IEEE P802.3 10GBASE-T Minutes

Study Group Plenary Meeting
November 11th – 13th, 2003
Albuquerque, NM.

Prepared by:
Jeff Warren
IEEE@nc.rr.com
Independent Consultant

Administrative

The meeting convened at 8:30am, November 11th, 2003. 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 Flatmann 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. At the start of the meeting the attendance was approximately 75 people, of those only 6 were new participants. Later during the 1st meeting day the attendance topped out at around 145 individuals. A motion by Jeff Warren and Bob Grow to accept the minutes from the September 2003 interim meeting passed by acclimation.

The hot ticket items for this meeting were closing the PAR, 5 Criteria and Objectives, presumably to make some very minor clarification modification.

The 'proposed' 10GBASE-T standards time line targets a 2Q06 completion date for the final standard. At this point in time the 10GBASE-T standards effort is 27 % complete; 12 of 43 months have passed.

Motion to adjourn by Jeff Warren at 10:15am on Wednesday November 13, 2003 passed by acclimation.

Some important links:

- Agenda: http://grouper.ieee.org/groups/802/3/10GBT/public/nov03/index.html
- 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/nov03/5Criteria_2_1103.pdf
- PAR = http://grouper.ieee.org/groups/802/3/10GBT/public/nov03/par_2_1103.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/

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; this was achieved. Another goal was to reply to a couple of liaison letters; this was achieved too. The most significant accomplishment was the 802.3 working group and SEC approvals to advance the 10GBASE-T effort to a task force. This will be official in January 2004 after NesCom approves the PAR.

The first technical presentations used for baseline material will come into the January 2004 10GBASE-T task force interim meeting.

Given the aggressive near term 10GBASE-T schedule an interim meeting in late April is highly likely. By this time a solid set of baseline technical proposal material should have stabilized and those agreed upon baseline proposals shall be used as the basis for draft 0.9 by the Editor in Chief who has yet to be identified. By July 2004 draft 1.0 should be produced. Remember a 75% approval of the baseline proposals will be needed, this means a lot of technical work will need to take place in an efficient manner between meetings. A "formal" technical forum would have been the best way to address this technical work, however an attempt to organize such a group failed.

As it turns out this week's 10GBASE-T meeting was a very lightweight effort with approximately one day's worth of meetings split between Tuesday and Thursday of this plenary meeting week.

Some members of the 10GBASE-T Study Group were very busy between the September and November meetings preparing a comprehensive 10GBASE-T tutorial. This tutorial intended to garner support from the 802.3 and 802 community at large for moving forward from a SG to a Task Force was a success. The key contributors to that 10GBASE-T tutorial material were as follows:

1. Alan Flatman — Independent Consultant (**presenter - cabling**)
2. Brad Booth — Intel Corporation (**presenter - system**)
3. Bruce Tolley — Cisco Systems
4. Chris DiMinico — MC Communications
5. Geoff Thompson — Nortel Networks
6. George Zimmerman — SolarFlare Communications (**presenter – PHY, part 1**)
7. Jeff Warren — Independent Consultant
8. Joseph Babanezhad — Plato Labs
9. Randy Below — The Siemon Company
10. Sailesh Rao — Intel Corporation (**presenter – PHY, part 2**)
11. Sanjay Kasturia — Teranetics
12. Shadi AbuGhazeleh — Hubbell Premise Wiring
13. Shimon Muller — Sun Microsystems
14. Sterling Vaden — Superior Modular Products
15. Valerie Rybinski — Hitachi Cable Manchester

The 10GBASE-T Study Group phase has ended and we are now moving into Task Force mode.

During the week we heard from an end user, Michael Bennett from Lawrence Berkley Labs on data center requirements. The bottom line is our end users are demanding a Cat 5e Objective, they fully understand the concerns about 10GBASE-T operating over Cat 5e cabling however given the facts that nearly all DC link lengths are under 45-meters and that 10G operation should work up to 50-meters over Cat 5e cabling a reduce link length objective for Cat 5e cabling is a reasonable request.

Several presentations dealt with ANEXT mitigation techniques to achieve 100-meter operation over Cat 6 (Class E) cabling. This looks promising and after the PHY component vendors sign off on the analysis this work, for example a simple mitigation patch cord would progress to TIA and ISO for further definition and specification.

The TIA TR42 and ISO liaison letters have been formally responded to. In short we're very appreciative that they will help IEEE by expanding the performance limits or enhancements that are necessary to achieve 10G operation over enhanced Class E & F cabling.

Outline for these Minutes

Future IEEE P802.3 10GBASE-T Meetings

Month	Days	Year	Meeting Type	City	State/Country
January	14th & 15th	2004	Interim	Vancouver	BC, Canada
March	14th – 19th	2004	Plenary	Orlando	FL
April	TBD	2004	Interim	TBD	TBD

There's a link to the next two meetings http://www.ieee802.org/meeting/index.html in Vancouver and Florida. The interim is just as large as a typical plenary with nearly all of 802 meeting at this venue.

IEEE P802.3 10GBASE-TObjectives

- 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

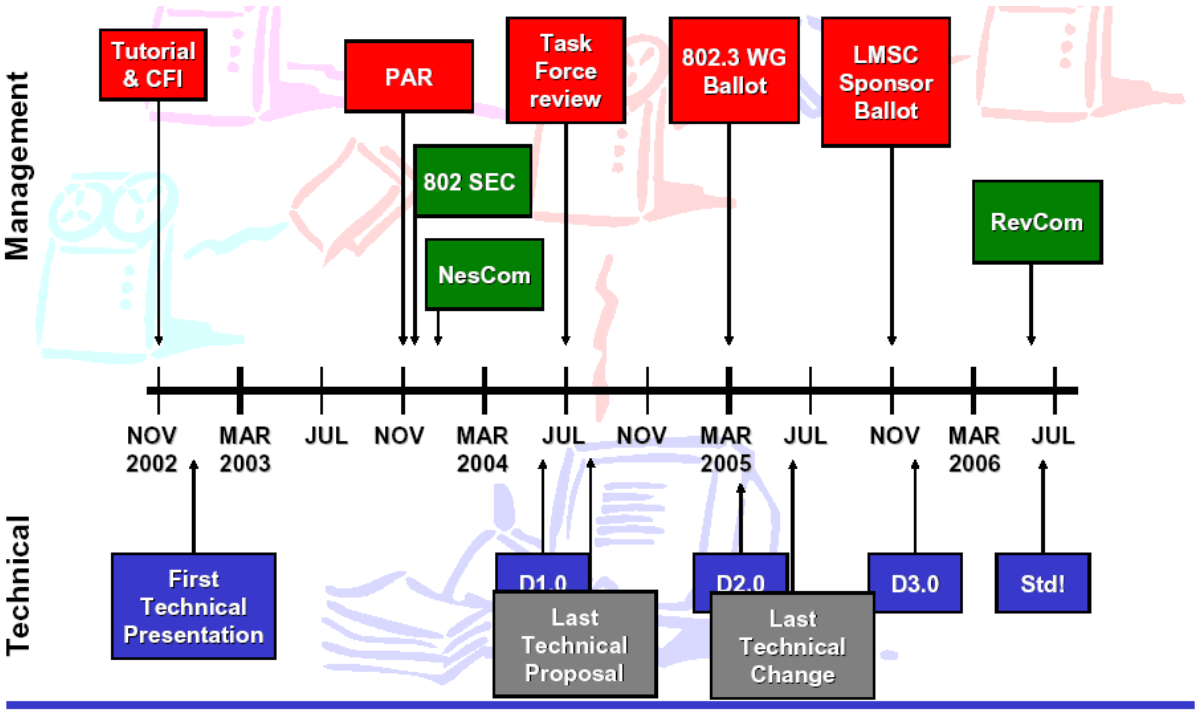
IEEE P802.3 10GBASE-T Contacts

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://grouper.ieee.org/groups/802/3/contacts.html this web page is maintained by David Law.

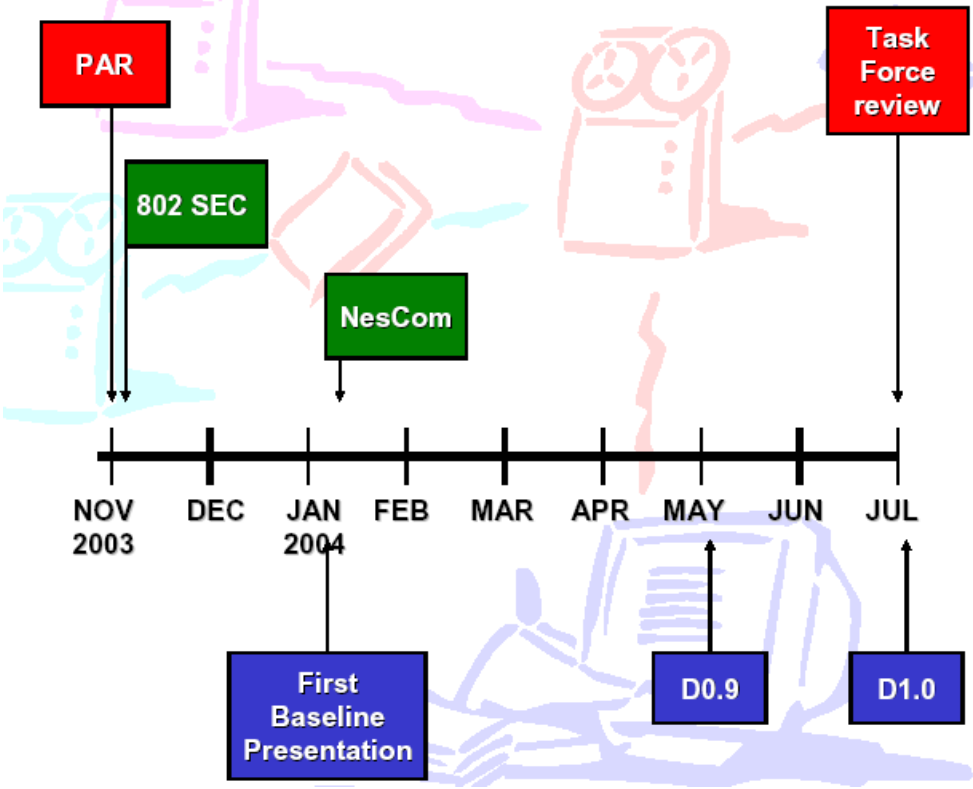
Name	802.3 & 10GBASE-T Standards Title	E-mail
Brad Booth	10GBASE-T Chairman	bradley.booth@intel.com
Jeff Warren	10GBASE-T Recording Secretary	IEEE@nc.rr.com
Bob Grow	802.3 Working Group Chair	Bob.Grow@Intel.com
David Law	802.3 Working Group Vice Chair	David_Law@3Com.com
TBD	Task Force Chief Editor	TBD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

IEEE P802.3 10GBASE-T Standards Timeline

Complete schedule, start-to-finish



Near term schedule (next 6 months)

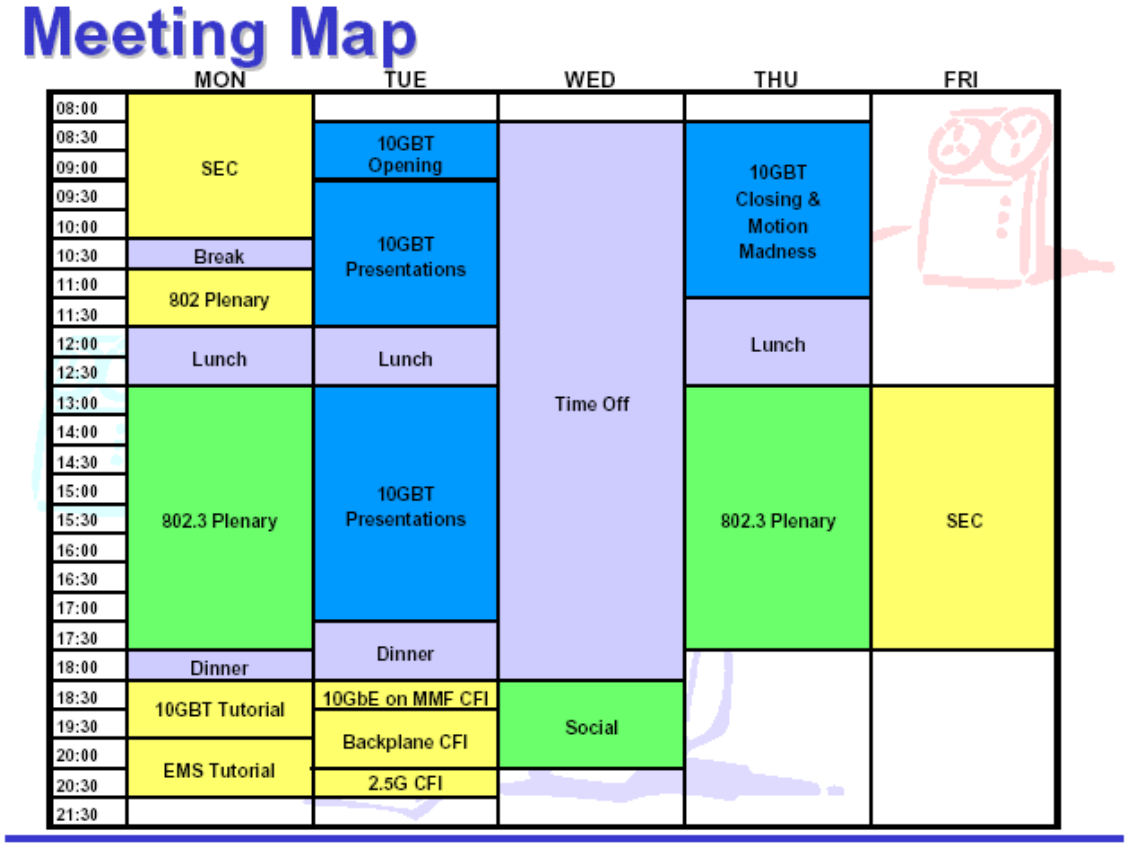


With regards to the near term 10GBASE-T schedule the effort ahead for this task force should not be under-estimated. The process of developing and agreeing on the set of baseline proposals is absolutely critical to the success of this project maintaining their aggressive schedule. This means that a significant amount of technical work must occur outside the IEEE meetings. In the past this type of work has been organized by alliances.

Agenda, Meeting Times, and Meeting Map

Tuesday **July 22, 2003**	
Presenter	
	Welcome and Introductions
Booth, Brad (Intel)	**Agenda and General Information**
Michael Bennett (Lawrence BL)	**10GBASE-T: Broad Market Potential in Data Centers**
DiMinico, Chris (MC Communications)	**Data Center Design Considerations**
Bernie Hammond (KRONE)	**Feasibility of Augmented Category 6 UTP Cabling Supporting 100m 10GBase-T Channels**
Ron Nordin Paul Vanderlaan (Panduit & Belden)	**Alien Crosstalk Mitigation Technique Update**
Mohsen Kavehrad (Penn State)	**Transmission Strategies for 10GBASE-T over Category-5e and 6 Copper Wiring**
Sailesh Rao (Intel)	**The 4D-PAM8 Proposal for 10GBASE-T**
Brad booth (Intel)	**PAR, 5 Criteria and Objectives Feedback**

This meeting map developed by Brad Booth shows when the 10GBASE-T meetings took place on Tuesday and Thursday. 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: Move that the Study Group approve Geoff Thompson's 10GBASE-T PAR feedback w.r.t. clarification of Scope. "*Specify a Physical Layer (PHY) for operation at 10 Gb/s on standards based structured copper cabling, ...".*
Motion Type: Technical 75% required
Moved By: Jeff Warren
Seconded By: Alan Flatman

SG Voters	Y: 48	N: 0	A: 1
802.3 Voters:	Y: 23	N: 0	A: 1

Results: **100 %** P/F: **Passed**

Motion # 2

Description: Move that the Study Group approve Tony Jeffree's 10GBASE-T 5 Criteria feedback w.r.t. Compatibility. "*Conformance with 802.1 and 802.2 is provided by the overlying 802.3ae MAC sub-layer*".
Motion Type: Technical 75% required
Moved By: Jeff Warren
Seconded By: George Eisler

SG Voters	Y: 45	N: 0	A: 1
802.3 Voters:	Y: 24	N: 0	A: 0

Results: **100 %** P/F: **Passed**

Motion # 3

Description: Move that the Study Group accept the two Liaison Response letters (TIA TR-42 & ISO/IEC 11801 JTC1/SC25/WG3) drafted by the Cabling Ad Hoc and forward the letters to 802.3 for editing and approval.
Motion Type: Procedural 50 % required
Moved By: Jeff Warren
Seconded By: R. Mei

SG Voters	Y: 51	N: 0	A: 0
802.3 Voters:	Y: 27	N: 0	A: 0

Results: **100 %** P/F: **Passed**

Discussion: The two liaison response letters developed by the Cabling Ad Hoc committee for 802.3 were reviewed prior to voting on this motion.

Motion # 4

Description: Move that the 10GBASE-T Study Group request approval of the 10GBASE-T 5 Criteria, per 5Criteria_1_0903.pdf plus the modifications from Motions #2 & #3 to be listed in 5Criteria_1_1103.pdf, by the 802.3 WG and requests that 802.3 WG forward the 10GBASE-T 5 Criteria to the 802 SEC for approval.
Motion Type: Procedural 50 % required
Moved By: Jeff Warren
Seconded By: J. Babanezhad

SG Voters	Y: 54	N: 0	A: 1
802.3 Voters:	Y: 26	N: 0	A: 1

Results: **100 %** P/F: **Passed**

Discussion: Since the 5Criteria_1_1103.pdf wasn't created at the time of this motion

Motion # 5

Description: Move that the 10GBASE-T Study Group request approval of the 10GBASE-T Objectives document, per objectives_1_0903.pdf, by the 802.3 WG.
Motion Type: Procedural 50 % required
Moved By: Jeff Warren
Seconded By: Alan Flatman

SG Voters	Y: 56	N: 0	A: 0
802.3 Voters:	Y: 32	N: 0	A: 0

Results: **100 %** P/F: **Passed**

Discussion: The key here is that our Objectives have not changed since they were refined a few months ago.

Motion # 6

Description: Move that the 10GBASE-T Study Group request the 802.3 WG to approve the 10GBASE-T PAR, as per par_1_0903.pdf plus the modification from Motion #1 to be listed in par_1_1103.pdf, and request the 802.3 WG to forward the PAR to the 802 SEC and NesCom for approval.
Motion Type: Technical 75% required
Moved By: Jeff Warren
Seconded By: B. Hammond

SG Voters	Y: 54	N: 0	A: 0
802.3 Voters:	Y: 28	N: 0	A: 0

Results: **100 %** P/F: **Passed**

Discussion: We're using the continuous process for NesCom approval, this means they would approve this project in January as opposed to March 2004.

Motion # 7

Description: Move that the Study Group add the following text to the 10GBASE-T 5 Criteria feedback. "Exhibit similar cost balance as 802.3ab (1000BASE-T) for LAN 'vs' attached stations."

Motion Type: Technical 75% required

Moved By: Brad Booth

Seconded By: Bert Armijo

SG Voters	Y: 42	N: 1	A: 5
802.3 Voters:	Y: 26	N: 1	A: 1

Results: **100 %** P/F: **Passed**

Discussion: The intent is that this standards body will develop a 10GBASE-T standard where components can be developed at a cost on par with the overall product cost of the device(s) this technology goes into. Even though we cannot elaborate on precious costs within this standards body there is an awareness of device costs outside the IEEE 10GBASE-T group. If anyone who participates within the 10GBASE-T committee feels that balanced costs

Motion # 8

Description: Move that the 10GBASE-T Study Group request the 802.3 WG to approve 10GBASE-T Interim meeting(s).

Motion Type: Procedural 50% required

Moved By: Terry Cobb

Seconded By: P. Vanderlaan

Results: **100 %** P/F: **Passed by acclimation**

Motion # 9

Description: Move that the 10GBASE-T Study Group request the 802.3 WG to forward additional 10GBASE-T approved liaison letters relating to the definition of the cabling channel to TIA TR-42 and ISO/IEC SC 25/WG 3 after the 10GBASE-T interim meeting(s).

Motion Type: Procedural 50% required

Moved By: Terry Cobb

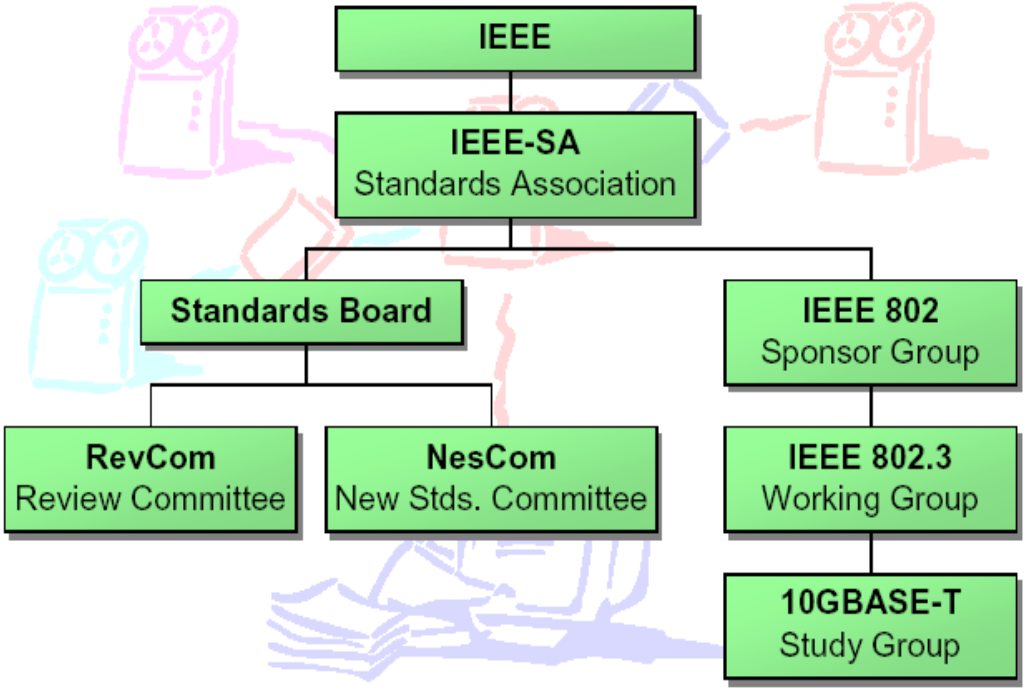
Seconded By: V. Rybinski

Results: **100 %** P/F: **Passed by acclimation**

General Presentations & Minutes

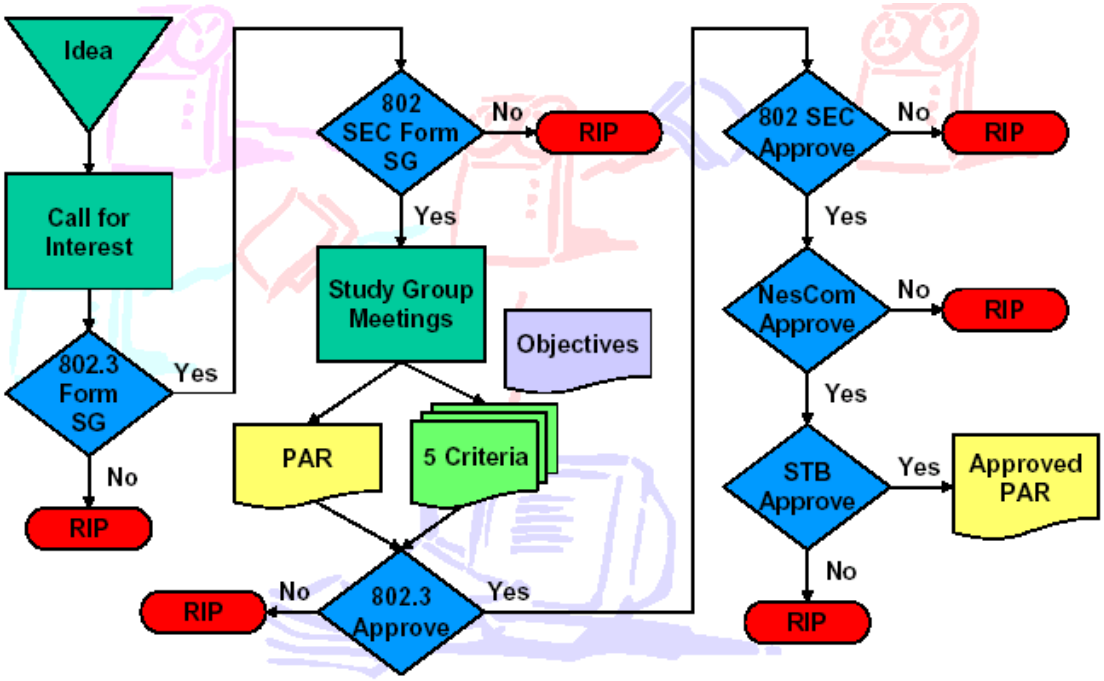
1. Opening Business (Brad Booth)

- Mr. Booth's opened the meeting welcoming everyone to Albuquerque, NM. We had a round of introductions, 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, 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. The 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, which 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).
- 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.
- Brad read the patent Bylaw Rules verbatim. He began this process at 8:36am and ended at 8:40am. These rules apply to meetings and reflector conversations, they can be found at: http://standards.ieee.org/sa/sa-bylaws.pdf
- The standards process steps coming up that are important include:
  - This week 802.3 Approval
  - Then 802 Standards Executive Committee Approval
  - Then in January 2004 NesCom Approval
    - Because of this timing another SG extension is required.



2. ISO/IEC 11801 JTC1/SC25/WG3 Liaison Letter to 802.3

- ISO/IEC SC25/WG3: Structured Cabling Systems – a new project has been initiated for the study of Electro-Magnetic (EM) performance of cabling. There is a firm offer to augment Class E/F for 10G operation.
  - At their last meeting they started to investigate the development of generic specifications for electromagnetic performance of balanced cabling. This initiative has been triggered by the need to define cabling for use in more severe electromagnetic environments and also to manage alien crosstalk for high bit rate applications such as 10GBASE-T. It is intended to specify the equivalence, in terms of electromagnetic immunity; of different cabling constructions including unscreened, overall screened and individually screened pair cables, and also installation mitigation techniques.

- JTC 1/SC 25 looks forward to working with IEEE 802.3 on the extended definition of Class E and Class F channels, possibly up to higher frequencies than presently specified by ISO/IEC 11801 2nd edition, and also addressing alien crosstalk. This is a firm offer to help, not to be underestimated.

- This international standards body is poised to assist 10GBASE-T as it transitions to an IEEE sanctioned task force.

3. Response to Liaison Letter ISO/IEC 11801 JTC1/SC25/WG3 Liaison Letter to 802.3

- This response letter is nearly identical to the one sent to TIA TR42. See that response below, number 5.

4. TIA TR42 Liaison Letter to 802.3

- They have initiated about ten new projects, two are relevant to the 10GBASE-T group and those two projects are discussed in this liaison letter.

1. **Project PN-3-0134:** Investigation of balanced cabling performance up to 625 MHz for both TIA category 6 and category 5e cabling for 10GBASE-T applications. The project consists of a study of measurements of category 5e and category 6 cabling transmission performance and alien cross-talk up to frequencies of 625 MHz, including the relationship of transmission parameters and alien crosstalk and their field testing and mitigation. Applicable category 6 data and guidelines from the study will be presented in a new Technical Systems Bulletin or Engineering Publication. Category 5e and category 6 measurement data will be shared directly with IEEE 802.3 10GBASE-T Task Force as it becomes available.

2. **Project SP-3-4426-AD10:** Augmented category 6 cabling. To develop cabling and component specifications and test procedures to support the operation of IEEE 802.3 10GBASE-T over 100 meters of structured balanced twisted-pair copper cabling. This project includes extending the frequency range and adding requirements to those specified in TIA -568-B.2-1. The resulting requirements will be presented in a new revision or addendum to the TIA-568-B standard.

5. Response to TIA TR42 Liaison Letter

- In the response letter the TIA TR42 group was advised that the 10GBASE-T Project Approval Request (PAR), 5 Criteria and Objectives have been approved, and the Study Group is on the path to becoming the 802.3al Task Force.

- The letter goes on the thank TIA for their willingness to help the 10GBASE-T group with our investigation of running 10 Gbit/s operation over 100 ohm horizontal cabling.

- The cabling objectives we've adopted were outlined, they are:
  - Support operation over 4-connector structured 4-pair, twisted-pair copper cabling for all supported distances and classes
  - Define a single 10 Gbit/s PHY that would supports links of:
    - at least 100m on four-pair Class F balanced copper cabling
    - at least 55m to 100m on four-pair Class E balanced copper cabling
  - Support star-wired local area networks using point-to-point links and structured cabling topologies
  - Select copper media from ISO/IEC 11801:2002, with any appropriate augmentation to be developed through work of 802.3 in conjunction with ISO/IEC SC25 WG3.

- A pointer to our 10GBASE-T Tutorial was given to TIA, that URL is http://www.ieee802.org/3/10GBT/public/nov03/10GBASE-T_tutorial.pdf

- 10GBASE-T technical feasibility has been demonstrated based on the following assumptions of the cabling channel. The basic approach has been to extrapolate the cabling performance limits to an upper frequency of 625 MHz and to utilize alien crosstalk measurements contributed to the 10GBASE-T Study Group cabling ad hoc http://www.ieee082.org/3/10GBT/public/material/index.html

- Our group requested that TIA TR42 review our project objectives and cabling models towards the development of the 10GBASE-T cabling requirements. Alien crosstalk to insertion loss ratio is a critical relationship to the achievable capacity. For operation over 100m, 4-connector channels we are currently requesting an improvement in insertion loss and a significant improvement in alien crosstalk specifications. DSP techniques have been presented which may relax the alien crosstalk performance requirements, and we will provide additional guidance as it becomes available.

- Based on presentations received by the Study Group it is anticipated that some level of alien crosstalk mitigation is achievable for installed cabling with the utilization of patch cords. We would be grateful for guidance on patch cord mitigation techniques.

- 10GBASE-T cabling will require channel field testing up to 625 MHz. It would also be desirable to include power-sum alien crosstalk as a field test parameter.

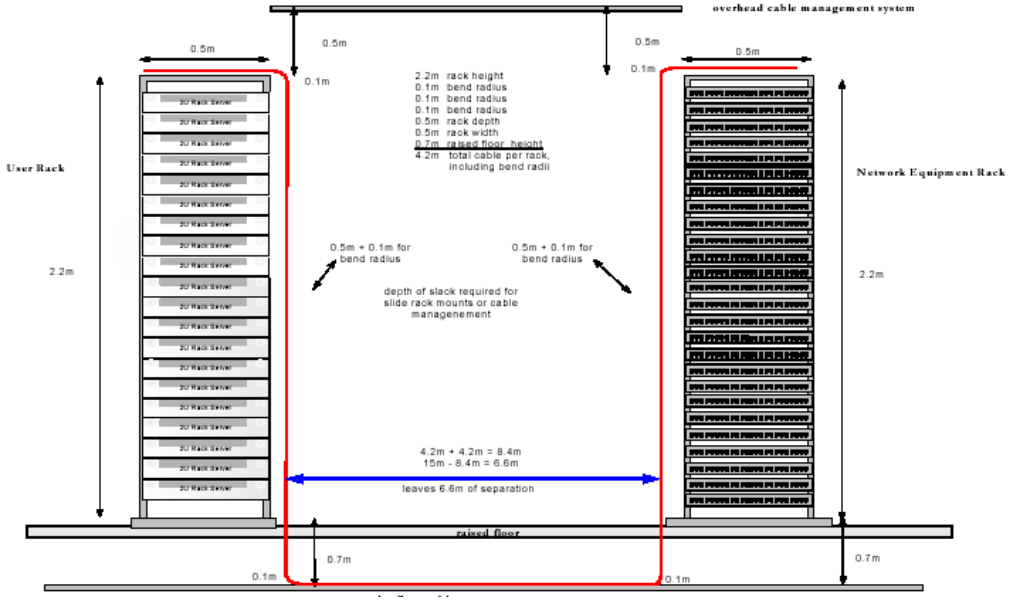
We would be grateful for your view on the feasibility of field testing equipment that meets these requirements and also the practicality of alien crosstalk (both near and far end) field testing.

- Lastly we told the TIA TR42 group that we look forward to continued cooperation between our respective organizations.

6. 10GBASE-T: Broad Market Potential in the Data Center (Mike Bennett)

- Michael began by recognizing other contributors and supports of the material he presented. They are:
  - Brent Draney National Energy Research Supercomputing Center
  - Roberto Morelli Energy Sciences Network
  - Greg Chartrand Pacific Northwest National Laboratory
- This discussion gets into where does 10GBASE-T technology fit in the market place, what's driving the demand for the technology and what alternatives exist.
- Looking back on 10GE optical we have only LR and ER shipping with SR just now happening and LX4 still missing. CX4 is beginning to kick in but it's only a 15m solution per the spec.
- The current costs of optical 10GE is preventing it from taking off, especially considering the relative cost of 10GE optical as compared to 1GE is 10x, that's too high.
- Servers can't take full advantage of the network BWs available to them. High performance servers and server clusters are the most likely place for 10GBASE-T. These high-end servers however can only push 5G in BW. As long as 10GE is 10x the cost of 1GE combined with high-end servers only able to utilize 50% of the BW it does not makes sense from a dollars point of view to implement 10GE optical. The promise of much lower-cost 10GBASE-T will solve this dilemma.
- Using link aggregation is a possibility however it is not easy from a configuration point of view and the cost of multiple ports on the LAN switches and PCI server cards.
- Since CX4 doesn't cover all the cabling distances needed in the DC and 10GE is too expensive the needed for 10GBASE-T is high.
- When you factor in the physical dimensions of racks and the way cabling is routed an additional 4-5 meters is needed for each rack when interconnecting equipment in different racks. This impacts the use of CX4, especially CX4 links that are limited to 15-meter runs.

4.2 m of cable in each rack (8.4m) allows only 6.6m between racks for 10GBASE-CX4 (15m)



- The 10GBASE-CX4 15 meter runs are not going to cut it.
- Cable runs are not true star configurations.
- LBL has four data centers, most cabling is Cat 5e. Maximum distances are under 50 meters on average.
- Here's a comparison of the national labs physical attributes that contributed to this presentation material. The maximum distance column is the distance from the equipment rack, which is usually placed in the center of the data center to the farthest rack.

Lab	Lab Area (Sq. Ft.)	Cable Mgmn't.	Max. Distances (meters)	No. of Racks
LBLnet	3,500	Overhead cable trays and raised floors	27	32
IT Services	5,000	Overhead cable trays and raised floors	32	113
NERSC	15,000	Overhead cable trays and raised floors	**48**	250
ESnet	5,000	Overhead cable trays	33	60

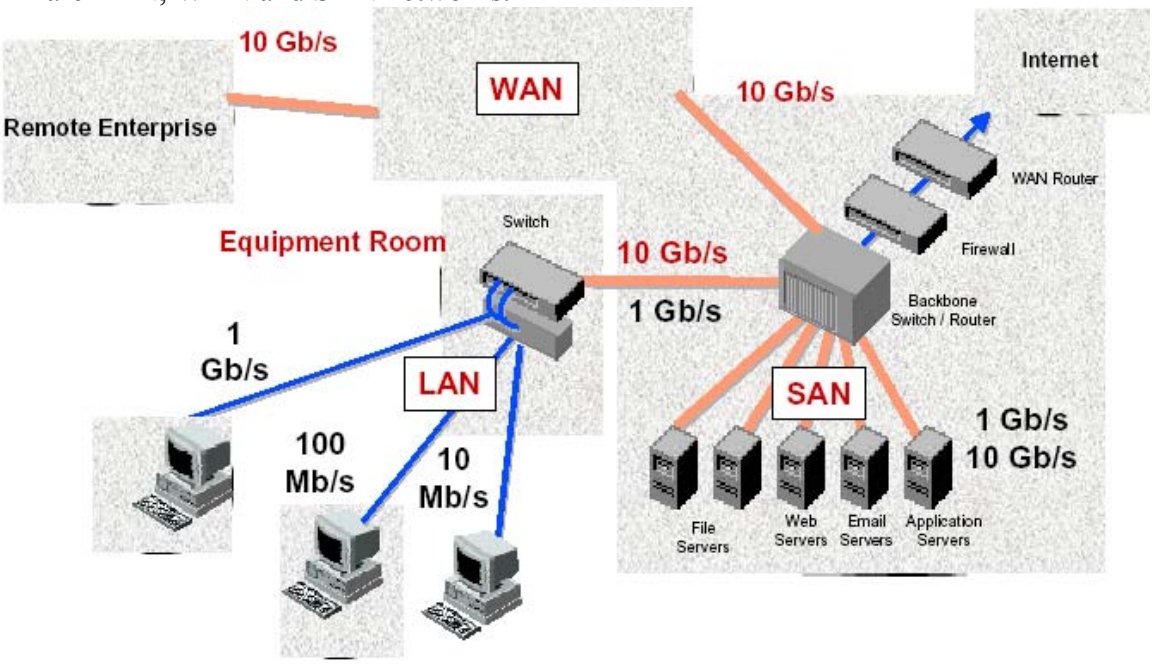
- When we get to sponsor balloting Michael reported that the lion's share of installed cabling will be Cat 5e and under 50 meters.
- Michael presented a number of questions to the group, all centered on allowing his 10GBASE-T DC applications to run over Cat 5e. He's the end user; we need

to pay attention to the customer's needs, they are Cat 5e at 50meters. It's time to add such an objective.

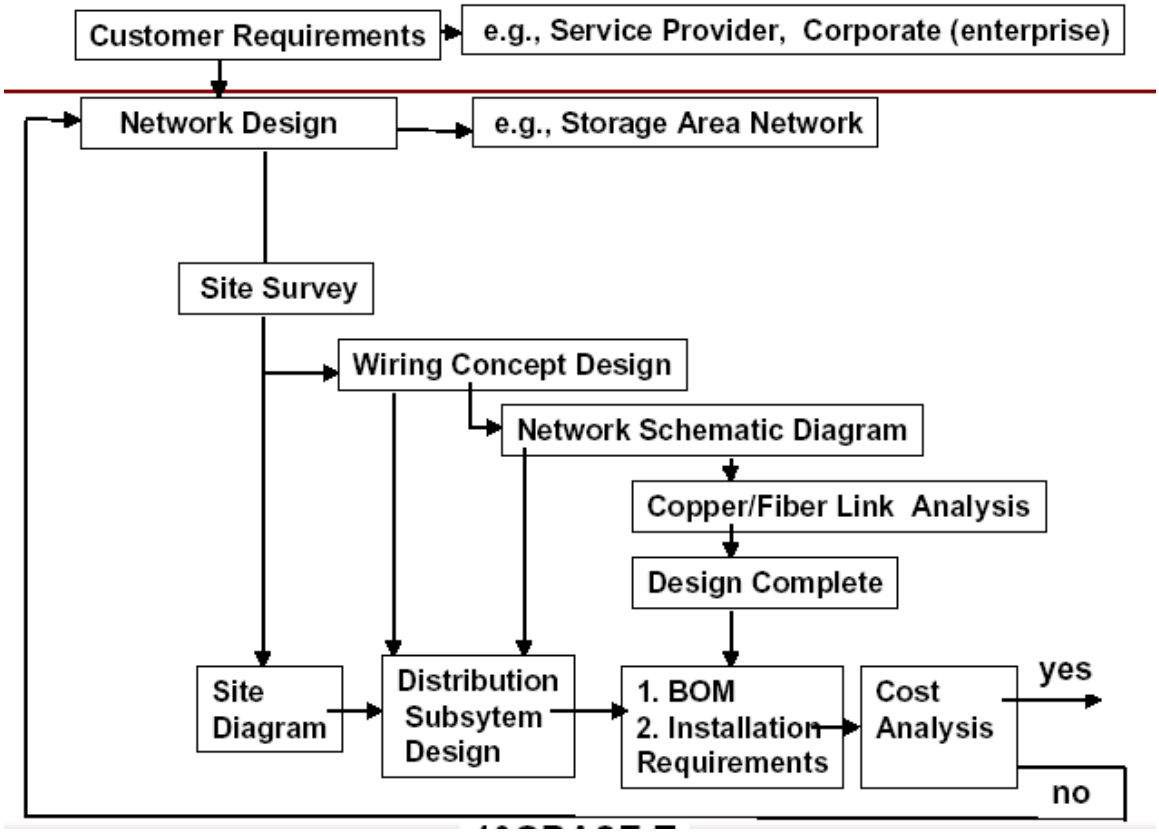
- QUESTIONS:
  - In the maximum distance did it account for all cable runs, answer yes.
  - It was pointed out that some small fraction of MMF can support other distances.
  - How typical is your installation to others. Michael suggested that his 4 DC's considered are representative of others.
  - Will you still pull new cabling, answer is still yes but he prefers to get it to run on the installed base of Cat 5e.
  - Luc Who should take the risk if the solution doesn't work. He wants some test equipment to qualify the cabling.
  - Luc Who will step up to say the channel will work. It's this group to specify a channel specification that clearly shows how to make this work. It will ultimately be the end-user that takes the risk to ensure the solution works.
  - Luc Alien NEXT will not be testable in the field. The dilemma is that the cabling vendors are not going to step up to the task of qualifying from an Alien NEXT perspective.
  - Shimon agreed that 50 meters would cover most of the DC. He also wants some degree of confidence that Cat 5e installs will work. It would be better to mention Cat 5e from a Broad Market perspective as an objective.
  - Terry mentioned that none of the testing vendors will offer Alien crosstalk testers.
  - Pat says reliability and uptime is most important and with Alien NEXT being something that varies over time this is a concern. Operating well beyond Cat 5e performance specs (extended frequency range) concerns her too.
  - John thinks that even though you can't test now a tester could be developed in the future. It's our responsibility to say what the channel can do from a spec point of view.
  - Luc says it's not that it can't be done it's more important to consider that the cost of doing this Alien NEXT testing is most likely to be more expensive than just replacing the cable.
  - Alan also agrees with Luc that this testing technique will be very challenging. He still feels our approach is to still pressure the cabling people to support the effort of running 10GBASE-T over Cat 5e but that it can't be done w/o them.

7. Data Center Design Considerations (Chris DiMinico)

- In addition to the presenter, Chris DiMinico, the contributors to this effort are from architecture and engineering firms. They are:
  - Jonathan Jew who is the president of J&M Consultants a telecommunication engineering firm and co-chairman of the TR42.1.1, Data Center Standard
  - Phil Isaak who is an associate and senior communications engineer with Mazzetti & Associates, also an engineering firm, and
  - William Baxter, who is a telecommunications practice leader with OWP/P (A&E Firm).
- Looking back at 80's style networks there were many different physical and networking technologies used. Ethernet has solved this mixed bag of technologies problem by allowing new topologies to be deployed with all Ethernet links. These all Ethernet solutions address all three critical data and storage topologies, they are LAN, WAN and SAN networks.



- The DC standard Chris is talking about is being developed under TR42, called TIA-942 "*Data Center Standard*". Draft 3.0 of the standard is expected by end of November 2003.
- This group understands what the DC cabling requirements are since they generate a living out of providing cabling solutions and they are very active in the TR42 cabling standards bodies among others.
- Chris outline the process of DC design starting with Customer requirements to cost analysis. This chart from Chris's presentation shows the various decisions that need to be made when planning for new cabling installations.



- A recent DC build-out shows 93% of data canter horizontal cables are <= 45 to 55 meters. Another build-out shows 83% less than 45 meters and 94 % less than 55 meters.
- 2003 Data Center cabling by category (actual data for this year):
  - Cat 5 0 %
  - Cat 5e 35 %
  - Cat 6 65 %
- A lot of recent cabling install data was shared with the 10GBASE-T committee. These are actual installs, no projections. Luc asked for 2006 data on cabling, Chris said the data he showed was actual installed cabling and that's why it only shows data up to this year, 2003.
- The table below shows year-by-year cable install percentages by cable type, these are not cumulative percentages, rather percentages for each particular year. Notice that Cat 5e is still being installed in sizable percentages of DC's even in this current year and that the shift to Cat 6 is evident.

Category	1999	2000	2001	2002	2003
Category 5	10.00	1.67	0.33	0.33	0.33
Category 5e	66.67	60.00	55.00	46.67	35.00
Category 6	23.33	38.33	44.67	53.00	64.67

- Next in the table below we see reporting on a mixture of DC types, i.e. government, corporate and internet DC's. For each DC the size of the DC is recorded in square footage and the length of the cables installed. Some conclusions to draw here are that the bulk of cable installs are lengths less than 45

meters, i.e. 92.9% fit within the 45-meter length or shorter. This data is consistent with the data presented by Michael Bennett.

Data Center Type	Data Center Size (sq ft)	0-30 m	31-45 m	46-55m	56-75m	76-100m
Corporate	5000	100%	0%	0%	0%	0%
Corporate	8000	90%	10%	0%	0%	0%
Govt	10000	70%	20%	10%	0%	0%
Corporate	20000	70%	25%	5%	0%	0%
Corporate	20000	90%	9%	1%	0%	0%
Internet	40000	60%	35%	5%	0%	0%
Corporate	45000	65%	25%	8%	1%	1%
Internet	60000	35%	48%	15%	1%	1%
Internet	60000	55%	35%	8%	1%	1%
Internet	80000	55%	35%	8%	1%	1%
Internet	100000	55%	35%	8%	1%	1%
Average		67.7%	25.2%	6.2%	0.5%	0.5%

Source: Jonathan Jew, J&M Consultants, Co-chair TR42.1.1- Data Center Standard

8. Feasibility of Augmented Cat 6 UTP Cable Supporting 100m 10GBASE-T Channels (Bernie Hammond)

- This presentation reported on a lot of ANEXT testing that occurred since the last IEEE meeting. Seven unshielded "UTP" cables were tested for a variety of cabling parameters. Each test was a 6 around 1 configuration with the victim cable in the middle of the bundle. The measurements were correlated with independent measurements taken at SolarFlare.
- Based on a target Shannon capacity of 18 Gbit, 100m channels on improved UTP cabling are feasible w/o alien crosstalk mitigation.
- Data presented was on the metal conduit. Also shielded connectors otherwise there is a 7-10 dB hit. Used 2-connectors in the test set-up, no cross-connect used.
- Looks like shielded connectors are going to be needed.
- Some comments and questions that came in at the end of this pitch:
  - All the test data can be made available.
  - The gauge of the cabling is 23AWG.

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

- This is an update pitch on enhancing the capability of the installed base of Class E (Cat 6) cabling for 100-meter link lengths at 10G operation using a simple mitigation patch cord.
- How do these patch cords mitigate ANEXT? The claim is that three aspects of the patch cord which allow it to mitigate the effects of ANEXT, they are patch cord length, separation and loss. All these have the effect of changes the transfer function of the cabling channel, adding insertion loss.
- The change in transfer function as a result of the simple patch cord alters the signal-to-noise (SNR) is a positive way such that the usable cabling channel BW increased.

- These patch cords can either be shielded or non-shielded.
- A 15 or 3 meter shielded patch cord can remove the cross talk equally well.
- Multiple patch cords are needed, on both the transmitting and receiving ends of the channel.
- Cable separation can also be used as a mitigation technique.
- Val the mechanics of this mitigation cord, length, UTP or ScTP, gauge size. The end user needs to be more aware of what size cord is required; they could end up with a single length but haven't reached that point yet. It was a screened cable. This could be a 26 AWG stranded cable.
- The data for this testing will be made available.
- How would a field person know when to use this patch cord, what lengths, etc. First one might measure their installed cable, and then this could determine the length of the cord. You want to maximize the insertion loss out to the limit.
- The plan now is to gain support from the 10GBASE-T PHY vendors that these mitigation techniques are valid and worth investing time on. If that turns out to be the case then these cabling vendors will that the patch cord concepts to both TIA and ISO for further development and standardization. This could turn out to be another spec the 10GBASE-T committee would need to "wait" for to be in a position to close it's standards effort by 2006.

10. Transmission Strategies for 10GBASE-T over Category 5e and 6 Copper Wiring (Mohsen Kavehrad)

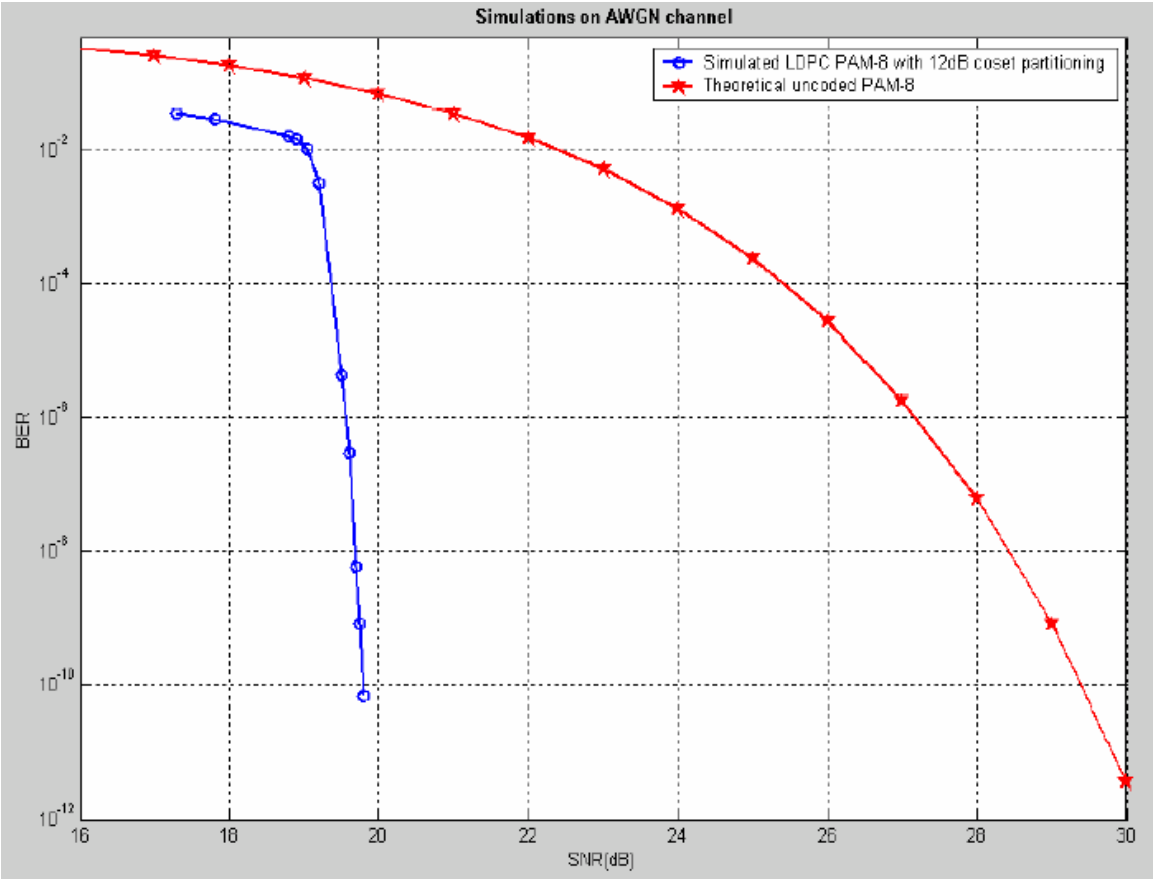
- This analysis from Penn State Department of Electrical Engineering shows 10G operation over Cat 6 cabling is possible at a bit error rate of 10EE-12 using recent ANEXT measurements. However these effects of ANEXT will limit the supported distance over Cat 5e to 55 meters or less. The recent focus within the study group and externally at 10GBASE-T companies has demonstrated the importance of getting a handle on the ANEXT specifications for 10G operation as soon as possible.
- There are huge amounts of differences in the ANEX modeling currently being used in the industry.

11. The 4D-PAM8 Proposal for 10GBASE-T (Sailesh Rao)

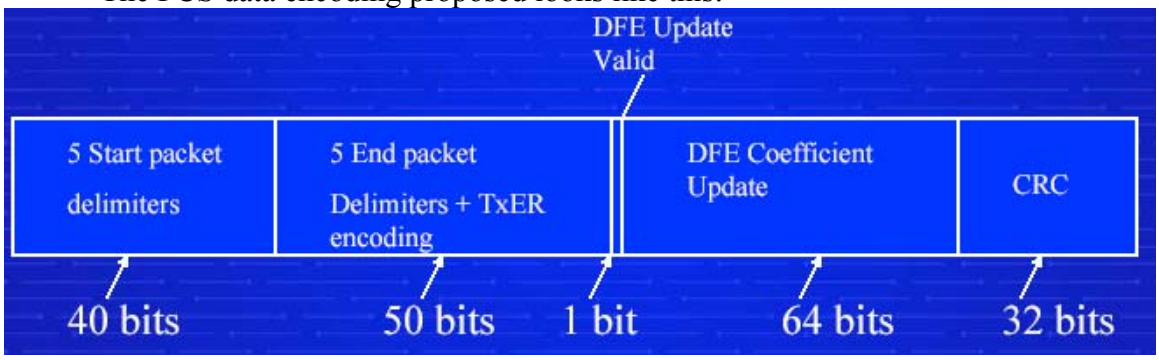
- Sailesh and two others from Intel developed this material presented. Much of this material is a repeat of what was presented at the 10GBASE-T Tutorial this week.
- The goals of this presentation were to touch on a review of the 10GBASE-T coding proposals to date, discuss noise budgets and coding gains as well as some specifics on the Tomlinson Harashima pre coding techniques because Sailesh thinks they can be applied to 10GBASE-T.
- Several 10GBASE-T PAM proposals have come forward to date. They all propose using the 1000BASE-T PCS signaling and 4D Trellis coding techniques, they are:
    - Cicada 625MHz PAM-20
    - SolarFlare 833MHz PAM-10

- Plato Labs 1,250MHz PAM-5

- Sailesh feels that the coding gain of all the proposals on the table today need to be improved to have better noise immunity.
- Since full duplex operation is the only mode 10GBASE-T shall support and the reason for 1000BASE-T using the 4D Trellis coding was for half-duplex support Sailesh thinks that different coding technique could be used especially since the 4D Trellis code shows a weak BER reduction as a function of receiver SNR.
- The folks at Intel in Sailesh's area felt that the Tomlinson Harashima pre coding techniques are worth investigating further and to apply this to the 10GBASE-T project especially since
- A fairly recently published code, July 2003 shall be leveraged by Intel's work on 10GBASE-T coding. Some properties of the code are:
  - Girth of the Tanner graph = 6
  - Degree of each variable node in Tanner graph = 6
  - Degree of each check node in Tanner graph = 32
  - Hamming distance of the code = 8
  - Minimum Euclidean distance between 4D PAM-8 code words >= 16
  - Euclidean distance between points in each co-set is 16
  - Therefore coding gain over un-coded PAM-8 is 12 dB
- A simulation of the theoretical uncoded PAM08 (red line) 'vs' this new code shows some remarkable results in the BER to SNR ratio. Check out the graph below.



- The Tomlinson Harashima pre coding if used would reduces the complexity of the receiver analog front end, however one drawback is that it would increase the complexity of the transmitter.
- The PCS data encoding proposed looks like this:



- The presenter feels that this code will allow operation of 10G over 100 meters of Cat 6 cabling considering worst case cabling.
- What was the baud rate = 1 Gbaud/sec.
- The 833 rate would go up to 1G for this scheme.
- What is the advantage of including '0' or not including '0' in the coding levels? The presenter doesn't see a value using '0' for this coding scheme.
- More details will be disclosed at the next meeting.
- Speak to the complexity of the decoder – this is done at a block level.
- The above questions came in from Plato Labs, Mysticom, Broadcom, TI, Avaya,

12. PAR 5 Criteria and Objectives Feedback (Brad Booth)

- During the past couple of months feedback from various 802.x members has been compiled. The feedback was received on our PAR and 5 Criteria only, no feedback of the current Objectives. The scope needs better focus.
- With regards to Compatibility we need to address 802.1D.
- Any changes we make as a result of these PAR & 5 Criteria comments will require a motion on Thursday for adoption then present the changes to 802.3 and 802 SEC.
- These modifications to the project documents would be limited to the few comments received from the Sponsored Executive Committee. The proposal from Geoff Thompson on Scope was selected; here the words "structure cabling" were added for additional clarification of scope.
- Jeff Warren prepared and made a number of motions for the changes necessary to address Geoff & Tony's suggested modifications.
  - Geoff's scope
  - Tony's 802.1
- Howard requested technical feasibility shown during WG Balloting but the SG did not want to sign up for this challenge.
- An attempt to make a technical feasibility change failed.
- Chris DiMinico will host a liaison (TIA & ISO) letter response meeting tomorrow at 10am.