IEEE P802.3 10GBASE-T Minutes

Study Group Plenary Meeting
July 22nd – 24th, 2003
San Francisco, CA.

Prepared by:
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Independent Consultant

Administrative

The meeting convened at 8:30am, July 22nd, 2003. Mr. Booth (Brad), the 10GBASE-T (a.k.a. 10GBT) study group chairman, opened the meeting with a discussion of the agenda and goals for this meeting. A motion to approve the agenda passed by acclamation. Brad then reviewed all the administrative items such as e-mail reflectors, membership, voting procedures, future meeting locations, call for patents and sign-in rules.

This 10GBT committee is in study group mode refining a set of objects and justification for a new 10GBASE-T standards project. In short the 802.3 working group tasked this study group to go off and study feasibility (technical and economic) of a new 10 Gigabit Ethernet copper PHY that's capable of running over some percentage of the installed base of horizontal structured twisted-pair copper cabling (exact details TBD) as well as new higher bandwidth cabling such as Cat 7 (Class F). This new PHY must not impact the existing 10 Gigabit Ethernet MAC and media independent interface as specified in IEEE 802.3ae™, 2002 because the adoption of this new PHY depends highly on its ability to working with existing MAC silicon produced over the past 2 years. The copper medium (cabling) is assumed to be ISO/IEC-11801:2002 Class D or better copper cable.

The hot ticket items for this meeting were simple; closure on the PAR & 5 Criteria.

The 'proposed' 10GBASE-T standards time line targets a 2Q06 completion date for the final standard. At this point in time the 10GBT standards effort is 21 % complete; 9 of 43 months have passed.

Some important links:

- Agenda: http://grouper.ieee.org/groups/802/3/10GBT/public/jul03/agenda_1_0703.pdf
- E-mail Reflector: http://grouper.ieee.org/groups/802/3/10GBT/public/index.html
- Voting Rules: www.ieee802.org/3/rules/member.html
- Typical Plenary Meeting: www.ieee802.org/3/plenary.html
- 5 Criteria: http://grouper.ieee.org/groups/802/3/10GBT/public/jul03/5criteria_2_0703.pdf
- PAR = http://grouper.ieee.org/groups/802/3/10GBT/public/jul03/par_0703.pdf

- 802.3 Patent Policy www.ieee802.org/3/patent.html
- Bylaws: http://standards.ieee.org/guides/bylaws/sb-bylaws.pdf
- Operating Rules: http://www.ieee802.org/3/rules/

The 10GBASE-T study group meeting adjourned at 12:38pm on Thursday July 24th, 2003.

Goals & Accomplishments for this Meeting

This meeting was dedicated to the refinement and enhancement of the project approval request (PAR), 5 criteria, and 10GBASE-T objectives. Another goal was to listen and discuss presentations concerning 5 criteria justification and refinements that will help the SG zero in on final project objectives. A total of seventeen (17) presentations were given. During the study group phase we're also tasked with formulating a set of baseline proposals to build off of. These are presentations that form the genesis of the most fundamental features, normally widely if not unanimously agreed upon. We listened to and discussed this type of baseline material at this meeting.

Jeff Warren was appointed as the permanent executive recording secretary for 10GBASE-T Study Group and subsequent Task Force.

All of the 5 Criteria and PAR were updated and voted on. The amendments made to these documents all passed, here's a snapshot of the voting results:

Broad Market Potential	90 %
Compatibility with IEEE Standards	81 %
Distinct Identity	100 %
Technical Feasibility	78 %
Economic Feasibility	88 %
PAR	100 %

While it's true the 10GBASE-T study group successfully amended the PAR & 5 Criteria with the positive voting results shown above, this success was tempered a bit during the closing 802.3 working group meeting. The 10GBASE-Tstudy group is struggling with modifications to the objectives where some participants are attempting to broaden the scope of the effort to include operational speeds other than 10G; such as 2.5G and 5G. There are pros and cons to both sides of this attempt to broaden the project scope with intermediate speeds between 1G and 10G. However history has shown us that the evolution of Ethernet has consistently avoided these small incremental speed increases. It was mentioned that if 2.5G operations is needed then combining 2 or 3 existing 1G links into a trunk group makes more sense, problem solved right now. An appealing feature of the multi-rate PHY is its ability to adapt the speed to the media it is attached to. Some system vendors are having heartburn considering the modifications necessary to support the intermediate speeds, especially the MAC silicon which is now stable for 10G operations after 2+ years of development.

This low cost 10GBT (relative to 10G optical) market will initially emerge in the data center for applications such as switch-to-switch, switch-to-server, and switch-to-storage. In this environment the link lengths are shorter than the horizontal structured wiring market, however it is still a primary objective to support 100-meter link lengths for this new 10G copper PHY standard. Some new cabling length distribution data presented at this July plenary meeting shows that 95% of the data center link lengths are 40 meters or less. Numerous study group presentations suggest that 10G transmission over 40-meters of Class D, E, and F (i.e. Cat 5e, 6, and 7) cabling is possible without the complexities of alien crosstalk mitigation techniques such as new patch cords. Also new channel models are not needed either so there's no reliance on outside cabling standards bodies to develop new channel models for the lion's share of data center solutions. However it's not that easy, distances greater than 40-meters in the data center are possible. Ethernet is Plug-and-Play, so the small fraction of data center links (i.e. 5%) that are greater than 40 meters need a solution. We listened to Lawrence Berkeley National Laboratory say that if the mitigation techniques are simple they will use them; if the unbundling solution is not possible they will use new cabling trays, if there is no way to verify the circuit they will install new cabling. If all else fails new Class F cabling will be used for these longer links. Over time the broader market may include 100-meter horizontal runs for the switch-to-server applications outside the data center, probably not switch-to-desktop for quite some time to come. Looking at the same new cabling length distribution data we see that 90% of the horizontal link lengths are 65-meters or less. It's probably fair to say that a standard that supports 75-meters in the horizontal is good enough. This will require alien crosstalk mitigation techniques and/or new channel modes if we are to rely on use of the installed base of cabling.

Subsequent to the July plenary a poll was taken. A dozen experts responded favorably that 10G over Class F cabling is technically feasible and power requirements for the application space is also feasible.

1. Do you believe that 10 Gigabit Ethernet over 100m on Cat7 is not technically feasible?
   Answers: No, No, No, No, No, No, No, No, No, No, No, No,
2. Do you believe that the power required for 10 Gigabit Ethernet over 100m on Cat7 make it not technically feasible?
   Answers: No, No, No, No, No, No, No, No, No, No, No, No,
   Thinks power will be greater than 5W. Power dissipation must be appropriate for server line cards and multi port switch implementations to achieve broad market potential. We heard a reasonable power target should be around 5W for server cards. If early products are 2-3 watts higher, then that should be OK for some applications. I hope this issue will be addressed to the study group by September meeting.

The study group drafted an ISO Liaison response letter, the letter was approved by both the 10GBASE-Tstudy group and the 802.3 working group then forwarded on to ISO/IEC JTC 1/SC 25/WG 3. The ISO response statement to us was that they will not even investigate Cat 5e. Once we step outside the bounds of TIA's previously specified cable operation on Cat 5e this group will most likely be required to write channel requirements,

not a full blown cabling spec. The TIA Liaison response was not approved for forwarding on to the TR-42 group. Opposition to specific numbers in the response (requirements) with regards to alien crosstalk prevented this effort from coming to closure. Some argued that the SG should not be doing design work at this time.

A significant amount of time by the Cabling Ad Hoc participants was spent reviewing data they collected and the interpretation of that data as well as the alien crosstalk mitigation techniques they felt were going to be needed. Some mitigation techniques include enhanced patch cords, separation of patch cords and varying their lengths, removal of tie wraps, etc. Receiver based alien crosstalk mitigation was also proposed, it results in a 3-6dB performance improvement. In this case the range of improvement varied with tightly 'vs' loosely bundled cables. The presenter for this type of mitigation gives strong hope that 10G over Cat5e is possible. Some concerns were raised about this analysis, those concerns were factored into subsequent simulations (e.g. offset the disturber and victim cables so they are not frequency synchronized). The results still correlate well and show positive gains in the SNR.

At one point the topic of magnetics was discussed. Here the presenter explained that magnetics with bandwidth beyond 500MHz is possible and with decent transmission characteristics including insertion loss and return loss. Turns ratios and center tap considerations were presented as well.

A baseline proposal for a cabling specification for 100% coverage was reviewed in great detail. This new channel model shows how screened Cat 6 and Cat 5e cabling that exists today can achieve 10G operation at distances of 100-meters. This model includes both cabling and connectors, RJ-45 connectors! Three issues this analysis dealt with are ANEXT (dominant issue), Insertion Loss, and Return Loss. Ultimately this type of presentation material needs to find its way to the TIA TR42.7 group so that they too can jump in and help draft the new channel model.

Some limitations in extending Cat 5e cabling were presented, this has to do with a notch in the frequency response of the cable in question. It's called *Attenuation Notch* and Bell Labs has known about this for years. Many participants requested data on this issue and Terry Cobb from Avaya agreed to post this vector data. Bottom line is that the TF will have to get into the physics of this issue and deal with it. Along these lines some PAM-10 transceiver simulations showed that an 8dB notch will cause a 6dB degradation in the SNR.

Several multi-rate PHY presentations were given; the bottom line is that the presenters feel that 10G operations over Cat 5e and Cat 6 are not possible with alien crosstalk presenting a fundamental limit. The incumbent PHY vendors supported these presentations. Their design approach to the perceived issue of running 10G over the installed base is to use speed adaptation where the speed of the link is determined using techniques like monitoring signal quality. The rate adaptation scheme was not presented. The proposal was for a (XGBase-T, where $1 < X <= 10$). As presented this did not mean

variable speeds such as 1,2,3,4,5G, rather it included three specific speeds. They are 2.5G, 5G, and 10G. More specifically the solution is:

- A minimum of 2.5 Gb/s over an ISO Class D or better 100 meter channel and with an alien crosstalk requirement to be specified.
- A minimum of 5.0 Gb/s over an ISO Class E or better 100 meter channel and with an alien crosstalk requirement to be specified.
- For greater than 5.0 Gb/s to operate over a distance and media type suitable for the rate.

A concern was raised about the additional standards work necessary to add the two additional speeds. This PHY group probably doesn't have the expertise to take on the various hits to clauses out side the scope of PHY clauses. If these slower speeds do find their way into this 10GBASE-Tstandards effort in the end PHY vendors are most likely not going to produce PHYs that include both 10G and 2.5G operational modes because if the media only supports 2.5G why spend the extra dollars on a PHY capably of 10G rates when that comes at a higher cost?

Some stimulating conversation on analog front ends (AFE's) was conducted by Dr. Spencer from the University of Califorina. To reduce the complexity and power consumption of the receivers placing some equalization in the AFE makes sense. This will also pay dividends on the overall cost of the solution.

A couple of line signaling presentations were given, one on interleaved trellis coded modulation and decoding and another continuation effort on the two approaches for implementing the PHY; a DSP approach and an analog approach.

Another baseline consensus proposal for the 10G PHY was given by a team of four, a Consultant, a PHY vendor, a Systems vendor, and an End User. This focused on maximizing coverage on Class D and E installed cabling and 100% coverage for new installations. A lot of worse case analysis went into this presentation as well as real life installed base characterizations are factored into the simulations that go into determining the link distances that can be supported. The same mitigation techniques that were discussed earlier were raised again. The End User stated that all of these mitigation techniques and some guiding principles on how to make choices are very reasonable. The system vendor explained that the paramount issue is 10G at a lower cost than present day solutions.

The formalities of moving out of Study Group and into Task Force mode were discussed.

There was considerable discussion on the PAR and 5 Criteria, please reference section 19 below for the final text on those important documents. That text is in blue.

Outline for these Minutes

Future IEEE P802.3 10GBASE-T Meetings

Month	Days	Year	Meeting Type	City	State/Country
September	17th – 18th	2003	Interim	Portonovo	Italy
November	9th – 14th	2003	Plenary	Albuquerque	NM
January	TBD	2004	Interim	TBD	TBD
March	14th – 19th	2004	Plenary	Kissimmee	FL

There's a link to the next two meetings:

- September 2003 Interim: http://grouper.ieee.org/groups/802/3/interims/index.html
- November 2003 Plenary: http://www.ieee802.org/meeting/index.html

IEEE P802.3 10GBASE-TObjectives

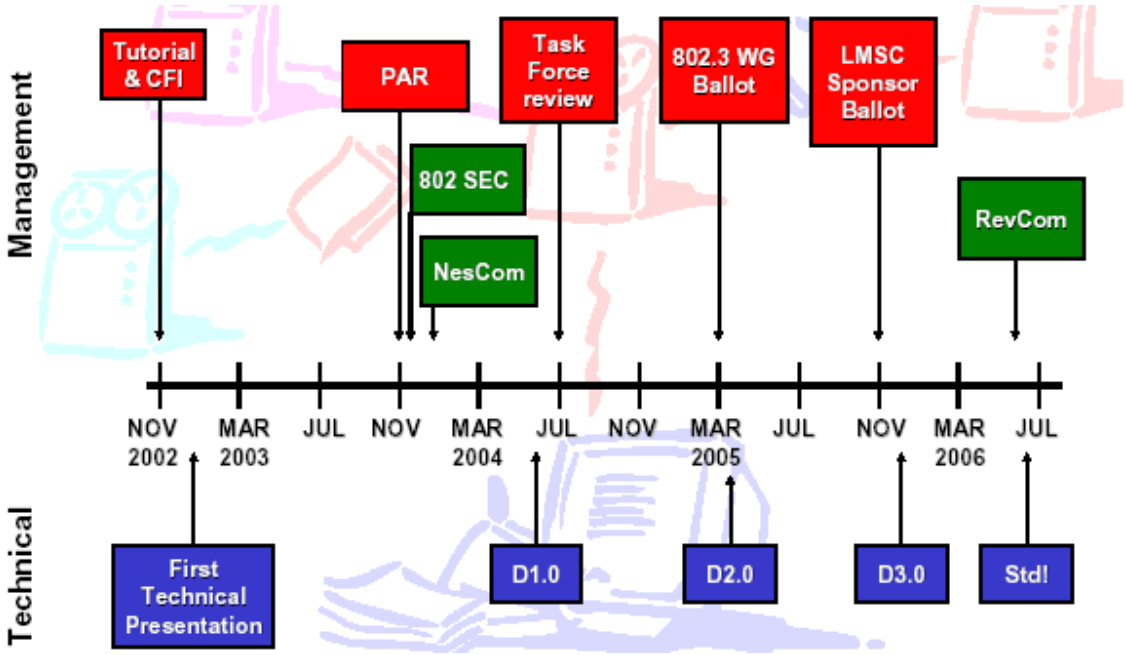
- Preserve the 802.3/Ethernet frame format at the MAC Client service interface
- Meet 802 Function Requirements, with the possible exception of Hamming Distance
- Preserve minimum and maximum frame size of the current 802.3 standard.
- Support full duplex operation only
- Support star-wired local area networks using point-to-point links and structured cabling topologies
- Support a speed of 10.000 Gb/s at the MAC/PLS service interface
- Select copper media from ISO/IEC 11801:2002, with any appropriate augmentation to be developed through work of 802.3 in conjunction with SC25/WG3
- Support 100 meters over 4-connector structured 4-pair, twisted-pair copper cabling
- To not support 802.3ah (EFM) OAM unidirectional operation
- Support coexistence with 802.3af
- Support Clause 28 auto-negotiation

IEEE P802.3 10GBASE-T Contacts

For the latest list of key IEEE P802.3 10GBASE-T contacts please reference the IEEE 802.3 CSMA/CD Task Force/Study Group chairs and editors web page located at http://grouper.ieee.org/groups/802/3/contacts.html this web page is maintained by David Law.

Name	802.3 & 10GBASE-T Standards Title	E-mail
Brad Booth	10GBASE-T Chairman	bradley.booth@intel.com
Jeff Warren	10GBASE-T Recording Secretary	IEEE@nc.rr.com
Bob Grow	802.3 Working Group Chair	Bob.Grow@Intel.com
David Law	802.3 Working Group Vice Chair	David_Law@3Com.com
TBD	Task Force Chief Editor	TBD
TBD	Clause X Editor	TBD
TBD	Clause Y Editor	TBD
TBD	Clause Z Editor	TBD

Proposed IEEE P802.3 10GBASE-T Standards Timeline



Agenda, Meeting Times, and Meeting Map

Tuesday **July 22, 2003**				
Presenter	**Topic**	**Length**	**Start**	**Finish**
	Welcome and Introductions	0:10	8:30 AM	8:40 AM
Booth, Brad (Intel)	**Agenda and General Information**	0:45	8:40 AM	9:25 AM
DiMinico, Chris (MC Communications)	**Cabling Ad Hoc Report**	0:15	9:25 AM	9:40 AM
Morning Break		0:15	9:40 AM	9:55 AM
Nordin, Ron & Vanderlaan, Paul (Panduit & Belden)	**Alien Crosstalk Mitigation Technique**	0:25	9:55 AM	10:20 AM
Aldana, Carlos (SolarFlare)	**Receiver Based Alien Crosstalk Mitigation**	0:30	10:20 AM	10:50 AM
AbuGhazaleh, Shadi (Hubbell)	**Alien NEXT, IL Effect on Channel Capacity**	0:15	10:50 AM	11:05 AM
Dinh, Thuyen (Pulse)	**Magnetics for 10GBase-T**	0:20	11:05 AM	11:25 AM
Flatman, Alan (LAN Technologies UK)	**Installed Horizontal Cabling Length Distribution**	0:15	11:25 AM	11:40 AM
Lunch		1:00	11:40 AM	12:40 PM
Cohen, Larry (SolarFlare)	**Proposed Cabling Specifications for 100% 10Gbps Coverage**	0:30	12:40 PM	1:10 PM
Cobb, Terry (Avaya)	**Extending Category 5e Limits**	0:20	1:10 PM	1:30 PM
Powell, Scott (Broadcom)	**Impact of Insertion Loss Notch on PAM-10 Transceiver**	0:20	1:30 PM	1:50 PM
Powell, Scott (Broadcom)	**Feasibility Study on High Speed Transmission over UTP Cables**	0:45	1:50 PM	2:35 PM
Afternoon Break		0:15	2:35 PM	2:50 PM
Yousefi, Nariman (Broadcom)	**Multi Rate PHY**	0:50	2:50 PM	3:40 PM

Spencer, Richard (UC Davis)	Analog Front Ends for Ethernet on Copper	0:50	3:40 PM	4:30 PM
Parhi, Keshab (University of Minnesota)	Interleaved Trellis Coded Modulation & Decoding	0:30	4:30 PM	5:00 PM
Babanezhad, Joseph (Plato Labs)	10GBASE-TLine Signaling	0:30	5:00 PM	5:30 PM

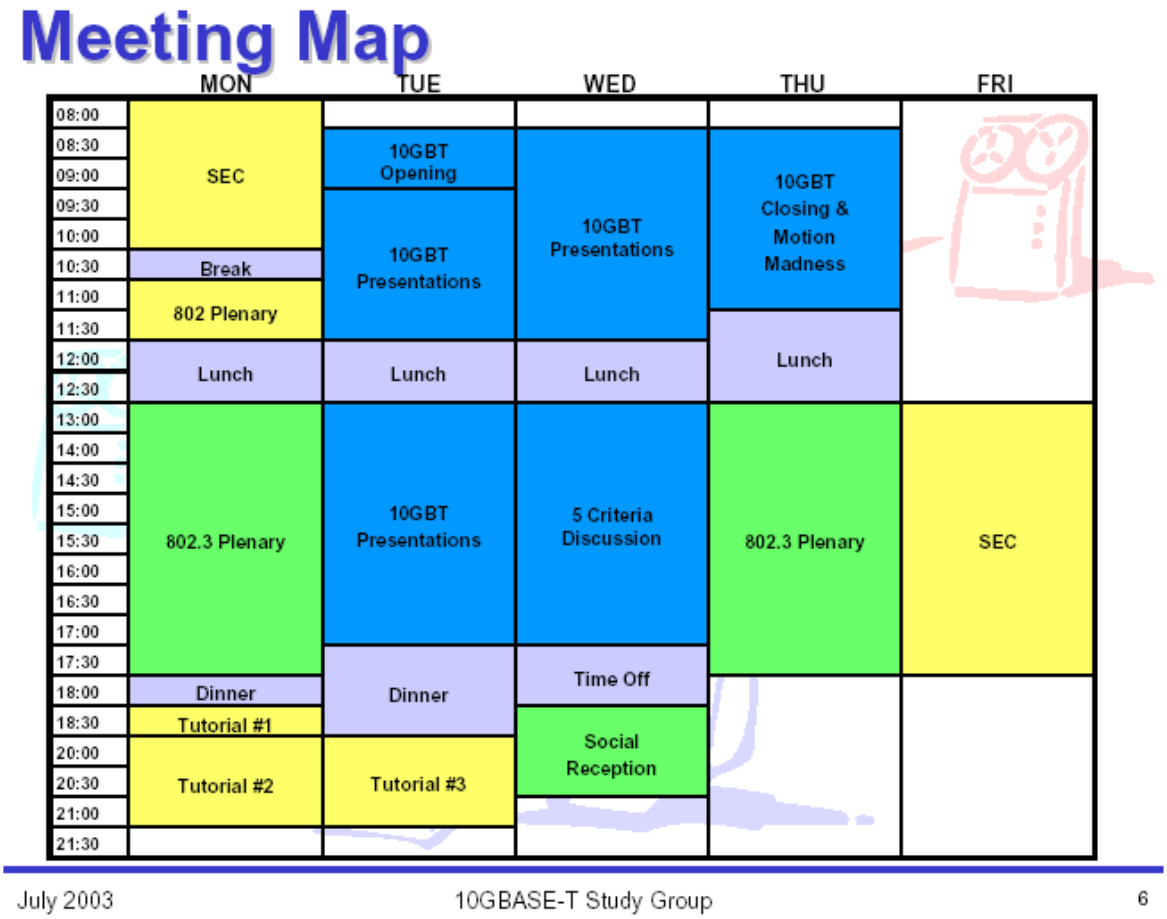
Wednesday
July 23, 2003

Presenter	Topic	Length	Start	Finish
	Welcome	0:00	8:30 AM	8:30 AM
Di Minico, Chris (MC Communications)	10GBASE-TCabling Baseline Proposal	1:00	8:30 AM	9:30 AM
Morning Break		0:15	9:30 AM	9:45 AM
Group	5 Criteria (amended)	1:45	9:45 AM	11:30 AM
Lunch		1:30	11:30 AM	1:00 PM
Group	Draft PAR 5 Criteria (amended) TR42 Liaison Letter	4:30	1:00 PM	5:30 PM

Thursday
July 24, 2003

Presenter	Topic	Length	Start	Finish
Warren, Jeff (Extreme Networks)	10GBASE-TTransition from a Study Group to a Task Force	0:15	8:30 AM	8:45 AM
Group	Motion Madness – Closing Items	0:00	8:45 AM	11:50 AM

This meeting map developed by Brad Booth is tailored to show the how the 10GBASE-T meetings on Tuesday, Wednesday, and Thursday fit in with other important IEEE meetings going on that week. The blue time slots are 10GBT meetings and the green slots with the exception of the social are the 802.3 working group meetings. Individuals attending plenary meetings are required to select a specific task force or study group that they wish to participate in and give their full attention to that group's activities.



Motions

Motion # 1

Description: Nominate Jeff Warren to be the permanent executive recording secretary for 10GBASE-T Study Group and subsequent Task Force.
Motion Type: Procedural 50 % required
Moved By: Shimon Muller
Seconded By: Terry Cobb
Results: **100 %** P/F: **Passes by Acclimation**

Brad Booth spoke in favor of this motion and cited Jeff's past efforts as the permanent executive recording secretary in the IEEE P802.3ae task force.

Motion # 2

Description: Adopt the letter developed by the SG Ad Hoc.
Motion Type: Technical 75% required
Moved By: Pat Thaler
Seconded By: Shimon Muller
Results: **no vote** P/F: **Tabled**

Motion # 3

Description: Amendment - Several proposals are currently being considered to achieve the desired ratio of insertion loss to alien crosstalk.
Motion Type: Technical 75% required
Moved By: Shadi AbuGhazaleh
Seconded By: Luc Adriaenssens
Results: **73 %** P/F: **Failed**

Yes: 35	**No: 12**	**Abstain: 5**	**Failed 1st count**
Yes: 36	**No: 13**	**Abstain: 8**	**Failed 2nd count**

Motion # 4

Description: Motion to Table Motion #2 above– no timeframe
Motion Type: Procedural 50% required
Moved By: Terry Cobb
Seconded By: Sterling Vaden
Results: **73 %** P/F: **Passed**

Yes: 31	**No: 18**	**Abstain: 0**

Motion # 5

Description: Motion to accept the ISO liaison letter
Motion Type: Procedural 50% required
Moved By: Terry Cobb
Seconded By: Pat Thaler
Results: **73 %** P/F: **Passed**

Yes: 47	**No: 0**	**Abstain: 5**

This liaison letter response to ISO/IEC JTC 1/SC 25/WG 3 will be uploaded later today.

Motion # 6

Description: Accept Broad Market Potential Criteria
Motion Type: Technical 75% required
Moved By: Shimon Muller
Seconded By: Bennett
Results: **90 %** P/F: **Passed**

Yes: 57	**No: 6**	**Abstain: 5**

Discussion: Geoff spoke against this motion because he feels the text as written on addresses the server market. Kevin from Broadcom felt the text was somewhat altered from what was presented to the Ad Hoc yesterday. Geoff felt the wording around the number of companies participating is not speaking directly to the point that's important, such as how many people are going to actively participate in the draft of this standard.

Motion # 7

Description: Delete 10 gigabit speed from final paragraph
Motion Type: Technical 75% required
Moved By: Terry Cobb
Seconded By: Nariman

Results: **16 %** P/F: **Failed**
Yes: 9 **No: 47** **Abstain: 8**

Discussion: The slower speed PHY will not work with any of the 10G MAC's out there in the industry. The removal of 10G is too large of a change to the 10GBASE-T's charter.

Motion # 8
Description: Add existing to the final sentence of paragraph
Motion Type: Technical 75% required
Moved By: Terry Cobb
Seconded By: Nariman
Results: **23 %** P/F: **Failed**
Yes: 11 **No: 37** **Abstain: 13**

Discussion: The 802.3 objected strongly that the SG is not where we modify the objectives of the project. The movers of this motion felt that the new text is needed to broaden the market potential. Muller felt that just like the evolution of 1000Base-T this will follow the same track and will have a large market potential when this standard closes in a few years and the technology solution costs are lower. George felt that the next level of speed is required for aggregation of lower speeds, etc. he is in favor of leaving the text as is. Pat Thaler felt the text should remain as is. This SG has no business making this modification because it is in violation of the objectives that formed the SG. Pat's comments were consistent with an end-user's comments stated earlier this week, such as if I need new cabling for this to work in my environment then I'll install that cabling. Chris felt that the added text is not necessary, the lack of "existing" implies both existing and non-existing.

Motion # 9
Description: Accept the Compatibility with IEEE Standards Criteria
Motion Type: Technical 75% required
Moved By: Shimon Muller
Seconded By: Jeff Warren
Results: **81 %** P/F: **Passed**
Yes: 43 **No: 10** **Abstain: 10**

Discussion: The functional requirements document doesn't exist anymore. Nariman felt that approving this as written will remove the possibility of multi-rate PHY.

Motion # 10
Description: Motion to postpone until after the Objectives and technical feasibility are dealt with

Motion Type: Technical 75% required
Moved By: Nariman
Seconded By:
Results: **26 %** P/F: **Failed**

Yes: 14 **No: 39** **Abstain: 15**

Motion # 11
Description: Accept the Distinct Identity Criteria
Motion Type: Technical 75% required
Moved By: Muller
Seconded By: Warren
Results: **100 %** P/F: **Passed**
Yes: 54 **No: 0** **Abstain: 10**

Motion # 12
Description: Accept the Technical Feasibility Criteria
Motion Type: Technical 75% required
Moved By: Muller
Seconded By: Shadi
Results: **78 %** P/F: **Passed**
Yes: 49 **No: 14** **Abstain: 7**

Discussion: Nariman argued that technical feasibility has not been shown. Bob Grow our 802.3 WG chair gave his impression on what technical feasibility means at this point in time, meaning the study group phase, and that is it's Subjective. The point in time for exhaustive proof is when the yet to be formed 10GBASE-T Task Force says this technology is ready for working group balloting. The point is there is time to formulate definitive technical feasibility. Those that have been in the Ethernet committee for some time may remember the issues around DMD (launching laser light on multimode fibers) were territory that was not fully investigated at the time the TF formed. Alan clearly stated Class F support is solid with a very comfortable margin. The modeling Ad Hoc chair said the capacity model was agreed upon. Joseph Plato Labs felt that 2.5G and 5G technical feasibility has been shown. Val made a hostile amendment. Pat made a procedural point about all the technical criteria being approved, Pat says that time is November.

Motion # 13
Description: Accept the Economic Feasibility Criteria
Motion Type: Technical 75% required
Moved By: Muller
Seconded By: Shadi
Results: **88 %** P/F: **Passed**
Yes: 44 **No: 6** **Abstain: 6**

Discussion: Geoff suggested some minor text change – it was accepted.

Motion # 14
Description: Accept the PAR as amended at this meeting
Motion Type: Technical 75% required
Moved By: Dineen

Seconded By: Muller
Results: **97 %** P/F: **Passed**
Yes: 34 **No: 1** **Abstain: 0**

Motion # 15
Description: Request 802.3 Chair to submit the ISO liaison letter to the corresponding standards bodies."
Motion Type: Technical 75% required
Moved By: Rubin
Seconded By: Goudie
Results: **100 %** P/F: **Passed**
Yes: 33 **No: 0** **Abstain: 0**

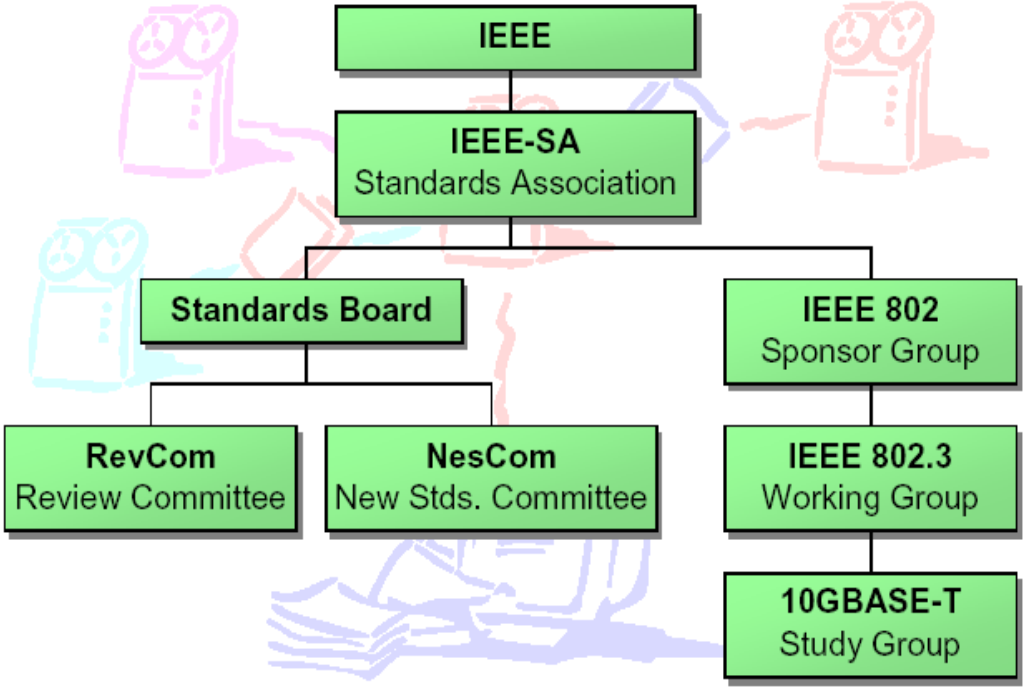
Motion # 16
Description: Motion to approve the PAR and 5 Criteria as written and to request the 802.3 chair to forward same to the LMSC Executive Committee and NESCOM for consideration in December, with the understanding that if Executive Committee and 802.3 approval is not received, the PAR will be removed from the NESCOM agenda
Motion Type: Technical 75% required
Moved By: Rubin
Seconded By: Goudie
Results: **94 %** P/F: **Passed**
Yes: 29 **No: 2** **Abstain: 1**

Motion # 17
Description: Motion to request an extension for the 10GBASE-Tstudy group from the SEC
Moved By: Rubin
Seconded By: Dineen
Results: **100%** P/F: **Passed by Acclimation**

General Presentations & Minutes

1. Opening Business (Brad Booth)

- Mr. Booth's opened the meeting welcoming everyone to the beautiful city of San Francisco. We had a round of introductions, selected Jeff Warren as the recording secretary and quickly got into the goals and objectives (outlined above) for this meeting. The meeting agenda remained basically unmodified. The important reflector and web addresses were shown. The ground rules for how these meetings are conducted were also reviewed. During this meeting we had to come back to this point several times where individuals were confusing their representation in the meetings with that of their employers. Participation by all parties is on an individual basis. The issue of how IEEE deals with patents was reviewed. This is a mandatory "call for patents" was made, this time consuming process is very important – anyone with patents they think apply to 10GBT are strongly encouraged to identify them. Please reference the patent process www.ieee802.org/3/patent.html
- The complexities of how a project is routed through the IEEE standards process was discussed at great length; in particular the transition from a study group to a task force is our highest priority right now.



- This study group must get the PAR, 5 Criteria, and Objectives to the appropriate standards bodies in a timely fashion. For example NesCom, the standards board, and the standards executive committee (SEC). This study group has been extended a few times now, time is running out. The highest priority now is developing strong consensus among the group on our objects for this new project.

- The study group is not supposed to have all the answers; this group is tasked with setting the direction for the project. The topic of technical feasibility for example is not something that must be analyzed to the Nth degree, in fact it is OK to rely on simulation models as a means of proving technical feasibility while in a task force mode.

2. Cabling Ad Hoc Report (Chris DiMinico)

- Mr. DiMinico mentioned that the 10GBASE-T Study Group needs to prepare responses for two liaison letters; one from the ISO/IEC, which we received in March 2003, and the second TIA liaison letter also received this year.
- Chris provided a summary of the cabling AdHoc measurement objectives regarding the development of Alien crosstalk limits based on measurement configurations that are representative of the installed cabling. Alien crosstalk measurements were taken of cabling pulled into conduit (to the fill capacity) and tie-wrapped. Shadi AbuGhazaleh, and Michel Bohbot presented their measurement results of the cabling ad hoc Alien NEXT measurement configurations.
- TR-42 has responded in a positive manner on the work they are willing to do on 4-pair 100 ohm balanced twisted pair copper cabling for 10GBASE-T. They will help our group with Cat 5e and Cat 6 characterizations as well as enhancements to Cat 6 specifically for this 10GBASE-T standards group. There is no timeline for TIA's work efforts, we'll need to define a timeline that lines up with our project milestones and communicate that back to them. Typically setting new cabling standards is for new installations and applies to new cables, for example we'd end up with a Cat 6e cable. However at this time there is no commitment that a Cat 6e will be produced. TIA will study this and take some actions that might include a better spec for existing Cat 6 cables or it could include a new Cat 6e specification. The installed base clearly does not have a cabling standard that supports 10GBASE-Trequirements. If we go after support for some portion of Cat 5e installed cables this IEEE group will have to write the specifications that are required to define the operation in this previously uncharacterized operational zone.
- The ISO response statement to us was that they will not even investigate Cat 5e. Once we step outside the bounds of TIA's previously specified cable operation on Cat 5e this group will most likely be required to write channel requirements, not a full blown cabling spec. TIA will characterize the cabling up to 625MHz. There will be an issue that pops up with field-testing, specifically for parameters such as ANEXT. TIA's measurement commitments are for ANEXT lab test setups, not field tests.
- Quick Poll for those working with Chris in the Cabling Ad Hoc at 1:30pm (Baview B Room). Chris felt that this liaison response would be more effective after this larger group has more discussion.
- The Cabling Ad Hoc has been busy developing cabling models and characterizing alien cross-talk for the installed base taking into consideration conduit fill capacity, tie-wrap separation and cable types.

- Chris outline several measurement procedures used to collect data. For example seven 90 meter 4-pair cables along a non-conducting surface or supported in an aerial span. Tie-wrap every 5 ft - (90 meters) then measure NEXT between all of the seven 4-Pair cable pair combinations.
- Other study group members, such as Shadi AbuGhazaleh, Michel Bohbot, Ron Nordin, and Paul Vanderlaan, discussed measurement data and some conclusions drawn from these Ad Hoc measurements.

3. Alien Crosstalk Mitigation Technique (Ron Nordin & Paul Vanderlaan)

- This presentation describes two mitigation techniques to reduce the level of alien crosstalk in an installed cabling system. The mitigation techniques are applied at the switch and of a cabling system. The techniques include separating the patch cords for certain lengths and the incorporation of an enhanced patch cord. Capacity results for before and after the application of mitigation is shown.

- A new patch cord was suggested as a means of mitigating the ill effects of alien cross talk for the installed base of cabling. This patch cord interconnects 10GBT equipment to distribution panels.
- 90 meters of cabling was looked at for a baseline. This is bundled cabling. The ANEXT was shown w/o enhancement. Cable separation was shown to help a lot. Including a punch down the new shielded patch cord shows ANEXT minimizing. On page 12 Ron plotted the amount of ANEXT you have to suppress to get 10G operation against cable lengths. Longer lengths of installed base cabling can be supported with the enhanced cables. The black lines are bundled Cat 6 ANEXT specs. This is only as good as the cable model is. Some cable parameters as a function of length are not included in the model just yet. The enhanced patch cord is independent of length and depends more on its loss, for example insertion loss. An observation on the chart on page 12 is that lengths of 100m are probably not going to be achieved even with Cat 6 and the enhanced patch cords. Ron said the model is not good enough to make this conclusion just yet.

- In the end Ron suggests a two-pronged approach – one support for existing installations at 10G rates using mitigation techniques and the 2nd involves a new cable for new installations. With regards to the mitigation technique more work is needed on test measurement procedures, better cabling models are going to have to be developed as well, and lastly a mitigation specification would have to be developed.

4. Receiver Based Alien Crosstalk Mitigation (Bill Jones & Carlos Aldana)

- Dr. Jones gave this presentation. At previous meetings, several members of the study group requested quantified results for receiver based alien crosstalk mitigation. In response and as an existence proof, results were presented for a two-cable scenario. It was shown that both spatial and temporal correlation does exist. A system block diagram was presented which could be used in the receiver

to exploit the correlation and provide alien mitigation. Finally, performance results were given showing between 3dB and 6dB of mitigation.

- Again the purpose of this pitch is to address some Alien crosstalk concerns that have been raised at past meetings. Some basic results will be shown that mitigation is possible for this Alien crosstalk. The statistics of the signal are used to perform this mitigation.
- The disturber signal is coupling into the victim pairs, they compute the cross correlation between the pairs. Two cases are shown, tightly and loosely bundled.
- PAM-10 signals are used on both the disturber and victim pairs. The MIMO EP feeds back a decorrelating signal back to the RX before the slicers to improve the slicer SNR.
- The SNR improves to about 6dB for one particular case. This is a positive gain in the Slicer SNR.
- The range of improvements for the tightly and loosely bundled cases was presented.
- Correlation does exist to improve Alien Mitigation and techniques do exist to provide receiver based alien mitigation of 3-6dB making 10G transmission over Cat5e possible.
- Scott from Broadcom asked about the setup on page 5. Are you assuming that all disturbers are 10G, answer yes. The simulation did not assume phase synchronous between the pairs, but was in the frequency domain. They will look at the effects of adding more cables (disturbers and victims) and the suppression goes now as the number goes up. However SolarFlare postulates configurations where the number of cables can be controlled may be required in the end. This work is strictly at the decoder level, doesn't include the Trellis coder blocks.
- It looks like the Temporal Correlation chart on page 4 only factors in one disturber cable, it was suggested that additional disturbers be added to this simulation mix.
- This adaptive process has coefficients that adapt to the received signal.
- This pitch is very special to a specific case of one disturber and one victim and while it's true the correlation does exist for this case one person challenges if the correlation does exist for the general case. In the early deployments of 10G it is possible that cabling can be sorted out and these assumptions are valid. Others challenged this and said the worse case installed base is six disturbers around one victim, and this must be considered with the correlation data.
- This presentation does not give enough detail for others to verify the results. For example showing what the RX does.
- Bill feels that adding these techniques along with cabling practices will get us to 10G over Cat 5e. The amount of improvement you get is greater when the pair has more Alien. This may add 25% more to the chip size to add this functionality.
- A loosely bundled case does resemble a conduit cabling solution, so it's realistic.
- George from SolarFlare says this really boils down to a cabling practice that this standards body will most likely require as part of the overall 100% coverage of running 10G over copper, not specifically Cat 5e.
- Error propagation was not considered because Bill wanted to isolate the gain from just this technique.

5. Alien NEXT, IL Effect on Channel Capacity (Shadi AbuGhazaleh)

- Dr. AbuGhazaleh reported his measurement results of the cabling ad hoc Alien NEXT measurement configurations. Shadi's summary was:
  - Insertion Loss has significant effect on capacity.
  - ANEXT of hardware has a diminishing effect as overall ANEXT drops.(~2Gbps)
  - ANEXT mitigation (10 dB), combined with C6 may achieve the desired 20+ dB improvement over C6 channel PSNEXT levels.
  - Most significant source of ANEXT improvement is CABLE performance

- Shadi's presentation focused on the capacity of Category 6 channels. The intent was to illustrate that there is a majority of category 6 existing installations that have a Shannon capacity exceeding 18 Gbps. The ANEXT was measured along with all the other parameters using the ADHOC configuration, and the capacity was calculated from the resulting data. It was pointed out how category 6 channels whose length is less than 85 m (great majority of installs) have sufficient capacity for 10G. This was offered as a way to show market potential in category 6 and help the study group move forward.

6. Magnetics for 10GBASE-T(Thuyen Dinh)

- Mr. Dinh's presentation showed that magnetics with bandwidth beyond 500 MHz was possible, with decent transmission characteristics including insertion loss and return loss. It was also pointed out that certain criterion such as transformer turns ratios, and the presence of the center taps should be carefully considered because these may significantly affect the bandwidth of the magnetics.
- Two design examples for the magnetics were presented along with the test setups. For the 1st example they came up with a 1:1.4 turns ratio for 50-ohm : 100-ohm impedance matching w/o a center tap. This part is not in any packaging and the packaging will have an effect on the results. They used a back-to-back test setup for measuring the insertion loss with a network analyzer. The return loss was tested from the driver side. The blue line on page 6 is for the insertion loss; notice there's little loss until around 300MHz. This insertion loss was limited to 5dB at the 600MHz range. At 100kHz there's 6.1dB combined insertion loss. Return loss (back-to-back) measurements were also taken.
- The next example uses a 1:1 ratio for 100-ohm : 100-ohm impedance matching. This is more realistic from a manufacturing point of view. It's also in a surface mount plastic package. The test results show a resonance notch that is probably cause by not splitting the ground planes. This may be invalid data; it will be re-measured and re-posted. Still see very good return loss.
- In summary the performance at high frequencies are very sensitive to package size and whether center taps on the transformer are needed. BW of 3dB from less than 200kHz to more than 400MHz is feasible. If center taps are needed the odd

number of turns ratios will be difficult to achieve and manufacture. The big notch in the 2nd example was in the insertion loss.

- Two things that greatly affect the return loss are the number of turns that results in higher leakage. The non-unity return ratios also cause leakage. Nothing is as good as a 1:1.
- The linear phase (group dispersion) is a useful measurement; the response was that the complex measurement data is available. An HP measurement device was used and the presenter is willing to share this data.

7. Installed Horizontal Cabling Length Distribution (Alan Flatman)

- Dr. Flatman presented installed horizontal cabling link lengths for commercial office buildings and medium-sized data centers. Office building data was sourced from "The Cabling Partnership and Fluke Networks" and covered five (5) large buildings and a total of 65,000 links.
- This is new cable measurement data.
- Some key data points:
  - At approximately 90 meters 100% of the links are covered.
  - At 50-65 meters (or less) approximately 90% of the links are covered.
- These links are all copper, either Cat 5e or Cat 6 cables.
- In the data centers the lengths are much shorter for obvious reasons, here's the break-down of data center link lengths:
  - ~ 27% are 11-20m NOTE: This is where the 10GBase-CX4 market is.
  - ~ 47% are 21-30m
  - ~ 20% are 31-40m
  - ~ 5% are 41-90m

  NOTE: An interesting conclusion to draw from this data is that the initial market for 10GBASE-T(i.e. the Data Center) is best served with a solution that reaches 40 meters or less.

8. Proposed Cabling Specifications for 100% 10Gbps Coverage (Larry Cohen)

- Mr. Cohen gave this presentation. The subject of the presentation was a proposed specification for a new cable type (more specifically a channel model) that allows full 100-meter reach of 10GBASE-T without requiring any field qualification and mitigation procedures. It was shown through lab measurement of existing cable samples that the proposed cable is technically feasible and, in fact, may already exist in some manufacturer's versions of Cat 6 ScTP and Cat 5e ScTP.
- This is a first cut proposal – it will require some tweaking. This is a channel specification it includes both cables and connectors (e.g.RJ-45).
- If the existing cable standards have limits, what kind of cable do we need (more specifically what channel specification)? This would be defined from DC to 625MHz, components must be based on existing specifications and measurement techniques.
- The three particular issues that must be dealt with are:
  - ANEXT – very critical (dominant issues)

    - Insertion Loss
    - Return Loss
- Insertion loss spec would be slightly better than Cat 6 specifies. Balance should be keep as high as possible.
- In determining the necessary requirements for the new cabling they considered what is feasible and what is required. Page 4 red line is proposed limit. Using a screened cable is a possible solution.
- Alien NEXT – The test bed used was very much so w/c, if you just slightly unbundled this you can get a significant improvement in Alien NEXT.
- Which is the dominant disturber in a long channel, is it Alien NEXT or FEXT. The Alien NEXT was found to dominate, see slide 6.
- The second area for tweaks was the insertion loss. The Cat 5e nearly met the new limits but Cat 6 would achieve the insertion loss requirements.
- The bundle was six (6) tightly bundled disturber cables around one (1) victim cable with tie-wraps every four (4) inches.
- Larry suggested that his new channel specification proposal would be forward to the TIA TR42.7 group as per request in liaison letter.
- The new proposed limit line for Alien NEXT is based on measurement data.
- The specification for Cat 6 is a limit line; it inherently has some amount of margin built into it.
- Some argued that a different gauge wiring might be necessary, different manufactures will eventually need to weigh in on the proposal.
- Some suggested a less ridged approach with TIA, to give them some broader parameters to work within. Larry's point is we'll need several iterations on this with TIA to hone in on the specification. That the point is we need to get started with TIA now as per their liaison request. Larry feels his work (data) is adequate as a starting point.
- Since there were a number of vendors that challenged the data, that it's not ready to move forward just yet until they have a chance to run some of their own analysis. Some break-out meetings will be held to work these types of task, i.e. formulating a liaison response.

9. Extending Category 5e Limits (Terry Cobb)

- Mr. Cobb presented an example of a commercially available Category 5e cable that would not meet an extended frequency limit. The cable failure exhibited a -14 dB notch in the attenuation within the 625 MHz band along with a significantly larger one above 900 MHz. In addition the cable exhibited significant peaks in NEXT and differential to common mode conversion.
- Attenuation (notch) - a defect that was predicted many years ago by Bell Labs was found by some testing Terry did. This happens on pairs 1 & 4. This can be observed from 650MHz on out. Another manufacturing defect shows up on pair 3 around 550MHz. Terry mentioned this could happen in any length links. This cable is fine for 100MHz operation.
- Differential to Common Mode – Terry felt this defect would radiate, claimed this would cause failures with FCC compliance.

- Some of the installed base of Cat 5e will not meet an extended frequency limit. The percentage of these links is an unknown.
- Larry commented he sees some of these notches, and in each particular case when they replaced the connector on the test setup the notch went away, this was the case approximately six times.
- There was a disagreement with this being a measurement issue. The Cat 6 cable has an order of magnitude better performance w.r.t. these anomalies.
- George requested the physics behind these notches. If these physics are unknown then how can the group mitigate the issue?
- One person suggested the effects of most of these notches are negligible. However Terry said we would not be able to ignore the radiation issue that appears to be an FCC issue.
- Bruce Tolley said we have to discuss the physics around the notches.
- If TIA knows about this issue, they will not write a standard that can't work.
- Brad Booth requested a 3rd party that is agreeable to other vendors in the room work with Avaya to study this notch issue.
- Chris DiMinico – This is not a mystification – it was a known issue we will deal with it during the course of developing our standard.
- From a PHY manufactures perspective it is extremely valuable to have a model (e.g. time domain data) of this notch for further work. Testing by a 3rd party will not validate or invalidate this notch, what's really needed is to narrow down where in the frequency range that this can happen.
- Terry will post the vector data.

10. Impact of Insertion Loss Notch on PAM-10 Transceiver (Scott Powell)

- Dr. Powell gave this presentation. The 10GBASE-Tstudy group has been operating with the assumption that UTP cabling is "well behaved" beyond its rated bandwidth. However, several companies have noticed degradation in the insertion loss characteristics of Cat 5e cabling beyond the rated 100MHz bandwidth. These companies have verified this observation and presented measurements of a Cat 5e cable from a major manufacturer that exhibits a large "notch" in the insertion loss. Assuming the equalizers of a PAM-10 transceiver are designed under the assumption of a "well behaved" channel, an unexpected insertion loss notch will degrade the performance. Using an FIR filter to model an insertion loss notch, Scott simulated a PAM-10 transceiver with a notch at various frequencies and depths. The simulations show that PAM-10 with baud spaced DFE adaptive (LMS) equalization is not degraded for notches outside of the Nyquist band (Fbaud/2). However, an in-band notch will seriously degrade the equalized SNR. An 8dB notch (similar to the one observed) is observed to degrade SNR by more than 6dB. A 16dB notch is observed to degrade SNR by more than 12dB.
- Scott took measurements of the "notch" cable from the previous presentation to make sure it is not a measurement issue. They heard from other PHY vendors that this exists.
- Scott wanted to look at the impact of this notch on PHYs. He saw the same notch around 550MHz and folded the data back into his models of a PAM transceiver.

He varied the frequency and size of the notch in and out of band. If the notch is in-band (Nyquist frequency) it caused significant SNR degradation. If the notch is out of band by 15-20% it did not have any effect on the transceiver. An 8dB notch close to being in-band caused significant issues.

- This is all time domain simulation. Some implementations may be able to tolerate this notch. It's very algorithmic dependent.
- The key here is the groups' ability to sort out where (frequency) these notches will occur. DSP's have an ability to deal with these notches, but we'll need to know where they occur.
- This has been looked at from a receiver point of view only.

11. Feasibility Study on High Speed Transmission over UTP Cables (Scott Powell)

- Dr. Powell started out by saying several presentations have shown that there is less than 10Gbps capacity on nominal 100m Cat 5e and Cat 6 channels; alien crosstalk presenting a fundamental limit. Since not all Cat 5e or Cat 6 cables are "worst case", a multi-rate PHY could determine the maximum supportable rate up to 10Gbps and establish link at that rate. A multi-rate approach can offer higher speed operation (2.5Gbps - 10Gbps) over the existing install base while permitting 10Gbps operation over new cabling. This presentation presents capacity analysis, MMSE analysis, and simulation results that all demonstrate the technical feasibility of 2.5Gbps over the worst-case Cat 5e 100m channel and 5Gbps over the worst-case Cat 6e channel (Cat 6e = Cat 6 with specified ANEXT). In both cases, the solutions stay within the rated bandwidth of the cable so that 2.5G/5G minimum operation can be guaranteed.
- The results here have been verified with five different PHY vendors, they are Broadcom, Cicada, Marvell, Mysticom, and Vativ.
- Channel capacity is directly proportional to Shannon Capacity, this tops out at 9G for a two-connector Cat 5e channel. Moving to Cat 6 things improve a bit but not greatly and capacity is still below the magical 10G number. The fundamental limit is Alien crosstalk. A new cable is needed for this issue.
- A new UTP cable could be developed or use of shielded cabling or shorter links. Some other options are a PHY that can operate over 10G for some media and has the ability to back off for some media.
- Simulations indicate 2.5G transmissions are feasible for Cat5e, 5G for Cat 6 with some amount of alien crosstalk mitigation.
- Three feasibility techniques are used to verify the design will work:
    - Shannon capacity
    - Minimum MSE
    - Time domain simulation
- 2.5G operation:
    - The MMSE analysis shows 27.7dB for 2.5G operations over w/c 100m Cat 5e.
    - The time domain analysis for 2.5G operations also shows positive results.
    - The Shannon capacity for 2.5G is around 3.9G so that passes the test as well.
- 5.0G operation:

    - The MMSE analysis shows 28.9dB for 5G operations over w/c 100m Cat 6. The BER used was 10EE-11. A 3dB of design margin.
    - The time domain analysis for 5G operations also shows positive results.
    - The Shannon capacity for 5G is around 9.4G so that passes the test as well.
- In summary 10G on Cat5e and Cat6 is not feasible on the installed base. The rate of 2.5G will work for 100m of Cat 5e and 5G for 100m links using Cat 6 with specified ANEXT.
- The cabling AdHoc data has better capacity numbers.
- The MMSE and time domain analysis are both based on measurements.
- Brad Booth – is this work based on a four-connector 100meter channel, answer yes. Relative to 2.5G have you given any thought to the market acceptance in the 2006 timeframe.
- The 2.5G operations only has 2dB of design margin. So a new code may be needed.
- Given 5 PHY vendors backing this data, has anyone considered cranking up the clock on a 1G PHY – laughter?
- Rate adapting is a scheme they've considered. It was not discussed here just yet. If multi-rate PHY happens then we'd come back to this.
- This approach is geared towards a cable based solution. Knowing what cable you have or using auto-negotiation the highest data rate would be zeroed in on.
- The point of this presentation is to know what is achievable for the currently installed base as specified by ISO 11801.
- The pie charts in this pitch assume that Alien crosstalk are reduced by 12dB.

12. Multi Rate PHY (Nariman Yousefi)

- Mr. Yousefi gave this presentation. The presentation has support from 16 companies and 22 individuals, they are:
    - Dave Koenen - HP servers
    - Dan Dove - HP Networking
    - Steven Hunter – IBM (x-Series Servers)
    - Rich Hernandez - Dell servers
    - Kevin Ketller - Dell
    - Rich Graham - Enterasys
    - Terry Cobb - Avaya
    - Richard Mei - Avaya
    - Luc Andriaenssens - Avaya
    - Nariman Yousefi - Broadcom
    - Scott Powell - Broadcom
    - Xiaopeng Chen - Marvell
    - Sreen Raghavan - Vativ
    - PJ Sallaway - Vativ
    - Vivek Telang - Cicada
    - Sterling Vaden - Superior Modular
    - Rob Wessel - CommScope
    - Eric Ellwanger

- Bob Jensen - Fluke Networks
- Joe Dupuis - Ortronics
- Bernie Hammond - Krone
- Ed Pivonka- Ideal Industries

- The estimated WW installed base for YE05 was presented. Mr. Flatman originally presented these numbers earlier this year.
  - 925 million outlets by YE05
    - 138M Cat5
    - 462M Cat5e
    - 314M Cat6
    - 4M Cat7

      Note: The Cat 5/5e/6 installed base can't be ignored.
  - Nariman projected which media data rates (2.5G, 5G, and 10G) will work for each cabling type, see page 3.
- Use a multi rate PHY to accommodate the various installed cabling, in other words negotiate the speed to the highest capable for the channel or media type.
- A transceiver has methods (e.g. signal integrity analysis) that it can use to determine how good the channel is.
- An enhanced auto negotiation is used to zero in on the highest speed. On some links you may not want the speed to change, perhaps for a link that's part of a trunked link group. The least common denominator for this multi-rate PHY is 2.5G running over Cat 5e cabling or better.
- The market identified for the various speeds are:
  - 2.5/5 desktop workstations (horizontal – highest volume 80+%)
  - 2.5/5/10 servers (medium volume 10%)
  - 5/10 switch to switch (data center – low volumes 1-2%)

    NOTE: These percentage estimates are annual shipments of higher speed copper solutions for Ethernet.
- The claim is that all users benefit from multi-rate PHY. It maximizes the use of higher speed copper technology. More technology vendors competing for a large market sounds like a good thing.
- There is negligible difference incremental cost to add 2.5/5 to a 10G PHY.
- The presenter addressed the 5 Criteria with this presentation.
- In conclusion, this is a PHY for data rates higher than 1G. That this expands the broad market potential by supporting an adaptable speed.
- The proposal was the inclusion of lower rate speeds (XGBase-T operates at $1 < X <= 10$)
  - A minimum of 2.5 Gb/s over an ISO Class D or better 100 meter channel and with an alien crosstalk requirement to be specified.
  - A minimum of 5.0 Gb/s over an ISO Class E or better 100 meter channel and with an alien crosstalk requirement to be specified.
  - For greater than 5.0 Gb/s to operate over a distance and media type suitable for the rate.
- Brad Booth – This presentation confirmed that a PHY, which ONLY supports 2.5G, is a valid PHY to bring to the market. That this PHY does not need to support 5G and 10G speeds as well. Brad is concerned that this approach allows a

2.5GBASE-T only PHY. This opens up the issue of three PHYs as opposed to one.

- Shimon has reservations w.r.t. this proposal. Looking at chart 3 the 900+M links the 64 thousand dollar question is how many need 10G. Then when that question is answered how many of those would want a lower cost 2.5G or 5G as opposed to a 10G copper solution. In the past the same argument could have been valid but it wasn't. Meaning when going from 100M to 1000M we could have gone to 200M much easier. It will take a few years for this market to kick in so lets get it right and not micro-optimize this for step changes from 1G to 10G, just go straight to 10G. Response was that at 100m lengths Cat 5e and Cat 6 couldn't support 10G. So if a fixed length of 100m is required we're up against a brick wall. When we do network architecture we can allow a link to settle in on the speed for that link. This must be predetermined. The response was that if 10G is really required here then use the more expensive 10G PHY for that application and be sure the proper cabling is in place. This multi-rate PHY operation will impact the MAC, and cause hits to 3 or 4 clause (4, 45, 30, others), this is more work for the 10GBASE-Tcommittee. None of today's existing silicon designs support this multi-rate PHY, primarily because of the hits to the MAC logic**.** The 10G MACs were developed 2 years ago; we need to leverage that MAC silicon.
- Scott Simon – support for 2.5G is approximately 1.5X that of 1G. Going to 10G will be a lot greater. If I know my wires only support 2.5G why would I want to purchase a multi-rate PHY that includes the 10G operational rate? The core discussion needs to be what can the channel do.
- Based on the statistics for 2.5G are the PHY vendors more interested in jumping into this market and produce products if 2.5G is allowed? Yes. The proposal is to add 2.5 and 5G to the objectives.
- Lawrence Berkley Labs – how will two 2.5G links compete with one 5G? He will not spend the money on a multi-rate PHY and prefers to spend the bucks on the 10G PHY and the better cabling if he has to for the specific applications where it is needed.
- Terry – the more inclusive a standard is the better off we are.
- George – the targets for slower speeds stopped prematurely, could have gotten higher speed. He's in favor of running at higher speeds for some percentage of existing cabling.
- The goal should always be to guarantee a data rate for a specified channel.
- Chris – the focus for the group prior to this presentation has been focused on developing a 10G solution. This proposal adds additional complexity to a task that is already complex enough. Lets defer back to 10G where the group is focused. The response is that the 5 PHY vendors on this proposal do not think this 10G rate will operate on the installed base. History says we are allowed to use distance lengths to address data rates, after all look at the various optical distance options we have standards for.
- Why stop with 3 data rate? Answer is that they perceive them as the limiting data rates for the cabling technologies that are out there.
- Bruce Tolley – He's not quite sure there are people in IEEE that are willing to take on the added standards work beyond PHY modifications that will be required

for the multi-rate PHY proposal. Bruce also thinks this is out of order, should stay focused on 10G.

- Mr. Youseif's summary highlights are:
  - Multi rate PHY supports speeds of 2.5Gbps, 5Gbps and 10Gbps.
    - 2.5Gbps is the highest speed achievable on ISO specified 100m Cat5e.
    - 5Gbps is the highest speed that supports 100m Cat6.
    - 10G should be considered for 100m Cat7 or short reach Cat6.
  - Multi Rate PHY provides speed upgrade for all installed base of 100m Cat5e, Cat6 and Cat7.
  - Multi rate PHY enables users to have flexibility in choosing media appropriate for application.
  - Implementation of 2.5Gbps and 5Gbps rate is essentially free as part of 10GBASE-T PHY
  - An auto-sensing scheme is developed in Multi rate PHY to determine cable capability and select the maximum speed that cable can support.
  - Servers and desktops will benefit the most since they are typically connected with UTP cables with structured wiring.

13. Analog Front Ends for Ethernet on Copper (Richard Spencer)

- Dr. Spencer (University of California) discussed the potential benefits of including some equalization or echo cancellation in the analog front end (AFE) of a 10GBASE-TEthernet receiver. Richard gave a brief overview of the work that his group has done on 1000Base-T receiver front ends and discussed their conclusion that putting some of the equalization in the AFE makes good sense in terms of reducing the overall complexity and power consumption of the receiver. For 10GBase-T, the AFE may be even more critical since it may not be possible to build a receiver in the near future without including greater functionality in the AFE.
- High speed Ethernet over UTP requires very complex digital signal processing but the solution also requires an analog front end. A more complex AFE may be beneficial from an echo cancellation point of view and equalization. This complex front end can lower the over all solution cost and more importantly lower the reduction in power. The penalty is that analog solutions don't port that well to new process silicon, i.e. lower that 0.18u.
- Echo cancellation can be in the AFE or the DSP.
- The state of the art high-speed CMOS ADCs were reviewed.
- The 1000Base-T solutions were reviewed. 4 @ 250MHz with each of the 4 channels using their own AFE.
- A mostly digital solution will severely tax state of the art ADC capabilities. May want to include some echo cancellation and/or NEXT cancellation in addition to equalization.
- One promising filter topology for 10GE might be a continuous time analog FIR filter.
- There are some options for the AFE that should be considered.
- Was the AFE you built for the disk drives ever shipped? Answer No.

- Some practical circuit design issues prevent you from applying some of these techniques on the transmitter side of the channel.

14. Interleaved Trellis Coded Modulation & Decoding (Yongru Gu and Keshab Parhi)

- Mr. Gu presented the material. It is highly likely that 10GBASE-Twill employ PAM-10 modulation and a 4D 8-state trellis code. The trellis code can be used in a traditional way as in 1000BASE-T, where four wire pairs share a trellis encoder and the resulting 4 1D symbols of each iteration are transmitted over the four pairs with one dimension per pair. To meet the throughput requirement, the corresponding joint equalizer and decoder (JED) need to operate at 833 MHz. However, there is a long feedback loop in the JED since the currently decoded 4D symbol is needed for next iteration in order to compute ISI. Due to the long loop critical path, it is hard for the JED to achieve the required decoding speed of 833MHz. To solve this problem, an interleaved trellis coded modulation approach is proposed where each wire pair has its own encoder, and the encoding for different wire pairs is independent. The decoding for different pairs is also independent. Thus four parallel JEDs can be used with one JED per pair. The required decoding speed for each JED is only 208MHz but 3 more JEDs are needed. To reduce the hardware overhead, an interleaved JED can be used where the computations of the four parallel JEDs are time-multiplexed to a single JED, and each delay in the JED is replaced by four delays. The silicon area comes down by a factor of 4 compared with the parallel structure. The critical path can be reduced by a factor of 4 after path balancing by retiming. The clock speed can be increased by factor 4 to 833 MHz in order to maintain a throughput of 10Gbps. Compared with traditional non-interleaved JED, the critical path of the interleaved JED is reduced by a factor 4. It makes the JED design easier.
- The historical (traditional) trellis encoder block diagram was shown. Driving this 4D Trellis Encoder with 12-bits at 833MHz (1.2ns). Some difficulties with clocking were raised, called Long Loop Critical Path. An interleaved decoder with low hardware overhead (meaning 1 decoder instead of 4) would require an even higher speed clock 4x 833MHz. Yongru ended with a suggestion that the interleaved trellis coded modulation by temporal interleaving be used.

15. 10GBASE-TLine Signaling (Joseph Babanezhad)

- Dr. Babanezhad presented this material. Joseph's presentation is a continuation of the ones given in Dallas and Portsmouth NH. Up to page 6 of 9 these charts are basically a repeat of what Joseph has shown before. In the past Joseph has shown that there can be two approaches for implementing the PHY; a DSP approach, that would require an AFE such as the one shown here, and analog approach that briefly was shown in the Vancouver & Portsmouth meetings. So this AFE is more suitable for DSP implementation. For the analysis that follow Joseph did not discuss the required accuracy of the ADC since it was done at the Vancouver meeting. The following linearity analysis therefore only applies to the seven analog blocks that precede the ADC; starting from DAC and ending with PGA.

- The 0m analysis is more of a loop-back test for the AFE itself. The input signal in this case is large. In order to maintain the maximum signal level PGA's gain is selected such that the signal at the ADC input is 2Vp peak-to-peak. Under this condition the worst-case error happens at +/-(Vp/sqrt(3))*sqrt(1+9*alpha*Vp^2). If the resulting error is more than the amount given on pg.4 then there shall be missing states at the output of the slicer. For this error corresponding alpha is given by the formula (pg.4). It shows that higher the PAM levels (M) and higher the peak voltage Vp will need to have smaller non-linearity. In fact alpha has inverse squared dependency on Vp.
- The maximum amount of non-linearity (alpha) that can be tolerated by 3 line signals 2Vpp PAM5, 3.134Vpp PAM10 and 2Vpp PAM10 is given in a table on page 6.
- The analysis so far has not included AAF frequency response. To that end Joseph has assumed a critically damped 2nd order AAF for both PAM5 and PAM10. Their f-3dB are 625 & 416.66 MHz respectively while the amount of overshoot is around 3.9% not causing any error as a result.
- Joseph wrote a MATLAB program by including all the block's non-linearity and AAF's frequency response. The BER for every case is plotted in this graph for three line codes. The knee of these three curves gives the maximum amount of non-linearity. In fact by switching the scale from linear to log and considering where the three curves cross BER=1e-3 he can calculate the critical non-linearities. These numbers are very close to the ones given in the table two slides ago. The results of approximate hand analysis, HSPICE and BER run in MATLAB all in agreement. The results show that PAM5 has the highest tolerance for the non-linearity in the AFE.

16. 10GBASE-TCabling Baseline Proposal (Chris DiMinico, Bill Jones, Michael Bennett, and Bruce Tolley)

- Mr. DiMinico opened with a brief discussion of the framework of 10GBASE-T consensus proposal focused on developing PHY objectives. The consensus position is based on agreement by the proponents to develop specifications to:
  - maximize 10GBASE-Tcoverage for Class D and Class E cabling (installed cabling).
  - establish 100% coverage for new installations.
- Bruce Tolley, William Jones, and Mike Bennett each delivered a portion of the presentation, which covered market considerations (Tolley), technical feasibility (Jones), and end-user concerns (Bennett). Fifteen (15) individuals signed-off on their support of the proposal, they are:
  - Bruce Tolley - Cisco Systems
  - Shimon Muller - Sun Microsystems
  - Wael Diab - Cisco Systems
  - Michael Laudon - Force 10 Networks
  - Joel Goergen - Force 10 Networks
  - Rick Rabinovich - Spirient
  - Randy Below - Siemon Company
  - Ron Nordin - Panduit Corporation

    - Chris DiMinico - MC Communications
    - Shadi AbuGhazaleh - Hubbell
    - Paul Kish - Nordx/CDT
    - George Zimmerman - SolarFlare
    - Joseph N. Babanezhad - Plato Labs, Inc.
    - Bijit Halder - Telicos Corporation
    - Mike Bennett - Lawrence Berkeley National Laboratory
- The led in on this discussion is that this is a 10G effort. There is an extensive list of supports on this baseline proposal from system vendors and users, see above. Fundamentally the goal is to get some percentage over the installed base of Class D and E and 100% coverage for a newly specified cabling standard.
- The history of 1000Base-T was discussed. Here again the same thing happened, they looked at the installed cabling plant and got some coverage then went off and worked with the cabling industry to come up with a foolproof way of getting 100% coverage with a new channel specification.
- A lot of worse case analysis has gone into this presentation, measurements, impairments, connectors, distance and alien NEXT.
- The target distances are 100m. However when looking at the installed base, using cabling manufacture's data (e.g. Hubbel data) they see that 85% of links are 70 meters or less. Other data shows 96% at 80 meters, 97% at 75 meters.
- The building considerations are the main drivers here w.r.t. link lengths.
- A distribution of connectivity was discussed; different topologies can be used such as 2, 3, and 4 connector solutions for the various channel implementations.
- These real life installed base characterizations (data) are factored into the simulations that go into determining the link distance that can be supported. Things like backgroup noise, RL-NEXT-FEX-TX cancellation.
- Starting on page 13 the capacity verses 10GBASE-Tcabling topology was shown. Some additional cases include other impairments such as ANEXT. The capacity is good for 75 and 50 meter cases. The purpose is we need to define the minimum requirements for the installed base.
- Alien Crosstalk can be mitigate with some simple cabling practices, such as removing tie wraps, patch panel separation, limiting use of tightly bundled cables to lower speed copper transmissions. Another accepted practice is special patch cords, e.g. patch cord lengths.
- Michael (LBN Labs) – took the floor to discuss mitigation techniques. It just needs to be simple. If the unbundling solution is not possible he's willing to do new cabling trays. If there is no way to verify the circuit he will install new cabling. He is confident that new test gear will come to market by the time he gets to mass deployment.
- The perspective from another end-user was she would just go with the new cable that can be distinguished from the other cabling.
- At Berkley the cables are not tightly bundled, they have fully understood this issue in the past. He does not buy the idea that 'only' new cables are the choice we should make. Allowing some portion of the installed base to participate makes sense.

- There was a suggestion that CX4 be used for 15-meters and use optics for over 15-meters. The cost of 10G and having to deal with the various mitigation techniques will not be accepted very well.
- At 50-meters these mitigation techniques are not needed. Remember Mr. Flatman's presentation above, this 50meter length covers more than 95% of the data center link lengths.
- There was a suggestion that the practicality of doing Alien NEXT testing in the field is a big concern. The procedure seems complex; consider the idea of taking down service in the disturber cables while the tests are run, etc. Who has the liability when it doesn't work, is it the cabling manufacture, the system provider, the PHY vendor?
- While it is true that in the past these mitigation techniques were resolved and developed the main concern is the Alien NEXT field measurements. TR-42 has agreed to take on the measurement issues as well. These Alien NEXT measurements are not a concern for shorter links, e.g. 50meters.
- Shimon – agrees this is a chicken and egg problem. Not all customers and data centers have been created equally. The point is there are some things that can be done. At the end of the day when this standard is done we'll have some rules. The customer will be given some guiding principles on how to make choices that ultimately lead to 10G operating in their environments. Michael says this range of choices that's been discussed are all reasonable.
- Scott – question some of the capacity numbers. Are scaled to limit lines used? The measured data was scaled to the distances used. The Alien Cross Talk was not changed over the lengths used. Some more analysis on insertion loss is needed and will be done.
- The purpose of Study Groups is to define goals for projects. In terms of time 1000Base-T was in SG in 1996. Here in 2003 we need to get out of SG and move on with developing the standard. Cheaper 10G solutions are needed ASAP. Bruce is happy with some percentage of installed base at 100m, will be happy with 80+ percent for example. Must have 100% on a new cabling channel spec that's worked out with TIA, etc. Some technical feasibility goals must be developed and more importantly agreed upon very soon.
- Luke – why is 2 vs 4-connector capacity different, what were the assumptions there? The assumptions are on page 12 of the pitch. This model sums up the impairments. The return loss was not scaled as a function of length. The reason why 2 vs 4 connectors was used and to distinguish between them is because we're in design mode to see and characterize what will work. The only thing that wasn't scaled was insertion loss.

17. PAR & 5 Criteria (Group)

- Shortly after lunch the 10GBASE-T SG began the process of getting into modifications to the 5 Criteria. Terry from Avaya was under the impression that non 10G PHYs are allowed in this 5 Criteria. The chair mentioned this SG was tasked with creating a 10G PHY, not a multi-rate PHY. Getting into other speeds is not within the scope of this SG, the SEC does not allow this deviation. The chair said another Call for Interest is OK for other speeds. We need a PAR and 5

Criteria by November; otherwise it will be very difficult to extend this SG beyond Nov 03. The minimum requirement is not there to met the 100m on all classes of cables. If we can met 100m on Class F at 10G then we are done and don't have to do anymore. The objectives could be broadened to allow solutions other than new high BW cabling. One person felt that SG could be extended indefinitely. This may be allowed but it will more than likely not be looked upon favorably by 802.3. Getting 802.3 to change this will more than likely require another Call for Interest. Also along these lines the output from this group needs to be one PHY, not multiple PHYs. The odds of getting another extension for this SG without a PAR and 5 Criteria are slim to none.

Bert took on the Broad Market Potential re-writes.
George took on the Economic Feasibility re-writes.
Shadi took on the Technical Feasibility re-writes.

********** Thursday Meeting **********

- Mr. Warren, the 10GBASE-Tsecretary – took the group thru the logistics necessary to transition from a SG to a TF. There's the material Jeff presented.

  <u>This July Plenary Meeting:</u>
  - Thursday Morning
    - Come to terms on acceptable text for the PAR, 5 Criteria, and Objectives.
  - Thursday Afternoon
    - The 10GBASE-T SG shall present the PAR, 5 Criteria, and the Objectives to the 802.3 WG.
    - The 10GBASE-T SG chair shall make the following motion:
      - Request permission from 802.3 for the 10GBASE-T Study Group to pre-submit their PAR,5 Criteria, and Objectives to the SEC 40-days prior to the November 2003 IEEE 802 plenary meeting
      - 802.3 to request that the SEC give permission to the 10GBASE-TStudy Group to pre-submit their PAR to NesCom 50-days prior to the Dec03 standards board meeting.

  <u>September 10GBASE-TSG Interim Meeting:</u>
  - Last chance for the 10GBASE-TStudy Group to make minor modifications to the PAR, 5 Criteria, and Objectives.
  - If changes are made this is the version that shall be sent to both:
    - NesCom 50-days prior to their December 2003 meeting
    - SEC & 802.3 40-days prior to the November 2003 Plenary h
  - Immediately after the September Interim send:
    - PAR to NesCom
    - PAR, 5 Criteria to SEC
    - PAR, 5 Criteria, and Objectives to 802.3

November IEEE Plenary Meeting:

- This should be the last 10GBASE-T Study Group meeting.
- The 10GBASE-T SG responds to any 802 WG
- 802.3 affirms the potentially revised PAR, 5 Criteria, and Objectives during the 802.3 WG closing plenary.
- The 802.3 Chair will request approval of the PAR & 5 Criteria during the Friday closing SEC meeting:
  - PAR to NesCom shall remain as is, otherwise substitute if modified
  - Revised PAR and 5 Criteria, to the SEC
- NOTE: 802.3 has the ability to remove the previously submitted:
  - PAR from the Standards Board meeting.
  - PAR and 5 Criteria from the SEC closing meeting.
- Request a final 10GBASE-TSG extension to mitigate any delay by the Standards Board

December Standards Board Meeting:

- Hopefully the 10GBASE-T PAR is approved.

January 2004 Interim Meeting:

- The 1st 10GBASE-T Task Force meeting is held

18. TR42 & ISO Liaison Letter (Group)

- Mr. DiMinico reported on the TIA Liaison response his Ad Hoc developed on Wednesday. This Ad Hoc agreed to send the letter that Chris reviewed with the 10GBASE-TSG. The letter described the challenges of running 10G over Class D & E cabling and that multiple approaches are being used to mitigate the challenges. At this point we don't want to presume that this body is writing cabling specifications.

- Mr. Cobb opposed this letter. Terry and others objected to specific numbers in the response (requirements) the SG should not be doing design work at this time. Terry asked for the alien crosstalk equation to be removed. Alan who participated in crafting this letter explained that a lot of thought went into this letter and he suggested the Alien NEXT numbers in this response letter to get the process of an active dialogue going with TIA. The Alien next value in the letter is a baseline (guideline) simple to get the effect underway. George felt that it's far to premature for the SG giving out specific numbers at this time. Bruce felt that if people cared about the wording of this letter they should have participated in the Ad Hoc. The Alien numbers in the letter are assuming an improved insertion loss for Cat 6 that does not exist. However this cabling Ad Hoc was set up to deal with these issues of resolving channel specification design goals, etc. and if there are cabling experts that are not participating in the Ad Hoc they should come join the team and work the issues there, not after the Ad Hoc creates a formal response on behalf of the overall SG team. Hubble felt that cabling vendors will look at the numbers as a specification. Bob Grow asked that the letter be modified to indicate that this group is not an official project just yet and to reword, for example "if a

standards development project is approved it is possible we would request". Note the liaison relationship is not between the SG and TIA, it's between 802.3 and TIA. The letter was additionally enhanced with an amendment "Several proposals are currently being considered to achieve the desired ratio of insertion loss to alien crosstalk".

- **Motion on SG Ad Hoc TIA Liaison Letter:** Adopt the letter developed by the SG Ad Hoc was tabled.

- **Motion on SG Ah Hoc TIA Liaison Letter:** Amendment - Several proposals are currently being considered to achieve the desired ratio of insertion loss to alien cross-talk failed by one vote.

- The next topic was another liaison letter response to ISO/IEC JTC 1/SC 25/WG 3. This letter will be uploaded later today.

- **Motion on ISO Liaison Letter:** Accept the ISO liaison letter passed.

- Now the group went through the PAR & 5 Criteria. The text below was the final version the 10GBASE-T Study Group settled in on for submission to 802.3 WG.

19. Motion Madness (Group)

- **Motion on Broad Market Potential:** Accept Broad Market Potential Criteria passed.

- Discussion: Geoff spoke against this motion because he feels the text as written on addresses the server market. Kevin from Broadcom felt the text was somewhat altered from what was presented to the Ad Hoc yesterday. Geoff felt the wording around the number of companies participating is not speaking directly to the point that's important, such as how many people are going to actively participate in the draft of this standard.

- **Motion on Broad Market Potential:** Delete 10 gigabit speed from final paragraph failed.

- Discussion: The slower speed PHY will not work with any of the 10G MAC's out there in the industry. The removal of 10G is too large of a change to the 10Gbase-T's charter.

- **Motion on Broad Market Potential:** Add existing to the final sentence of paragraph failed.

- Discussion: The 802.3 objected strongly that the SG is not where we modify the objectives of the project. The movers of this motion felt that the new text is needed to broaden the market potential. Muller felt that just like the evolution of

1000Base-T this will follow the same track and will have a large market potential when this standard closes in a few years and the technology solution costs are lower. George felt that the next level of speed is required for aggregation of lower speeds, etc. he is in favor of leaving the text as is. Pat Thaler felt the text should remain as is. This SG has no business making this modification because it is in violation of the objectives that formed the SG. Pat's comments were consistent with an end-user's comments stated earlier this week, such as if I need new cabling for this to work in my environment then I'll install that cabling. Chris felt that the added text is not necessary, the lack of "existing" implies both existing and non-existing.

1. Broad Market Potential
   - Broad set of applications
   - Multiple vendors, multiple users
   - Balanced cost, LAN vs. attached stations

Current trends suggest the steady migration of LAN speeds from 100 Mb/s 100BASETX) today toward 1000 Mb/s (1000BASE-T). In particular, as the density of computer devices (servers, switches, routers and storage modules) located in data centers and enterprise networks increases, so will the demand for higher speeds at data aggregation points. Additionally, there is an increasing demand for high performance servers to support bandwidth intensive applications such as CAD/CAM, digital animation, storage and cluster computing. Clearly there is a need for a low cost 10Gb/s solution that will utilize twisted pair copper infrastructure.

Interest in 10GBASE-Thas been demonstrated by the attendance of more than 69 vendor and user representatives at technical meetings at the November 2002 Plenary, attendance at subsequent Interim meetings, and by participation in an email forum devoted to facilitating technical development in this area. 34 companies have indicated they will participate in the technical development of a standard for 10GBASE-T. This level of commitment indicates that the standard will be supported by multiple vendors, and that there will be a wide variety of equipment available to support 10-gigabit speed applications on twisted pair copper links.

- **Motion on Compatibility with IEEE standards:** Accept the Compatibility with IEEE Standards Criteria passed.

- Discussion: The functional requirements document doesn't exist anymore. Nariman felt that approving this as written will remove the possibility of multi-rate PHY.

- **Motion on Compatibility with IEEE standards:** Motion to postpone until after the objectives and technical feasibility are dealt with failed.

2. Compatibility with IEEE Standard 802.3
   - Conformance with CSMA/CD MAC, PLS
   - Conformance with 802.2
   - Conformance with 802 FR

The proposed standard will conform to the full-duplex operating mode of the 802.3ae
MAC.

In a manner similar to the 100BASE-TX and 1000BASE-T standards, a new Physical
Layer (PHY) will be defined for operation at 10Gb/s over structured copper cabling.

The Management Information Base (MIB) for 10GBASE-T will maintain compatibility with the current 802.3 MIB, allowing a consistent management model at all operating speeds.

Conformance with 802.2 is provided by the overlying 802.3ae MAC sub-layer.

The proposed standard will conform to the 802 Functional Requirements Document, with the possible exception of the Hamming distance.

The proposed standard will not support the OAM unidirectional mode specified in P802.3ah. The proposed standard will support co-existence with 802.3af.

- **Motion on Distinct Identity:** Accept the Distinct Identity Criteria passed.

3. Distinct Identity
   - Substantially different from other 802.3 specs/solutions
   - Unique solution for problem
   - Easy for document reader to select relevant spec

The proposed standard is a 10Gb/s upgrade for 802.3 users based on the 802.3
CSMA/CD MAC.

It is the only standard that will use horizontal structured twisted pair cabling as defined in ISO/IEC 11801, offering upgrade paths to 10Gb/s for present Ethernet users connected with copper.

The proposed standard will be formatted as a new clause to the 802.3 standard.

- **Motion on Technical Feasibility:** Accept the Technical Feasibility Criteria passed.

- Discussion: Nariman argued that technical feasibility has not been shown. Bob Grow our 802.3 WG chair gave his impression on what technical feasibility means at this point in time, meaning the study group phase, and that is it's Subjective. The point in time for exhaustive proof is when the yet to be formed 10GBASE-TTask Force says this technology is ready for working group balloting. The point is there is time to formulate definitive technical feasibility. Those that have been in the Ethernet committee for some time may remember the issues around DMD (launching laser light on multimode fibers) were territory that was not fully investigated at the time the TF formed. Alan clearly stated Class F support is solid with a very comfortable margin. The modeling Ad Hoc chair said the capacity model was agreed upon. Joseph Plato Labs felt that 2.5G and 5G technical feasibility has been shown. Val made a hostile amendment. Pat made a procedural point about all the technical criteria being approved, Pat says that time is November.

4. Technical Feasibility
   - Demonstrated Feasibility
   - Proven Technology
   - Confidence in Reliability

Presentations made to the 10GBASE-T Study Group illustrate the technical feasibility of 10Gb/s signaling using structured twisted pair cabling as defined by ISO/IEC 11801. These presentations covered all aspects of feasibility including simulation and theoretical analysis based on proven technology of 1000BASE-T, known cabling technology, and state of the art process technology; and demonstrated that there is sufficient channel capacity for the transmission of 10Gb/s.

The study group acknowledges that 10Gb/s operation is achievable on Class D and Class E cabling and augmentation of their specifications is required to higher frequencies for performance parameters such as insertion loss and the addition of alien cross-talk characterization. The study group also agrees that the 10Gb/s operation is achievable on Class F cabling. The channel models are supported by the measurement of the properties of cables and network hardware in both laboratory and field installations.

The technology to be utilized in the realization of the 10GBASE-T PHY will rely heavily on previous 802.3 standards; 100BASE-TX and 1000BASE-T. It is recognized that the relevant technologies have greatly advanced at every level since the inception of work on the 1000BASE-T standard approximately six years ago.

This study group has received contributions from PHY, system and cabling vendors; end users; and industry/academic experts.

- **Motion on Economic Feasibility:** Accept the Economic Feasibility Criteria passed.

- Discussion: Geoff suggested some minor text change – it was accepted.

5. Economic Feasibility
   - Cost factors known, reliable data
   - Reasonable cost for performance expected
   - Total installation costs considered

The implementation of a single 10GBASE-T PHY device is estimated to require an approximate complexity level of 1.5 times the currently available quad 1000BASE-T chip. The experience curve of the semiconductor industry ensures the future reduction of the size, and hence the cost, of implementation. In production, the 10GBASE-TPHY device is projected to meet the 3x cost versus 10x performance guidelines applied to previous advanced Ethernet standards.

The widespread use and low cost of installation of structured twisted pair cabling systems supports economic feasibility with regards to total cost of installation.

The PAR as amended was reviewed and uploaded to the IEEE web site.

- **Motion on PAR:** Accept the PAR as amended at this meeting passed.

- **Motion on ISO Liaison Letter:** Request 802.3 Chair to submit the ISO liaison letter to the corresponding standards bodies passed.

- **Motion on moving the PAR and 5 Criteria Forward:** Motion to approve the PAR and 5 Criteria as written and to request the 802.3 chair to forward same to the LMSC Executive Committee and NESCOM for consideration in December, with the understanding that if Executive Committee and 802.3 approval is not received, the PAR will be removed from the NESCOM agenda passed.

- **Motion to request an extension:** Motion to request an extension for the 10GBASE-T study group from the SEC passed.

Meeting adjourned at 12:38pm on Thursday July 24th, 2003.