**VISIT Deliverable Report Cover Sheet**

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<tr>
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<td>Deliverable number</td>
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<td>Assessment II of IEEE standard definition</td>
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**Deliverable description and summary of achieved results (max. 2400 char.):**

The enclosed Deliverable D5.3 Report is an assessment of the current on-going and future planned Standards activities that are relevant to the systems technology under development within the EC-funded FP7 VISIT project. The purpose of this assessment is multi-fold, and in particular aims to ensure that the technology developed in VISIT meets or exceeds the relevant Standards and is thus able to result in EU-based competitive manufactured goods while at the same time assessing the VISIT consortium’s ability to influence the specific technical content of these same Standards.

While the focus is on IEEE-directed Standards for optical data transfer such as the IEEE 802.3ba 40G and 100G Ethernet Standard, this assessment includes overviews and relevant comments on several other Standards activities including electrical and optical interfaces for: 16G and 32G Fibre Channel, 26G per lane Infiniband, Peripheral Component Interconnect Express (PCIe) from 8G to 32G, and general consumer interfaces such as the HDMI standards for home tele-video distribution from 3.4G to 21G, and the Universal System Bus USB at 4.8G and faster.

Several Standards bodies are completing and certifying new standards in the June to September 2010 timeframe. One example is the IEEE 802.2ba 40/100G Ethernet Standard due for certification and publication by Fall 2010. For this reason this version of Deliverable D5.3 serves as a draft document and we will submit a final D5.3 document by 30 September 2010 that includes all the most recent standards decisions and final published specifications.

**Contributors:**

VIS
VISIT Deliverable Report Technical Annex

Deliverable number: D5.3
Deliverable name: Assessment II of IEEE standard definition

In this report we include the following:

1. The current status of the various key Standards related to the technology under development in the VISIT project including the purpose, timeline, and expected market applications of these Standards;
2. A brief review of VI Systems’ involvement and role in these standards; and
3. A brief assessment of the significance of recent selected Standards’ events.

This first document is a draft and will be updated with several significant Standards specifications and events that are due to be completed during the summer 2010.
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1. INTRODUCTION

1.1 VIS STANDARDIZATION ACTIVITIES

Ethernet

Within the present period VIS was actively involved into the standardization activities. VIS was invited to present at the Ethernet Alliance Technology Forum (15th of September, Santa Clara, CA) and made a presentation “40GbE/100GbE over duplex MMF for Data Centers”.

Figure 1: Presentation at the Ethernet Alliance Technology Forum.

At the meeting VIS continued advocating applicability of high serial bit rate over multimode fiber to meet the growing demand, particularly the bottlenecks in the structured cabling MMF solutions, which do not match the “ribbon” solution and the bandwidth density bottleneck, which evolved with parallel 10Gb/s standards. See Figure 2.
Motivation for MMF high serial speed

- Installed single duplex MMF base in LAN and Datacenter
  - HSSG PAR A “Purpose: ...maximum compatibility with the installed base ... and principles of network operation and management” (agenda_01_0307.pdf)
- Structured Cabling:
  - ceilings, walls,...
  - no Structured Cabling installed (or standardized) with fiber ribbon for parallel optics
- >>10 Gb/s Serial Copper Signaling Standards:
  - 17 Gb/s FC (2009);
  - 34 Gb/s FC (2012)
  - 20 Gb/s Infiniband (2011)
  - 28 Gbaud OIF interface (CEI-28G) for next generation chip-to-chip and chip-to-module applications
- 10 Gb/s parallel optical signaling is not compatible with key electrical interfaces to come. “Serial” optics is a must in any case.

Figure 2: Scaling of the price per transistor and the bandwidth growth of the processor per generation leverage the problem of interconnects.

Optical Interconnect Forum

VIS participated at the OIF CEI Workshop in Cupertino, CA, on 02 February 2010.

Fibre Channel


Computecon

VIS attended the Comutercon Symposium at OFC-2010, San Diego 2010.


30 May 2010
1.2 GENERAL TRENDS

As it will be clear from the following discussions the understanding of VIS on the need of high speed serial data transmission over multimode fiber was fully correct. The second generation of 40/100G Ethernet standards will be addressing serial bit rates of 25, 28 and 40 Gb/s with 25-28 Gb/s solutions targeted for multimode fiber taking an advantage of electronics already demonstrated for 25Gx4 long reach (10 km 100G Ethernet standard) and 40 Gb/s.

The 10 Gb/s parallel solutions do not satisfy the port bandwidth density of line cards. Some of the statements made at IEEE 802.3ba meetings just 1.5 years ago that 10 Gb/s parallel standard will stay for a long time of about 10 years failed. Similarly, at the present stage the fast evolution of 40 Gb/s NRZ long reach (2-10 km) solution over single mode fiber (1.3 µm or 1.55 µm) creates a basis for 40 Gb/s serial solution. Electronics (SerDes) with low power consumption matching QSFP module requirements (assuming VIS TIA and driver ICs are applied) is already developed. This solution will serve as the basis for future 40Gb/s serial transmission over multimode fiber, while the electronics developed will support development of a new generation of electrical interfaces (possibly CEI-50).

According to the general trends in datacenters (reduction of the total space) the characteristic optical link distance covering >90% of all the links will continue to shrink relaxing the 100 m length requirement for 40Gb/s transmission within the first generation.

As is clear from the following discussion the major markets expected for VCSEL-based multimode fiber links are:

- Infiniband (25Gb/sx4), expected beginning 2011
- Fibre Channel 34G FC with 28 Gbaud (28 Gb/s I/O) (the timeframe is under discussion)
- Ethernet 25Gb/sx4 (within about a year)

Furthermore a single mode 40 Gb/s serial solution for 40G Ethernet is expected the beginning of 2011 and will open the way for “out of standard” MMF solutions (if optical components and matching ICs are available) as openly discussed by system vendors.

1.3 COMPUTING SYSTEMS

It was broadly announced at OFC 2010 by IBM that the coming Power7 10 Petaflops system will have 850 nm VCSEL based optical links at multiple levels and will consume 420 thousand of optical modules. Prototypes of the boxes were demonstrated (Avago-IBM booth). The next generation systems will be 30 May 2010.
also based on VCSEL arrays running at 25Gb/s (25Gx24 channels) and will consume 2.5 million optical modules each and 20000 kilometers of multimode fiber. The prototypes of the subsystems were demonstrated (IBM-Emcore). It was also stated that silicon photonics must speed up to be ready for the next serial bit rate, which, most probably, will be realized with VCSELs.
2. **CEI-25/CEI-28**

There are two types of electrical interfaces being standardized. CEI-25 is a longer reach version and it goes through 2 lanes with MUX/DEMUX SerDes up to 1 m.

Short reach CEI-28 28 Gb/s goes thorough two lanes over 10 cm distance (chip-to-everything). One notes that once CEI-28 becomes the dominant electrical interface the role of copper links except of some on-board links will be reduced to marginal.

Electrical transmission is realized in NRZ coding as presented in **Figure 3**.

### Signaling Conclusions

◆ **Multi-level signaling will not produce better results because it is already part of the potential solution space for equalized NRZ.**

◆ **OIF selection of equalized NRZ signaling for CEI-25 was partially based on this conclusion. Additionally:**
  - **No contributions were received which demonstrated advantage to any other signaling scheme over a range of channels.**
  - **Contributions which were received demonstrated that equalized NRZ performed equivalent or better than alternatives.**

*Figure 3*: OIF CEI-25 Workshop. CEI Signaling. David R Stauffer, Ph.D., IBM Senior Technical Staff Member OIF Physical & Link Layer WG Chair February 1, 2010

CEI-25G Channel attenuation limit at 0.686 m is presented in **Figure 4**
Figure 4: CEI-25LR / CEI-28SR Channel Models, Joel Goergen – VP and Chief Scientist, Review of channel models used in CEI-25LR and CEI-28SR interface specifications for 25Gbps, CEI Workshop, February 2010
3. **ETHERNET**

Presently the 100G Ethernet standard will be finalized in June 2010 and the work on amendments has started.

In the present standard the following key solutions are foreseen:

1. 10 Gb/s channel speed
2. 40G and 100G transmission via copper cable assembly (x4, 10) up to 7 m
3. 40G and 100G via multimode fiber ribbon links and 10Gb/s 850 nm VCSELs

For longer reach transmission 1300 nm 10Gb/s edge emitting layers are to be used (10G, 100G).

25 Gb/s x 4 transmission using 1300 nm edge emitting lasers is also standardized.

### 3.1 25 Gb/s INTERFACES

As the face plate bandwidth must match 1 Tb/s by 2012 and this is impossible with the existing solutions, further standardization work is launched by the Ethernet Technology Alliance Forum and IEEE.

The need in increased I/O serial bit rate for Ethernet applications is explained in the following slide *(Figure 5).*

*Figure 5: Equalization, Power, and Channel Requirements for 100GbE, Ali Ghiasi, Broadcom Corporation Feb 1, 2010*
The potential of CEI-25G-LR and CEI-28G-SR for 100GbE define the roadmap for 25 Gb/s-related copper interfaces as shown in Figure 6.

**Figure 6**: John D’Ambrosia, Chair, IEEE P802.3ba 40Gb/s and 100Gb/s Ethernet Task Force, Director, Ethernet Based Standards, CTO Office, Force10 Networks February 1, 2010 “How could 25 Gb/s electrical signaling be applied to current family of 100GbE physical layer specifications?”

In his report “Channel discussion” Adam Healey, LSI Corporation, OIF CEI Workshop, Cupertino, CA, February 2, 2010 concluded that the CEI-28G-SR draft has become a subject of interest for a second generation 100 Gb/s Ethernet chip-to-module interface – 4 lanes at 25.78125 GBaud/lane. He mentioned that a closer inspection of the CEI-28G-SR draft reveals areas that could be brought into better alignment with chip-to-module prior art.
The connector exerts a significant influence over the performance of the channel:

- It is a focal point for crosstalk noise coupling
- Impedance discontinuities and related resonance structures are reflected in the insertion loss deviation
- Connector impedance is not well isolated from the test point due to the low insertion loss of the compliance board and is a dominant term in return loss.

The tasks for the new Ethernet standards are commonly agreed as being at 27 Gb/s (Figure 7).

**Double or Nothing!**

- FC has done well by doubling the speed
  - 16GFC should complete by June and work on 32GFC has just begun
- Ethernet has finally quadrupled their speed to 40GE
  - But the electrical lanes are still at 10 Gbps
- Nice convergence on 25-28Gbps electrical speeds for FC, Ethernet and telecom
  - 2.5X speed of backplane is better than doubling the port count

<table>
<thead>
<tr>
<th>New Backplane Speeds</th>
<th>Line Rate / Throughput (Gbps)</th>
<th>BW / Blade (Gbps) w/ 32 channels</th>
<th>Chassis BW (Gbps)</th>
<th>100 Gbps Ports / chassis</th>
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<td>4X25GE in a few years</td>
<td>25.78 / 25</td>
<td>800</td>
<td>6400</td>
<td>64</td>
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<tr>
<td>32GFC in a few years</td>
<td>28.05 / 27.2</td>
<td>870</td>
<td>6963</td>
<td>70</td>
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**Figure 7**: High Density Backplanes for Modular Switches, Scott Kipp, Standards, Technology and Architecture Group, Brocade

Next generation of 100G Ethernet standards applied to multimode fiber are in general confirmed by transceiver vendors and represent a consolidated opinion of the industry (Figure 8). For multimode fiber this is the SR4 interface at 25Gb/s x 4 which should match the QSFP module.
At present a Call for Interest (CFI) is proposed by the IEEE 100G Ethernet group to standardize 25 Gb/s electrical interfaces and MMF optical interfaces. Without low cost extension of the length electrical interfaces can’t solve the bandwidth problem. The CFI was initially proposed for July 2010. However, it was delayed by the group with multiple members worrying about the delay “1. Is the technology sufficiently mature and the need sufficiently large to garner support for a study group in November? 2. How is the market development of 100G impacted by the November 2010 vs. July 2011 timing of a CFI? “. A definite answer of transceiver manufacturers were requested.” The answer of the transceiver manufacturers was: “For point 1, the technology required for a 4x25G solution for 100G SR is not sufficiently mature to be able to make sensible spec choices; I don’t think that will have changed significantly by November this year” (end of June 2010). This clearly indicates that low cost optical components are indeed urgently as the key building block for the coming Ethernet systems of the near future. The system deployment is dramatically affected by the delay in optical components and a dramatic under-investment in this field during the “post-telecom-bubble” decade.

Figure 8: 100GE Roadmap, OIF CEI Workshop, Chris Cole, Finisar 1 February 2010.
3.2 40 Gb/s interfaces

The Ethernet Alliance and IEEE launched a group for the development of 40 Gb/s serial transmission over single mode fiber. Even this initiative is aimed at single mode solutions it has an immense effect on the perspectives of short-reach solutions as the basic electronics (multiplexers, demultiplexers) becomes available. Presently, the power budget of VSR2000-3R2 transceiver are considered as the basis (*Figure 9, Figure 10*). The wavelength chosen is in the 1530-1565 nm range with the receiver and optical fiber wavelength range standardized at both 1300 nm and at 1550 nm wavelength ranges. The latter aspect allows one to add 1300 nm wavelength without a major change of the standard.

### VSR2000-3R2 budget

<table>
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<th>Unit</th>
<th>Value</th>
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<tbody>
<tr>
<td>Format</td>
<td>-</td>
<td>40G NRZ</td>
</tr>
<tr>
<td>Wavelength range</td>
<td>nm</td>
<td>1530 to 1565</td>
</tr>
<tr>
<td>Max mean Tx output power</td>
<td>dBm</td>
<td>+3</td>
</tr>
<tr>
<td>Min mean Tx output power</td>
<td>dBm</td>
<td>0</td>
</tr>
<tr>
<td>Min side mode suppression ratio</td>
<td>dB</td>
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<tr>
<td>Min extinction ratio</td>
<td>dB</td>
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<tr>
<td>Eye mask</td>
<td>-</td>
<td>See next slide</td>
</tr>
<tr>
<td>Max path attenuation</td>
<td>dB</td>
<td>4</td>
</tr>
<tr>
<td>Min path attenuation</td>
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<td>0</td>
</tr>
<tr>
<td>Max chromatic dispersion at 1565 nm</td>
<td>ps/nm</td>
<td>38</td>
</tr>
<tr>
<td>Max chromatic dispersion at 1530 nm</td>
<td>ps/nm</td>
<td>34</td>
</tr>
<tr>
<td>Max DGD</td>
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<tr>
<td>Max return loss of cable plant at Tx</td>
<td>dB</td>
<td>24</td>
</tr>
<tr>
<td>Max discrete reflection in cable plant</td>
<td>dB</td>
<td>-27</td>
</tr>
<tr>
<td>Receiver sensitivity (1E-12 BER)</td>
<td>dBm</td>
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</tr>
<tr>
<td>Min receiver overload</td>
<td>dBm</td>
<td>+3</td>
</tr>
<tr>
<td>Max optical path penalty</td>
<td>dB</td>
<td>2</td>
</tr>
<tr>
<td>Max reflectance of receiver</td>
<td>dB</td>
<td>-27</td>
</tr>
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*Figure 9: Optical link budget compatibility, Pete Anslow, Nortel, Gary Nicholl, Cisco, 40Gb/s Ethernet SMF PMD SG, New Orleans, January 2010.*

Involvement of 1300 nm wavelength in the transmission was heavily discussed by the Standardization community (see *Figure 10, Figure 11*), however, failed to be included at the present stage.
Wavelength

- The wavelength range of VSR2000-3R2 is 1530 to 1565 nm
- The first version of G.693 had a note requiring it to have:
  - a minimum operating range of 1290 to 1330 nm and 1530 to 1565 nm
- The 2005 revision of G.693 increased the sensitivity requirement of VSR2000-3R2 by 1 dB and the note was revised to:
  - It will also operate in the application code VSR2000-3R1 if its operating wavelength range includes 1290-1330 nm
- Many existing VSR2000-3R2 receivers operate satisfactorily in the 1290-1330 nm range.
- Consequently, the Task Force will need to debate whether operating at 1310 nm provides sufficient compatibility with the installed base and also whether the benefits of 1310 nm (e.g. lower dispersion) outweigh the drawbacks (e.g. test gear issues).

**Figure 10**: Optical link budget compatibility. Pete Anslow, Nortel, Gary Nicholl, Cisco, 40Gb/s Ethernet

Opnext’s presentation addressed technical feasibility of 40Gb/s solution with an emphasis of different link lengths for 1300 nm and 1550 nm solutions.

In spite of multiple advantages (cost, power consumption, and long reach) 1300 nm wavelength was not chosen for the standard for the following reasons:

"Analysis of legacy module manufacturers' data indicated that ~25% of existing carrier 40 Gb/s client interfaces would not be compatible with a 1310 nm solution"

"A failure rate of 25% does not meet normal IEEE performance expectations"

1550 nm wavelength was approved by voting by the IEEE 802.3bg group

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Figure 11: 40 Gb/s Ethernet optimized for client applications in the carrier environment: TECHNICAL FEASIBILITY, Jon Anderson & Matt Traverso – Opnext

The main motivation of choosing the 1550 nm wavelength was that it is “Interoperable with VSR 2000-3R2” while the power budget considerations and an option of advanced 1300 nm solutions (for example 1300 nm GaAs VCSELs) for very low power 2 km links was not considered at this stage.

However, the evolution of the standard and development of 40Gb/s serial interfaces including serializer-deserializer (SerDes) ICs can be extended in the future to 40Gb/s VCSEL links at 850 nm, 1300 nm (Ethernet, Fibre Channel) and 1490 nm (Fibre Channel).

### 3.3 Market evolution

Market potential was estimated for 40G Ethernet SM solutions. Development of the market is expected to proceed in a similar way for LR solutions at 10Gb/s where initially telecom applications dominated with datacom taking over at a later development stage.
Figure 12: Historical growth of 10G unit volume shipments. 40 Gb/s Ethernet optimized for client applications in the carrier environment: BROAD MARKET POTENTIAL Andy Ambrose, Alcatel-Lucent

Figure 13: Projected growth of 40 Gb/s Ethernet modules optimized for client applications in the carrier environment: Andy Ambrose, Alcatel-Lucent
4. **INFINIBAND**

The InfiniBand® Trade Association (IBTA) recently announced an update to its InfiniBand roadmap, showing current and projected link speeds for the technology from 2010 through 2011 and beyond. The roadmap shows 4x EDR ports at 104Gb/s data rate in 2011 (26Gb/s per lane); the IBTA’s previous roadmap, published in June 2008, had projected 4x EDR at less than 80Gb/s data rate in 2011 (Figure 14).

*Figure 14: Infiniband Roadmaps from 2008 (a) and 2010 (b). The actual serial bit speed outperforms that forecasted by the 2008 Roadmap*
The IBTA increased data speeds for 2011 due to the increased demand for higher throughput and to provide the base for next-generation, high-performance and data center interconnect solutions.

The new projected speeds will provide end users with enhanced cost/performance benefits and robust network capabilities to support multi-core processors and accelerators. The roadmap is aimed to continue and define InfiniBand as the performance leader in interconnects, while ensuring end user investment protection.

4.1 INFINIBAND MARKET EVOLUTION

The IBTA unveiled a new naming convention for bandwidth that expands the previously-defined terms – DDR, QDR, EDR and HDR – to include FDR and NDR. FDR (14Gb/s data rate per lane in 2011) was added for midrange enterprise data center solutions that are looking to optimize the cost and power/performance ratio for their communications networks.

The roadmap details 1x, 4x, 8x and 12x EDR and FDR, incorporating 64/66 encoding, with bandwidths reaching 300Gb/s data rate EDR in 2011. The newly defined link speeds are designed to keep the rate of performance increase in line with systems-level performance increases.

For vendors with a stake in the interconnect business, the InfiniBand roadmap provides a vendor-neutral outline for the progression of InfiniBand so that they may plan their product development accordingly. For enterprise and high-performance computing end users, the roadmap provides specific milestones around expected improvements to ensure their InfiniBand investment is protected. The updated roadmap is available on the IBTA website at www.infinibandta.org/technology.

The IBTA also announced today that InfiniBand is the only growing standard interconnect technology on the June 2010 TOP500 list of supercomputers. InfiniBand is connecting 208 systems of the TOP500, or 41.6 percent. This represents a 37 percent increase from the list published one year ago.

InfiniBand is the most prevalent interconnect in the TOP100, TOP200 and TOP300, connecting the most powerful clusters in the world:

- 64 percent of the Top100 (64 systems)
- 56.5 percent of the Top200 (113 systems)
- 47 percent of the Top300 (141 systems)

Additionally, the total number of InfiniBand-connected CPU cores on the TOP500 list has grown 73 percent, from 1.04 million in June 2009 to 1.8 million in June 2010. InfiniBand enables the highest system efficiency and utilization, up to 96 percent.

Published twice a year and publicly available at www.Top500.org, the TOP500 list ranks the world’s most powerful computer systems according to the Linpack benchmark rating system. The TOP500 list is a respected industry report that indicates usage trends in computing and interconnect solutions.
### 4.2 Next Steps in Standardization Beyond 2011

The timeframe for the new standard coming after 26 Gb/s is defined in the new roadmap as 2014. A simple extrapolation ([Figure 15](#)) gives a single channel bit rate around 70 Gb/s and an aggregated bit rates up to 840 Gb/s.

![Figure 15: Infiniband Roadmap extended to the next standard expected by 2014.](#)

Presently the power of supercomputers is increasing 100-fold each 5 years. The first petaflops-class supercomputer (Roadrunner, IBM) was launched in 2008. The first 10 petaflops supercomputers are announced for 2010 (NEC) and for 2011 (Blue Waters) by IBM. As exaflops-scale computers are expected then to appear by ~2016 these should be based on the 2014 Infiniband standard. The copper may not be considered at the expected bit rates as viable solution. Advanced optical interconnects can solve the problem, however, lack of committed investment in the field may slow down and jeopardize the roadmaps. In case the optical components are delayed an immense increase in the power consumption in data centers and high-performance computing may be expected due to the need in active copper cabling solutions to extend the copper link length.

The average data center uses as much electricity as 40,000 homes annually, and data centers represent 3% of all energy use in the U.S., according to Environmental Leader Insights, a subscription research service.⁶

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⁶ [http://www.fastcompany.com/1683653/green-data-center-market-to-more-than-triple-over-next-five-years](http://www.fastcompany.com/1683653/green-data-center-market-to-more-than-triple-over-next-five-years)
The power consumption of the datacenters is continuously growing at an annual rate of about 11 percent a year according to the survey from the Uptime Institute (2010) in spite of all the extreme measures on the energy efficiency undertaken.

### 4.3 Optical Cables

The Infiniband standard addresses electrical interfaces and the optical solutions are to pick up. IBM announced that the next generation of supercomputers to be based on 26 Gb/s 850 nm VCSEL-based optical links. This effectively indicates a solution to be used in the near future.

At present Open Fabric Alliance is working on the specifications of optical interfaces matching the Infiniband 26 Gb/s standard. The optical transceiver manufacturers cooperating within Infiniband are different from those in the Ethernet group. For example IBM is heavily involved in the development of 26 Gb/s per channel links in cooperation with Emcore and Avago, while Ethernet Group is traditionally closely linked to Finisar and JDSU.
5. FIBRE CHANNEL

Fibre Channel is expected to double the existing bit rate of 14 Gb/s and run at 28 Gb/s. The standard is described in the previous Standard Review. At present FC group is heavily involved in the discussion at the FCIA and T11 meetings (see VIS Standardization Activities).

Non OIF Standards requirements

- **Ethernet**
  - Chip to fully retimed CLFP module to support medium density 100G
  - Chip to ‘simple’ QSFP module to support high density 100G

- **Infiniband**
  - 4x25G QSFP or similar direct attach Passive Copper cable
  - Chip to ‘simple’ QSFP or similar module to support 100G
    - Needs to support both direct attach active copper and direct attach active optical cables

- **Fibre Channel**
  - Single lane 28G optical channel
  - Possibly backplane connections

*Figure 16:* The future of 25G I/O Tom Palkert, Member IEEE 802.3ba, Member Infiniband Trade Association, Chair of Fibre Channel T11.2 WG, Former member BOD OIF.
6. CONSUMER INTERFACES

LightPeak technology is broadly described and presented in the media. The USB 3 specification includes a protocol up to 25 Gb/s and one of the USB 3 upgrades (or analogues) will run at 25 Gb/s serial speed. Among the other interfaces is the evolution of HDTV cable standards going beyond 20 Gb/s aggregated bandwidth.

The Video Electronics Standards Association (VESA) disclosed in January 2010 digital communication interface standard for transporting display, audio and other data. VESA’s DisplayPort Version 1.2 is a comprehensive extension to the original DisplayPort standard. Benefits include: double the data rate of the previous DisplayPort v1.1a standard (enabling higher performance 3D stereo displays, higher resolutions and color depths, and fastest refresh rates); multiple monitor support from a desktop or notebook computer using only one DisplayPort connector; the ability to transport USB data between a PC and Display, supporting Display USB functions such as a webcam and USB hub.

DisplayPort v1.2 is backward compatible with existing DisplayPort v1.1a systems, including existing cables and the MiniDisplayPort connector.

DisplayPort v1.2 increases performance by doubling the maximum data transfer rate from 10.8 Gbps (Giga-bits-per-second) to 21.6 Gbps, greatly increasing display resolution, color depths, refresh rates, and multiple display capabilities. DisplayPort v1.2 supports “multi-streaming”—the ability to transport multiple independent uncompressed display and audio streams over a single cable, supporting protected content and high performance applications such as 3D gaming. This enables the use of multiple monitors connected by cable in a daisy chain or hub configuration.

Whereas the current Display v1.1a standard can support one 2560 x 1600 monitor at 60Hz, DisplayPort v1.2 can support two such monitors with one cable, or four 1920 x1200 monitors. Many other combinations are possible, including multiple video sources, multiple displays (even at different resolutions) and multiple audio speakers.

Another new feature is the ability to support high-speed, bi-directional data transfer, allowing USB 2.0 or Ethernet data to be carried within a standard DisplayPort cable. For DisplayPort v1.2, the maximum data rate of this “AUX” channel has been increased from 1 Mbps (Mega-bit-per-second) to 720 Mbps, providing suitable bandwidth for USB 2.0. The DisplayPort cable can therefore support USB data to/from the display to support Display USB functions, in addition to sending the video and audio information. Standard Ethernet can also be transported in the DisplayPort cable.

DisplayPort v1.2 was designed to be compatible with existing DisplayPort systems and cables. To take advantage of the new capabilities, a PC will need to be DisplayPort v1.2 enabled, however existing standard cables can still be used, including those with the new Mini-DisplayPort connector. To achieve
the 21.6 Gbps rate, **the per-lane data rate is doubled from 2.7 Gbps to 5.4 Gbps**, over the four lanes that exist in the standard cable.

For a single display, this enables up to 3840 x 2400 resolution at 60Hz, or a 3D display (120Hz) at 2560 x 1600.

DisplayPort v1.2 also adds new audio enhancements including the following:
-- Audio Copy Protection and category codes
-- High definition audio formats such as Dolby MAT, DTS HD, all Blu-Ray formats, and the DRA standard from China
-- Synchronization assist between audio and video, multiple audio channels, and multiple audio sink devices using Global Time Code (GTC)

DisplayPort v1.2 also includes improved support for Full HD 3D Stereoscopic displays:
-- Life-like motion using up to 240 frames-per-second in full HD, providing 120 frames-per-second for each eye
-- 3D Stereo transmission format support. Field sequential, side by side, pixel interleaved, dual interface, and stacked
-- 3D Stereo display capability declaration Mono, Stereo, 3D Glasses

“DisplayPort is a truly open, flexible, extensible multimedia interconnect standard that is ubiquitous in the PC, notebook and display markets and is rapidly gaining traction in consumer electronics applications,” said Bill Lempesis, VESA’s executive director.

“DisplayPort Version v1.2 offers a complete set of benefits and capabilities that no other standard can provide. It is completely backward compatible with DisplayPort v1.1a and requires no new cables or other equipment, making it the standard of choice across the industry.”
7. CONCLUSIONS

The targets and time tables of the VISIT project were properly set.

A 40Gb/s serial single mode solution (100G Ethernet) over single mode fiber will be standardized in 2011\(^7\).

26 Gb/s per channel multimode fiber solution will become necessary in the beginning of 2011 (Infiniband). Realization of 40Gb/s VCSELs and the related transmitter and receiver packages helps the industry to find a proper choice of solutions for the nearest future.

The technology will be demanded in 32G FC interfaces (~2012) and will define the basis for 60-70 Gb/s interfaces for the over-next generation of Infiniband (2014, ~60 Gb/s).

The work on multi-level coding of VCSELs aimed at reaching this goal has already started and the results on the advanced device linearity are positive.