10GBASE-LRM PLENARY MEETING
PORTLAND, OR
P802.3aq Task Force Minutes

TUESDAY 13 JULY 2004

Referenced to: http://www.ieee802.org/3/aq/public/jul04/index.html

Opening Session
Welcome and Introduction
Appoint Recording Secretary: John Ewen
Ground Rules
Review IEEE Patent Policy
Reflector and Web Information
Review of 10GBASE-LRM Voting Rules
Review of the IEEE Standards Process
Review of Task Force Objectives

- Comment, S. Swanson: The Objectives as posted on the web do not agree with the Objectives in opening_1_0704.pdf.
    - D. Cunningham: The objectives in opening_1_0704.pdf are correct, reflecting the modifications adopted at the March meeting, and the web will be updated.

Review of Draft Project Timeline
Goals for the Meeting
Review baseline technology proposals

- Comment, I. White: A new proposal will be presented at this meeting to use spatial filtering at the receiver that is not reflected in the current summary.
- Q: J. Abbott: Do we need to break out and be more specific in the definition of NRZ and EDC?
    - NRZ and EDC can be viewed at this point as technology building blocks, and the detailed definition will be developed as the draft progresses.

Review of the Agenda

- Move J. Abbott's presentation, abbott_1_0704.pdf, prior to P. Kolesar's review of the TIA Liaison letter and supporting presentation, kolesar_1_0704.pdf.

Motion#	**1**			
Accept the Agenda as presented by D. Cunningham.				
Moved	D. Cunningham			
Seconded	J. Ewen			
	Yes	**No**	**Abstain**	**Result**
	by acclamation			**Passes**

Request attendees to review the minutes from the May 2004 meeting for approval at the closing session.

Presentations

IEEE 802.3aq Channel Modeling Ad-Hoc: Recent Progress, Future Goals & Plans
Ian White

Key Points:

- Two telecons held to date (17-June & 30-June), with good attendance
- Task leaders have been appointed
    - FDDI-grade / OM2 / OM3 model – Richard Penty
    - Time-varying study & modal noise – Jonathan King
    - Input and output parameters – Lars Thon
    - Launch and filter modeling – Yu Sun
    - Validation – Nick Weiner

- FDDI-grade / OM2 / OM3 model
    - Two telecons held to date. Agreed at 1-July telecon to take forward both the restricted set "81 fiber" and Monte Carlo models
        - Both models are based on modal delay sets.
        - Differ only in how these modal delay sets are generated.
        - Both can be used in design activity – flexibility from user perspective
        - Require cross-validation that the two models yield same results
    - Need to agree on types and magnitude of perturbations.
    - Goal: adopt static channel model at Sept. interim meeting.
- Time variation & modal noise:
    - Provide input for impact of time-varying impulse response to LRM spec (e.g. link budget)
    - Input for Rx compliance test
    - Verify modal noise is correctly accounted for in the LRM specifications & modeling
    - First meeting to be held at this meeting to identify tasks, contributors, and target schedule.
- Inputs & outputs
    - Identify minimum set of data and parameters to specify the system
    - Common data format to exchange information
- Launch & mode filtering
    - One telecon held to date
    - Require index profile to generate modal fields
    - Investigate launch & filtering effects in Sept. – Nov. (after index profiles are available)

Questions & Discussion

- Q: S. Swanson: What is meant by 10GbE extended reach operation?
    - Extended reach refers to the distance objectives of 220m and 300m.
- Q: J. Abbott: The web refers to "worst case" while the presentation refers to "81 Fiber". Is this significant?
    - The original summary was circulated to the Task 1 sub-group and the presentation modified based on feedback. The intent is that there are two philosophical approaches being presented – a worst case model and a Monte Carlo model.

Channel Modeling Ad Hoc Task 1 – Channel Model Methodology Proposal
Ian White (for Richard Penty)

Key Points:

- FDDI-grade fiber is the highest priority
- Required outputs: modal delay time set, method to generate impulse response, index profile, method to derive performance for arbitrary launches
- Outputs not required: modal fields, impulse response sets, internal workings of models
- Agreed to carry forward both the 81-fiber model and the Monte Carlo model
- New DMD data from fiber manufacturers may require enhancements to the initial 62.5μm model

Questions & Discussion

- Q: J. Abbott: In the 81-fiber set, the ratio of the center perturbation relative to the alpha perturbation is fixed. How was this ratio arrived at in the original work?
    - I. White: Also developed 160 and 300 fiber sets in the original 1 GbE study with different parameters (e.g. variation of alpha transition radius, changing the center perturbation width) and the results were similar to the 81-fiber set.
    - D. Cunningham: A smaller fiber set was desired to manage computational complexity. The perturbations were chosen as proxies for what happens in real fibers. A wide variety perturbations were analyzed before settling on the 81-fiber set. The scaling process should make the precise perturbations less important.
- C: J. Abbott: Scaling is a complicated process. Scaling may be better applied to the index profile, as this is more closely related to the physics of the light propagation and the manufacturing process.

Modeling MM Light Propagation using measured index error, DMD, and bandwidth
John Abbott

Key Points:

- Typical fiber manufacturing metrics: index profile and the resulting impact on DMD and bandwidth
- DMD data can be generated from index profiles via perturbation theory

- Inverse problem (generating index profile from DMD data) can also be solved via least squares techniques.
- 1GbE MBI index profiles
    - Modeled OFL bandwidth distribution is lognormal – which implies the distribution has long tails.
    - Center, edge, and alpha defects are observed similar to the 81-fiber set. Additional defects are present in these results.
    -

Questions & Discussion

- Q: Lars Thon: Is lognormal intrinsic to the problem or characteristic of the manufacturing process?
    - It is not a characteristic of the manufacturing process. If one assumes Gaussian variation of the process parameters (e.g. center defects, alpha change, etc.) and converts the results to bandwidth, then the resulting distribution will be lognormal
- Q: Sudeep Bhoja: How does the lognormal distribution relate to the 5% limit (i.e. -2 sigma intercept)
    - The measured MBI data includes a number of known bad fibers which skew the distribution away from lognormal and suggest that the 5% limit would occur for extremely low bandwidths. These bad fibers were not included in the original 1GbE analysis.
    - The extrapolated -2 sigma point for the "good" data from the MBI is approximately 400 MHz-km.
- C: Paul Kolesar: Should the scaling be based on a 400 MHz-km OFL bandwidth or 500 MHz-km?
    - This will need to be addressed during the course of the standard. The fiber specification is 500 MHz-km and this will need to be addressed if another number is chosen.
- Q: S. Swanson: How does this impact the "installed base"? Some fibers may fall below the 500 MHz-km spec and some will far exceed this specification. What percentage of installed base are we dealing with in this effort?
    - Target is upgrading SX links in the building backbone. A. Flatman's presentation suggest that a significant number of these links exist.
- Q: A. Van Schyndel: How do vibrations affect the bandwidth and DMD analysis?
    - The mode coupling could change which would affect the bandwidth, but the quantitative impact to bandwidth or DMD isn't well known.
- Q: Ian White: How many of the 310 index profiles from the MBI investigation would you consider to be particularly interesting?
    - The 81-fiber set does a good job of characterizing "typical" index perturbations, which are then scaled to represent the worst case.
    - The 310 profiles are "atypical" index perturbations which generate worst case in the extremes without scaling.
    - Augmenting the 81-fiber set with these atypical perturbations and comparing with the scaled 81-fiber set results would be a good next step.

Multimode Fiber Model Issues

Paul Kolesar

Key Points:

- The 81-fiber delay set falls into roughly 5 different groups
    - DMD magnitude dominated by high-order modes
- Six index perturbations are identified which may not be captured by the 81-fiber set.
- Measured DMD examples
    - Three manufacturers contributed measurements (approximately 30 fibers)
    - DMD for 62.5µm fibers at 1300nm, all fibers rated at > 500 MHz-km OFL BW
    - DMD magnitudes not representative of 98th to 99th percentile of installed base. Older fibers could have significantly higher DMD
- Recommendations
    - Extract group delays from these DMD plots & include representative delay sets if not already present
    - Re-examine core-cladding perturbations as magnitude of high order DMD seems overly dominant.
    - Scale all delay sets to 500 MHz-km OFL BW (possibly a little lower) without limiting the DMD to 2 ps/m.
        - Perhaps modify the scaling process to be a function of the local index difference to better reflect what is seen in manufacturing.

- Recommendations for overall modeling effort
  - Use two models (worst-case & Monte Carlo) as cross check for each fiber type.
  - Enhance 81-fiber set and create equivalent delay set for 50µm fiber
  - Enhance FO-4.1.2 fiber set for 1300nm and FDDI-grade and create delay set for 62.5µm fiber.

Motion#	**2**			
Place Kolesar/Swanson motions 2 and 3 in the queue for discussion on Wednesday, July 14, 2004.				
Moved	P. Kolesar			
Seconded	S. Swanson			
Procedural (50%)	**Yes**	**No**	**Abstain**	**Result**
	19	31	11	**Fails**

- Kolesar/Swanson Motion #2
  - Enhance Cambridge model as follows. Extract group delays from the DMD plots in kolesar_1_0704r1. Include representative delay sets from these DMDs and the delay sets of fibers 1 to 25 from abbott_1_0704 in Cambridge model. Re-examine perturbations of present Cambridge model to ensure alignment with observed behavior. Scale all delay sets to 500 MHz-km OFL BW without limiting DMD to 2 ps/m. Examine other scaling approaches, such as scaling as a function of local index delta.
- Kolesar/Swanson Motion #3
  - Apply the following approach to channel modeling effort. Use both the Cambridge and FO-4.1.2 models as cross check for each fiber type after modification as follows. Enhance the Cambridge fiber set by modifying 62.5 µm set per Kolesar/Swanson motion 2 and create 50 µm equivalent sets for OM2 and OM3. Enhance FO-4.1.2 fiber delay set by modifying OM3 set for 1300 nm operation and create OM2 and 62.5 µm equivalent sets. Converge on common model, or pass/fail criterion for two models.
- Discussion
  - N. Weiner: What is the rationale for this motion?
    - These modeling issues deserve first consideration since they have a great impact on the subsequent technology choices.
  - J. Abbott: The discussion is only to put these motions in the queue, not on the motions themselves.
  - P. Dawe: The fine detail of the channel model does not have a major impact to technology choice at this time. It can proceed in parallel. He is strongly against this motion.
    - P. Kolesar: The ClariPhy presentation clearly depends strongly on the model and the modeling effort should be addressed first.
  - S. Swanson: This is intended to give the group a preview of what Steve and Paul would like to discuss during the closing session on Wednesday afternoon.
  - D. Cunningham (interpretation if motion is approved): When dealing with motions during the closing session, these two motions would be discussed first before any other motions would be considered. This does not preclude any other motions from being made.
  - J. George: Strongly supports this motion.
    - Call the question:
      For: 45 Against: 6 Motion to call the question passes
  - M. Fukatsu: A motion was made in Long Beach that is on the table. Does that preclude this motion?
    - D. Cunningham (interpretation): Someone must make a motion to take that motion off the table, which can be done, but which would occur after considering these motions.

Questions & Discussion

- Q: Lars Thon: Some of these fibers are very long (8km). How would this change if the fiber was only 200m or 300m
  - Index will vary along the length of the fiber. How quickly it varies is a function of the manufacturing process and where it was in the preform when drawn. The data is an average of the index over the length.

- Q: Lew Aronson: If we include these new index perturbations to the delay set and scale to some other metric, what is the impact to the statistics of the delay set? Does is still represent the 5% population or something else.
    - Defer answer on statistics to the fiber manufacturers. More interested in the types of index perturbations that are observed and ensuring these are included in the model.
- Q: Yu Sun: Can you comment on the differences between the data from different manufacturers? The DMD data can vary significantly depending on the spot-size used in the measurement.
    - The results depend on the manufacturing process (three different processes are represented), and when the fiber was manufactured. The differences due to the measurement process should be relatively minor.
- Q: P. Pepeljugoski: If there is any mode coupling, the OFL BW will be much higher than for the distance of interest (e.g. 300m). The BW-distance product is not linear and the measured BW of these long fibers may not actually pass the 500 MHz-km specification.
- C: J. George: This is the way fiber manufacturers build and measure the fiber, i.e. manufacture long lengths that are measured and then cut into shorter lengths as required. These defects should be included in the 98^{th} – 99^{th} percentile population.
- J. Abbott: Comments,
    - In modern fibers the coupling is very low so you normally see linear BW-distance products.
    - 2 ps/m is an estimate, and should not be taken as a specification.
    - The higher order modes could well be attenuated in real, cabled, fiber as a possible explanation for why DMD measurements do not seem to be dominated by higher-order mode-groups as seems to be the case in the 81-fiber set.
- C: D. Cunningham: The 81-fiber DMD plots should be compared against the measured DMD, and not against a mode-group delay plots in order to make a fair comparison. The 81-fiber set will create DMD plots that are very similar to the measured results presented. The 81-fiber set seems generally consistent with the delay sets presented by J. Abbott (although some detailed features may not be reproduced). The PIE-D metric for the fibers presented by J. Abbott seem generally consistent with those generated by the 81-fiber delay set. It does not appear that base technology decisions would change with the addition of the delay sets presented by J. Abbott.
- C: P. Pepeljugoski: Mode coupling in long fibers (30m – 1km) measured in the past showed nonlinear dependence of BW-distance product.

Ian White will gather an Ad-Hoc of interested people to meet in the evening of Tuesday, July 13 and begin drafting a response to the TIA Liaison letter.

Break for Lunch

Channel Ad-Hoc Task 3: Input / Output Parameters and Data Exchange Formats
Lars Thon

Key Points:
- Purpose & Goals
    - Support efficient system performance evaluation
    - Permit cross checking of results
    - Clearly define underlying assumptions
    - Define the minimum set of parameters needed for system evaluation
    - Aid the conversion of data into needed formats
- Future work
    - Additional parameters required? E.g. index profiles, mode fields?
    - Support for other simulation tools (other than matlab)?

Questions & Discussion
- Q: P. Dawe: Suggests that the progress of this sub-group be tracked more closely on the reflector so everyone is aware of what's happening. Also concerned that matlab format is tied too closely to a particular tool (matlab), and it's binary representation is not readable by other tools. A more generally accessible format (e.g. CSV) would be preferred.
- C: P. Pepeljugoski: Supports the use of matlab. Public versions of matlab are available if necessary, and translation programs could be written to convert to other formats.
- C: J. Abbott: Supports Piers' concern.
    - Lars Thon: The concern of the sub-group is that the amount of data will become unmanageable when a Monte Carlo model is developed unless some format similar to matlab is adopted.

Multimode Fiber Communication System Simulation
Gary Shaulov, et al.

Key Points:
- Have developed a MMF simulator based on index profiles.
- Includes the effect of chromatic dispersion
- Have compared the results with those of two fibers from the Cambridge model
- Can generate eye diagram and BER simulations from the generated impulse responses.
- Simulations can include time-varying channel responses.

Questions & Discussion
- Q: M. Traverso: Slide 17 and 18 – is the input power fixed?
  - Yes the input power is fixed, and the fiber length is 300m.
- Q: J. Abbott: Does this software work for fiber at 850nm and shorter wavelengths?
  - If a significant amount of power is leaking into radiation modes a warning is generated that the basic assumptions of the simulator may be violated.

StatEye supports MMF
Albrecht Rommel

Key Points:
- StatEye introduced by A. Saunders of Infineon as a physical layer simulation tool.
- Open source available at http://www.StatEye.org
- Input is the system pulse response.
- Tool has been modified to read the frequency response data from the Cambridge 81-fiber model.
- Simulator includes forward and DFE equalizer components.
- Looking to extend the analysis to include non-linear elements.
- Preliminary simulations have been done using the Cambridge 81-fiber data.

Questions & Discussion
- Q: J. Abbott: Is this an interactive tool or a batch-mode tool.
  - Today it is an interactive tool, but it could also be modified if a common data format is defined.
- Q: P. Pepeljugoski: Currently the tool assumes a linear channel. How can it be extended to include nonlinear elements?
  - In general, a linear approximation would be needed.
- Q: S. Swanson: Slide 11. What assumptions were made about the TOSA?
  - A bandwidth was assumed for the TOSA along with a transfer gain. A fiber is considered "useable" as long as the eye opening exceeds 0.2 UI.
- Q: A. Shanbhag: How is the transmit de-emphasis chosen, and was an FFE also included?
  - Only a feedback EQ is included. The feedback coefficients are optimized by the simulator.

Ian White: Looking for volunteers from fiber manufacturers and fiber modeling experts to respond to the TIA Liaison letter.
- I. White, D. Cunningham, Lars Thon, Petar Pepeljugoski, John Jaeger, Steve Swanson
- Will meet immediately after today's session closes.

Break

Simulation and Correlation of DMD Based on Index Profile
Ali Ghiasi, et al.

Key Points:
- This is an update of the presentation made at the May Interim meeting.
- Broadcom and Optium DMD results show strong correlation.
- Reasonable simulation time requirements
- Strongly recommend making the index profiles available for additional simulation work.

Polarization Effects in Multimode Fiber Transmission
Stefano Bottacchi (for J.R. Kropp), et al.

Key Points:
- Have performed measurements of polarization effects including the effect of MMF connector offsets.
- Without connector offset there is little effect due to polarization at both 0μm and 20μm offsets.

- With connectors, there is polarization induced noise whose magnitude is greater for the 0μm offset (i.e. center) launch. Similar effects are seen in the eye diagram.
- Concerned that the effect is not included in the current model and its power penalty should be evaluated.

Analysis of Center Launch and Mode Filtering in Multimode Fiber Transmission
Stefano Bottacchi (for J.R. Kropp), et al.

Key Points:
- Evaluate performance with three sources: EML, DFB, and FP
- Include effects of connector offsets and include a central mode filter at the Rx
- General characteristics
    - Mode filtering introduces about 2 dB of loss
    - Connector offset of 5μm introduces another 2.5 dB of loss
    - Strong signal degradation with offset
    - Large variation in data pattern when moving the fiber.

Questions & Discussion
- Q: J. Tatum: Were the lasers isolated? Reflections could lead to variation in link performance.
    - The lasers were not isolated. Reflections could cause polarization changes.
- Q: J. Tatum: What was the spectral width of the sources?
    - DFB would be dominated by the chirp characteristics. The spectral width of the FP and EML were not measured.

Simulation of polarization effect in a fiber link with offset connectors
Yu Sun, et al.

Key Points:
- Power coupling coefficient of each mode depends strongly on input beam location and diameter.
- The impact to link performance is a strong function of the bit rate.
- Offset launch is less sensitive to polarization variation, but pulse broadening degrades the system performance.
- Modal filtering with center launch provides significant improvements for difficult fiber channels

Questions & Discussion
- Q: Lew Aronson: Does the mode filtering approach have an additional polarization penalty?
    - There can be a large power penalty.
- Q: Did you include elliptical polarization?
    - The simulations used linear polarization, and the results are expected to be similar for elliptical polarization.
- C: D. Cunningham: What are the assumptions on connector offsets? The large power fluctuations are unexpected.

Spectral Coding for Extended Reach
Albrecht Rommel

Key Points:
- Spectral coding can appear as a reduction in the effective baud rate.
- Phase Noise Amplification (PNA) is effectively high frequency jitter amplification, and occurs when the baud rate is significantly higher than the channel bandwidth.
- Propose that the standard include spectral coding as an option and that 8b16b RLL3 code is the preferred option.

Questions & Discussion
- Q: N. Swenson: Does 8b16b imply doubling the baud rate?
    - The Tx VCO and serializer operate at a faster rate, but the spectral density decreases (e.g. the minimum run length is 3).
- Q: D. Cunningham: How is this compatible with the objective to maintain the current 10GBASE-R PCS? A new PCS is outside the scope of the this project.
    - It would have to replace the current PCS (as an option).

MMF Reach Extension for 10 Gbps by Spatially Resolved Equalization
Stephen Ralph (for Ketan Patel)

Key Points:
- Implement Rx photodetector with inner and outer active areas and subtract the currents from the two active areas.
- Measurements and simulations are presented showing approximately 2x improvement in bandwidth are possible.
- Proposal works synergistically with DFE at the receiver.

Questions & Discussion
- Q: P. Kolesar: If the beam needs to be expanded, will this limit the speed performance due to a large photodetector?
    - It should scale to 10Gb/s with MSM technology and possibly a PIN. It's unclear whether it would scale to 40Gb/s. A lens could be used, but has not in this work.
- Q: How sensitive is this approach to offsets?
    - ±10µm offset gives similar performance.
- C: N. Swenson: The high order modes are essentially equally distributed across both detectors and the low order modes are concentrated near the center (inner) detector. Therefore, the subtraction reduces the high order modes, with a corresponding power penalty.
- C: D. Cunningham: This would be built into the receiver and can be viewed as another form of equalization.
- Q: P. Kolesar: Could spectral width requirements be different in order to control modal noise effects?
    - Measurements with an FP laser do not show a modal noise problem, but it could be an issue with DFB lasers and would need to be investigated.

Closing Comments

Motion #2 from the May interim meeting (to adopt the Cambridge model as a baseline) was postponed until this meeting (not put on the table as previously thought). Lew Aronson (original mover) will inform the task force tomorrow morning on whether or not he intends to bring this motion forward on Wednesday afternoon as the first order of business during "motion madness".

Stawpoll: Strong objections to continue Task Force meeting through Thursday morning: 3 objections

Adjourn for the day.

10GBASE-LRM PLENARY MEETING
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WEDNESDAY 14 JULY 2004

Opening Comments

The chair reviewed the agenda for the day.

Lew Aronson withdraws Motion 2 of the May interim meeting which had been postponed until this meeting.

Channel Metrics for EDC-based 10GBASE-LRM
Sudeep Bhoja, et al.

Key Points:
- 3dB bandwidth is not an accurate metric
- No single metric can adequately describe all types of EDC
- Recommend using both PIE-L and PIE-D metrics for now
- Link budget validated for OSL and vortex launches
- Recommend deriving TP3 compliance parameters using the PIE channel metric.

Questions & Discussion
- Q: J. Abbott: Is this a typical set of taps?

    - The number of taps is really an implementation detail, but the larger the number of taps, the better the correlation with the PIE metric.
- Q: P. Kolesar: Is the Vortex launch for 62.5µm fiber or 50µm fiber?
    - Data presented on the Vortex launch is based on a design for 62.5µm fiber that was presented at the last meeting. Work is in progress on 50µm. There is not yet a fiber model for FDDI-grade 50µm fiber to do this analysis.
- Q: J. Abbott: The penalty in SX was limited at 3.6 dB. Where does the extra margin come from?
    - The dispersion penalty is the amount of dispersion that the EQ can compensate, it is not equivalent to the ISI penalty in an unequalized link.
    - The penalty is really a noise enhancement penalty in addition to any residual ISI. The MMSE algorithm arrives at the best compromise between noise enhancement and residual ISI.
- C: P. Dawe: Although the correlation appears worse for the IFR metric, it does appear to be conservative relative to the PIE metrics. All three metrics should be carried forward.
    - The IFR metric is completely empirical, while there is a good theoretical background for the PIE metrics.
    - P. Dawe: There will always be some empirical aspect to this work, e.g. the implementation penalty for the equalizer.
- Q: J. George: Were connectors included in the analysis? They need to be included to complete the analysis.
    - No connectors were included. Connectors are not yet included in the channel model. This is an action for the channel modeling ad-hoc.
- C: N. Swenson: Sees no harm in carrying IFR forward, but sees no additional benefit either.
- C: L. Aronson: We need data from the channel ad-hoc so that an "effective" number of taps can be determined. This is required in order to define the appropriate parameters for the TP3 compliance test.
- Q: J. Abbott: Slide 7. Are there cases where the eye closes completely?
    - There were no such cases in the OSL data set considered.

Relaxation of Tx Speed Requirements
Paul Voois (for Tom Lindsay), et al.

Key Points:
- Initial analysis on the effect of the rise/fall time on the link performance. It is not a formal proposal.
- Initial discussion of TP2 tests – is a TDP test required?
- Requesting volunteers to develop a proposal for the September interim meeting.
- EDC has potential to reduce cost through relaxed optical specs
- This work fits within the current EDC framework and can proceed in parallel.

Questions & Discussion
- Q: P. Kolesar: Where does the lower cost come from? Is it a yield issue or a volume issue?
    - Yield improvements and reduction of complexity are possible areas of cost reduction.
- C: M. Traverso: Even in high volumes, the TOSA continues to dominate cost, so it is important to study ways in which the Tx costs can be reduced.
- Q: B. Taylor: Why did you focus on the rise time and assume symmetric rise and fall times? Other aspects, e.g. single-mode alignment tolerances, could be much more significant.
    - Rise time was used as a proxy for bandwidth, and is a typical laser spec. We are not suggesting it is an encompassing spec. Asymmetric rise/fall times (i.e. laser nonlinearity) is a task to be further considered.
- Q: J. George: Are the benefits outweighed by the cost of relaxing these specs (e.g. link budget)?
    - This is a question for further study. A detailed response requires more study by the group.

Statistical Study of NRZ, PAM-4, EDC, and Low-Cost Optics
Norm Swenson, et al.

Key Points:
- Compare the relative advantages of NRZ and PAM-4 when combined with EDC and low-speed optics.
- NRZ performs better or equivalent to PAM-4 when using the Cambridge 81-fiber data-set. PAM-4 offers superior performance for a Gaussian channel
- Recommend that NRZ should be the baseline.
- Should further study the low-speed Rx for lower noise vs. larger distortion trade-offs.

Efficient Estimation of Bit Error Rates and Eye Diagrams in Equalizer Enhanced Links
Kasyapa Balemarthy, et al.

Key Points:
- Compute the ISI statistics analytically, based on the channel response and resultant ideal equalizer coefficients. This allows more accurate estimate of BER with much less (1000x) computational complexity.
- Permits the eye diagram to be estimated

Questions & Discussion
- Q: L. Thon: Is noise enhancement of the FFE being included in the analysis?
  - Yes it is included via the computed tap weights which are included in the d_i coefficients.

EDC Experimental Results, Part 1: Fiber characterization, Part 2: Link testing with EDC using FP and DFBs.
Jan Peeters Weem

Key Points:
- Characterized five "bad" fibers with 4 offsets (0µm, 3µm, 17µm, and 19µm), 300m and 220m lengths and computed PIE-L metrics for the fibers.
- Compared link test results with FFE EQ and FFE+DFE EQ and used cooled DFB, uncooled, isolated DFB and uncooled, unisolated FP sources.
- To define OMA, measured ER at TP2 and used the attenuation + ER to compute OMA at TP3.
- Demonstrated ability of both FFE and FFE+DFE to compensate fiber distortion
- Unisolated, uncooled FP laser in 10G TOSA shows no degradation relative to DFB.

Questions & Discussion
- Q: S. Swanson: Laser comparison slide uses wider bandwidth fiber. What was the fiber bandwidth?
  - The bandwidth was larger. Other fibers were not measured due to lack of time. This is work in progress.
- Q: J. Dallesasse: What is the stability of the frequency measurements? Was the OFL bandwidth measured. Did you look at BER over longer gating times?
  - There was some variability in the response. The fiber was not intentionally manipulated with a fiber shaker. The fiber was not investigated with a mode-scrambled launch, i.e. OFL bandwidth. Longer gating times were not investigated.
- Q: L. Thon: Can the frequency data be made available?
  - Yes, it will be posted to the reflector.
- Q: L. Aronson: How do the measured results relate to the dispersion penalty in the link budget?
  - Haven't measured the baseline sensitivity so can't comment on the relation of the PIE metric to the measured penalty. Expect a back-to-back sensitivity on the order of -17dBm.
- Q: P. Dawe: Does the calculation of the PIE metric require a knowledge of the phase information?
  - S. Bhoja: No, phase information is not required to compute the PIE metrics.
- Q: D. Cunningham: How did you verify the offset?
  - The offset patch cords were designed according to a specification, but not verified.

Budget- and Penalty-oriented EDC System Performance Evaluation
Lars Thon

Key Points:
- Budget & penalty based system performance evaluation
- Sorting the EDC penalty according to the raw ISI penalty provides insight into the distribution.
- Consideration of specific implementation choices are an important complement to idealized metrics.
- Results indicate that at least 4 dBo of budget is required to cover the Cambridge fiber model.

Questions & Discussion
- Q: P. Kolesar: What launch conditions were used in the model?
  - All 195 cases were simulated, e.g. the 65 fibers with 17, 20, and 23µm offsets
- C: P. Dawe: The sorting technique appears very powerful. Your simulations seem to suggest 80% coverage is possible with approximately 2 dBo penalty. This appears more optimistic than other simulation results.
  - These simulations do not include the 4^{th} order BT filter for the receiver. The definition of yield (i.e. considering all 195 cases) may be different as well.
- Q: N. Weiner: What is meant by an incorrect bit in the DFE?
  - This is an incorrect decision by the DFE, not an incorrect tap weight.

    - Regarding the Adaptation Figure of Merit, 0 dB corresponds to a eye that is just closed. 6 dB implies the cursor amplitude is 2x the sum of all the feedback tap weights.
- Q: P. Kolesar: The yields predicted without EQ seem much too optimistic for a model representing "worst case" fiber.
    - For an unequalized link, the correct ISI limit is not 6 dBo. The correct value is in the range of 2.6 dBo to 3.6 dBo. At this budget limit the results are much more in line with the 10Gb/s and 1Gb/s link estimates.

Channel Metrics: Benchmarking with TIA OM3 model results & recent IEEE work
John Abbott

Key Points:
- Evaluation and comparison of proposed channel metrics using the TIA OM3 "no connector" data set.
- f_bit metric collapsed the TIA data the best.
- IFR collapses the data the next best. Consistent with the IEEE link model
- P_E collapses the data in 1:1 proportion to ISI or dispersion penalty but with larger scatter.

Questions & Discussion
- Q: N. Swenson: Does this apply to equalized or unequalized links.
    - Looking for a metric that will predict the dispersion penalty prior to equalization.
- C: N. Weiner: The Phyworks data was not trying to draw conclusions about the channel, but about the metric. Therefore, corner cases were included to stress the metric. If these cases are removed then the "clumps" in the data disappear.
    - J. Abbott: The TIA model includes chromatic dispersion (850nm) which could also "spread out" clumps in the data.
- C: A. Shanbhag: A match-filter bound should be a good metric for both equalized and unequalized links, so there is some theoretical background for these metrics.
- C: J. Abbott: The TIA data includes all the data points which would include non-compliant fibers and non-compliant sources. The intent was to investigate the metric not the link components.

NRZ EDC Proposal for 10GBASE-LRM
Mike Lawton

Key Points:
- This is a presentation on the structure of a proposal for an NRZ EDC baseline.
- Demonstrated strong technical feasibility for EDC
- Tx areas for further study
    - eye mask
    - launch conditions
- Link budget is defined but needs to be validated

Questions & Discussion
- Questions will be taken on this and the following presentation as a set.

Proposed Details for TP2 and TP3 Tests
Lew Aronson

Key Points:
- Philosophy
    - Make specific proposals to establish specification structure
    - Err on the side of test simplicity
    - Use –LR and other existing test specifications where applicable
    - Test parameters to come from channel figure of merit (whichever is finally adopted)
- TP3 Tests
    - Static stressed Rx sensitivity test
    - Dynamic adaptation penalty test
    - Informative sensitivity test – ISI impairment only

Questions & Discussion
- Q: S. Swanson: What is the implication of specifying two encircled flux specs? Does this imply multiple PMDs or port-types?
    - Use 1000BASE-SX as an example where two CPR tests are specified (one each for 50µm and 62.5µm fibers) within a single PMD.
- Q: A. Phanse: Is an informative specification on linearity required? It seems this would be helpful.
    - This is implicit in the stressed Rx test.

- Q: N. Swenson: What is the justification for excluding UI spaced impulse responses?
    - How does equal weight with unit spacing relate to the 99% coverage. The final choice deserves further study.
- Q: M. Traverso: It would be good to leave the ER specification for further study.
    - D. Cunningham: All of the numbers in this proposal are open to debate and modification by the task force.
- Q: P. Voois: Does this proposal preclude any studies of bandwidth/ sensitivity trade-offs in the link budget?
    - This spec is starting with an LR receiver to identify the basic Rx input noise characteristics along with the minimum Tx launch power. It is intended to demonstrate feasibility and not preclude other options.
- Q: J. George: What was the basis for the encircled flux numbers? It should be left open at this time.
    - The 50µm spec was copied from 10GBASE-SR. It was chosen as a starting point only. For 62.5µm fiber, the 50µm spec was scaled by the core diameter ratio for the outer region and left unchanged for the inner radius.
- C: M. Lawton / L. Aronson: The items listed in red in the presentation would be listed as TBD in the draft proposal with an editor's note including the suggested values (in red) that require further study.
- Q: J. Abbott: How does this proposal interact with the channel modeling ad-hoc effort?
    - This is meant to be a parallel effort to progress other aspects of the draft. The results of the channel modeling ad-hoc will feed into this effort as they become available.
- Q: Why is the EDC initialization time not included in the specification?
    - D. Cunningham: Typically, the link should come up within 1 sec. or so.
    - P. Dawe: 802.3ae included a specific comment that it may take some time for a link to come up.
- Q: P. Kolesar: Should different tests be included to stress different types of equalizers, e.g. two-peak response and a Gaussian response?
    - This is a subject for further study as noted in the presentation. The important point is whether different response shapes, with the same metric value, will stress the EDC in significantly different ways.

D. Cunningham: The items in red would be included as editorial notes. The chair would direct the editor to create a draft based on lawton_1_0704.pdf.

Break for Lunch

Closing Session and Motions

Jonathan King announced a meeting of Sub-group 2 of the channel modeling Ad-Hoc at 10:00am on July 15, 2004, in the Queen Marie meeting room

David Cunningham reviewed:
- Agenda for the afternoon's business
- IEEE Patent Policy & inappropriate topics for discussion at this meeting
- Reflector and Web Information
- 10GBASE-LRM Voting Rules
- IEEE Standards Process
- Task Force Objectives
- Draft timeline

Motion#	3			
Approve the minutes from the May interim meeting with the following amendment: (Al Brunsting's addition to p. 4 of the minutes regarding his response to Paul Kolesar's question.) "Yes, non-Gaussian responses will improve accuracy which is easier to do in the frequency domain. The differences due to these improvements are significant. According to the spreadsheet model, ISI is the most dominant power penalty. An accurate accounting of the total power penalty is required to meet the transmission speeds and be economically justifiable."				
Moved	Steve Swanson			
Seconded	Bob Zona			
Technical (75%)	**Yes**	**No**	**Abstain**	**Result**
	by acclamation			**Passes**

Ian White reviewed a draft letter in response to the TIA Liaison letter.

- P. Kolesar: Agrees with the content of the letter, but points out that due to time constraints all points in the TIA letter have not yet been addressed.

Motion#	4 (Kolesar/Swanson Motion 2)			
Direct the channel modeling ad-hoc to enhance Cambridge model with consideration of the following input. • Re-examine perturbations of present Cambridge model to more closely represent observed behavior shown in DMD plots of kolesar_1_0704 and delay sets of abbott_1_0704. Possibilities to accomplish this include seeding the existing delays with those taken from this data and/or generation of a new class of index perturbations to replicate underrepresented delay set behaviors of installed fiber (e.g. “kinked” delays).				
Moved	Paul Kolesar			
Seconded	Steve Swanson			
Technical (75%)	**Yes**	**No**	**Abstain**	**Result**
	50	0	7	**Passes**

Discussion

- Bob Zona: Would like to see some consideration given to the fraction of the installed fiber population that exhibits these types of new perturbations. "of installed fiber" added as a friendly amendment.

Motion#	5 (Kolesar / Swanson Motion 3)			
Direct the channel modeling ad-hoc to enhance Cambridge model with consideration of the following input. • Consider scaling all delay sets to 500 MHz-km OFL BW without limiting DMD to 2 ps/m. • Consider non-uniform scaling methods, such as scaling delays as a function of local index delta, should uniform scaling produce delay structures not observed in manufacturing.				
Moved	Paul Kolesar			
Seconded	Steve Swanson			
Technical (75%)	**Yes**	**No**	**Abstain**	**Result**
	8	31	11	**Fails**

Discussion

- L. Aronson: Strongly objects to removing the reference to 2 ps/m since this is the only parameter today that connects the model to the statistics of the installed base.
- P. Dawe: It is not necessary to direct the ad-hoc to consider specific items. Interested individuals are free to bring their proposals to the ad-hoc directly.
- S. Swanson: This motion is intended to address points raised in the TIA Liaison letter. If passed, then this information could be included in the response to the TIA.
- John Jaeger – calls the question (no objection)

Motion#	6 (Kolesar / Swanson Motion 4)			
Agree to apply the following approach to channel modeling effort. Use both the Cambridge and FO-4.1.2 models as cross check for each fiber type after modification as follows. Consider using the Kolesar/Swanson motion 2 to enhance the Cambridge 62.5 µm fiber set and consider creating 50 µm equivalent sets for OM2 and OM3. Enhance FO-4.1.2 fiber delay set by modifying OM3 set for 1300 nm operation and create OM2 and 62.5 µm equivalent sets.				
Moved	Paul Kolesar			
Seconded	Steve Swanson			
Technical (75%)	**Yes**	**No**	**Abstain**	**Result**
	45	0	10	**Passes**

Discussion

- I. White: Friendly amendment to add the phrase "consider creating"
- P. Dawe: Friendly amendment – Change the last sentence to "Agree on pass/fail criterion for the two models".
- S. Swanson: Friendly amendment: "Consider using the Kolesar/Swanson Motion 2 to enhance the Cambridge 62.5µm fiber set …"
- D. Cunningham: What is meant by pass/fail criterion?
    - In the past the TIA used ISI penalty or EMB as pass/fail criteria to judge the whether a link or fiber passed. What criteria should be used in this situation?
- D. Cunningham: Setting link pass/fail criteria is beyond the scope of the channel modeling ad-hoc. Friendly amendment to remove the last sentence: "Agree on pass/fail criterion for the two models."
- J. George: Speaks in favor of the motion and calls the question (no objection)

Motion#	7			
Accept the letter to TIA FO-4.1.2 concerning MMF modeling concerns.				
Moved	Petar Pepeljugoski			
Seconded	John Dallesasse			
Technical (75%)	**Yes**	**No**	**Abstain**	**Result**
	by acclamation			**Passes**

Motion#	8			
Move that the 802.3aq task force adopt the NRZ EDC based proposal (lawton_01_0704) all of the diagrams on page 10,11 & 13 in aronson_2_07_04 as the basis for on-going committee tasks in order to focus & progress the work towards a draft standard as modified according to the notes 1 and 2 below. Note 1: This motion does not change the draft TF timeline nor does it preclude new proposals from being brought forward in the September interim. It does direct the task force to work on key areas of the NRZ EDC proposal. Note 2: All the table entries in lawton_01_0704 with items in red & all of diagrams from pgs. 10, 11, 13 in aronson_2_0704 shall be considered and identified as "TBD", with a corresponding Editors note based upon the placeholder value to be considered by the value / parameter in red.				
Moved	Mike Lawton			
Seconded	Pete Hallemeier			
Technical (75%)	**Yes**	**No**	**Abstain**	**Result**
	59	0	2	**Passes**

Discussion

- D. Cunningham: Friendly amendment to remove the last parenthetical phrase "(no other material from aronson_2_0704 is to be included)" It is understood that no other material is intended to be included, other than what is specified in the motion.

- J. George: Friendly amendment to clarify that notes 1 and 2 are linked to the first paragraph of the motion, insert "as modified according to the notes 1 and 2 below"
- D. Cunningham: At the next meeting the draft will need a 75% vote to be accepted as a baseline for the task force. Until that time all values and text in the draft have the same status.
    - David Law: Once an item is accepted with a 75% vote it takes a 75% vote to change it.

David Cunningham will direct Nick Weiner to create a draft based on the results of this motion to be distributed approximately one week prior to the next interim meeting.

Motion#	**9**			
Adopt the timeline as presented by David Cunningham in his closing comments presentation.				
Moved	David Law			
Seconded	John Jaeger			
Technical (75%)	**Yes**	**No**	**Abstain**	**Result**
	by acclamation			**Passes**

John Jaeger raised the question of creating additional ad-hoc committees to address some of the TP2 and TP3 compliance test work items. The meeting will be extended to allow interested people to create a specific proposal for one or more ad-hocs for the chair to consider.

After some consideration, no requests for additional ad-hocs will be made at this time, but people will continue to pursue these issues and contact the chair if they feel an ad-hoc is required.

Jonathan King has scheduled a meeting of sub-group 2 of the channel modeling ad-hoc for 10am on July 15, 2004 in the Queen Marie Meeting room.

Motion#	**10**			
Motion to adjourn				
Moved	John Dallesasse			
Seconded	John Ewen			
Procedural (50%)	**Yes**	**No**	**Abstain**	**Result**
	by acclamation			**Passes**

Adjourn 802.3aq Interim Meeting