X3T9.2/88-75

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TO: X3T9.3 Fiber Optic Study Group Members

FROM: Roger Cummings

SUBJECT: FIBER OPTIC STUDY GROUP MINUTES

Please find attached a draft of the minutes of the Fiber Optic Study Group that met in Sunnyvale, CA. on June 2 and 3, 1988. Note that there are also eight Attachments to the minutes (slides presented at the meeting).

If there are any corrections required or omissions noted I can be reached as follows:

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Note that the date and location of the next Fiber Optic Study Group meeting will be decided at the plenary in Milpitas, CA on June 20 and 21.

Regards

Roger Cummings

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FIBER OPTIC WORKING GROUP MINUTES

A study group was convened on June 2 and 3 to work on the definition of a Fiber Optic physical interface for the Intelligent Peripheral Interface (IPI). The group met under the auspices of a project proposal (SD3) that is pending at the X3T9 committee of the American National Standards Institute (ANSI).

The meeting was called by Dal Allan of ENDL Consulting and hosted by Jayshree Ullal and Jim Kubinec of Advanced Micro devices (AMD). It was held at the Holiday Inn, 1217 Wildwood Way, Sunnyvale CA.

A total of thirty-four people attended, as follows:

ADAPTEC	Robert N Snively
AMD	John Jaeger
	Jim Kubinec
	Paul Scott
	Rudy Sterner
AMP	Charles Brill
	Glenn Moore
AT&T	Reinhard H Knerr
	James E Morris
	Ruben Travieso
AVANTEK	Gary LaBelle
BT&D TECHNOLOGIES	John Lowell
CANSTAR	Karl Lue Shing
CDC	Wayne Sanderson
CDC CANADA	Roger Cummings
DATA GENERAL	Scott Solomon
ENDL	I Dal Allan
FUJITSU AMERICA	Bob Driscal
	Jim Luttrull
GAZELLE MICROCIRCUITS	Chris Popat
GIGABIT LOGIC	John H. Kemps
HEWLETT PACKARD	Del Hanson
	Steve Joiner
	Issac Ohel
IBM	Gerry Heiling
	Horst L Truestedt
INTEGRATED PHOTONICS	Michael Pugh
LOCKHEED	John Van Saders
LOS ALAMOS NATIONAL LAB	Don Tolmie
LYTEL	Pat Clarke
MMD	Paul Ralston
NCR	John Lohmeyer
POTTER & BRUMFIELD/SIEMENS	Schelto Van Doorn
RAYCOM SYSTEMS	Mas Nakamori
UNISYS	Robert L Bergey
	Peter Dougherty

The meeting began with Dal Allan reviewing the contents of the proposed SD3 and a proposed agenda. Dal's document is Attachment 1.

Dal emphasized that the proposal was concerned with a channel, i.e. a "closed" system rather than an network that followed the Open Systems Interconnect (OSI) model. He also noted that he knew of two existing fiber optic channels - one produced by Hewlett Packard (HP) and the other by International Computers Ltd. (ICL) in England. It was agreed that presentations on these channels would be solicited for future study group meetings. The work being done by Protocol Engines on defining hardware for layers 3 and 4 of the OSI model was also referenced as having some channel-type protocols that might be relevant.

It was also generally agreed that the scope of the SD3 should be expanded beyond IPI to include support for the Small Computer System Interface (SCSI) command set and the yet to be defined higher protocol layers of the High Speed Channel (HSC).

Dal then solicited from all attendees their reasons for attending the group. The replies were simply classified as follows:

a) Semiconductor companies looking for an opportunity to provide high performance silicon to handle most of the Physical Interface.

b) Fiber-optic component manufacturers looking to bring their mostly telecom expertise to the channel definition.

c) Existing IPI and SCSI implementors looking to extend the distance over which their channels operate.

d) Other systems companies who are interested in a fiber optic interface for reasons of noise immunity etc.

As a result of the comments fault tolerance was added to the list of functional requirements identified in Dal's agenda (Page 2 of Attachment 1).

John Lowell of BT&D (British Telecom and Dupont) then made a comprehensive presentation detailing the available types of laser and led emitters, and pin and avalanche diode detectors. Some of the components described were unmounted, some were enclosed in a module and yet others were complete transmitters and receivers. He also described integrated optical devices such as Mach-Zenhnder switches, multi-port couplers and wavelength division multiplexors. For each device type John described the construction and listed the characteristics and advantages. John concluded his presentation with a predicted "Optical Ether" configuration consisting of multiple devices operating at different frequencies interconnected by an n-way passive coupler.
Because of space (and weight) considerations all of John's slides cannot be attached. However data sheets for some devices are included as Attachment 2.

The following are notes on John's presentation:

1) He classified requirements for less than 2 Km as "datacom" with longer distances being "telecom" requirements.

2) The "Logic to Light" type packages are presently aimed at telecom applications i.e. dual voltage rails, single mode fiber, high power into cable, wide operating enviroment. A datacom application would probably be single rail and use a multimode fiber.

3) The preferred transmitter process in Metal Organic Vapor Phase Epitaxy (MOVPE) because of its stability and good yield. Molecular beam epitaxy is a promising research process.

4) The threshold of all lasers moves with time and thus all packages incorporate a monitor photodiode to allow the drive current to be adjusted as necessary. Temperature compensation is also important with some packages incorporating a Peltier Thermoelectric Device (TED). However some problems were described with the TEDs and it appears that they are becoming less common as the manufacturing process is developed.

5) Work is known to be being done in Japan on integrated Gallium Arsenide transmitters for 850 nm. No commercial product is expected for five years however.

6) The learning curve of many of the processes used for fiber optic components is not well defined and therefore long term quantity pricing is uncertain.

7) Clock extraction in the receiver would probably be done by a PLL or SAW device for datacom.

8) Integrated optical devices are expensive with a wavelength division multiplexer typically costing $3K. At present they are mostly sold into research labs.

Schelto van Doorn of Potter and Brumfield then presented a parallel/serial converter that had been developed by Siemens for a specialized medical application. This is an 100K ECL chip contained in a 128 pin grid array package which provides a full duplex interface at speeds up to 200 MBaud. It uses an 18/22 encode/decode scheme (the completely balanced interval was not known) and incorporates a scrambling facility. It has a 16 bit data path with two additional user-defined bits which can be used to synchronize multiple chips or carry parity. A single unit cost of $550 was quoted. Schelto's slides are Attachment 3.

P&B also have available a single eurocard sized evaluation board which use the parallel/serial converter and includes transmitters and receivers to form a complete interface to a point to point fiber optic link. A block diagram and layout diagram of this board are Attachment 4.

Reinhard Knerr of AT&T then gave a short presentation on some of the difficulties that can be encountered in multiplexing multiple links on to a single fiber. He stated that the couplers at each end are required to have very high directivity to avoid self-triggering of the receiver and contribute 4 dB loss each. Reflections from inline connectors were also identified as a cause of false signals at the receiver. He believed that such reflections were typically -20 dB but Glenn Moore of AMP believed that -40 dB was feasible. Reinhard also described an AT&T product which was designed to extend the operating distance of an RS232 interface. It used an led as both transmitter and receiver, and avoided some of the above problems by operating in half duplex (i.e. TDM between each end). It also performed self-calibration at startup.

Dal Allan then presented an interpretation of industry trends as they effect interfaces and particularly storage interfaces. His conclusions were that the trend is towards greater functional integration into the peripheral, that cost is the primary factor and that transfer rate is also a factor because of ganged disk arrays. He noted that the widening of the spectrum of systems that incorporate SCSI is an indication of the importance of the cost factor.

Dal then described how fiber optics could be integrated into an IBM architecture mass storage configuration. He demonstrated that the easiest point of integration was at the interface to the head of string controller. He also described the difficulties of porting low-level, timing-dependent protcols such as Level 2 IPI to a fiber implementation because of their necessarily close integration with the physical transmission media.

The first day of the meeting then closed with the compilation of a list of parameters for further consideration and an attempt to identify values for each parameter. The result was as follows:

SPEED	5, 10, 50, 200 Megabytes/s
DISTANCE	> 50m, < 2 Km, > 2 Km
PERFORMANCE	
Station Delay	(5-8 bits for FDDI)
Overhead	
Throughtput/Latency	
Error Rate	10^{-9} detected, 10^{-16} undetected
Burst Size	32, 1K, 2K, 4K, 32 K bytes
POWER CONTROL	Standby/Power sequencing
APPLICATION	
Number of Nodes	2, 32
Protocol	ECC/Bursts (EDAC vs CRC)
ENVIRONMENTS	
"Weather"	0 - 65 degrees C typical
	10 - 95 % humidity non-condensing
Power	5 V + or - 10% at less than 1 A
Shock	Bend radius
	MTBF of connect 200K Hrs min
	1000+ insertions for 0.5 dB loss
Workstation	
Mainframe	
FAULT TOLERANCE	
Redundant Paths	
Passive Paths	
FOOTPRINT	No greater than existing Cu scheme
CONNECTOR	Pigtail or Ribbon

During the above discussions Jim Morris of AT&T noted that there are good reasons why the Bit Error Rate (BER) of the link be specified at 10^{-9}. He displayed two graphs to illustrate this - one plotting BER versus Time and the other plotting BER versus Average Optical Power on a quasi-logarithmic grid. Jim's slides are Attachment 5.

The second day of the meeting began with tutorials on the various ANSI interfaces that had been requested by the attenders new to ANSI working groups. The SCSI and IPI tutorials were presented by John Lohmeyer and Dal Allan respectively using slides previously created by Bill Burr of the National Bureau of Standards. These slides are Attachment 6 (note that Bill's complete package (with FDDI) is included for reference).

It was noted during the tutorials that in these applications, unlike the telecom ones, replacing cables is not a serious concern as they are not installed in a plenum or underground. However the ability to terminate the cables in the field is a concern. It was stated that single fiber cables can be field-terminated by a special technician using special tools with considerable effort, but that multiple-fiber cables are too dificult.

Michael Pugh of Integrated Photonics then presented their Toplinc product. This is a complete full duplex link with parallel digital interfaces, which operates at up to 2.4 GBits/s and is conservatively defined as operating over 1 Km of multimode fiber. It uses a separate fiber for each direction and operates in the 800 nm region. Mike noted that Toplinc is a "closed" system in which the coding is closely matched to the fiber characteristics. A data sheet for Toplinc is Attachment 7. Mike estimated the total cost for a 25 Mword (8 or 16 bits with parity) to be $2K per end.

Don Tolmie then gave a brief introduction to the High Speed Channel (HSC). He noted that there is no project currently working on a full duplex datalink protocol for HSC, but one is expected to commence in the fall of 1988. Don's slides are Attachment 8.

Dal Allan then lead an attempt to further refine the parameter values previously identified with the intent of forming the basis of the functional requirements for new Physical Interfaces. The results were presented on three separate sheets titled Market, Technology and Cost as follows:

MARKET

The requirements are:

a) Greater then 10 MB/s over a distance of greater than 500 meters and less than 2 Kilometers.

b) Less than 10 MB/s over a distance of less than 100 meters.

c) Greater than 100 MB/s over a distance of less than 500 meters.

TECHNOLOGY

The capability of the various technologies were stated to be as follows:

FIBER TYPE	PROP MODE	TRANSMITTER TYPE	WAVELENGTHS (nm)	FREQUENCY DIST PROD (GHz.KM)	DIST LIMIT (KM)
Plastic	Mult	Surface LED	620	0.0005	0.1
Glass	Mult	Surface LED	800	0.5	5.0
		Laser	1300,1500	1.0	10
	Single	Laser	1300,1500	10	25

Notes:

1) Silica was also mentioned as a fiber material but no parameters were known.

2) Edge-emitting leds were classified as "failied lasers" and ignored

3) Coherent mode was recognized but was regarded as only being at the research stage

4) The parameters for the plastic fiber are more easily stated as 0.5 MHz.KM with a 100 meter distance limit (10 meters is more practical).

COST

The costs for the various types of system were determined to be as follows:

SPEED (MB/s)	DISTANCE (KM)	PRESENT COST [3Q88] ($)	DESIGN-IN COST [3Q90] ($)	PROD VOL IN 1992 (1000s)
50	1	<= 4K	< 1K	50
12.5	2	<= 2K	< 600	200
50	>10	<= 6K	< 2K	25
125	>10	<= 10K	<= 5-20K	< 0.1
1	<.05		<= 25	1000

Notes:

1) The Present and Design-In costs are for a complete 500 meter full-duplex link (1 KM fiber, all transmitters, receivers and connectors) at quantity of 250 assuming the production volume shown will be shipped in 1992.

2) The 50 MB/s, >10 KM link assumes single mode.

3) The 125 MB/s link is not yet in product but is thought to be feasible. The costs do not include the sizable non-recurring element that will be necessary.

The meeting then closed with a review of action items. These were as follows:

1) Make available some of AMP's internal fiber-optic training information to the Group. Action to Glenn Moore of AMP.

2) Orgainize a presentation of the Hewlett-Packard fiber-optic link to the Group. Action to Del Hanson of HP.

3) Organize a presentation to the Group of the AT&T parallel fiber cable and the MAC connector. Action to Jim Morris of AT&T.

4) Organize a presentation to the Group of DQDB (the physical level of the IEEE 802.6 network).

5) Organize a presentation to the Group of SONET.

6) Contact ICL to arrange a presentation of their fiber-optic link to the Group.

There was some discussion of the site for the next study group. The preference was for August 11 and 12 (i.e. the Thursday and Friday before the August X3T9 plenary week) at a location either in Denver or to the west of it. It was agreed that final arrangement would be made at the plenary in Milpitas, CA on June 20 and 21.