Past Performance is not Indicative of Future Results

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May 23, 2019

Introduction –

stassar_cu_adhoc_041719 raises concerns related to wavelength spacing for 400GBASE-LR4

- "While the preference for a 20 nm spaced CWDM grid appears obvious (because of the anticipated lowest device cost) at the same time it will be necessary to obtain stable and "plug-and-play" capable BER performance."
- Deployment of G.652 fiber where zero dispersion wavelength is between 1305 and 1320nm.
  - Non-public data from some telecom operators indicates 98% coverage.
  - Will testing be required for 10km applications?
- Stated Observations
  - Assuming a max fiber chromatic dispersion range of ~-47 to 23 ps/nm only the 800 GHz spaced configuration comfortably supports these dispersion levels for both the standard IEEE 802.3 and the fiber with restricted dispersion characteristics.
  - Only when restricting the CWDM wavelength ranges from ±6.5 nm to ±3 nm AND restricting the fiber dispersion characteristics, can the assumed maximum dispersion limits just be met.
  - Without restrictions – CWDM solution: 8.3 to 8.6km max suggested. Engineered Link at 10km?
- Questions / suggestions
  - How conservative are the proposed approaches?
  - CD Penalty over temperature?
  - Reasonable maximum TDECQ value?
  - TDECQ minus SECQ requirement need?

From Broad Market Potential Responses

- Noted Responses
  - Ethernet is widely deployed in telecom client interconnects and in switch-to-switch applications in hyperscale and enterprise data centers where these 100 Gb/s and 400 Gb/s interconnects are expected to be widely utilized.
  - The opportunity to have common 100 Gb/s per wavelength technology building blocks across all required SMF reaches in these applications enables solutions with reduced component count, increased density, and lower costs.

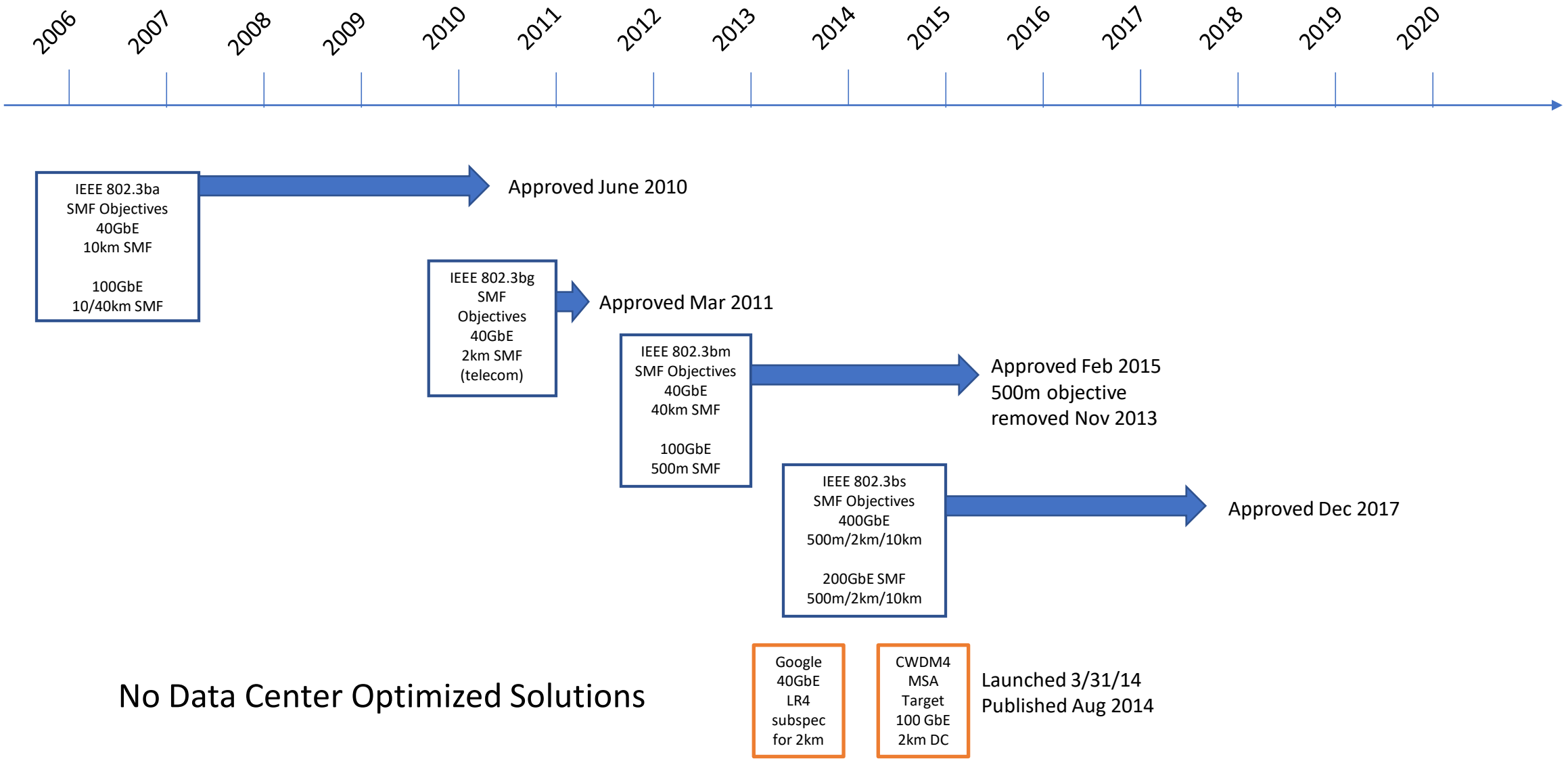
- Observations
  - Telecom and data center applications are different
  - No requirement that the solution for both be identical – or interoperable
  - What is important – solution(s) for the specific application meets the requirements of the target application space
  - 8.3 to 8.6 km solution does not satisfy the 10km deployments – telecom space will either a) limit deployments of new PHYs or b) use existing 400GBASE-LR8

From Economic Feasibility Responses

- Noted Response –
  - In consideration of installation costs, the project is expected to use proven and familiar media consistent with industry deployments, namely single-mode fiber.
  - Network design, installation and maintenance costs are minimized by preserving network architecture, management, and software.

- Observations
  - Decision to use CWDM grid
    - Limit CD penalty for devices targeting 10km? (extra cost)
    - Might require link / fiber testing? (extra cost)
    - Might limit deployments for 10km applications (network architecture not preserved – so costs are not minimized)

Looking Back….



No Data Center Optimized Solutions

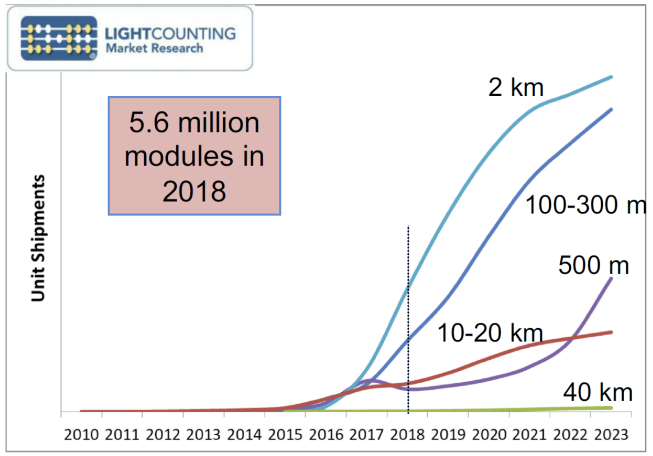
Observations Regarding DC SMF Solutions

- 40GbE: Per Dale Murray, LightCounting – "No data center needs internal reach beyond 2km. By reducing certain specs relative to the IEEE standard, Google created a more economical 2km variant of the 40G-LR4 PMD. Over time, as both variants reached high volume, yields became very high and manufacturing costs converged. [Note – Google shifted the entire market to 88% 'subspec' variants in 2013.]"
- 100GbE: CWDM4 MSA launched about 4 months after IEEE 802.3 approves removal of 500m objective in 802.3bm (3/31/14 http://www.cwdm4-msa.org/files/03.31.14_CWDM4_MSA_Press_Release.pdf)
- 200GbE: serviced by 200GBASE-FR4 (IEEE 802.3bs)
- 400GbE: 400GBASE-FR4, being developed by IEEE P802.3cu believed to meet DC power / density needs

Lesson Learned

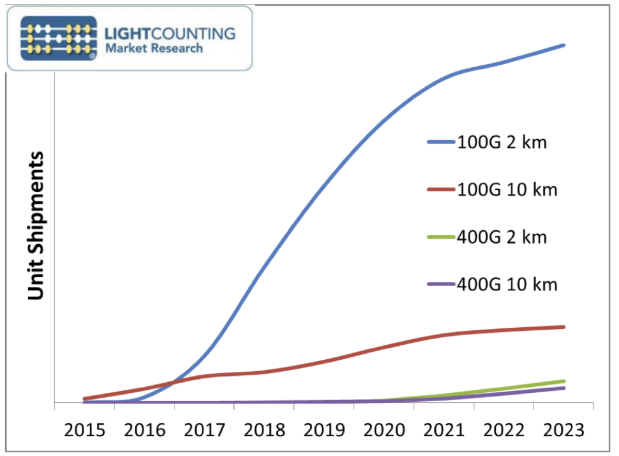
Market Forecast slides

100 GbE Modules by reach



Courtesy Dale Murray, Light Counting

100 GbE & 400 GbE 2 & 10 km SMF Modules



Courtesy Dale Murray, Light Counting

- 100 GbE optics market still in strong growth phase
- 400 GbE at start of its ramp but expected to be fast

} Both market conditions benefit from cost reductions

9

Source: **100 Gb/s per lane optical PHYs CFI Consensus Presentation:** http://www.ieee802.org/3/cfi/1118_1/CFI_01_1118.pdf

- For 100GbE (2023) – 2km usage is projected to be ≈ 4x 10/20km. It is expected that this trend will repeat at 400GbE.

Summary

- It has been argued that 2km data center applications were not served best by past IEEE projects
- Early adoption was seen by non data center 10km solutions
- No reservations are being expressed about the 2km CWDM solution proposed for this project. It is expected it will work well with a 100Gb/s per lane electrical signaling solution.
  - Data center space served!
- At 10km there have been observations that raise concerns about CWDM proposed solutions, but not 800GHz grid spacing.
  - Resolution of these concerns needs additional data / time.
  - Rush to decision could result in YAMSA!