Extended Reach Annex Proposal

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Outline

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Background
Extended Reach (XR) ad hoc Charter

Munich Straw Poll

- **"Straw Poll #15**: Should we continue to work on a proposal for an annex to extend the reach of a 40GBASE-SR4 and 100GBASE-SR10 in addition to the proposal ("pepeljugoski_01_0508.pdf") as in "jewell_01_0508.pdf".
  Yes: 55
  No: 3
  Approximate Room Count: 108"

- "Petar Pepeljugoski suggested that an Ad-Hoc be formed to study an extended reach option over parallel multimode fiber. The Chair noted the interest from the straw poll the previous night, and asked the group if there were any objections to forming an Extended Reach Parallel MMF Ad-Hoc. There were no objections. The Chair appointed the Alessandro Barbieri and John Petrilla as Co-Chairs of the Extended Reach Parallel MMF Ad-Hoc. The Ad-Hoc's mission is to formulate a technical proposal for extended reach over parallel multimode fiber."

See Munich Minutes,
http://www.ieee802.org/3/ba/public/may08/minutes_01_0508_approved.pdf

Extended Reach Options
Summary/Conclusions

- **Any additional module or module development cost required for an extended reach option for 40G and/or 100G will discourage suppliers and reduce competition.**
  - The incremental market size is small (~1.2% of links > 10 m) and will be further reduced due to availability of alternative solutions, including user-selected 100 m MMF modules, 10 km SM variants, ganged SFP+ modules, FEC, repeaters and point-to-point links to justify investment.
  - The total market will shrink due to the higher cost structure.
- **Since the small market size for > 100m links doesn't justify additional investment but a high percentage of PPI modules and nAUI modules will support extended reach lengths, we should take advantage of this and enable it as a solution in a more formal and cost effective manner.**
  - An informative annex is proposed that will identify alternative approaches and develop methods to determine if a particular system can support the target extended reach.

Data Center Link Distribution

Interpreting flatman_01_0108

Application	Sample Size (all lengths)	Sample Size (> 10 m)	Ratios (> 10 m)	> 100 m % Flatman	> 100 m % Kolesar*
Client to Access, C-A	250000	166750	55.6	0% of C-A 0 links 0% >10m	
Access to Distribution, A-D	16000	16000	5.3	11% of A-D 1760 links 0.95% >10m	11% of A-D 1760 links 0.95% >10m
Distribution to Core, D-C	3000	3000	1.0	15.2% of D-C 456 links 0.25% >10m	

- The above table is derived from analysis of the results in flatman_01_0108 adjusted per the Alan Flatman message of August 29, 2008. The reported sample sizes are used to estimate the relative sizes of the different data center applications. These are combined with the percentages given for links longer than 100 m to estimate the number of links greater than 100 m. Finally the percentages (>100m links / total >10m links) are calculated for each application.
- The above data is appropriate to data centers and may not reflect high performance computer installations. If available and included such data would further reduce the percentages seen for > 100 m links.

* As reported in flatman_01_0108.

Other Solutions

- 10 km SM modules
- Ganged 10GBASE-SR & 10GBASE-LR modules
- User selected 100 m MM modules and/or fiber paths
- FEC
- Point-to-point links
- Repeaters or active cross-connects

None of the above is expected to be implemented for all cases where links lengths longer than 100 m are desired. However, each offers advantages for particular circumstances. In these circumstances they may well be the most cost effective solution. The overall effect will be that the already small market size for modules developed to support > 100 m lengths is fragmented.

Extended Reach Annex Proposal

- Goal: Prepare an informative annex that offers methods that may be used to extend operation of 40GBASE-SR4 and 100GBASE-SR10 beyond the maximum link length in clause 156.
- Approach:
  - Using the same Tx aggregate measurement as clause 156, determine criteria required to support the target extended reach.
  - Using the same Rx aggregate measurement as clause 156, determine criteria required to support the target extended reach.
  - Consider additional methods as they become apparent.
  - Evaluate, improve as appropriate and select one or more for the annex.
  - Detailed specs can be addressed once the baseline specs are firm.

Example Tx Aggregate Attribute Approach

	Tx Inner Eye Mask Coordinates			
Case	X1, UI	X2, UI	Y1, uW	
100 m OM3	0.216	0.342	170	100m Tx to 100m Rx
150 m OM3	0.217	0.370	222	150m Tx to 100m Rx
250 m OM4	0.202	0.334	183	250m Tx to 150m Rx

Accommodating an extended reach can be based on Tx and Rx aggregate tests. Here, for example, the aggregate Tx test criteria is first adjusted to support the worst case Rx over 150 m of worst case OM3, then repeated for 250 m of worst case OM4 but with Rx criteria adjusted to support 150 m of worst case OM3. The above table compares examples based on use of a Tx eye mask as the Tx aggregate test and extended reaches of 150 m of OM3 and 250 m of OM4 with such a test for the baseline 100 m case.

Example Rx Aggregate Attribute Approach

	Stressed Rx Sensitivity Conditions			
Case	SRS, dBm	VECP, dB	J, UI	
100 m OM3	-5.40	1.67	0.374	100m Tx to 100m Rx
150 m OM3	-5.70	2.15	0.385	100m Tx to 150m Rx
250 m OM4	-6.38	2.21	0.369	250m Tx to 150m Rx

Accommodating an extended reach can be based on Tx and Rx aggregate tests. Here, for example, the aggregate Rx test criteria is first adjusted for signal degradation for the worst case Tx over 150 m of worst case OM3, then repeated for 250 m of worst case OM4 but with Tx criteria adjusted to support 250 m of worst case OM4. The above table compares examples based on use of a stressed receiver sensitivity test as the Rx aggregate test and an extended reaches of 150 m of OM3 and 250 m of OM4 with such a test for the baseline 100 m baseline case.

Reference Informatiion

The following three pages present the parameter values used in the baseline/example 100 m case.

40GBASE-SR4 & 100GBASE-SR10 Proposal

Baseline/Example Transmitter Attributes (Each Lane)

- Min OMA: -3.0 dBm
- Min ER: 3.0 dB
- Min Center Wavelength: 840 nm
- Max RMS Spectral Width: 0.65 nm
- Max Transition Time (20%, 80%): 35 ps (1)
- Max RIN12OMA: -130 dB/Hz (2)
- RIN Coefficient: 0.70 (1)
- Mode Partition Noise Coefficient: 0.30 (1)
- Min Optical Reflection Tolerance: -12 dB
- TP1 Jitter Allocation: TJ = 0.300 UI, DJ = 0.150 UI (3)
- TP2 Jitter Allocation: TJ = 0.488 UI, DJ = 0.284 UI (3)

Above attributes are included in the baseline proposal unless otherwise noted.

(1) Attribute is required for link model but is not part of proposal.

(2) Proposal is examining values in the range of -128 dB/Hz to -132 dB/Hz.

(3) TP1 DJ, TP1 TJ & TP2 DJ are informative.

40GBASE-SR4 & 100GBASE-SR10 Proposal

Baseline/Example Receiver Attributes (Each Lane)

- Max Sensitivity: -11.3 dBm (1)
- Min Bandwidth: 7500 MHz (1)
- RMS Base Line Wander: 0.025 (1)
- Max Rx Reflection: -12 dB
- TP3 Jitter Allocation: DJ = 0.284 UI, DCD = 0.103 UI (1)
- TP3 Jitter Allocation: TJ = 0.511 UI (2)
- TP4 Jitter Allocation: TJ = 0.700 UI
- TP4 Jitter Allocation: DJ = 0.367 UI (2)

Above attributes are included in the proposal unless otherwise noted.

(1) Attribute is required for link model but is not part of proposal.

(2) TP3 TJ, & TP4 DJ are informative.

40GBASE-SR4 & 100GBASE-SR10 Proposal

Baseline/Example Link Attributes (Each Lane)

- Signal Rate: 10.3125 GBd
- BER: < 10^{-12} (Q = 7.034)
- 100 m of OM3
- 1.5 dB connector loss allocation
- Signal Power Budget: 8.3 dB (1)
- Attenuation = 0.36 dB (1)
- Center Eye Penalties (1)
  - Pisi = 1.40 dB
  - Pdj = 0.22 dB
  - Pmn = 0.30 dB
  - Pmpn = 0.02 dB
  - Prin = 0.15 dB
  - Pcross = 0.14 dB

Above attributes are included in the proposal unless otherwise noted.

(1) Output of link model.