VITESSE

Consider Parallel MMF XR Extended Reach Options

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Introduction

From system vendors' perspective, there are system requirements for an option of longer parallel MMF reach at 200-250m.

- An extension of those 100m baseline proposal in pepeljugoski_01_0508, quite likely handled informatively as an annex.
- Concern about operational simplicity (gustlin_xr_01_0508.pdf).

There are 4 competing options under review by XR MMF Ad Hoc

- OM4 with tightened TX.
- Add CDR inside module
- EDC in host IC with linear RX
- KR FEC in host IC

It's time to examine various implementation considerations.

- > XR Ad Hoc is to prepare proposal comparison matrix in very details.
- ▶ <u>Key figure of merit</u> performance, optics cost, power consumption, latency.....

OM4 with tightened TX

Modules achieving extended pre-std OM4 reach via tightened Tx specs (jewell_xr_01_0508)

| Parameter | OM3 | OM4 (1) | Unit |
|---|------|---------|--------|
| Modal bandwidth as measured at 850nm ⁽²⁾ | 2000 | 4700 | MHz-km |
| Power budget ⁽³⁾ | 8.3 | 8.3 | dB |
| Operating distance | 150 | 250 | m |
| Channel insertion loss (4) | 2.1 | 2.4 | dB |

(1) At this time, OM4 is not standardized.

- (2) Depends on launch conditions; simulations used a derated value of 4400 MHz-km at 840nm.
- (3) For further study
- (4) Connector loss under study

Could be simpler in implementation, but system cost increase as major concern

- Cost sources: module cost premium of 20%, new ribbon fiber link cost premium of 20%(?) (assume installation cost the same).
- Normal assumption is fiber link cost is typically 6-8x of module cost for 200m.
- ▶ So OM4 with tightened TX specs could introduce ~1.5 –2x of module cost which is significant!
- In contrast various chip solutions will leverage low-cost silicon.

CDR Inside Module

- CDR contained within the module help with crosstalk and reset jitter budget (latchman_xr_01_0508)
 - Media independent module interface.



- Major concern to increase the cost/power consumption of the module.
 - Typical extra power from CDR is about 200mW/250mW per direction.
 - May be tolerable for single-port SFP+ ports, thought particular prohibitive for multichannels like 10x10 solutions.
- Optics module cost/power increase could limit final port density...
 - Integrating CDR with module PMD could help, but historically being considered limited due to TOSA and ROSA optical packaging.

EDC In Host IC with Linear RX

- Analog EDC much simpler than LRM could provide longest possible reach among all 4 options (ghiasi_xr_01_0508)
 - ▶ Simpler adaptive EDC circuit such as 6T/2 FFE+2T DFE or well-established KR EQ.
 - ▶ EDC integrated into "bigger" host IC retimer/CDR, serdes, and/or ASIC.



- Maintain low-cost optics, while major concern to increase the host power consumption, complexity due to linear interface.
 - Integration of EDC circuit into host IC can facilitate further power reduction using e.g. 65nm CMOS.
 - Complexity can be leveraged by emerging SFP+ SR/LR deployments.

KR FEC In Host IC

KR FEC option transcodes 64/66B into 64/65B, reusing freed bits to provide 32-bit FEC code (2-2.5dB coding gain at 10⁻¹²) (petrilla_xr_01_0508)



- ▶ Corrects raw <4.4x10⁻⁸ BER to 10⁻¹² BER, OR <10⁻¹² BER to 10⁻¹⁸ BER (for carrier req.)
- Simpler implementation by reuse of KR FEC, major concern on latency of 0.3-0.5us.
 - Data centers require low latency as competitive advantage.

Recommendations

EDC in host IC with linear RX better support the longest XR link that is possible.

- ▶ Simpler EDC circuit in terms of 6T/2 FFE+2T DFE or well-established KR EQ.
- Provide margins to help optics mfg yield, its adaptation simplify system tune-up.
- Leverage SFP+ deployment with EDC adaptation and
 - Current 10GbE SFP+ SR (or later LR) deployment are using EDC as host.
- Clear roadmap to address host IC power concerns by deep-node CMOS.
- Support 220-300m reach with OM3 link.
 - Compatible with limiting and linear module as well as 10m copper.
 - NO extra cost added using linear I/F with EDC-based host.
- KR FEC could be optional should address the needs where higher latency is tolerable.
 - KR FEC has few deployment in field for now, but already exist as optional in many of-theshelf KR PHYs.
 - One benefit could be to provide 10⁻¹⁵ BER capability required by Carrier Ethernet.
 - Believe 40G/100G Ethernet will eventually provide end-to-end Carrier Ethernet