No-FEC Link for 50GE

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Outline

- Is no-FEC link needed?
- Technical feasibility
- Economic feasibility

Why No-FEC link is desired?

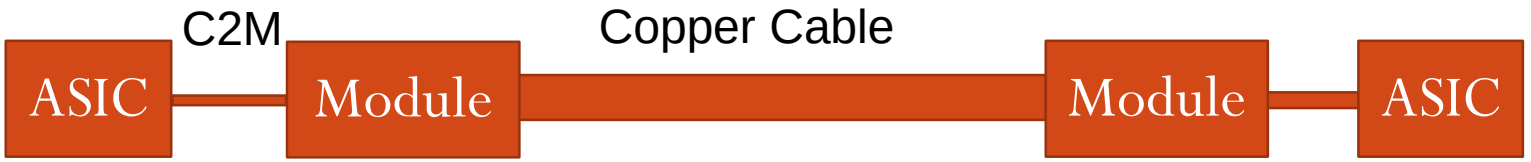
- **Low-latency link is highly desired in applications such as high-performance computing, financials, and etc.**
  - Latency is a limiting factor of parallel computing.
    - Lower latency results in faster computation.
- **Because of the promising market potential, tremendous efforts have been put in 802.3by to achieve 3m no-FEC link, for example:**
  - [1] http://www.ieee802.org/3/by/public/Sept15/andrewartha_3by_01a_0915.pdf
  - [2] http://www.ieee802.org/3/by/public/July15/goergen_3by_02a_0715.pdf
- **Can these achievements in 802.3by 25GE be carried to 50GE?**
  - 25GE efforts may be compromised if these low-latency systems cannot be upgraded to the next speed.

Why more important for 50GE?

- **FEC Latency Comparison**
  - If KP4 FEC is used for 50GE, FEC latency will be ~**200ns** without interleaving and ~**300ns** with interleaving. It is much longer than ~85ns latency (2.4 to 3.5 times) of 25GE Base-R FEC..
- **What if there is no low-latency 50GE IEEE standard?**
  - What is the impact on 25GE low-latency users?
    - Do not upgrade to 50GE? (Unlikely)
    - Find other solutions? (Obviously)
  - Industry is actively seeking low-latency solutions:
    - Engineered solutions.
    - Other standards.
  - IEEE standard can support the market demand.
    - Less confusion/test efforts of end users/manufactures.

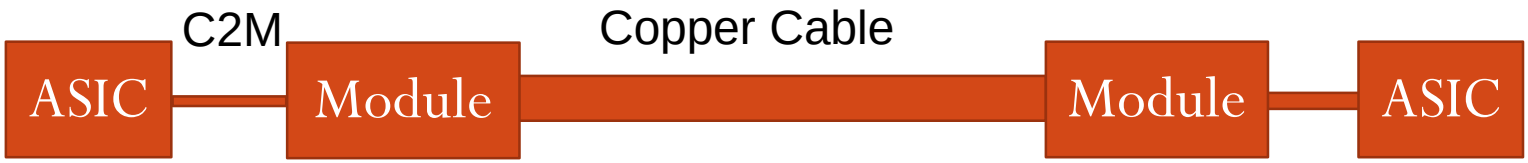
Requirements and Solutions

- For top-to-bottom applications, ~3m is needed.
- For connections to “middle racks”, ~2m is needed.
  - 2m may be enough for majority of the applications.
- Can we achieve “low BER” on
  - No-FEC C2M?
  - ~2m with passive cables?
  - ~3m no-FEC link with active cables?



Options for No-FEC C2M

- No-FEC C2M brings flexibility for the cable link.
- Goal: 1e-13 (or some other “low BER” target) without FEC
- Options and feasibilities:
  - 802.3bs currently defines PAM4 C2M with 1e-5 BER target as FEC is mandatory.
    - More work is needed to prove whether no-FEC BER target is achievable by PAM4 PMD.
  - “Low BER” link has been reported on more than 20dB (@25GHz) copper channel by using 50Gb/s NRZ PMD.
    - Good enough for C2M and 3m active cable.



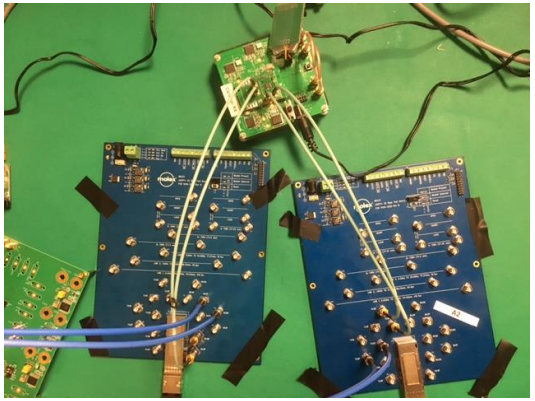
Technical Feasibility-NRZ

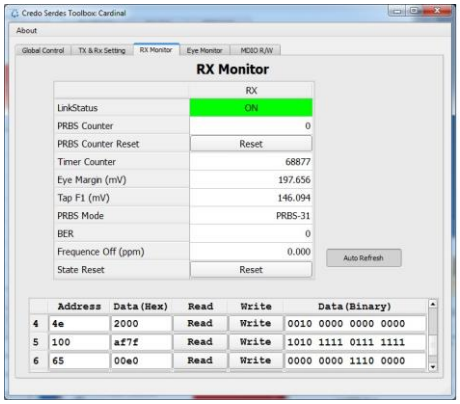
- **50Gbps no-FEC link has been reported achievable on silicon.**

  [3] http://www.ieee802.org/3/bs/public/15_01/qian_3bs_01b_0115.pdf

  [4] http://www.ieee802.org/3/bs/public/15_03/twombly_3bs_01a_0315.pdf

- **The design in [3, 4] achieves 1e-15 BER no-FEC link on 2m 26 AWG passive cables.** (Tests on 3m passive cables are being performed.)





2m no-FEC link enabled by Credo 50Gb/s NRZ PMD

- Further improvements have been identified, and is expected to safely enable greater than 2m “low BER” link on passive cables.
- Low-BER C2M is not a problem.
- 3m active cables have less loss/distortion and will not be a problem.

Technical Feasibility-PAM4

- **Test setup and results:**

Trace Length	Insertion loss @ 12.5GHz (dB)	BER
6" trace	13.3	3.00e-10
9" trace	17.9	1.27e-07
12" trace	22.5	9.00e-06

Test Results of a Credo 50Gb/s PAM4 C2M PMD

- 3e-10 BER is achieved for 13.3dB Insertion Loss.
  - This is a low-power design for 802.3bs C2M with 1e-6 BER target.
  - Further improvements have been identified.
- PAM4 performance is greatly impacted by how to overcome nonlinearity. More test results and analysis will be helpful to prove whether “low BER” can be achieved for PAM4 C2M.

Economic Feasibility

- **For active-cable approach:**
  - The cost and power of active cables should be considered.
    - FEC power may be saved.
  - Overall cost should be compared to other low-latency solutions.
  - Active cable cost may be less than 2 times of passive cables.
  - If active cables are needed for low-latency links in the future, cost may drop with the growth of volume.

- **Passive cables cost less.**

Conclusions and Proposals

- **Conclusions:**
  - No-FEC link is highly desired by certain applications.
  - No-FEC link is technically and economically feasible.

- **Proposals:**
  - **Low-Latency (No-FEC) 50GE on copper cable.**
  - **No-FEC C2M objective.**

Thanks!