



OFC/NFOEC 2011 - Review

Datacenter Networks: potential and challenges for Optics

Prepared and presented by:

Uttam Mandal

April 19, 2011



Sessions

- ❑ OMV Meeting the Computercom Challenge
Symposium II: Emerging Interconnect Technologies
 - ❑ OTuH Meeting the Computercom Challenge
Symposium III: Optics in Data Center
 - ❑ OWR Optical Network Applications
 - ❑ OWU Optical Technologies for Data Centers
 - ❑ OThR Optical Switching
 - ❑ NThD Data Center Connectivity
-



Sessions

- ❑ OMV Meeting the Computercom Challenge
Symposium II: Emerging Interconnect Technologies
 - ❑ OTuH Meeting the Computercom Challenge
Symposium III: Optics in Data Center
 - ❑ OWR Optical Network Applications
 - ❑ OWU Optical Technologies for Data Centers
 - ❑ OThR Optical Switching
 - ❑ NThD Data Center Connectivity
-



Short Reach Optical Interconnection

Code	Title	Authors/Affiliation	Abstract
OMV1 Invited ★★	The Limits of Switch Bandwidth	Scott Kipp Brocade	Electrical lane speeds need to be increased to increase Gigabit Ethernet switch throughput. For 100 Gbps Ethernet switches, industry must adopt 4x25 Gbps electrical lanes over 10x10 Gbps lanes.
OMV2 Invited ★★	The Future of 100GbE Physical Layer Specifications	John D'Ambrosia Force10 Networks	Networking applications' bandwidth requirements (2x every 18 months) growing more than the requirement of computing applications (2x every 24 months). 100 GbE will be required to meet the challenge.
OMV3 ★★	Compact, Thermally-Tuned Resonant Ring Muxes in CMOS with Integrated Backside Pyramidal Etch Pit	John E. Cunningham, <i>et al.</i> Oracle, USA	The authors present add-drop filters manufactured as ring resonators in commercial 130 nm SOI CMOS technology with thermal tuning.



Short Reach Optical Interconnection

Code	Title	Authors/Affiliation	Abstract
OMV4 ★★★	40 Gb/s 8×8 Low-latency Optical Switch for Data Centers	Roberto Proietti , S. J.B. Yoo , <i>et al.</i> UC Davis, NPRC, Japan	This paper reports on the result of a 40 Gb/s 8×8 hybrid electrical optical switch for data centers. Error free operation, lower latency and energy efficiency is reported.
OMV5 Invited ★★★	State of the Short-Reach Optics Market	Lisa Huff Discerning Analytics , DataCenterStocks.com USA	This paper gives an overview of the opportunities for component suppliers in the short-reach optics market. Overall forecast of Gigabit Ethernet, 40g, and 100G Ethernet is discussed.

Trend: Short reach interconnect technologies, optical interconnects.



Sessions

- OMV Meeting the Computercom Challenge
Symposium II: Emerging Interconnect Technologies
 - OTuH Meeting the Computercom Challenge
Symposium III: Optics in Data Center
 - OWR Optical Network Applications
 - OWU Optical Technologies for Data Centers
 - OThR Optical Switching
 - NThD Data Center Connectivity
-



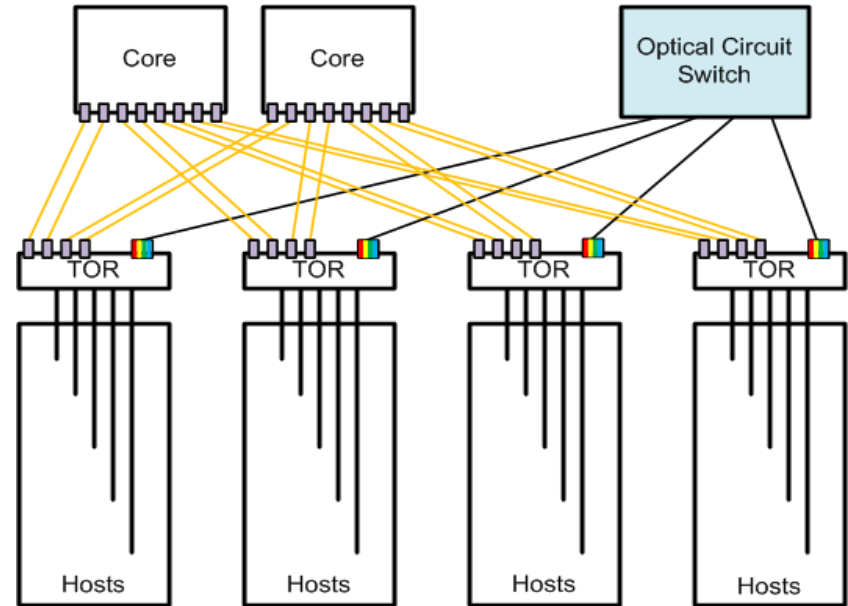
Optics in Data Center

Code	Title	Authors/Affiliation	Abstract
OTuH1 Invited ★★	Optical Systems for Data Centers	Ron Ho, <i>et al.</i> Oracle, USA	Drivers for adopting optical technology in the Data Centers are discussed. Bandwidth, light weight, energy efficiency, and potential for on-chip communication is emphasized.
OTuH2 Invited ★★★★	The Emerging Optical Data Center	Amin Vahdat, Hong Liu, Xiaoxue Zhao and Chris Johnson Google, UCSD.	Architectures of modern datacenter networks is reviewed. High-level requirements for deploying optical technologies in datacenters is presented through a hybrid optical circuit switching and packet switching architecture.
OTuH3 ★★★	Hardware Requirements for Optical Circuit Switched Data Center Networks	Nathan Farrington, Amin Vahdat, <i>et al.</i> UCSD, Google	Performance of hybrid electrical-packet-switched/optical-circuit-switched data center networks is measured for Helios. With traffic stability within certain limit OCS works as good as EPS.



OCS in Data Center

- Hybrid of packet and optical circuit switch may be used.
- WDM technology could be used.





Optics in Data Center

Code	Title	Authors/Affiliation	Abstract
OTuH4 ★★	A Bidirectional 2×2 Photonic Network Building-Block for High-Performance Data Centers	Howard Wang and Keren Bergman Department of E E, Columbia University	The design of a bidirectional 2×2 SOA-based optical switch is detailed and experimentally validated.
OTuH5 Invited ★★	Fiber and Copper Cabling in Data Centers	Doug Coleman Corning Cable Systems	This article discusses the data rate scalability, pathway and spaces, power and cooling benefits of optical fiber connectivity in Data Centers.

Trend: Optical technologies in Datacenters.



Sessions

- OMV Meeting the Computercom Challenge
Symposium II: Emerging Interconnect Technologies
- OTuH Meeting the Computercom Challenge
Symposium III: Optics in Data Center
- **OWR** **Optical Network Applications**
- OWU Optical Technologies for Data Centers
- OThR Optical Switching
- NThD Data Center Connectivity



Optical Network Applications

Code	Title	Authors/Affiliation	Abstract
OWR1 Invited	The Non-Wireless Part of Cellular Networks: What's With the Backhaul?	Peter D. Magill and Byoung-Jo "J" Kim AT&T Labs, USA	A brief overview of regulatory, business, and technological conditions of the wireless backhaul is presented. (Maybe important for WOBAN research)
OWR2 ★★★★	Energy-efficient Flow Aggregation for IPTV Program Delivery in Optical Backbone Networks with Multiple Line Rates	Yi Zhu and Jason P. Jue CS Dept., UT Dallas	The authors propose energy-efficient multicast flow aggregation (E ² MFA) to minimize the end-to-end power consumption for IPTV.

★★★★

E²MFA

- Set of heads (x), set of programs (y) and a set of Access Routers (z)
- Modeled as a tri-partite graph
- Different energy specification for different line rate
- Energy-efficiency is minimized
- Higher line rate gives better results

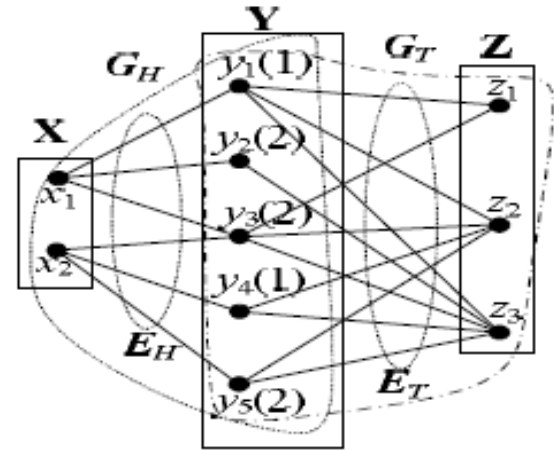


Fig. 2. Tri-partite graph for E²MFA



Optical Network Applications

Code	Title	Authors/Affiliation	Abstract
OWR3 ★★★	Energy Efficient Content Distribution for VoD Services	Chamil Jayasundara, <i>et al.</i> Uni. of Melbourne, Australia	The energy consumption of VoD services arising from storage and transport of video contents stored in different content placement locations is investigated.
OWR4 Invited ★★★	Interaction between Applications and the Network	Malathi Veeraraghavan and Zhenzhen Yan Uni. of Virginia, USA	Dynamic circuit switching has been employed for applications that require disproportionately larger allocation of rate-hop-duration product. The interaction between the two complimentary network (circuit and packet) is discussed.

Trend: Next generation Optical network applications.



Sessions

- OMV Meeting the Computercom Challenge
Symposium II: Emerging Interconnect Technologies
- OTuH Meeting the Computercom Challenge
Symposium III: Optics in Data Center
- OWR Optical Network Applications
- OWU **Optical Technologies for Data Centers**
- OThR Optical Switching
- NThD Data Center Connectivity



Optical Technologies for DC

Code	Title	Authors/Affiliation	Abstract
OWU1 Invited ★★★	Scaling Networks in Large Data Centers	Donald C. Lee Facebook	This talk discusses cluster computing, fat-tree topologies, novel routing techniques, higher-speed links, optical building blocks, and future designs for large data centers. (No paper)
OWU2 ★★★	Feasibility Study on Topology Malleable Data Center Networks (DCN) Using Optical Switching Technologies	Ankit Singla, <i>et al.</i> University of Illinois, Urbana–Champaign, NEC Laboratories, USA	The implementation issues of a DCN architecture (Proteus) that supports on-demand, run-time topology malleability using WDM and optical space/wavelength switching is discussed. The architecture was presented earlier.



Optical Technologies for DC

Code	Title	Authors/Affiliation	Abstract
OWU3 ★★	Performance of Optical Fast-OFDM in MMF-Based Links	E. Giacomidis, <i>et al.</i> Athens Information Technology, Greece, Bangor Uni., UK	The authors show that 19.375Gb/s optical Fast-OFDM signals can be transmitted over 500m. FOFDM has lower subcarrier channel spacing and uses M-ASK modulation.
OWU4 Invited ★★	Low-power, high-density optical interconnects to the processor	Ashok V. Krishnamoorthy Oracle Labs	The presentation demonstrates the existing optical technologies (optical interconnects) that are used in datacenter networks.

Trend: Optical interconnection technologies for Datacenter.



Sessions

- ❑ OMV Meeting the Computercom Challenge
Symposium II: Emerging Interconnect Technologies
- ❑ OTuH Meeting the Computercom Challenge
Symposium III: Optics in Data Center
- ❑ OWR Optical Network Applications
- ❑ OWU Optical Technologies for Data Centers
- ❑ OThR **Optical Switching**
- ❑ NThD Data Center Connectivity



Optical Switching

Code	Title	Authors/Affiliation	Abstract
OThR1 Invited ★★★	Transport Network Evolution: from TDM to Packet	Nabil Bitar Verizon	Transport network is transforming from TDM to packet switching, embedded on equipment with DWDM, OTN, and SONET/PDH switching. The drivers and technologies are summarized.
OThR2 ★★	400 Gb/s optical packet switching node design with coherent detection	Jianjun Yu, et al. ZTE, USA, Georgia Inst. of Tech Hunan Uni., and Fudan Uni., China	The authors demonstrate how to realize 400 Gb/s optical packet switching (Label Switching).
OThR3 Invited ★★★★	Optical Switch Architectures for Emerging Colorless/Directionless/Conte nionless ROADM Networks	Richard A. Jensen Polatis Inc., USA	This paper discuss on emerging Colorless, Directionless and Contentionless (C/D/C) ROADM architectures using optical matrix switches.



Optical Switching

Code	Title	Authors/Affiliation	Abstract
OThR4 ★★	Adaptive Classified Cloning and Aggregation Technique for Delay and Loss sensitive Applications in OBS Networks	Shavan Askar, <i>et al.</i> University of Essex, UK	An adaptive classified cloning and aggregation technique is introduced for deployment with Optical Burst Switching. Up to 74% reduction in loss rate for applications with specific delay and loss requirements.
OThR5 ★★	A Novel Optical Burst Ring Network with Optical-Layer Aggregation and Flexible Bandwidth Provisioning	Ning Deng, <i>et al.</i> Networks Research, Huawei, China	An optical burst ring network is proposed by employing fixed-tuned transmitters. Wavelength and dynamically-adjusted sub-wavelength granularity can be flexibly provisioned on the optical layer for all optical aggregation/bypas.
OThR6 ★★★	Novel Hierarchical Optical Cross-Connect Architecture Utilizing Dedicated Add/Drop Switches that Effectively Offer C/D Capability	Y. Yamada, <i>et al.</i> Nagoya University, Japan	Hierarchical optical cross-connect (HOXC) architectures based on dedicated add/drop switches is proposed. Uses a hierarchy of WBXC and WXC.

Trend: Optical switching, OPS, OBS.



Sessions

- OMV Meeting the Computercom Challenge
Symposium II: Emerging Interconnect Technologies
 - OTuH Meeting the Computercom Challenge
Symposium III: Optics in Data Center
 - OWR Optical Network Applications
 - OWU Optical Technologies for Data Centers
 - OThR Optical Switching
 - NThD **Data Center Connectivity**
-

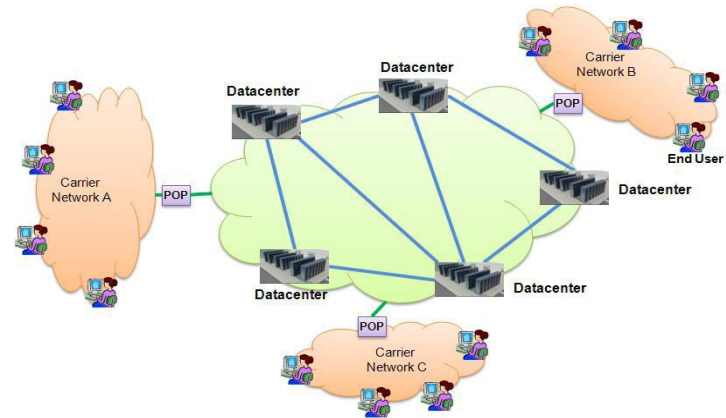


Data Center Connectivity

Code	Title	Authors/Affiliation	Abstract
NThD1 Invited ★★	Microsoft Datacenter connectivity and requirement on Optical Networks	Microsoft	Microsoft Datacenter connectivity and requirement on Optical Networks. (Nothing else exists)
NThD2 Invited ★★★★	Drivers and Applications of Optical Technologies for Internet Data Center Networks	Vijay Vusirikala, <i>et al.</i> Google	The rise of large-scale Data Centers is driving new architectural directions for optical networking. This paper highlights these architectural options and discusses technology building blocks for scaling inter-Datacenter connectivity.
NThD3 ★★★	Application-Aware Aggregation and Traffic Engineering in a Converged Packet-Circuit Network	Saurav Das, <i>et al.</i> Stanford University, Ciena Corp., USA	SDN/OpenFlow architecture and control plane can create mutually beneficial interaction between IP and Transport networks by enabling new capabilities at the packet-circuit interface. Authors have outlined and demonstrated such capabilities.

Internet Data Center Networks

- Higher user traffic, much higher machine-to-machine traffic.
- Architectures: difference in layers for traffic types (U and M)
 - Overlay architecture (diff layers)
 - Converged architecture at Layer 1 only
 - Converged architecture at Layer 1 and 2
- With $M = 2U$, cost for overlay is less.





Data Center Connectivity

Code	Title	Authors/Affiliation	Abstract
NThD4 ★★★	Seamless Access Router Upgrades through IP/Optical Integration	Susan R. Bailey, <i>et al.</i> AT&T Labs	RFC is the new capability that minimizes customer outages during software and hardware upgrades in ISP networks. RFC is used to re-home customer routers to Access Routers (AR) in back bone network using integration of IP and Optical network.
NThD5 Invited ★★★	eScience Applications on the SURFnet RE Network	Jeroen van der Ham, Paola Grosso and Cees de Laat University of Amsterdam	The hybrid network paradigm pioneered by SURFnet provides the capacity demanded by modern eScience applications. Recent and ongoing developments for this NREN is discussed.

Trend: Data center connectivity.



Thank you



Stars

- 2 Stars -> this paper is not important/device or system paper
- 3 stars -> interesting paper worth the read but may or may not be relevant.
- 4 stars -> important paper and recommended to read.

