IEEE P802.3an 10GBASE-T Minutes

Study Group Plenary Meeting
January 14th and 15th, 2004
Vancouver, BC. Canada

Prepared by:
Jeff Warren
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Independent Consultant

Administrative

The 10GBASE-T meeting convened at 9:00 am on January 14th, 2004. Mr. Booth (Brad), the 10GBASE-T study group chairman, opened the meeting with a discussion of the agenda and goals for this meeting. A motion to approve the agenda by Alan Flatman & Luc Adriaenssens passed by acclamation. After a round of introductions Brad reviewed all the administrative items such as e-mail reflectors, membership, voting procedures, future meeting locations, call for patents and sign-in rules. Attendance at this meeting peaked at approximately 75 people; of those only one participant was new to the IEEE 802.3 10GBASE-T Study Group. A motion by Paul Vanderlaan and Richard Mei to accept the minutes from the November 2004 interim meeting passed by acclimation.

The hot ticket items for this meeting were to hear a couple of potential baseline technical proposals (link segment model and auto-negotiation) that could be agreed upon as representative baseline material for our initial 10GBASE-T draft. Two other items were to deal with a request for a new objective, i.e. Cat 5e support plus a review from our editor-in-chief on his views of what the 10GBASE-T standard will look like.

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 32 % complete; 14 of 43 months have passed.

Motion to adjourn by Tom Dineen at 6:16pm on Wednesday January 14th, 2004 passed by acclimation.

Important 10GBASE-T and IEEE 802.3 Links

- Agenda http://www.ieee802.org/3/10GBT/public/jan04/agenda_1_0104.pdf
- 5 Criteria http://www.ieee802.org/3/10GBT/public/nov03/5Criteria_2_1103.pdf
- PAR http://www.ieee802.org/3/10GBT/public/nov03/par_2_1103.pdf
- Objectives http://www.ieee802.org/3/10GBT/public/sep03/diminico_1_0903.pdf
- Reflector http://www.ieee802.org/3/10GBT/public/index.html
- Voting Rules www.ieee802.org/3/rules/member.html
- 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/

Goals & Accomplishments for this Meeting

The goals for this meeting were simple; to entertain technical proposals in support of developing a baseline for the initial draft, listen to our end user community w.r.t. the requirement for a Cat 5e objective and a 3rd focus item was for our editor in chief (Sanjay Kasturia) to review his proposal for the initial draft's architecture or outline.

Very little progress was made w.r.t. formulating a set of baseline draft proposals. Only two of the seven presentations given at this meeting were presentation types that could be considered baseline proposals for draft D1.0. They dealt with auto-negotiation and a link segment model. An attempt to adopt the link segment model presented by Chris Di Minico and Larry Cohen failed, that motion was tabled because:

1. Not enough time to review the proposal
2. The numbers in the presentation are contentious
3. The cabling industry has offered to do this work for us (e.g. TIA, ISO/IEC)
4. The limited amount of measured data that goes into this proposal doesn't come close to the Class E extended

Instead the motion that did pass (i.e. Motion # 2) declined the link segment model presented and shifted the focus on a future link segment specification back to ISO/IEC 11801-2002 Class E specifications extrapolated by using the formulas in that standard up to 625 MHz.

Auto-negotiation options for supporting 10GBASE-T were presented. The extensions included modifications to existing message codes (renaming of these codes) and the creation of new message codes specifically for 10GBASE-T, plus new ability and negotiation pages. While the 2nd option (i.e. new messages and pages) has the most flexibility in terms of future enhancements to auto-negotiation the process of convergence of auto-negotiation will take twice as long, in the order of 2 seconds. The decision will take time because the group needs to sort out what to negotiate besides speed and duplicity. There was an extended discussion on backwards compatibility with 10/100/1000 however no one was delusional on this and most understood the system requirement is for backwards compatibility primarily with 1000BASE-T only.

Outline for these Minutes

Future IEEE P802.3 10GBASE-T Meetings

Month	Days	Year	Meeting Type	City	State/Country
March	14th – 19th	2004	Plenary	Orlando	FL
May	TBD	2004	Interim		

Next meeting links:

- March 2004 Plenary in Orlando Florida
  http://www.ieee802.org/meeting/meeting_files/802-0304-MI-1.pdf
  Hilton Hotel at Walt Disney World

- May 2004 Interim (*a host for this meeting has not been identified yet*)

NOTE: Hosts for the 2004 May & September interims are needed. Our 802.3an TF is tasked with making these interim arrangements because we will be classified as the senior TF.

IEEE P802.3 10GBASE-T Objectives

- Preserve the 802.3/Ethernet frame format at the MAC Client service interface
- 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 operation over 4-connector structured 4-pair, twisted-pair copper cabling for all supported distances and Classes
- To not support 802.3ah (EFM) OAM unidirectional operation
- Support coexistence with 802.3af
- Support Clause 28 auto-negotiation
- Define a single 10 Gb/s PHY that would support links of:
  - At least 100 m on four-pair Class F balanced copper cabling
  - At least 55 m to 100 m on four-pair Class E balanced copper cabling
- Support a BER of 10EE-12 on all supported distances and Classes

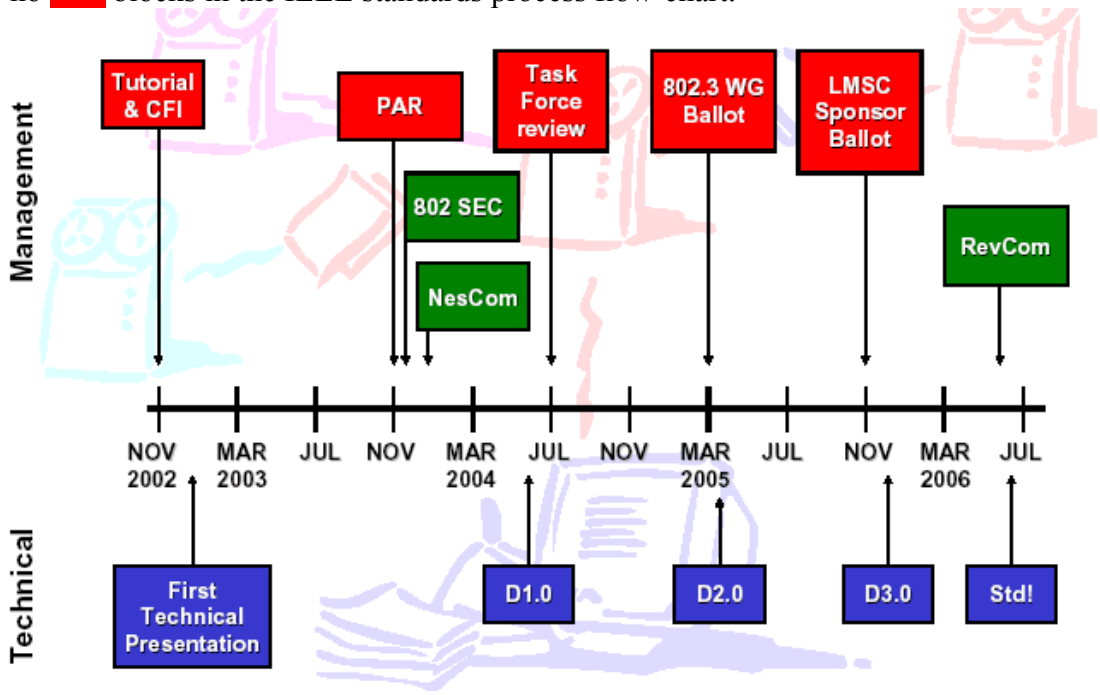
IEEE P802.3 10GBASE-T Contacts

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://www.ieee802.org/3/contacts.html this web page is maintained by David Law.

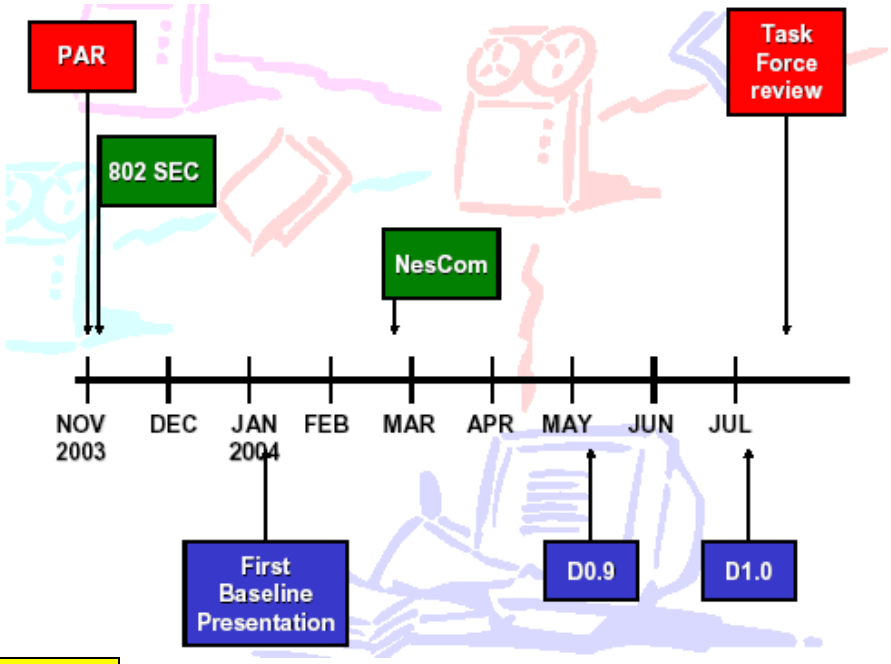
Name	802.3 & 10GBASE-T Standards Title	E-mail
Brad Booth	10GBASE-T Chairman	bradley.booth@intel.com
Jeff Warren	10GBASE-T SG Recording Secretary	IEEE@nc.rr.com
Bob Grow	802.3 Working Group Chair	Bob.Grow@Intel.com
David Law	802.3 Working Group Vice Chair	David_Law@3Com.com
Sanjay Kasturia	Task Force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

Proposed IEEE P802.3 10GBASE-T Standards Timeline

IEEE NesCom (New Standards Committee) has our PAR (Project Authorization Request) and should approve it by the end of February 2004. This means our 10GBASE-T committee is still a Study Group for this week's interim meeting although the group will perform work that is typically performed by a task force. Once NesCom approves there is no risk of termination of the project while generating and reviewing the draft standard, i.e. no blocks in the IEEE standards process flow-chart.



Detailed schedule for the next six months.



Meeting Agenda

Document	Presenter	Representing
Minutes – **You're reading them** *21-Jan-04* *600K*	Jeff Warren	Independent
Agenda and General Information ***new*** *20-Jan-04* *1386K*	Brad Booth	Intel
802.3an 10GBASE-T Document Structure *13-Jan-04* *153K*	Sanjay Kasturia	Teranetics
Auto-negotiation for 10GBASE-T *8-Jan-04* *407K*	Eric Lynskey	UNH IOL
Updates on Magnetics for 10GBase-T *8-Jan-04* *57K*	Thuyen Dinh	Pulse
10GBASE-T: The Need to Support Cat 5E ***updated*** *14-Jan-04* *258K*	Mike Bennett	Lawrence Berkeley National Lab
Shedding Some Light on Coding Gain ***updated*** *14-Jan-04* *1264K*	Scott Powell	Broadcom
Channel Code Considerations for 10GbT Signaling ***updated***	Ofir Shalvi Jose Tellado	TI Teranetics

16-Jan-04 *166K*		
10GBASE-T Link Segment Specifications and ANEXT Considerations *13-Jan-04* *346K*	Chris Di Minico Larry Cohen	MC Communications SolarFlare Communications

The group did not split up at this meeting.

Motions

Motion # 1

Description: Move that the Task Group accept the link Segment specifications of Insertion Loss, Return Loss, NEXT, PSNEXT, ELFEXT and PSELFEXT as the technical baseline link segment specifications for those parameters.
Motion Type: Technical 75% required
Moved By: Chris Di Minico
Seconded By: George Eisler
SG Voters Y: N: A:
802.3 Voters: Y: N: A:
Results: **N/A** P/F: **Tabled Motion**
Discussions: Terry felt that since the presentation was not posted a week prior he has not had time to study the equations in Chris's proposal. Scott felt that the timing was too fast, just saw it today and now you expect me to accept it right away. Other channel specs for Class E & F already exist and TIA has offered to do this work for us. A straw man channel model needs to come out of this meeting otherwise we'll have discussions in the ½ dB range of detailed parameters that are not locked down in a channel mode. The channel models must be scalable in terms of distance so that proposals that have yet to be given can be evaluated. AXTIR will not be voted on at this meeting. The chair of TR-42.7 (Paul Vanderlaan) said time is critical, and what he sees is the numbers presented today look very contentious. His recommendation is go with Cat 6 extended to 600 MHz. There was a concern that the limited amount of measured data that goes into this proposal doesn't come close to the Class E extended

Motion to Table by Luc and Koeman
Procedural 50 % required 23 Yes 18 No 7 Abstain
The motion is tabled.

Motion # 2

Description: Move to set the starting performance requirements for 10GBASE-T cabling to: ISO/IEC 11801-2002 Class E specifications extrapolated by using the formulas in this standard up to 625 MHz.
Motion Type: Technical 75% required
Moved By: Henriecus Koeman
Seconded By: Luc

SG Voters	Y: 38	N: 0	A: 14
802.3 Voters:	Y: 17	N: 0	A: 8

Results: **100 %** P/F: **Passed**
Discussions: Scott wanted to make sure Class F was included. The goal of this motion is to use this ISO reference for the channel modeling (link specification) and that this standard be used to extend usage of Class E beyond 250MHz. Chris explained that we should strive to run on un-augment Class E cabling to 55 meters.

Motion # 3

Description: Move to set the starting performance requirements for 10GBASE-T cabling to Class F to 625 MHz for insertion loss (all other parameters to remain at Class E).
Motion Type: Technical 75% required
Moved By: Luc Adriaenssens
Seconded By: Val Rybinski

SG Voters	Y: 15	N: 24	A: 13
802.3 Voters:	Y: 10	N: 13	A: 3

Results: **38 %** P/F: **Failed**
Discussions: A motion to table failed by a vote of (Yes 20, No 21). George Zimmerman expressed his concern with the mover that he just 2nd a motion prior to this one that he immediately turn around and modified with this motion. Chris felt that this is not consistent with our cabling objectives. Chris stated, if this passes we'd have to go back and change the objectives for our distance and media objectives. Alan Flatmann felt that this motion was out of character for Luc and he's very disappointed. Koeman does not support this motion. George Eisler says this motion if it passes will eliminate all existing cabling.

Attendees of the IEEE802.3 10GBASE-T January 2004 Interim Meeting

1. Adriaenssens, Luc, Avaya
2. Alexander, Jan, Nexans
3. Armijo, Bert, SolarFlare
4. Babanezhad, Joseph N., Plato Labs
5. Behtash, Saman, Independent
6. Below, Randy, The Siemon Company
7. Bennett, Mike, LBL
8. Bohbot, Michel, NORDX/CDT

9. Booth, Brad,	Intel Corporation
10. Cates, Ron,	SolarFlare
11. Chen, Michael,	Chelsio Comm.
12. Cheong, Kok-Wui,	Marvell
13. CiMinico, Chris,	MC Communications
14. Cohen, Larry,	SolarFlare
15. DeAndrea, John,	Iterra communications
16. Dinh, Thuyen,	Pluse
17. Dove, Dan,	HP
18. Eaton, George	Independent
19. Fisher, William,	Santel Networks
20. Flatman, Alan,	Independent
21. Fukuchi, Kiyoshi,	NEC
22. Ghiasi, Ali,	Broadcom
23. Halder, Bijit,	Telicos Corp.
24. Hazarika, Asif,	Fujitsu
25. He, Runsheng,	Marvell
26. Higuchi, Tetsuya,	AIST
27. Horie, Takeshi,	Fujitsu
28. Hurwitz, Walter,	Broadcom
29. Jover, Juan	Independent
30. Kasturia, Sanjay,	Teranetics
31. Kazuhiro, Sato,	NTT East
32. Koeman, Henriecus,	Fluke Networks
33. Kota, Kishore,	Cicada Semiconductor
34. Koyama, Tetsu,	NEC Electronics
35. Lou, Dennis,	Pioneer PRA
36. McCallum David,	Molex
37. McConnell, Mike,	Key Eye Communications
38. Mei, Richard,	Avaya
39. Meisler, Alon,	Intel Corporation
40. Miao, Tremont	Analog Devices
41. Muller, Shimon,	Sun
42. Naganuma, Ken	Unknown
43. Nevits, Jeff,	Nortel Networks
44. Nordin, Ron,	Panduit Corp.
45. Okuyama, Takeshi,	Fujitsu Components America, Inc.
46. Powell, Scott,	Broadcom
47. Rado, Ted,	Analogix
48. Rodensky, Mike,	SolarFlare
49. Sallaway, Peter (PJ),	Vativ Technologies
50. Sampson, Rod,	Belden Electronics Div.
51. Sao, Sailesh,	Independent
52. Shalvo, Ofir,	TI
53. Sparrowhawk, Bryan,	Levitron Voice and Data Div.
54. Tanaka, Keiji,	KDDI

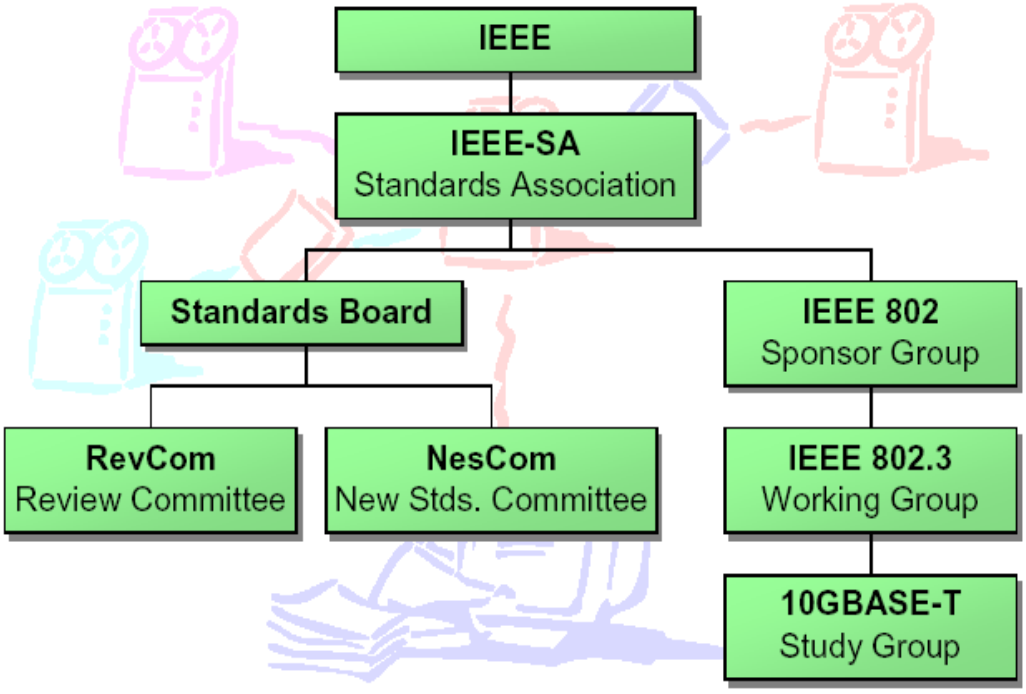
55. Tellado, Jose,	Teranetics
56. Toyoda, Hidehiro,	Hitachi
57. Vaden, Sterling,	Superior Modular Products
58. Vanderlaan, Paul,	Belden Electronics Div.
59. Warren, Jeff,	Independent
60. Yagil, Ariel,	Texas Instruments
61. Zimmerman, George,	SolarFlare

General Presentations & Minutes

1. Opening Business (Brad Booth)

Brad opened the meeting welcoming everyone to his hometown of Vancouver, BC. We had a round of introductions, and quickly got into the goals and objectives (outlined above) for this meeting. The meeting agenda remained unmodified. The important reflector and web addresses were shown. The ground rules for how these meetings are conducted were also reviewed, for example Robert's Rules of Order are used. Participation by all parties is on an individual basis. The issue of how IEEE deals with patents was reviewed. Karen Kenney, IEEE-SA staff and only staff member with voting rights on the Patent Committee (PatCom), read the IEEE patent policy at the start of our meeting on Wednesday, January 14th, 2004 at 9:22am. She explained that this topic is important because there are a number of IEEE working groups that are running into legal issues w.r.t. patent infringements. 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

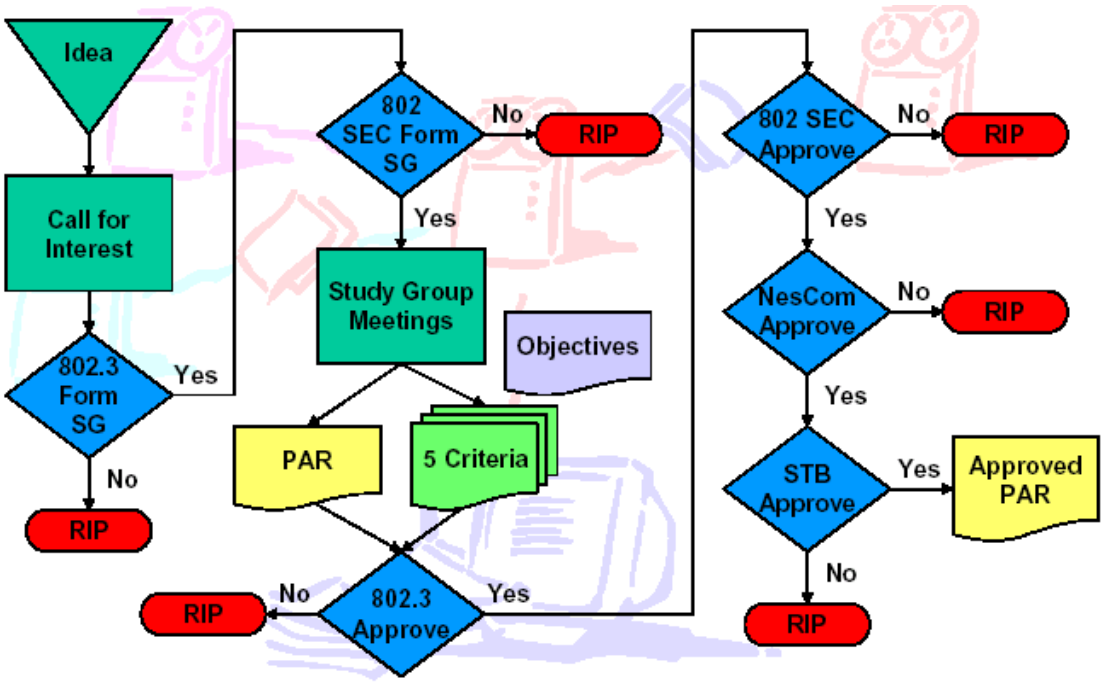
The complexities of how a project is routed through the IEEE standards process was discussed at great length. We are at the point in time where the group is transitioning from a study group to a task force. This transition will be completed when NesCom signs off on the 10GBASE-T PAR in early February 2004.



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.

If you don't have an IEEE-SA membership please get one, the cost is minimal and this is required to join 802 sponsor ballot pools.



2. 802.3an 10GBASE-T Document Structure (Sanjay Kasturia)

Sanjay has volunteered to take on the role of "Editor in Chief". Some would argue (myself included) that this is the most important role within the 10GBASE-T group. The purpose of this presentation was to begin the discussion on the 10GBASE-T document structure, the schedule for creation of the initial draft, the importance of zeroing in on group consensus for the core proposals and outline some next steps in support of writing the draft standard.

The 10GBASE-T Task Force will entertain technical presentations (Proposals) during a number of interim (e.g. January, April, May) and plenary (March, July) meetings that form the baseline set of presentations (technically agreed upon material, 75% or better by TF vote). These presentations typically find their way into a "Blue Book" that in the past has been published by a Technical Alliance. These agreed upon proposals will be incorporated in Draft D1.0 of the "10GBASE-T Task Force proposed standard". They are the foundation of the 10GBASE-T standard. Once incorporated into the draft standard it will be very difficult to remove them, however another TF vote of 75% or greater can alter or remove any portion of the evolving draft standard.

An intermediate draft, i.e. draft D0.9 is planned. This is an internal draft for TF edification; it's an aid to get D1.0 done on time - we'll capture as much agreed upon material as possible in D0.9 in an attempt to lock down the non-debatable material.

The last technical proposal for draft D1.0 is planned to be presented at the July 2004 plenary meeting. Draft D1.0 would be created after the July 2004 plenary meeting and it would incorporate all technical changes that were agreed upon up to the close of the July 2004 plenary meeting. Closure of some editorials may slip outside this July meeting; the various editors will resolve them. We would use draft D1.0 during our 2004 September interim; this is where the fun starts managing the 10GBASE-T comment database.

The last technical change is planned to occur just prior to the 2005 July plenary (this is most likely during the 2005 May interim) think of this as our *current stake in the ground* for final closure of the technical content for the standard. After this point in time the TF is in a fix-it-mode, not allowing feature creep to kill the standards progress during the final 1-year stretch to the finish line where the standard is finished from a TF perspective. The 10GBASE-T task force is going into a 6-month phase now of a lot of technical work.

This standards effort will impact a number of existing clauses that are currently under change by other active 802.3 task forces, e.g. EFM. A new clause 55 shall define the specific physical layer variants of a 10GBASE-T PHY, this includes but is not limited to PCS, PMA, and connectors. We'll model this new clause 55 after clause 40 because the 1000BASE-T clause 40 most closely resembles the functionality of this new 10G Copper PHY.

The most important next step is to round out the editors list. To date we have Sanjay, Eric Lynskey, David Law and Chris Di Minico signed up for some portions of the editorship responsibilities. With out a doubt there is also a need for non-IEEE venue technical activities in drafting the proposed 10GBASE-T standard. Here again more volunteers are needed to host these technical sessions between interim and plenary meetings. When they occur and invitation to the 10GBASE-T reflector should be provide so that the process is open and inclusive of all 10GBASE-T committee members.

The table below was provided by our Editor in Chief (Sanjay) and it identifies a potential break down of editors and sub-editors that are needed to complete the task of writing the 10GBASE-T standard. Notice the items in **red**; these are the critical areas where new volunteers are needed. If you are interested in helping Sanjay please contact him directly @ skasturia@teranetics.com and explain to him which areas of expertise you have and your willingness to help draft this 10GBASE-T standard.

Clause		Description	Clause Editor	Company
1		Introduction		
28		Physical Layer link signaling for 10 Mb/s, 100 Mb/s, and 1000 Mb/s Auto-negotiation on twisted pair	Eric Lynskey	UNH IOL
30		10 Mb/s, 100 Mb/s, 1000 Mb/s, MAC Control, and Link Aggregation Management	David Law	3 COM
40		PCS and PMA for 1000BASE-T		
44		Introduction to 10 Gb/s baseband network		
45		Management Data Input/Output Interface	Eric Lynskey	UNH IOL
55 New 10GBT Clause		PCS and PMA for 10GBASE-T	Sanjay Kasturia	
	.1	Overview		
	.2	10GBASE-T Service Primitives and Interfaces		
	.3	**Physical Coding Sublayer (PCS)**	**Volunteer Need**	
	.4	**Physical Medium Attachment (PMA) sublayer**	**Volunteer Need**	
	.5	**Management interface**	**Volunteer Need**	
	.6	**PMA electrical specification**	**Volunteer Need**	
	.7	**Link segment characteristics**	Chris DiMinico	MC Comm.
	.8	**MDI specification**	**Volunteer Need**	
	.9	Environmental specifications		
	.10	PHY labeling		
	.11	Delay constraints		
	.12	**Protocol implementation conformance statement (PICS) proforma for Clause 55 - Physical coding sublayer (PCS), physical medium attachment (PMA) sublayer and baseband medium, type 10GBASE-T**	**Volunteer Need**	

3. Auto-negotiation for 10GBASE-T (Eric Lynskey)

Eric has taken on an important responsibility of defining how auto-negotiation might work for a 10GBASE-T compliant PHY. To date the system vendor requirements that have echo'ed in the IEEE hallways are that this new 10GBASE-T PHY needs to be backwards compatible with 1000BASE-T. This is needed from a product migration point of view. Using Clause 28 auto-negotiation is one way to solve backwards compatibility with 1000BASE-T.

Luc asked what the requirements are to be 1G compliant? The question centered on the need for 10GBASE-T's MDI connector being an RJ-45. At present support for Cat 6 via RJ-45 is supported with existing products. Now w.r.t. Cat 7 there is not an RJ-45 commercially available connector. The referenced document in the 802.3

standard for the 1000BASE-T connector is IEC 60603-7: 1990, note this document is under revision.

If the 10GBASE-T committee decision is to support auto-negotiation using fast link pulses as defined by Cause 28 additional modifications to other existing clauses will be required, such as Clauses 22, 40, 45 and their associated annexes.

Eric gave a brief tutorial of the FLP exchange for 10/100/1000 devices and some possible extensions to auto-negotiation for supporting 10GBASE-T. The extensions included modifications to existing message codes (renaming of these codes) and the creation of new message codes specifically for 10GBASE-T, plus new ability and negotiation pages. While the 2nd option (i.e. new messages and pages) has the most flexibility in terms of future enhancements to auto-negotiation the process of convergence of auto-negotiation will take twice as long, in the order of 2 seconds. The decision will take time because the group needs to sort out what to negotiate besides speed and duplicity.

4. Updates on Magnetics for 10GBASE-T (Thuyen Dinh)

Thuyen has presented 10GBASE-T magnetics contributions in the past, this is an update to those contributions. Thuyen has looked at the backwards compatibility with 10/100/1000 magnetics and what are the practical achievable BW's for the magnetics. Since 10GBASE-T magnetics needs much wider bandwidth (>500 MHz), inductance has to be lowered to reduce parasitic elements. Some testing was performed using a couple of 140 meter Cat 5e cables and 10/100/1000 NIC cards. The testing showed that as open-circuit inductance (OCL) of the magnetics was reduced to about 100 uH, the 10 Mb/s & 100 Mb/s transmission modes exhibited errors, but the 1 Gb/s operation ran error free. Two 10GBASE-T magnetics designs were investigated.

Example # 1:

- 1CT:1CT turns ratio (center tap on each side).
- Insulation to meet 1500 VAC.
- OCL of about 140 uH.
- Wound on small core made out of common high-permeability ferrite material.
- No common-mode choke.
- Sample tested with direct connections to package from analyzer SMB connectors.

Example #2:

- Same as in design example 1, but with a common-mode choke of same design as those in typical 10/100/1000 magnetics.

Summary: Thuyen concluded that the 10GBASE-T magnetics must have more that 100 uH of OCL to ensure compatibility with legacy systems such as 10/100/1000 copper NIC's. He also felt that some relaxation of existing OCL requirements should be taken into consideration. In fact he wanted to proposed a motion to relax this OCL requirement. This was ruled out of order. It needs to be taken up during an 802.3

plenary meeting with David Law. Luc was concerned with just taking it out, rather he proposed a modification to the OCL requirement. Bandwidth (3dB) from less than 100 kHz to more than 500 MHz is feasible with transformer alone, but upper bandwidth may be reduced to less than 500 MHz with common-mode chokes. Since the numbers of turns will be small, odd turns ratios such as 1:1.4, 1:1.15, etc. may be difficult to implement.

5. 10GBASE-T: The Need to Support Cat 5E (Mike Bennett)

Mike's presentation was in large part a rehash of previous contributions. His position is there's a gap between the LX4 300-meter solution and CX4 15-meter solution that is addressed by 10GBASE-T for the 10G data center applications. This is a continuation of the plea for Cat 5e support by the 10GBASE-T standard, especially for the data center applications. Keep in mind that Mike is an end-user and 10G systems suppliers will satisfy his requirements one way or another.

The question is: *"Is it better to address these Cat 5e end-user requirements with a 10GBASE-T standards based solution or not?"*

Prior 10GBASE-T presentations indicate that 20 – 60 meters could be supported on Cat 5e. Michael concluded that the data center is where a large portion of the 10GBASE-T applications are and Cat 5e is prevalent so it's time to add an objective to support this. A couple of straw polls were taken to see if there was interest in supporting Cat 5e. Luc felt that this presentation content is largely identical to what was presented at the last November 2003 meeting. Luc felt that this standard should not be burdened with this objective because the cabling standards bodies will not support it. The cabling industry is aware that this is a customer requirement but they are not willing to take on more risk for a 10-year old Cat 5e product. George Eisler said anyone who builds a 10GBASE-T transceiver will do it in such a way as to support Cat 5e.

Straw Poll #1:

- Is there any interest in the study group to define a channel model based on category 5e UTP that can be included in the standard as an annex? **YES – 25.**
- **Discussion:** The issue of Cat 5e "definition" continues to come up. So the wording of this straw poll was modified to include "based on" text. Then the next issue came up which is the work to be performed involves writing a new cabling standard and the cabling committees will not touch this.

Straw Poll #2:

- And those willing to work on the effort **YES - 11 individuals & 4 companies**

  NOTE: There was a request by Terry Cobb to take a vote of the cabling industry individuals who are willing to support this effort. The 10GBASE-T chairman denied this request. There were 65 people in the room at the time of this vote.

6. Shedding Some Light on Coding Gain (Scott Powell)

Scott is not proposing any specific coding proposal with this presentation, rather he is giving the group some insight into the coding gains the group could expect with some of the coding schemes discussed to date and a look at the complexities of the design.

The maximum practical PAM coding gain is:

- 7.5dB @ 10^-6 BER, or
- 10.8dB @ 10^-12 BER.

Scott boiled down a lot of analysis to a single chart that shows for a normalized SNR in dB and BER the SNR can be computed.

Advanced coding techniques can get back as much as 7.5dB. Using Trellis codes you can get 4.2 dB back, other codes such as Turbo Codes can get back even greater gains. With all of these coding schemes there is always a 0.7dB margin that can't be retrieved. The achievable coding gain analysis was based on prior work from G. Ungerboeck going back to 2000.

LDCP can retrieve approximately 8.7dB @ BER 10^-12.

Some traditional commonly used codes, e.g. (RS) block codes could be used. These (RS) solutions all exist in silicon and the complexities are well known.

The latency is a yet to be considered requirement when making the coding choice.

All the coding gain charts Scott showed included an ideal interleaving assumption.

Summary the true coding gain for LDPC PAM-8 scheme is 8.7dB @ 10^-12. Some other better understood coding schemes can be used to get even higher coding gains. The decision of which coding scheme to use must be based on the real coding gain that's achievable. Latency requirements are needed very soon so they can be factored into the coding decisions ahead of the 10GBASE-T committee.

7. Channel Code Considerations for 10GBASE-T Signaling (Ifir Shalvi & Jose Tellado)

Ifir and Jose presented some comparative analysis of the two 10GBASE-T proposed signaling architectures on the table:

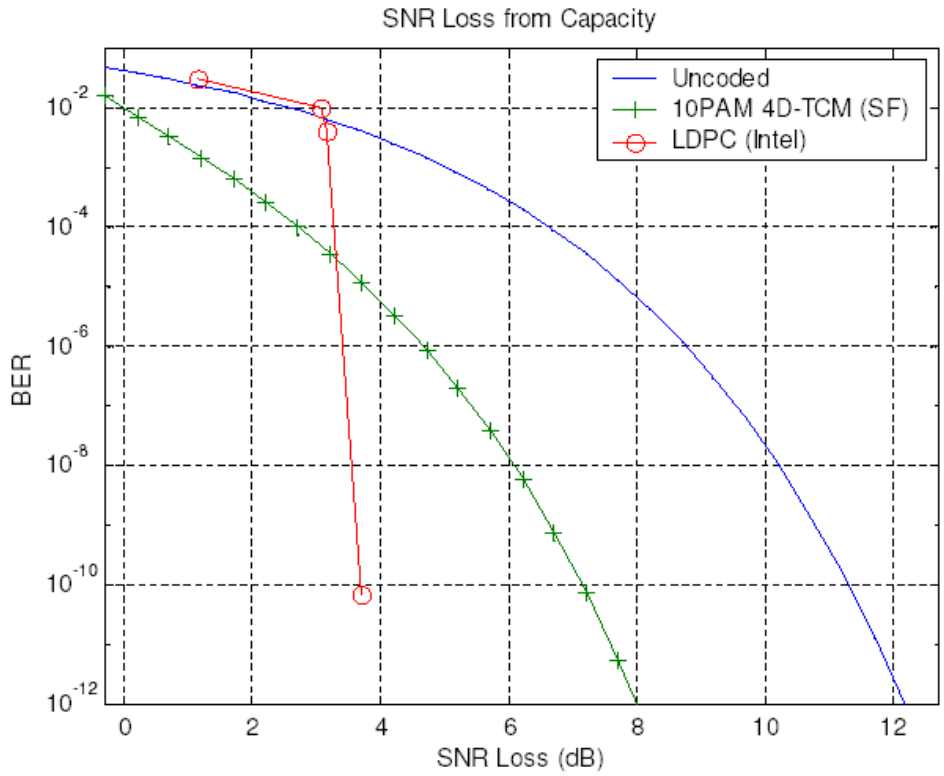
- Trellis Code Modulation - TCM: 10 PAM 4D-8State code @ 833Ms/s
- Low Density Parity Check - LDPC: 8 PAM (1723,2048) code @ 1,000Ms/s

Possible Channel Codes:

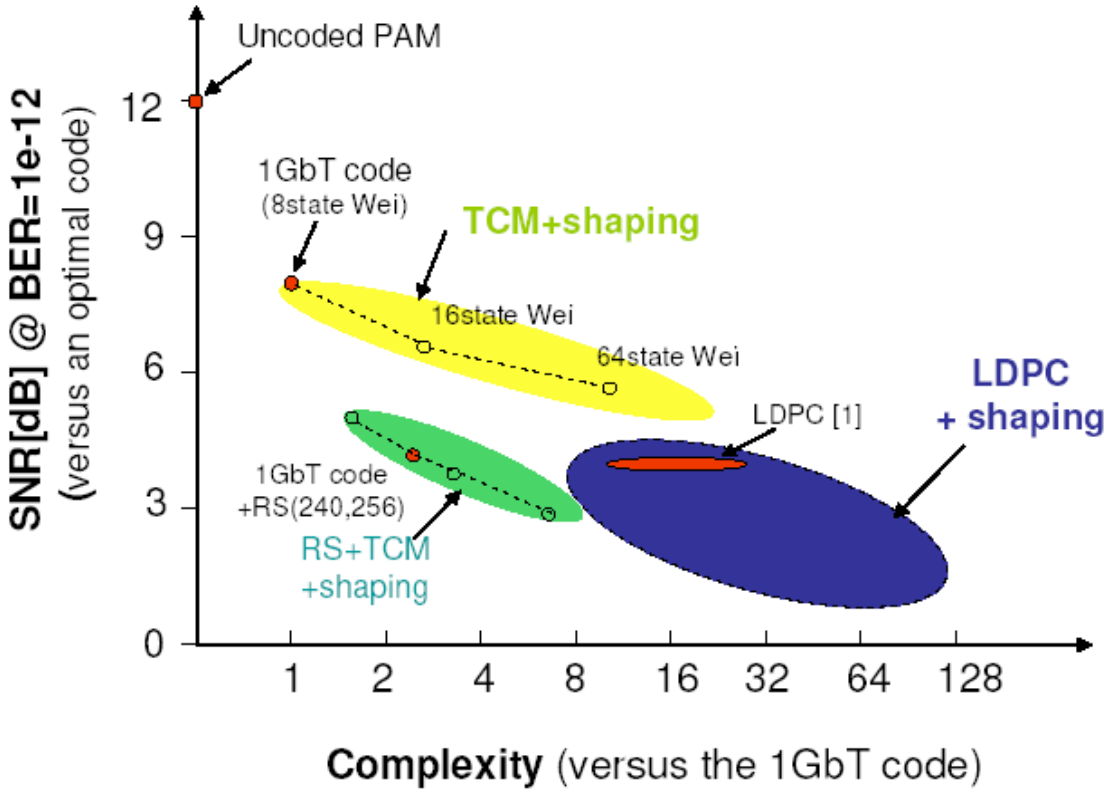
Scheme	Loss from Capacity @ BER=1e-12	Receive Complexity	Delay [sec]	Equalizer	Maturity
TCM + shaping	5-8dB (Solarflare TCM~8dB)	Low – moderate	< 0.1	Pre-coding or receiver equalization	Mature
TCM+RS +Shaping	3-6dB	Low – moderate	0.75-4.5	Pre-coding recommended	Mature
LDPC + shaping	1-4dB (Intel LDPC~4dB)	High	0.5-2	Pre-coding	New

Ifir and Jose are requesting additional input from task force w.r.t. latency budget requirements for the channel and some guidance on performance and complexity tradeoffs. When they get some guidance from this group they can optimize the concatenated codes they have presented.

The performance of the current proposals is represented here in this chart. Since IEEE participation is on an individual basis the names SF – SolarFlare and Intel should be removed from future contribution slides. While its clear that the LDPC proposal has better performance at a given BER it comes at a price. That price is latency and complexity. Hopefully during the next 10GBASE-T meeting we'll get more input from the proponent(s) of this proposal w.r.t. the design complexity and latency impacts.



Another very interesting and subjective chart presented deals with the performance and complexity tradeoffs of the proposals.



Better performances from the concatenated codes are possible by using constellation-shaping algorithms.

Some feel the first decision to be made was the latency requirement, then Shannon Capacity.

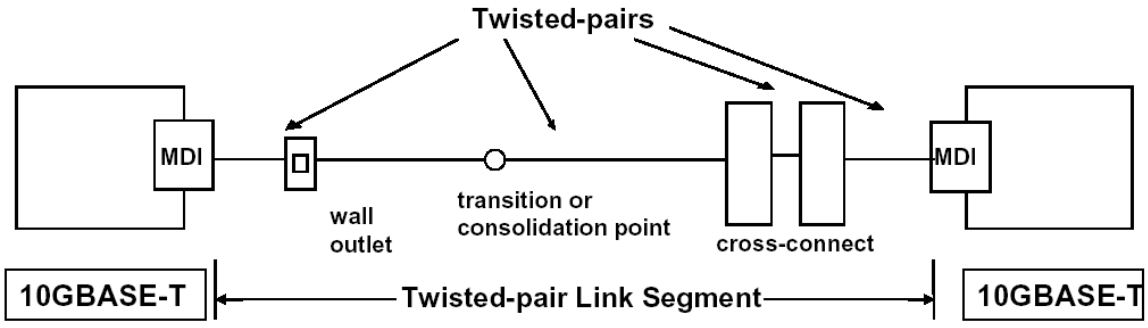
Bottom line – this committee needs to formulate a way to move forward and make progress, we need a **Decision Tree** for all these choices, e.g. 1st agree on a channel model, then latency requirements, then BER, then media, then coding scheme, then well you get the picture. We don't need all the answers on each technology decision but we definitely need to converge on some decisions very soon if there is any hope of drafting a standard by the July 2004 timeframe.

8. 10GBASE-T Link Segment Specifications and ANEXT Considerations (Chris Di Minico and Larry Cohen)

This presentation covers two items, a 10GBASE-T Link Segment Specification and usage of 10GBASE-T on the installed base of cabling. This presentation is a great example of the type of contribution the 10GBASE-T committee needs to formulate a baseline set of technical proposals in support of the initial draft standard. More specifically this was an attempt to get going on progress with the 1st draft standard dealing specifically with the two media and distance requirements we have:

- 100 meters on Class F, and
- 55 meters on Class D

This material includes a description of a 10GBASE-T link segment. This is mainly a legacy topology encompassing the MDI to MDI link.



The goal is to develop a single channel for the two-distance/media objectives we have. This model is a single transfer function. The types of performance parameters to be included are insertion loss, characteristic impedance, and return loss. Also included in the model are delay parameters like maximum link delay and link delay skew. The coupling parameters to be factored in are near end cross talk (NEXT), far end cross talk (FEXT + ELFEXT), and multiple disturber (MDELFEXT) plus alien cross talk.

Chris showed a number of performance and coupling parameter graphs including extended frequency range these individual link parameters. Also a proposed set of link segment equations that were used to graph these link parameters was presented.

Luc is concerned with the insertion loss graph. He thought it would make it difficult for the A/D converters that have to pull a weak signal out of the noise and would like to understand the trade offs now before any voting on the link model took place. Scott thought that Class E was going to be addressed by TIA. Terry questioned the equation for AXTIR; he thought there was a typo. Val explained that these equations never made it to TR-42. Chris took an action item to get back to the committee w.r.t. this AXTIR equation.

> *"Subsequent to this meeting Chris checked the AXTIR equation and found the equation to be accurate. A spreadsheet was posted to the 10GBASE-T web page* http://www.ieee802.org/3/10GBT/public/material/10GBT-AXTIR.xls *for clarification on the applicability and usage of the equation".*

Alien Cross talk is a very important variant for specifying the channel model. The ISO/IEC and TR42 groups will develop a specific alien crosstalk test methodology and test channel. They want to create an alien cross talk limit that changes with insertion loss changes; the goal is to achieve the 18Gb/s limit across all variations of distances. This work can be used for testing and the development of new Cat 6e cabling. Three classes of deployment are considered.

- **Case 1:** Installed base channel lengths and topologies less than or equal to minimum objective for specified cable class
- **Case 2:** Installed base channel lengths and topologies greater than minimum objective for specified cable class
  NOTE: Requires alien crosstalk field measurement
- **Case 3:** New cabling components specially designed to support 10GBASE-T

There was a question on the AXTIR Graph – @ 650 MHz what's the SNR? Does this remain constant as we extend the cabling length to 100 meters. Answer - it is possible for the SNR to go negative at 550 – 600 MHz.

Larry addressed the technical feasibility of performing field alien crosstalk testing. There was some interesting debate about the practicality of performing this field-testing especially when cables within a bundle are terminated in different physical locations.