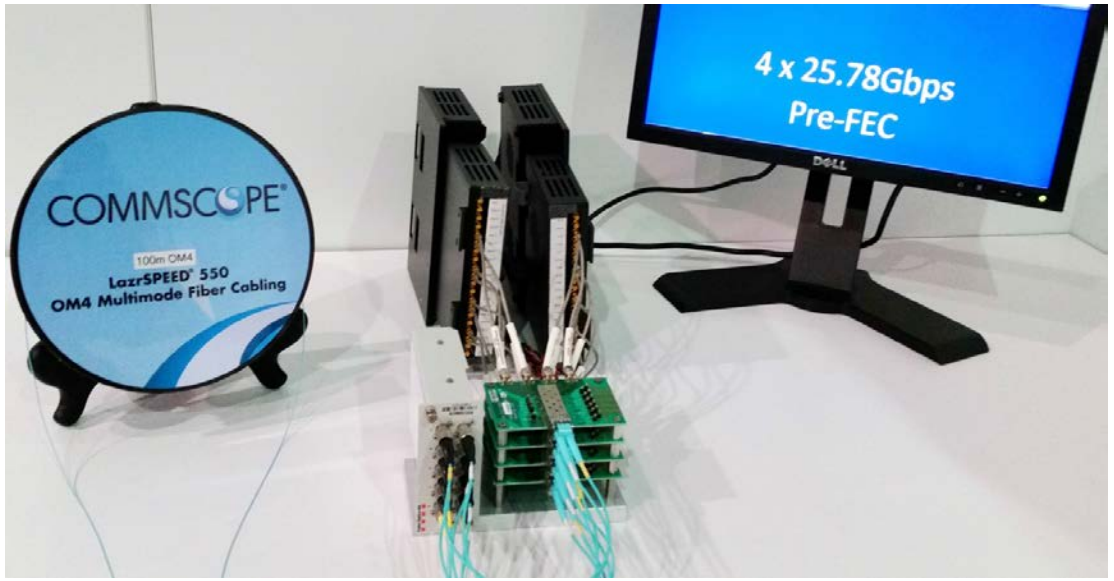
OFC, a couple of years ago

- 100 Gb/s four λ shortwave WDM (SWDM) technical demo
  - 25 Gb/s NRZ, error free operation over 150 m on OM4 (without FEC enabled)
- 30 nm channel spacing, centered at 850, 880, 910, 940 nm
  - Balances cost and performance of mux/demux optics, VCSEL wavelength pass-bands, and fiber wavelength range over which modal bandwidth is critical.



Technical feasibility for 4 wavelengths on MMF: 4x25 GBd SWDM over 100m OM4

- For example, the SWDM MSA - 100G-SWDM4
  - 4 wavelengths over duplex MMF
  - 30 nm channel spacing
  - NRZ 25 Gb/s per wavelength, same* symbol rate as in 802.3cd
  - Maximum reach 100 m on OM4, FEC supported (same FEC as 100GBASE-SR4)
  - Started shipping in 2017

*200GBASE-SR1.4 would have ~ 3% higher symbol rate, to accommodate the stronger FEC in 802.3cd

Four-wavelength SWDM links at 25 GBd

- From 25Gb/s per wavelength NRZ to 50Gb/s per wavelength PAM4
  - PAM4 more sensitive to crosstalk
  - PAM4 more sensitive to RIN
  - Slightly higher transmit bandwidth desirable for PAM4
  - Extra link budget needed for PAM4 (~5 dB)
- What's in the tool box for 200GBASE-SR1.4 ?
  - Use of stronger FEC per 802.3cd (~0.6 dB more FEC gain than used for 100GBASE-SR4)
  - PAM4 VCSELs
    - Improved launch optics, better RIN and output power (1 or 2 dB)
    - Longer wavelength VCSELs have intrinsically higher bias current limits than 850 nm – helps output power and VCSEL rise-fall times
  - Better designs for PAM4 receivers, better responsivity and TIA noise, ~2 dB improvement
  - Equalization in PAM4 optical receivers, mitigates ISI
    - ~2 dB or more for longer wavelength channels where MMF modal bandwidth is lower

Other technical feasibility examples in technical literature

- 50 Gb/s PAM4 VCSELs and SWDM
  - Many examples of published work, combined with shortwave wavelength division multiplexing (SWDM), have been published in the peer reviewed technical literature, including:

    Tatum, Jim A. et al, "VCSEL-Based Interconnects for Current and Future Data Centers," JLT V33, 727 (2015)
    - *which in 2017 was declared 'one of the two winning papers for this years JLTs Best Paper Award, honoring the most influential, highest-cited original paper published in JLT in 2015'*

- There's an excellent summary in parsons_3cd_01_0118

Conclusion

- There is a wealth of evidence supporting the technical feasibility of a 4 wavelength 200 Gb/s PMD with 100 m reach capability over OM4