Migration of Embedded Optical Interconnect into Data Centre Systems

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Overview

- Xyratex photonics research overview
- Data centre technology trends
- Migration of embedded optical interconnect
- Research and development milestones
- Optically enabled data storage platforms
- International standards for optical PCB
- Collaborative research projects
Xyratex Photonics Research and Development

**Future Data Storage Technologies**
Development of data storage systems with embedded optical interconnect for future Exascale data centre and HPC environments

**Research and Innovation**
Advanced research and innovation in embedded optical interconnect technologies and intellectual property development

**Network, Eco System and Standards**
Strategic presence and influence in global photonics market to drive component eco-system and international standards

**Collaborative Research Activities**
Leading international collaborative projects to develop disruptive embedded optical technologies for future data centre systems
System embedded optical interconnect refers to the emerging field of optical interconnect technologies, which enable optical connectivity within Information and Communication Technology (ICT) platforms including: Exascale Data Centre systems, High Performance Computers, Blade servers, Routers and Access Networks.
Building Blocks in the Data Centre

- Data Storage Array
- High Performance Computing and Storage
- Integrated Application Platform
- Storage Server
Increasing Disaggregation in ICT Networks

Servers, Racks and Data centres comprised of modular subsystems which can be broken apart and reassembled to satisfy broad range of ICT requirements.

Higher bandwidth optical connections required between non-localised dispersed modules working together.
Increasing Virtualisation in Data Centres

Software defined networks or storage solutions, which allow user programmable provision of a broad range of ICT requirements.

Actual hardware allocation for different configurations.
Increasing Virtualisation in Data Centres

Software defined networks or storage solutions, which allow user programmable provision of a broad range of ICT requirements

“Perfect” Virtual Machine
InfiniBand® protocol used predominantly for rack-to-rack communication in the switched fabrics inherent to enterprise data centres and high performance computers will provide 26 Gb/s per link by 2014 (EDR).
Serial Attached SCSI (SAS) architectures govern the high speed data links between controller peripherals and hard disk drives, which are set to increase to 24 Gb/s by 2016.
Data Centre Subsystem
Data Centre Subsystem

- Increase in Channel Density
- Increase in Channel Bandwidth
- Increase in Bandwidth Density
Cost and Performance Penalties of High Speed Copper

- Crosstalk
- Reflections
- Electro-magnetic interference
- Dielectric Loss / “Skin effect”
- Signal skew

![Diagram showing Cost and Signal Frequency relationship with penalties like Low skew connectors, Low loss PCB materials, Equalisation / Pre-emphasis circuitry, Via Stub Control, Number of layers.](xyratex)
The Light Alternative

- Send data further
- Higher density
- Higher link bandwidth (x100)
- Advanced passive and active functionality (SoC, WDM)
- No RFI / EMI from waveguides
Migration of Optical Interconnect

- Optical backplane connectors (active)
- Optical backplane connector (passive)
- Optical midboard transceiver
- Optical edge transceivers
- Passive copper interconnect
- Dual Port Disk Drives
- Air Flow Channels
- Power Module
- Multi-Layer Interconnect Midplane
- Controller Module
System Embedded Copper and Optical Architectures

- Copper layers for power distribution
- Copper layers for low speed communication
- Optical layers for high speed communication
Research and Development Milestones
Electro-Optical Printed Circuit Boards

Electro-optical Backplane

- 10 copper layers for power and low speed signal distribution
- 1 polymer optical layer for high speed optical signals

In collaboration with IBM Zürich, Varioprint
Optical Component Assembly

**Alignment and Assembly**

High precision reliable assembly of optical components onto embedded waveguides. Low cost solutions have been successfully developed and demonstrated.

Optical assembly equipment for optical PCB components

Lensed waveguide interface receptacles
Pluggable Electro-Optical PCB Connectors

FirstLight Demonstrator
10 Gb/s test card platform with electro-optical backplane and pluggable optical backplane connectors

Pluggable Optical Backplane Connector
Quad 90 Gb/s transceiver with custom pluggable optical interface and housing and mechanism allowing backplane pluggability
Waveguide Bend Losses and Dispersion

**Waveguide bend losses**
- Transition bend loss caused by NA mismatches between bend segments
- Greatest loss shifts when bend radius is reduced from one segment to another
- Bend scattering losses due to greater modal concentration on outer bend wall, therefore more sidewall scattering

**Mitigate bend losses**
- Research into proprietary nested core structures with reduced optical bend loss allowing tighter bend radii. This however has a dispersion penalty due to step-index waveguide profile
- Need to develop planar waveguide with graded index structure
Data Storage Systems with Embedded Optical Links

A technology demonstration of a data storage system enclosure with 12G optical polymer waveguide interconnects

- Prototype 4U Xyratex OneStor™ enclosure with embedded optical interconnect
- Collaboration with Finisar, Huber+Suhner, vario-optics ag, LSI to provide full eco-system for embedded optical interconnect in data storage platform
- First demonstration of 12G SAS optical links between internal data storage controllers
- Optical links comprised of polymer optical waveguides
Successful exhibition of LightningValley demonstrator at ECOC 2012 in Amsterdam
ThunderValley2 Demonstration Platform

Hard Disk Drive Carrier

Optical midplane receptacle

Optical disk drive connector

Electro-optical midplane

192 channel waveguide flex

24 channel waveguide flex

48 channel waveguide flex

Board mounted optical assembly 12 Tx + 12 Rx

Expander

SAS connectors

SAS connectors
ThunderValley2 Demonstration Platform

A technology demonstration of the first fully optically interconnected 2U24 OneStor™ data storage platform
International Standards Activities for Embedded Photonics

International Electro-technical Commission

Technical Committee
TC86 Fibre Optics

SC86A
Fibres and cables

SC86B
Fibre optic interconnecting devices and passive components cables

SC86C
Fibre optic systems and active devices

JWG9
Fibre optic interconnecting devices and passive components cables
Joint Working Group JWG 9
Optical functionality for electronic assemblies

To prepare international standards and specifications for optical circuit boards and optical back planes, intended for use with opto-electronic assemblies. Other devices intended for use with optoelectronic assemblies such as fibre optic connectors, passive optical devices, active devices, dynamic devices, etc., are directly standardized at the existing WGs in TC86.

Chairman: Etsuji Sugita
Collaborative Research and Development Activities
# System Embedded Photonics In Access Networks

## What

**SEPIANet**
Develop electro-optical PCBs with embedded glass waveguides and supporting interconnect technologies

## Who

**Germany**
- Fraunhofer IZM
- V-I-Systems
- ILFA GmbH

**UK**
- Xyratex
- Conjunct
- TerOpta

## When

**Start date**: 1<sup>st</sup> July 2011  
**End date**: 1<sup>st</sup> January 2014

## How

- **Access Network Framework**
- **Passive Technologies**
- **Active Technologies**

## Demonstration Platform

## Why

- Deployment of embedded glass waveguide in PCB technologies
- Development of universal optical PCB connector
- Development of high speed 1300 nm optical engine technology
- Demonstration of system bandwidth enhancement through board-level embedded photonic interconnect
WP2: Access Network guidelines

WP7: Midboard optical engine 1300 nm

WP6: 1300 nm VCSEL

WP5: Pluggable passive optical connector plug

WP5: Pluggable passive optical receptacle

WP3: Embedded glass waveguide layer

WP4: Electro-optical printed circuit board

WP8: Demonstration platform
SEPIANet Demonstration Platform

Technology demonstration of a high speed optically enabled communications system enclosure with PCB embedded planar glass waveguides, 1300 nm transceiver assemblies and pluggable connectors
Demonstrator Assembly Concept
Demonstrator Assembly Concept
**PhoxTrot** – Integrated Photonics for Data Centres and HPCs

**What**

**PhoxTrot**

EU Integrated Project focusing on high-performance, low-energy and cost and small-size optical interconnects across the different hierarchy levels in Data Centre and High-Performance Computing Systems: on-board, board-to-board and rack-to-rack

**Who**

- **Project type**: FP7 Integrated project
- **18 EU partners**
- **Coordinator**: Fraunhofer Institute

**When**

- **Start date**: 1st October 2012
- **End date**: 1st October 2016

**How**

- **Plasmonics**
- **Si Photonics**
- **CMOS electronics**
- **III-V**
- **Glass**
- **Polymers**

**Why**

- Generic building block technologies (transmitters, modulators, receivers, switches, optochips, multi- and single-mode optical PCBs, chip- and board-to-board connectors) that can be used for a broad range of applications, extending performance beyond Tb/s and reducing energy by more than 50%
- Unified integration/packaging methodology as a cost/energy-reduction factor for board-adaptable 3D SiP transceiver and router optochip fabrication whole "food-chain" of low-cost and low-energy interconnect technologies concluding in functional > Tb/s prototype systems for chip-to-chip, board-to-board and rack-to-rack interconnection (1.28Tb/s 16QAM Active Optical
PhoxTrot Milestones and Deliverables
**What**

**Optoelectronics**
Global industry led research and development project into polymer waveguide and high speed copper interconnect in electro-optical PCBs

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**Who**

**Project type**
Industrial collaboration

**Partners / Contributors**
- Xyratex
- Juniper
- National Semicon.
- Nihon Superior
- Multek
- Oracle
- Panasonic
- Philips
- Viasystems
- Amphenol
- Dow Electronic Materials
- Dow Corning
- Hitachi
- Isola
- Optical Interlinks
- Quandong Shenghyi
- Rogers

**Partners**
- **TTM**
- **Cisco**
- Alcatel-Lucent
- Boeing
- Celestica
- Compass EOS
- Ericsson
- Flextronics
- Fujitsu
- Huawei
- IBM
- Intel
- ITEQ

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**SDD21 (dB)** vs **Frequency (GHz)**

- **16inch group**
  - Hitachi679G__Straight__Line__gap__12.5__Layer2
  - Hitachi679G__Curved__Line__gap__12.5__Layer9
  - IsolaFR408__Straight__Line__gap__12.5__Layer2
  - IsolaFR408__Curved__Line__gap__12.5__Layer9
- **Curved Line gap**
  - Curved__Line__gap____15.5____Layer4
  - Curved__Line__gap____22.5____Layer4
Conclusion

- **Exponentially increasing bandwidth densities** approaching design limits of internal electronic interconnect
- **Emerging eco-system** in system embedded optical interconnect
- First fully **optically enabled data storage** platforms developed
- **International standards activities** in board-level optical interconnect and assembly technology
- Strong **global photonics research and development activities** to implement optical interconnect in future ICT systems
Thank you for your attention

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