

Objectives for 400 GbE

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Normal approach

- Adopt objectives that are easy, obvious, and non-controversial
- Identify areas where additional study and debate is needed to develop objectives, considering the form that those objectives might take in order to identify the questions that need to be answered

Framework for Objectives for 400 Gb/s Ethernet

- Support full duplex operation only
- Preserve the 802.3 / Ethernet frame format utilizing the 802.3 MAC
- Preserve minimum and maximum FrameSize of current 802.3 standard
- Support a BER better than or equal to 10^{-x} at the MAC/PLS service interface
- Provide appropriate support for OTN
- Support a MAC data rate of 400 Gb/s
- Provide Physical Layer specifications which support 400 Gb/s operation over:
 - At least x km over SMF
 - At least y m over OMx MMF
 - Copper??
- Specify optional Energy Efficient Ethernet (EEE) for 400 Gb/s operation

BER Objective Considerations

- Recent high rate interfaces have re-debated traditional 10^{-12} BER objective, but while expressing a desire for an improved BER, we have usually ended up with 10^{-12}
- Most 400 GbE interfaces are likely to carry large aggregates of lower rate services. For this kind of application, 10^{-12} would seem sufficient. Any given service would experience 10^{-12} BER whether it was carried over 400GbE or a lower rate interface
- For 400 GbE carrying large flow(s) (e.g., >100 Gb/s flows), 10^{-12} can amount to an average of an error per 2.5s
- BER better than 10^{-12} may be challenging without error correction
- Is Frame Error Ratio a more meaningful metric than BER?
- Study needed to identify what is required and what is achievable without significant cost or power penalty

BER – Possible Objective Forms

- Option 1
 - Support a BER better than or equal to 10^{-12} at the MAC/PLS service interface
- Option 2
 - Support a BER better than or equal to 10^{-x} at the MAC/PLS service interface (for some $x > 12$)
- Option 3
 - Support a BER better than or equal to 10^{-12} at the MAC/PLS service interface for PHYs without FEC (if any)
 - Support a BER better than or equal to 10^{-x} at the MAC/PLS service interface for PHYs with FEC (for some $x > 12$)
- Option 4
 - Support an FER better than or equal to 10^{-x} at the FEC service interface for 64-octet frames with minimum inter-packet gap for PHYs with FEC
- Others?

Single Mode Fiber Objective(s)

- Study and Debate required to identify feasible combinations of reach, modulation (not written in objective), and cabling type
- Dimensions to be studied:
 - Feasible modulation formats (bits per symbol)
 - Feasible number of wavelengths per fiber
 - Feasible number of fibers per cable at a given reach
- Possible objectives/objective forms – any or all of the following might be appropriate
 - At least 40km over duplex SMF
 - At least 10km over duplex SMF
 - At least 2km over duplex SMF
 - At least 500m over (parallel) SMF

MMF – possible objective forms

- If 100GBASE-SR4 has 100m reach over OM4, then a 400GBASE-SR16 would also work at 100m over OM4, however 32 strands of fiber could exceed what is considered to be a practical implementation
- Questions to be answered:
 - What cable size(s) would be acceptable to end users?
 - What alternative modulation (e.g., PAM4) or multiplexing (e.g., WDM) could be used over MMF to reduce the number of lanes, and what reach could be achieved based on those techniques?
- Based on those answers, agree on an objective to provide 400 Gb/s operation over:
 - At least y m over OMx MMF (determining the values of x and y appropriately)

Copper

- Implementations of copper cable or electrical backplane may not be practical at less than 50G per lane signaling
- Are there modulation formats feasible in the timeframe of the standard for a practical copper cable or electrical backplane implementation? If so, what is the achievable reach and is there broad market potential for an electrical interface at that reach?
- Even if there is no actual electrical PMD, does it make sense to define an electrical MDI to allow for the development and deployment of AOCs? If so, how would you write that as an objective, and how might you write it in a standard?

Conclusions

- “Easy” objectives could be adopted at any time
- Significant study is needed prior to adopting objectives on BER, SMF, MMF and Copper