OFC/NFOEC 2015 ARCHIVE

LOS ANGELES—The 2015 OFC Conference and Exposition concluded today at the Los Angeles Convention Center with 560 exhibitors, more than 1,100 presentations and 12,375 attendees from around the world. Marking a multi-year growth pattern, the exhibit floor grew 10 percent to 106,700 square feet year over year. Conference and exhibition programming provided attendees with valuable insights into the latest optical communications research (near- and long-term) and technology from more than a dozen topical areas (i.e. bandwidth demand, 100G/400G network design and optimization, 1 terabit (Tb) and beyond optical networking, and wavelength agile access networks). OFC 2015 took place 22-26 March at the Los Angeles Convention Center in Los Angeles, California, USA.

Hot Topics in Optics

Exhibiting companies made news with more than 100 news announcements highlighting technical advancements in 100G coherent modules, optical transceivers for data centers, and software-based solutions. This year's conference offered the insider's perspective on society's continued progression to constant connectedness and the Internet of Things, such as smart appliances and mobile apps. The diversity of the technical sessions indicated the convergence of the traditional telecom service providers and the data center. Exhibiting companies also provided technology insights through their participation in show floor programming with topics such as software defined networking, integrated photonics and intra-data center interconnects that encompass the complete landscape of optical convergence and network evolution.

"Each year, I look forward to OFC, as it's the place to come if you're working in optical fiber communication," said Seb Savory of UCL, United Kingdom and 2015 General Chair. "Not only can you catch up with the technical community and the latest research, but you can also see the industry trends and emerging technologies demonstrated on the exhibit floor."

Kathy Tse, AT&T and 2015 and 2016 OFC General Chair, added, "OFC is the one conference where I can learn about groundbreaking research from respected experts from academia and industry and to understand the latest business news and trends. This year we saw groups from around the world announcing the latest results in SDN, NFV, and silicon photonics, among others. I'm excited to keep this year's momentum going as we head to Anaheim for 2016."

Clint Schow, IBM T.J. Watson Research Center and 2015 General Chair, said, "Organizing a successful OFC conference each year is an enormous task that is under-taken by many volunteers. The high quality of the OFC program is a direct result of the efforts of the technical program chairs, subcommittee chairs and committee members. We would like to thank these volunteers for making it possible for OFC to continue as the foremost optical communications conference."

Light the Future: A Community Outreach Event

In celebration of the International Year of Light, OFC hosted "Light the Future: A Community Outreach

Event" today, Thursday, 26 March, in the exhibit hall at the Los Angeles Convention Center. This program featured light-focused demonstrations by university chapter members of The Optical Society and IEEE Photonics Society for local Los Angeles high school students and Girl Scouts of the USA. More than 100 students meet with representatives of the optics and photonics industry. The students also toured the exhibition floor.

Participating volunteers and chapters include:
Spectrobox; The Colors of Light
University of California, Irvine, USA
The Optical Society Student Chapter
Demonstration: Students will present a kit that they designed specifically for their own youth education outreach efforts. This kit provides lessons on the colors that make up white light as well as how light can be mixed as well as split.

Slinky Spring, Magic Balls, Color Mix Box and Guiding Light
University of Aveiro, Portugal
The Optical Society Student Chapter
Demonstration: Students will conduct four demonstrations in the wave-like properties of light, transparency, how wavelengths interact and light propagation.

Telecommunications, EM Spectrum and Lenses, Optical Illusions, Mirrors and Reflections, Music Transmission
University of Southampton, UK
The Optical Society Student Chapter
Demonstrations: Interactive topics to include optical illusions, holograms and telecommunications.

Music Transmission/Amplitude Modulation
IEEE Photonics Society
Demonstrations: Volunteers will use an interactive display to allow students to transmit sound from their smartphones with laser technology. A photodetector will capture the laser beam light and act as the receiver.

Solar Aid/Unite to Light
IEEE Photonics Society
Raising Awareness: Volunteers will how they are able to grow the efforts of Solar Aid and Unite to Light to bring access to safe, clean solar lights to Africa.

In addition to the demonstrations, all students will receive an International Year of Light "LIGHT BLOX" kit which features several optics-based projects which can be easily recreated at home or in the classroom.

Next year's OFC will be held in Anaheim, California, USA, 20 – 24 March 2016, at the Anaheim Convention Center. More than 80 percent of the exhibition space has been sold.

About OFC

OFC is the largest global conference and exposition for optical communications and networking professionals. For more than 40 years, The Optical Fiber Communication Conference and Exposition (OFC) has drawn attendees from all corners of the globe to meet and greet, teach and learn, make connections and move business forward. OFC includes dynamic business programming, an exposition of more than 560 companies, and high impact peer-reviewed research that, combined, showcase the trends and pulse of the entire optical networking and communications industry. For more information, visit ofcconference.org.

DOWNLOAD PAGES FROM THE OFC PROGRAM BOOK.

- Agenda of Sessions
- Abstracts
- Key to Authors

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Kathleen Tse, *AT&T, USA*

Seb Savory, *UCL, UK*

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Andrew Lord, *BT Labs, UK*

Shu Namiki, *AIST, Japan*

Peter Winzer, *Bell Labs, Alcatel Lucent, USA*

2015 Subcommittees

Track D: Optical Components, Devices and Fiber

OFC D1: Advances in Deployable Optical Components, Fibers and Field Installation Equipment
Robert Lingle, *OFS, USA,* **Subcommittee Chair**
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Shin Kamei, *NTT Science and Core Technology Laboratory Group, Japan*
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Daniel Peterson, *Verizon Communications, Inc., USA*
Lionel Provost, *Prysmian Group, UK*
Michael Sprenger, *Optical Technologies CableLabs, USA*

OFC D2: Passive Optical Devices for Switching and Filtering
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Dan Marom, *The Hebrew University of Jerusalem, Israel*
Brian Robertson, *University of Cambridge, UK*
Takashi Saida, *NTT Corporation, Japan*
Jochen Schroeder, *University of Sydney, Australia*
Joris van Campenhout, *Interuniversity Microelectronics Center, Belgium*

OFC D3: Active Optical Devices and Platforms for Photonic Integrated Circuits
Shinji Matsuo, *Nanophotonics Center, NTT Corporation, Japan,* **Subcommittee Chair**
Markus Amann, *Technische Universität München, Germany*
Steffan Andreas, *Finisar, Germany*
Larry Coldren, *University of California Santa Barbara, USA*
Po Dong, B*ell Labs, Alcatel Lucent, USA*
Jonathan Klamkin, *Boston University, USA*
Dan Kuchta, *IBM T.J. Watson Res. Ctr., USA*
Mike Larson, *JDSU*, USA
Jurgen Michel, *Massachusetts Institute of Technology, USA*
Gunther Roelkens, *Universiteit Gent, Belgium*
Takuo Tanemura, *University of Tokyo, Japan*

OFC D4: Fiber and Propagation Physics
Takashi Sasaki*, Sumitomo Electric Industries Ltd., Japan*, **Subcommittee Chair**
Shahraam Afshar Vahid, *University of Adelaide, Australia*
Scott R. Bickham, *Corning Incorporated, USA*
Andrea Galtarossa, *University of Padova, Italy*
Kazuhide Nakajima, *Nippon Telegraph & Telephone Corp, Japan*
Francesco Poletti, *University of Southampton, UK*
Stojan Radic, U*niversity of California, San Diego, USA*
Oleg V. Sinkin, *TE SubCom, USA*
Thierry F. Taunay, *OFS Laboratories, USA*
Sergei K. Turitsyn, *Aston University, UK*

OFC D5: Fiber-Optic Devices and Sensors
Kazi Abedin, O*FS Laboratories, USA* **Subcommittee Chair**
Camille - Sophie Bres, *Ecole Polytechnique Federale de Lausanne, Switzerland*
Tetsuya Haruna, S*umitomo Electric Industries Ltd, Japan*
Zuyuan He, S*hanghai Jiao Tong University, China*
Victor Kopp, *Chiral Photonics Inc.., USA*
Peter Krummrich, *Technische Universitaet Dortmund, Germany*
Rogerio Nogueira, *Instituto De Telecomunicacoes, Portugal*

Yoichi Oikawa, *Trimatiz Ltd., Japan*
Lutz Rapp, C*oriant, Germany*
Radan Slavik, *Southampton University, UK*

Track S: Photonic Systems and Subsystems

OFC S1: Advances in Deployable Transmission Subsystems and Systems
Chris Fludger, *Cisco Optical GmbH, Germany*, **Subcommittee Chair**
Chris Cole, *Finisar Corporation, USA*
Joerg-Peter Elbers, *ADVA Optical Networking SE, Germany*
Ali Ghiasi, *Ghiasi Quantum LLC,* USA
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Lynn Nelson, *AT&T Corp, USA*
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OFC S2: Photonic Subsystems for Digital System Applications
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Satoki Kawanishi, *Optoquest, Japan*
Tsuyoshi Konishi, O*saka University, Japan*
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Michael Vasilyev, University of Texas at Arlington, USA
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OFC S3: Radio-over-Fiber, Microwave Photonics, and Free-Space and Analog Applications
Michael Sauer, *Corning Incorporated, USA*, **Subcommittee Chair**
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Benyuan Zhu, O*FS Laboratories, USA*

Track N: Networks, Applications and Access

OFC N1: Advances in Deployable Networks from Access to Core and Applications
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Xiang Zhou, *Google, Inc., USA*

OFC N2: Dynamic Software Controlled and Multilayer Networks
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OFC N3: Network Architectures, Techno-Economics and Design Tradeoffs
Annalisa Morea, *Bell Labs, Alcatel Lucent, USA*, **Subcommittee Chair**
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OFC N4: Optical Access Systems and Wireless Backhaul Networks
Neda Cvijetic, *NEC Laboratories America, USA,* **Subcommittee Chair**
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Denis Khotimsky, *Verizon, USA*
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Peter Vetter, *Alcatel Lucent, USA*
Jun Shan Wey, *LightNotes Consulting, USA*

OFC N5: Service Provider Summit and Market Watch
Steve Plote, *BTI Systems, USA*, **Subcommittee Chair**
Frank Chang, *Inphi Corporation, USA*
Eve Griliches, *BTI Systems, USA*
Sam Liu, *Juniper Networks Inc., USA*
Mark Lum, *Layer 123, UK*
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Ray Mota, *ACG Research, USA*
Ian Redpath, *Ovum, Canada*
Soumya Roy, *Infinera, USA*
TJ Xia, *Verizon Communication Inc., USA*

Track DSN: Devices, Systems and Networks

OFC DSN6: Optical Devices, Subsystems, and Networks for Datacom and Computercom
Laurent Schares, *IBM T.J. Watson Res. Ctr., USA,* **Subcommittee Chair**

Drew Alduino, *Intel Corporation, USA*
Nathan Farrington, *Rockley Photonics, USA*
Marco Fiorenti, *Hewlett Packard Labs, USA*
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INVITED SPEAKERS

TRACK D - OPTICAL COMPONENTS, DEVICES AND FIBER

D1: ADVANCES IN DEPLOYABLE OPTICAL COMPONENTS, FIBERS, AND FIELD INSTALLATION EQUIPMENT

- Atsushi Aratake; *NTT Device Innovation Center, Japan*
  Field Reliability of Silica-based PLC Splitter for FTTH
- Mike Hughes; *US Conec Ltd., USA*
  Multi-fiber Connector Technologies
- Masaki Kotoku; *NTT Device Innovation Center, Japan*
  Compact InP-based Optical Modulator for 100-Gb/s Coherent Pluggable Transceivers
- Daniel Mahgerefteh; *Finisar Corporation, USA*
  Techno-Economic Comparison of Silicon Photonics and Multimode VCSELs
- Fumito Nakajima; *NTT Device Innovation Center, Japan*
  High-Speed Avalanche Photodiode for 100-Gbit/s Ethernet
- Kazuhiro Takizawa; *Fujikura Ltd., Japan*
  Splice-on Connectors: Design, Application and Development Trend
- Akio Tanabe; *Furukawa Electric, Japan*
  The Latest Fusion Splicing Technologies and Applications to FTTx Deployment

D2: PASSIVE OPTICAL DEVICES FOR SWITCHING AND FILTERING

- Joel Carpenter; *University of Sydney, Australia*
  LCOS Based Devices for Mode-division Multiplexing
- Uriel Levy; *Hebrew University of Jerusalem, Israel*
  Atomic Cladding Waveguide
- Jean-François Morizur; *CAILabs, France*
  Efficient Mode-selective Mode Couplers Based on Multi-plane Light Conversion
- Wolfram Pernice; *Karlsruhe Institute of Technology, Germany*
  Diamond-integrated Optomechanical Circuits
- Joyce Poon; *University of Toronto, Canada*
  Integrated Photonic Devices and Circuits
- Richard Soref; *University of Massachusetts System, USA*
  Mid-infrared Photonics
- Ming Wu; *University of California Berkeley, USA*
  Large-Port-Count MEMS Silicon Photonics Switches
- Steven Yerolatsitis; *University of Bath, UK*
  Tapered Mode Multiplexers for Single Mode to Multi Mode Fiber Mode Transitions

D3: ACTIVE OPTICAL DEVICES AND PLATFORMS FOR PHOTONIC INTEGRATED CIRCUITS

- Thomas Baehr-Jones; *California Institute of Technology, USA*
  Silicon Photonics Systems - Nonidealities and Nonlinearities
- Frederic Boeuf; *STMicroelectronics, France*
  Recent Progress on Silicon Photonics R&D and Manufacturing on 300mm Wafer Platform
- Joe Campbell; *University of Virginia, USA*
  Avalanche Photodiodes
- Shigeru Kanazawa; *NTT Device Innovation Center, Japan*
  EADFB Laser Array for 400 GbE and Beyond
- Christian Koos; *Karlsruhe Institute of Technology KIT, Germany*
  Silicon-organic Optoelectronics
- Bert Jan Offrein; *IBM Research GmbH, Switzerland*
  Silicon Photonics for the Data Center
- Petter Westbergh; *Chalmers Tekniska Hogskola, Sweden*
  High Speed and High Temperature operation of VCSELs
- Lars Zimmermann; *Technische Universität Berlin, Germany*
  BiCMOS Silicon Photonics Platform

D4: FIBER AND PROPAGATION PHYSICS

- Gilberto Brambilla; *University of Southampton. UK*
  Selective Excitation of High Order Modes in Few Mode Fibres Using Optical Microfibres
- Nicolas Fontaine; *Alcatel-Lucent Bell Labs, USA*
  Characterization of Space-Division Multiplexing Fibers Using Swept-wavelength Interferometry
- Lars Grüner Nielsen; *OFS Fitel Denmark, Denmark*
  Recent Advances in Low DGD Few-mode Fibre Design, Fabrication, Characterization and Experiments
- Brian J. Mangan; *OFS Laboratories, USA*
  Single Mode Hollow Core Photonic Crystal Fibers
- Tanya Monro; *University of Adelaide, Australia*
  New Trends in Fiber Based Sensors
- Luca Palmieri; *University of Padova, Italy*
  Modal Dispersion Properties of Few Mode Spun Fibers
- Yoshinori Yamamoto; *Sumitomo Electric Industries Ltd., Japan*
  Low Loss and Low Nonlinearity Fibers for Long Haul Transmission

D5: FIBER-OPTIC DEVICES AND SENSORS

- Shaif-Ul Alam; *University of Southampton, UK*
  Recent Progress in the Development of Few Mode Fiber Amplifier

- Fabrizio Di Pasquale; *Scuola Superiore Sant Anna di Pisa, Italy*
  Advanced Coding Techniques for Long-range Raman/BOTDA Distributed Strain and Temperature Measurements

- Julien Fatome; *CNRS University of Burgundy, France*
  All Optical Polarization Control for Telecom Applications

- Jason Moore; *NASA Langley Research Center, USA*
  Shape Sensing using Multi-core Fiber

- Karsten Rottwitt; *Technical University of Denmark, Denmark*
  Challenges in Higher Order Mode Fiber Raman Amplifiers

- Motohide Tamura; *National Astronomical Observatory Japan, Japan*
  Extra-solar Planets Exploration using Frequency Comb

TRACK S - PHOTONIC SYSTEMS AND SUBSYSTEMS

S1: ADVANCES IN DEPLOYABLE TRANSMISSION SUBSYSTEMS AND SYSTEMS

- Andreas Bisplinghoff; *Cisco Optical GmbH, Germany*
  Cycle Slip Tolerant, Differentially Encoded Aware, Soft-Decision FEC
- Annika Dochhan, *ADVA Optical Networking SE, Germany*
  Solutions for 80km DWDM Systems
- Kiyoshi Fukuchi; *NEC Corporation, Japan*
  Practical Techniques for Nonlinear Compensation and Mitigation
- Mitsunori Fukutoku; *NTT Network Innovation Laboratories, Japan*
  Next Generation ROADM Technology and Applications
- Jonas Geyer; *Acacia Communications, Inc., USA*
  Practical Implementation of Higher Order Modulation Beyond 16-QAM
- Lukas Kull; *IBM Research - Zurich, Switzerland*
  Challenges in Implementing High-speed, Low power ADCs
- Bruno Lavigne; *Alcatel-Lucent France, France*
  Practical Aspects of 200G Deployment
- Toshiya Matsuda; *NTT Network Service Systems Laboratories, Japan*
  Operational Issues Facing Commercial Raman Amplifier System: Safety Measures and System Designs
- Glenn Wellbrock; *Verizon Communications Inc., USA*
  The True Value of Flexible Networks

S2: PHOTONIC SUBSYSTEMS FOR DIGITAL SYSTEM APPLICATIONS

- Pierre-Alexandre Blanche; *University of Arizona, USA*
  Fast Non-blocking NxN Opitcal Switch Using Diffractive MOEMS

- Brandon Collings; *JDSU, USA*
  Advanced ROADM Technologies and Architectures
- Yuping Huang; N*orthwestern University, USA*
  Sub-systems for Gb/s Quantum Communications
- Klaus Petermann; *Technische Universität Berlin, Germany*
  Phase-sensitive Optical Processing in Silicon Waveguides
- Thomas Richter; *Fraunhofer Heinrich-Hertz Institut, Germany*
  Generation of Ultra-dense Superchannels using Frequency Conversion in Optical Fibers
- Dries Van Thourhout; *Ghent University, INTEC, Belgium*
  Photonics Subsystems for Optical Packet/Burst Switches Based on Heterogeneous SOI and III-V integration
- Andreas Wiberg; *University of California San Diego, USA*
  Photonic Analog-to-digital Conversion

S3: RADIO-OVER-FIBER, MICROWAVE PHOTONICS, FREE-SPACE, AND ANALOG APPLICATIONS

- Guillermo Carpintero; *Universidad Carlos III de Madrid, Spain*
  Integrated Photonic Transceivers for mm-wave Transmission
- Paolo Ghelfi; *CNIT, Italy*
  Fully Photonics-based Radar Demonstrator: Concept and Field Trials
- Ampalavanapilla Nirmalathas; *University of Melbourne, Australia*
  Photonic Assisted Gigabit Wireless
- Michel Poulin; *TeraXion Inc., Canada*
  Optically Phase-locked Lasers for RF Photonics Applications
- Chris Roeloffzen; *Universiteit Twente, Netherlands*
  Integrated Optical Beamformers
- Juan Jose Vegas Olmos; *Technical University of Denmark, Denmark*
  Reconfigurable Radio-Over-Fiber Networks
- Hejie Yang; *Corning Incorporated, USA*
  Optical Solutions for Mobile Access

S4: DIGITAL ELECTRONIC SUBSYSTEMS AND TRANSCEIVERS

- Sercan Arik; *Stanford University, USA*
  MIMO DSP Complexity
- Liang Dou; *Fujitsu Research and Development Center, China*
  Advanced Digital NL Distortion Compensation
- Chao Lu; *Hong Kong Polytechnic University, Hong Kong*
  Optical Performance Monitoring in DSP-based Coherent Optical Systems
- Jeremie Renaudier; *Alcatel-Lucent France, France*
  1Tb/s Transceivers
- William Shieh; *University of Melbourne, Australia*
  Linearization of Optical Channels with Stokes Vector Direct Direction
- Nebojsa Stojanovic; *Huawei Technologies Co., Ltd., China*
  Clock Recovery in Coherent Optical Receivers

S5: DIGITAL TRANSMISSION SYSTEMS

- Do-Il Chang; *Xtera Communications Inc., USA*
  Unrepeatered High-speed Transmission Systems
- Vittorio Curri; *Politecnico di Torino, Italy*
  HFA Optimization for NyWDM Tranmission
- Toshiaki Koike-Akino; *Mitsubishi Electric Research Labs, USA*
  Coded Modulation Design for Finite-Iteration Decoding and High-Dimensional Modulation
- Takayuki Mizuno; *NTT Network Innovation Laboratories, Japan*
  Dense Space Division Multiplexed Transmission over Multi-core and Multi-mode Fiber
- Danish Rafique; *Coriant GmbH & Co. KG, Germany*
  Fiber Nonlinearity Compensation: Practical Use Cases and Complexity Analysis
- Mark Shtaif; *Tel-Aviv University, Israel*
  The Dynamics of Nonlinear Distortion in Long-haul Transmission System
- Henk Wymeersch; *Chalmers Tekniska Hogskola, Sweden*
  On the Use of Factor Graphs in Optical Communications
- Fatih Yaman; *NEC Laboratories America Inc., USA*
  Bi-directional Transmission to Reduce Linear and Nonlinear Crosstalk

TRACK N - NETWORKS, APPLICATIONS, AND ACCESS

N1: ADVANCES IN DEPLOYABLE NETWORKS AND APPLICATIONS

- Michael Freiberger; *Verizon Communications Inc., USA*
  In-network Experiences with Installing OTN Switched Metro Core Optical Systems
- John Hollingsworth; *IBM TJ Watson Research Center, USA*
  Opportunities for Bandwidth-on-Demand between Large Datacenters
- Itsuro Morita; *KDDI R&D Laboratories, Japan*
  Network Control and Virtualization for Cloud and Mobile Services from Carrier's Point of View
- Toshikazu Sakano; *NTT Network Innovation Laboratories, Japan*
  Movable and Deployable ICT Resource Unit (MDRU) and Resilient Photonic Network
- Yutaka Takita; *Fujitsu Labs. Ltd., Japan*
  Agile Network Re-optimization Supporting Seamless Service Migration
- Vijay Vusirikala; *Google, USA*
  Google's Vision of the Next-gen Optical Network

N2: DYNAMIC SOFTWARE CONTROLLED AND MULTILAYER NETWORKS

- Dean Bogdanovic; *Juniper Networks Inc., USA*
  Autonomic Agent for Transport Networks
- Mazen Khaddam; *Cox Communications, Inc., USA*
  The Benefits of Optimization in Multilayer SDN Transport Networks
- Reza Nejabati; *University of Bristol, UK*
  SDN and NFV Convergence a Technology Enabler for Abstracting and Virtualising Hardware and Control of Optical Networks
- Vishnu Shukla; *Verizon Communications Inc., USA*
  SDN Transport Architecture and Challenges

- Atsushi Takahara; *NTT Device Innovation Center, Japan*
  Software-Defined, Virtualized Networking and Beyond 100G

N3: NETWORK ARCHITECTURES, TECHNO-ECONOMICS, AND DESIGN TRADEOFFS

- Gordon Brebner; *Xilinx, USA*
  Programmable Hardware for High Performance "Softly" Defined Networking
- Konstantinos Christodoulopoulos; *Department of Computer Engineering and Informatics, University of Patras, Greece*
  Elastic Bandwidth Allocation Algorithms
- Stéphane Gosselin; *Orange Labs, France*
  Fixed and Mobile Convergence: Which Role for Optical Networks?
- Matthias Gunkel; *Deutsche Telekom AG Laboratories, Germany*
  Elastic Black Link for Future Vendor Independent Optical Networks
- Hiroshi Hasegawa; *Nagoya University, Japan*
  Large Scale Optical Cross-connect: Architecture, Performance Analysis, and Feasibility Demonstration
- Rosanna Pastorelli, *Cisco Systems, Inc., Italy*
  Network Planning Strategies for Flexible Optical Networks
- João Santos; *Coriant Portugal, Portugal*
  Evaluating the Potential for Spectrally-Efficient Super-Channel Formats in Brownfield Networks with Legacy Services
- Marco Schiano; *Telecom Italia Lab, Italy*
  Flexible Node Architectures for Metro Networks

N4: OPTICAL ACCESS SYSTEMS AND WIRELESS BACKHAUL NETWORKS

- Silvio Abrate; *Istituto Superiore Mario Boella, Italy*
  Silicon Photonics and FDMA PON: Insights from the EU FP7 FABULOUS project
- Romain Brenot; *Alcatel-Thales III-V Laboratory, France*
  Demystification of Self-seeded WDM Access
- David Hillerkuss; *ETH Zurich, Switzerland*
  Software-defined Transceivers for Dynamic Access Networks
- Noriko Iiyama; *NTT Access Network Service Systems Laboratories, Japa*n
  Advanced DSP for Optical Access Networks: Challenges and Opportunities
- Jesper Jensen; *DTU Fotonik, Denmark*
  VCSELs for Coherent PON
- Fumio Koyama; *Tokyo Institute of Technology, Japan*
  Energy Efficient Tunable Light Sources for Next Generation Flexible Access Networks
- Thomas Pfeiffer; *Alcatel-Lucent, Germany*
  Next Generation Mobile Fronthaul Architectures
- Josep Prat; *Universitat Politecnica de Catalunya, Spain*
  Technologies for a Cost-effective Coherent udWDM-PON
- Keiji Tanaka, *KDDI R&D Laboratories, Japan*
  Next-Generation Optical Access Networks for C-RAN

DSN6: Optical devices, subsystems, and networks for Datacom and Computercom

DSN6: OPTICAL DEVICES, SUBSYSTEMS, AND NETWORKS FOR DATACOM AND COMPUTERCOM

- Stuart Elby; *Infinera Corporation., USA*
  Migration Services to the Cloud and its Impact upon the Carrier Network
- Frank Flens; *Finisar Corporation, USA*
  Optical Transceiver Packaging
- David Lariviere; *Columbia University, USA*
  Technology Trends to Speed up the Delivery of Wall Street Data
- David Maltz; *Microsoft, USA*
  SDN and Routing Strategies for Cloud-Scale Data Center Traffic
- Cyriel Minkenberg; *IBM Research, Switzerland*
  Optical Networking for Data-Centric Systems
- Matthew Sysak; *Intel Corporation, USA*
  Intel®'s Silicon Photonics on an Advanced Manufacturing Platform
- Ryo Takahashi; *NTT Device Innovation Center, Japan*
  Data Center Networks based on Optical Packet Switching with Flow Control
- Jason Taylor; *Facebook Inc., USA*
  Facebook's Data Center Infrastructure: OpenCompute, Disaggregated Rack, and Beyond

TUTORIAL SPEAKERS

Track D - Optical Components, Devices and Fiber

D1: ADVANCES IN DEPLOYABLE OPTICAL COMPONENTS, FIBERS, AND FIELD INSTALLATION EQUIPMENT

- **Raman Amplification: An Enabling Technology for High-Capacity, Long-Haul Transmission**
  Wayne Pelouch
  Xtera Communications Inc, USA

D2: PASSIVE OPTICAL DEVICES FOR SWITCHING AND FILTERING

- **Femtosecond Laser Inscribed Waveguides for New Optical Circuit Applications**
  Peter Herman
  University of Toronto, Canada

D3: ACTIVE OPTICAL DEVICES AND PLATFORMS FOR PHOTONIC INTEGRATED CIRCUITS

- **Silicon Photonics**
  John E. Bowers
  University of California Santa Barbara, USA

D4: FIBERS AND PROPAGATION PHYSICS

- **Propagation Effects in SDM Fibers**
  Antonio Mecozzi
  University of L'Aquila, Italy

- **Multicore Fiber Technology**
  Kunimasa Saitoh
  Hokkaido University, Japan

D5: FIBER-OPTIC DEVICES AND SENSORS\

- **Biomedical Fiber Optic Sensor Applications**
  Alexis Mendez
  MCH Engineering, LLC, USA

TRACK S - PHOTONIC SYSTEMS AND SUBSYSTEMS

S1: ADVANCES IN DEPLOYABLE TRANSMISSION SUBSYSTEMS AND SYSTEMS

- **Design Trade-offs in Practical ASIC Implementations**
  Oscar E. Agazzi
  ClariPhy Communication, Inc., USA

  Power Efficient Implementation of Soft-Decision FEC
  Sameep Dave
  ViaSat Inc., USA

S2: PHOTONIC SUBSYSTEMS FOR DIGITAL SYSTEM APPLICATIONS

- **Phase Sensitive Amplifiers and their Applications**
  Francesca Parmigiani
  University of Southampton, UK

S3: RADIO-OVER-FIBER, MICROWAVE PHOTONICS, FREE-SPACE, AND ANALOG APPLICATIONS

- **Visible Light Communication**
  Harald Haas
  University of Edinburgh, Scotland

S4: DIGITAL ELECTRONIC SUBSYSTEMS AND TRANSCEIVERS

- **Optical Coherent Communication Technology**
  Kazuro Kikuchi
  University of Tokyo, Japan
- **Role of Information Theory in Coherent Optical Transmission Systems**
  Frank Kschischang
  University of Toronto, Canada

S5: DIGITAL TRANSMISSION SYSTEMS

- **High-Capacity Submarine Transmission Systems**
  Alexei N. Pilipetskii
  TE SubCom, USA
- **400G and 1Tb/s Single-carrier Systems**
  Gregory Raybon
  Alcatel-Lucent Bell Labs, USA

TRACK N - NETWORKS, APPLICATIONS, AND ACCESS

N1: ADVANCES IN DEPLOYABLE NETWORKS AND APPLICATIONS

- **SDN Control of Packet-over-optical Networks**
  Guru Parulkar; *Stanford University, USA* and Tom Tofigh; *AT&T Labs, USA*

N2: DYNAMIC SOFTWARE CONTROLLED AND MULTILAYER NETWORKS

- **Control Architectures for Multi-layer Networking: Distributed, centralized, or something in between?**
  Ori Gerstel;
  Sedona Systems, Israel

N3: NETWORK ARCHITECTURES, TECHNO-ECONOMICS, AND DESIGN TRADEOFFS

- **Ethernet and OTN: 400G and beyond**
  Steve Trowbridge
  Alcatel-Lucent, USA

N4: OPTICAL ACCESS SYSTEMS AND WIRELESS BACKHAUL NETWORKS

- **OFDM for Optical Access**
  Christian Ruprecht and Johannes von Hoyningen-Huene
  Christian-Albrechts Universität zu Kiel, Germany

DSN6: OPTICAL DEVICES, SUBSYSTEMS, AND NETWORKS FOR DATACOM AND COMPUTERCOM

DSN6: OPTICAL DEVICES, SUBSYSTEMS, AND NETWORKS FOR DATACOM AND COMPUTERCOM

- **High Speed Circuits for Optical Communications**
  Alexander Rylyakov
  IBM TJ Watson Research Center, USA

WORKSHOPS

OFC Workshops provide opportunities to discuss and debate the latest technologies.

Workshop topics are controversial in nature and meant to be highly interactive, amongst both the speakers and the audience. The format of each session is determined by the organizers. In the past, many workshops have consisted of a series of short presentations (5 to 10 minutes) from people involved in the field followed by a panel discussion driven by questions from the audience.

The workshops provide an interactive learning environment and are open to all conference registrants. Like invited and tutorial speakers, workshop topics and organizers are chosen through a highly selective nominations process.

Do Small, Large, And Mega Data Centers Need Advanced Photonics Technology?
Organizers: Rich Baca; *CommScope, Inc., USA*; Nicola Calabretta; *Technische Universiteit Eindhoven, Netherlands*; Mark Feuer; *CUNY College of Staten Island, USA*; Adel Saleh; *University of California Santa Barbara, USA*

Flexible Optical Network, Technology Is Ready, But…?
Organizers: Tiejun (T.J.) Xia; *Verizon, USA*; Alan Pak Tao Lau, *Hong Kong Polytechnic University, Hong Kong*; Steve Plote, *BTI Systems, USA*

Silicon Photonics: Is it still in hype or on its way to the field?
Organizers: Daniel Kuchta; *IBM T. J. Watson Res. Center, USA*; Ken Morito; *PETRA/Fujitsu Labs., Japan;* Jonathan Klamkin; *Boston University, USA*; Po Dong; *Bell Labs, Alcatel Lucent, USA*

Are There Limits to High-speed Interface Rates?
Organizers: Sebastian Randel; *Bell Labs, Alcatel-Lucent, USA*; The'linh Nguyen; *Finisar Corporation, USA;* Ali Ghiasi; *Ghiasi Quantum LLC, USA*; Michael Sprenger; *Optical Technologies CableLabs, USA*; Takashi Saida; *NTT Photonics Laboratories, Japan*

Are Accurate Real-time Planning Tools for Physical-layer System Performance Possible?
Organizers: Annalisa Morea; *Bell Labs, Alcate-Lucent, USA;* Fabrizio Forghieri; *Cisco, Italy*; Oleg Sinkin; *TE SubCom, USA;* Robert Doverspike; *AT&T, USA*

Where Will The Real Value of SDM Research Be Realized First? Will It Be In Telecom Or Non-telecom Applications?
Organizers: Thierry Taunay; *OFS Laboratories, USA*; Kazuhide Nakajima; *Nippon Telegraph & Telephone Corp, Japan*; Victor Kopp; *Chiral Photonics Inc. , USA*; *David Neilson; Bell Labs, Alcatel-Lucent, USA*

Beyond The Hype: How Realistic are Claims of Benefits from SDN Control in Carrier Metro Networks?
Organizers: Mehran Esfandiari; *AT&T Corp, USA;* Dominique Verchere; Bell Labs *Alcatel-Lucent, France*

Short Reach Optical Networks: Highly Synergistic or Different Worlds?
Organizers: Peter Vetter; *Bell Labs, Alcatel-Lucent, USA;* David Piehler; *Fields and Waves, USA*; Anna Tzanakaki; *University of Bristol, UK;* Neda Cvijetic; *NEC Labs America, USA*

High Capacity, Scalable and Energy-efficient Networks: An achievable goal or an oxymoron?
Organizers:Kerry Hinton; *University of Melbourne, Australia;* Rod Tucker; *University of Melbourne, Australia*

PANELS

The panels provide an interactive learning environment and are open to all conference registrants. Like invited and tutorial speakers, panel topics and organizers are chosen through a highly selective nominations process.

FTTH Indoor Optical Fiber Installation Technologies
Organizer: Robert Lingle; OFS, USA

Optics in Access: Technology and Standards
Organizer: Frank Effenberger; *FutureWei Technologies, Inc., USA*

Tunable and Programmable Modulation Format Transceivers
Organizers: Steve Plote; *BTI Systems, USA*; Alan Pak Tao Lau; *Hong Kong Polytechnic University, Hong Kong*

PLENARY SESSION

THE FUTURE OF TRANSPORT NETWORKS

Pradeep Sindhu

Vice Chairman and Chief Technology Officer
Juniper Networks

Optics and electronics provide largely complementary capabilities for fundamental physical reasons:

Optics is good for communicating information over long distances and for limited forms of switching; Electronics is good for processing and storing information and therefore for sophisticated forms of switching, including packet switching and routing.

Optoelectronics bridges these two domains. Good progress has been made here, particularly with the development of coherent detection and the integration of high speed electronics and optics, but optoelectronics still remains too expensive and specialized for many applications.

The delivery of large scale computing in the form of massive data centers has prompted discussion of SDN-like approaches for the centralized handling of portions of network functionality.

The future of transport networks depends on developments in all these technologies. Unfortunately, the use of confusing terminology, industry silos, hype around a particular technology, and agendas to prolong the life of outdated technologies have obfuscated discussion on how transport networks should evolve.

This talk looks at developments in all of the above technologies and attempts to chart the course transport networks should take and will likely take over the next five years.

Biography: Pradeep Sindhu founded Juniper Networks in February 1996 and has held several key roles in shaping the company. He was the CEO and chairman of the company for the first eight months, and since then has been the vice chairman and chief technology officer. In this latter role, he is responsible for the company's technology roadmap and stays involved in the design and development of key future

products. He played key roles in the design and development of the company's first product, the M40, and the next two generations of products, the M160 and T640.

Prior to Juniper Networks, Sindhu worked as a principal scientist and distinguished engineer at the Computer Science Laboratory at Xerox's Palo Alto Research Center (PARC), where he worked on design tools for VLSI as well as on cache coherency algorithms and high-speed interconnects for shared memory multiprocessors. His key roles in the architecture, design and development of shared memory multiprocessors led to the commercial development of Sun Microsystems' first high-performance multiprocessor system family, which included the SS1000 and SS2000.

Sindhu holds a Bachelor's degree in electrical engineering from IIT Kanpur, as well as a master's degree in electrical engineering from the University of Hawaii. He also holds masters and doctoral degrees in computer science from Carnegie-Mellon University.

Sindhu has a broad interest in all areas of high technology, but particularly in computing, storage, and networking. He tends to focus on the interfaces between disciplines.

Undersea Fiber Optic Cables - Enabling a Connected World

Neal S. Bergano

Vice President, R&D and Chief Technology Officer
TE Connectivity SubCom, USA

Today, information flows across the globe as easily as it flows across the office.

This information might come from New York, London, Tokyo, Sydney, Rio de Janeiro, or Cape Town and arrive not from satellites but from cables that sit on the ocean floor. The Earth's continents are connected with a web of undersea fiber optic cables that join the world's major population centers. Anyone who surfs the Internet, makes overseas calls, or simply texts friends on other continents uses these undersea fiber optic cables.

Undersea cables have been providing global connectivity for nearly 150 years. The first successful transatlantic telegraph cable connected North America to Europe and went into service in 1866, about 30 years after the invention of the telegraph. Nearly 90 years after that first telegraph cable was installed, the first transatlantic telephone cable was installed. In 1956, the TAT system (transatlantic telephone cable) went into service with 36 telephone circuits between Newfoundland and Scotland. The first fiber optic cables were then deployed in the 1980s, using digital regenerators. In the 1990s, Erbium-doped fiber amplifiers with moderate bandwidth were used, and today, fiber optic cables use large bandwidth amplifiers and dense wavelength division multiplexing.

Modern undersea telecommunication cable systems are routinely installed with tens of terabits capacity over ten mega-meter distances. Cable systems can now offer an ultimate cable capacity approaching 100Tb/s, while being flexible enough to allow for future-proof growth. These systems use a combination of large effective area fibers, EDFA-based repeaters gain-equalized to milli-dB levels over the entire C-band, and coherent transponders with advanced signal processing. Optical add-drop multiplexing allows this large capacity to be shared among several landing locations.

Undersea fiber optic cable systems have also proven to be invaluable for offshore scientific studies in which oceanographers and offshore earth scientists need constant high-bandwidth connectivity and

electrical power. Also, as oil and gas industry assets continue to move farther offshore, the need for high-bandwidth connectivity to manage and monitor production grows. These communication needs are being met with the use of undersea fiber optic cables and a suite of special-built undersea cable equipment.

Biography: Neal S. Bergano is the vice president of R&D and the chief technology officer of TE Subsea Communications LLC (TE SubCom) in Eatontown, N.J., USA. From 1998 until 2013 he was the managing director of system research and network development at TE SubCom.

Bergano holds 31 U.S. patents in the area of optical fiber transmission systems. His main research has been devoted to the understanding of how to improve the performance and transmission capacity of long-haul optical fiber systems, including the use of wavelength division multiplexing in optical-amplifier-based systems.

Bergano received a B.S. in electrical engineering from the Polytechnic Institute of New York, and an M.S. in electrical engineering and computer science from the Massachusetts Institute of Technology. In 1981, he joined the technical staff of Bell Labs' undersea systems division. In 1992, he was named a Distinguished Member of the Technical Staff of AT&T Bell Labs, where he became an AT&T technology consultant in 1996 and AT&T technology leader in 1997.

Bergano is a Fellow of IEEE, The Optical Society (OSA), AT&T, and TE Connectivity. He served on the Board of Directors for OSA from 2009 to 2011, and served on the Board of Governors for the IEEE Lasers and Electro-Optics Society from 1999 to 2001. He is a long-time volunteer and supporter of OFC, which has included serving on the program and steering committees. He is the recipient of the 2013 TE Connectivity Life-Time Achievement Award and of the 2002 John Tyndall Award for outstanding technical contributions to and technical leadership in the advancement of global undersea fiber optic communication systems.

How Algorithms Shape Our Networked World

Kevin Slavin

Assistant Professor of Media Arts and Sciences
MIT Media Lab, USA

In their hearts, computers, smartphones, and other mobile devices are simply quantifying information and sewing it together however we tell them to.

But these devices aren't mere objects; they are the nervous system for a networked world. Their effects are broad, deep, and often quite difficult to discern, extending far off the desktop into our everyday lives.

Inside these networked devices are simply algorithms that are trying to make the kinds of decisions that humans find difficult. The algorithms themselves might not be new. But their domain most certainly is: everything from the way that elevators arrive to the way large content is distributed, and then, of course, there's Google, and the stock market. More and more of our everyday experiences have algorithms folded deep inside them. And fewer and fewer of those algorithms have human supervision integrated into their operations. With the emergence of the "Internet of Things" and as optical networks increasingly rely on complex algorithms to perform functions such as impairment mitigation in a

software-defined transceiver or routing and resource allocation in a software-defined network, the impact of algorithms on the future of optical networking is profound.

This is a tour, investigation, interrogation, and future vision of what these algorithms are, how they function, where they live, and what they'll become. It raises questions about this new form of physics; not just the physics of information, networking or finance, but of culture at large.

Biography: As an intellectual leader, Kevin Slavin has successfully integrated digital media, game development, technology, and design. His research revolves around themes of play and games, exploring the use of new media technologies to design a new generation of play experiences. He is a pioneer in rethinking game design and development around new technologies (like GPS) and new platforms (like Facebook).

In 2013, MIT's Media Lab appointed Slavin to start and lead "Playful Systems," a new division of the lab. He is leading projects at the intersections of entertainment, games, big data, next-generation technologies, and design. The work of this group has attracted global attention, including every major news network and coverage from *The Huffington Post*, *Discovery*, *Wired* and the *New Scientist*.

In 2013, Slavin also co-founded Everybody at Once, a consultancy focused entirely on how online audiences and fans interact with TV, movies, and sports. The company currently works with BBC America, BBC News, Starz, American Public Media, and the European soccer team Roma.

In 2005 he co-founded Area/Code (acquired by Zynga in 2011), where he developed large-scale, real-world games using mobile, pervasive, and location-aware technologies. This included work for major companies, including Nokia, Nike, Puma, MTV, A&E, the Discovery Channel, CBSl, and Disney. He co-founded AFK Labs in 2008, designing next-generation responsive environments, including one for what was then the largest and densest sensor mesh on the planet.

As a professor and teacher, he's taught at NYU's Interactive Telecommunications Program, Fabrica, MIT, and Cooper Union, where he is also an Alumni Trustee.

RUMP SESSION

Is it 'Game Over' for Hardware?

Moderator: Chris Cole; *Finisar Corporation, USA*; Glenn Wellbrock, *Verizon Communications Inc, USA*

Overview of the Session

Some industry trends like SDN appear to make optics hardware engineering and innovation irrelevant and shift innovation into software-based network control. Other industry trends like Silicon Photonics appear to create great new opportunities for hardware innovation.

- The rise of software monitoring and control in datacenters and transport networks enables bypassing of failing optical links. Geographically diverse back-up means entire datacenters can be spared.
- Profit margins in the optics industry are well below those expected of high technology companies. The majority of profits which are in software and applications are not reinvested in the physical layer.

- A strong expectation has developed that the bits/sec cost of advanced new optics, even at low initial volumes, has to be on par or below that of the established high-volume previous generations. This makes ROI unattractive for advanced optics hardware. High initial cost of 10G in the 90s was accepted by industry, while similar high initial cost of 100G has been widely criticized.
- Carrier revenues are flat, while bandwidth demand is increasing exponentially. Revenues of Cloud companies are climbing but their business model requires cheap, commodity hardware.

Questions for Discussion

- Are reliable optics no longer needed? Is it cheaper to just replace failed units since the failure doesn't impact operation in a software-controlled environment? Or do super cheap optics require even more creativity from hardware engineers?
- If the expectation of low cost for advanced new optics guarantees there is no return on hardware R&D, who will innovate? Who will pay for innovation?
- Does the optics hardware design paradigm need to change to keep hardware design relevant?
- Will the promise of Silicon Photonics fab-less design rescue optics hardware innovation through an ASIC design paradigm that has been successful in the IC industry? Will the resulting short design cycles create great new opportunities for hardware innovation?
- Low noise EDFAs enabled WDM, what will be the next big enabling technology? Will it be in hardware or software?
- What new datacenter and transport applications will be enabled by low cost fully integrated optics?
- When will optics replace copper traces for board and chassis level interconnect and which innovations will make it happen? Will the required extreme low cost further dilute the return on optics R&D investment?
- Is optical switching and computing in the datacenter a great opportunity or will it remain a niche application? Do we need hardware or software innovation to make it happen?

Format

- One slide presentations by invited participants to stimulate discussion on select sub-topics areas above.
- Ample audience discussions after each slide presentation, with co-organizers drawing out questions from the audience.
- Anybody interested to participate in the discussions is invited to prepare a single slide to support his/her point.

MARKET WATCH TALKS

PANEL I: REALITY CHECK ON MATURITY OF METRO 100G AND BEYOND

Tuesday, 24 March
10:30 - 12:00

Moderator: Tiejun Xia, *System Architect/DMTS, Verizon, USA*

PANEL DESCRIPTION:

The panel will take a close look at the current economics and market dynamics to determine the most common sense means of increasing capacity with the general traffic shifts in metro as well as long-haul networks. With a lot more shorter distance traffic, how will price points be affected, and what are the realistic growth levels for 100G in the metro sector? Will there be sufficient justification, especially in meeting the exploding number of new applications, for traditional service providers that have historically been resistant to quickly make major changes to their networks to move much faster on deployment of higher capacity gear? How much optimism is there for the relatively new types of very aggressive buyers of bandwidth like the Web 2.0 types of firms to greatly expand the need for 100G and higher rate metro-type deployments? Will the threat of hacking into fiber lead to second thoughts about going much higher than multiples of 100G on a single wavelength? How likely is it that the industry would leapfrog 400G in favor of a terabit?

SPEAKERS:

The High Capacity Metro Networks: Transport Requirements and the Implications on Next Generation Modems; Michel Belanger, *Scientific Staff, Ciena, Canada*

Integrated WDM Approach for Cost Effective High Capacity Transceiver; Jinghui Li, *President, Auxora, USA*

The Next Generation: When Super-channels Meet Metro 100G; Ian MacDonald, *Vice President of Product Management, Infinera, USA*

Randy Nicklas, *CTO, Windstream Communications, USA*

What on Earth is a "100G Metro System?; Bill Szeto, *CTO of Terrestrial Network Systems, Xtera, USA*

Economical 100G Metro Transport Solutions; Ryan Yu, *VP/GM, Oplink, USA*

BIOGRAPHY:

Tiejun J. Xia is an expert of photonic technologies and optical communications in research, development, and technology innovations. He is Distinguished Member of Technical Staff with Verizon where his responsibility is optical network architecture and technology development. He is also an adjunct professor at Miami University, Ohio. He has served as Director for Network Technology Development at Chorum Technologies and worked for MCI for next generation optical transmission

technologies. He has also been a research faculty member in the Department of Electrical Engineering at the University of Michigan and an adjunct professor at University of Texas at Dallas.He is co-founder and current president of the Advanced Fiber Connectivity & Switching Forum. He has served on Technical Program Committees of OFC/NFOEC, APOC, ACP, and OECC. He is a senior member of IEEE and serves the executive board of IEEE Dallas Section.Dr. Xia holds his Ph.D. degree in Physics from CREOL at the University of Central Florida, M.S. degree from Zhejiang University, China, and B.S. degree from University of Science and Technology of China. He has published more than 100 technical papers, given numerous invited talks, and holds more than 60 granted or pending U.S. patents. In 2011, he was featured as "Verizon Innovator" on YouTube. In 2012, he was elected a Fellow of The Optical Society.

Michel P. Belanger obtained B.Eng from Ecole Polytechnique in 1979 and a PhD in Electrical Engineering in 1987 from McGill University. He held R&D positions at Ecole Polytechnique in Montreal and at Canadian Marconi. With the National Optics Institute of Canada, he conducted research into the design and application of guided wave optical components and diffractive optical elements. After a brief period at Teleglobe working in submarine system engineering, he joined Northern Telecom (now Ciena Corporation) in 1995 as product manager for DWDM systems. Later, he moved to the optical development group as a member of scientific staff. He is currently leading a group developing deployment strategy for coherent, high capacity, optical systems.

Jinghui Li is President of Auxora, Inc., a leading supplier of optical thin film filters for customers who need to control or manipulate light. He has more 20 year experience of leading edge product development, technical marketing and team management on advanced optoelectronic component and system companies. Prior to taking the helm of Auxora in December 2010, he held different positions in R&D and technical marketing in both startups and well established companies, including Nortel, JDSU, Sycamore, RedClover, Emcore and Source Photonics. Jinghui got his bachelor, master, and Ph. D. degree from Tsinghua University, Beijing, China and finished his postdoctoral research at Ottawa University, Canada. Jinghui holds 39 issued or pending U.S., Canada, China and international patents. Jinghui is an IEEE senior member.

Ian MacDonald serves as the Vice President of Product Management for Infinera and joined the company in 2008. Ian is currently leading the Metro Business Group at Infinera. From 1998 to 2008, Ian was Director of Product Management at Cisco Systems where he drove over $1B/year in the high end routing service provider business. Prior to Cisco Systems, from 1998 to 2008, Ian held software engineering and product management positions at Nortel Networks.Ian holds a B.S.E.E. from Memorial University of Newfoundland.

Randy Nicklas is executive vice president – engineering and chief technology officer for Windstream. Nicklas is responsible for network planning and engineering, outside plant, records and capital management. Prior to joining Windstream in May 2013, Nicklas was senior vice president of engineering and chief technology officer for XO Communications. He had previously held engineering and technical management positions at Intelst, Cisco, and MCI. He has also worked in the areas of software development and systems engineering on a variety of aerospace programs for NASA, Los Alamos National Laboratory and Computer Sciences Corporation. Nicklas holds bachelor's and master's degrees in applied mathematics and a master's degree in physics, all from the Georgia Institute of Technology.

William Szeto joined Xtera in 2011 and serves as the CTO of Terrestrial Network Systems. He has over 35 years of experience in the telecom industry. Bill is active with the standards communities and was the Vice Chair of ATIS's COAST committee, and a member of the Board Of Director for ATIS. He is involved

with the ITU-T SG 15 on optical transport and Ethernet, and with the IEEE 802.3 committees. Prior to Xtera, Bill was the Founder, President and CEO of Ceterus Networks until 2003 and was CTO until 2009. Prior to Ceterus, he was President and CEO of Iris Labs in 2000. Bill left Sprint in 1999, where he was the senior manager for 28 years, to become the CTO for Monterey Networks, and later the Principal Technologist for the Core Optical Transport Business Unit for Cisco Systems. He holds a BSEE and an MBA from Ohio State University.

Rang-Chen (Ryan) Yu is the Vice President of Business Development and General Manager of Active Products at Oplink Communications, Inc. Prior to joining Oplink in 2009, he was Global Vice President of Product Development at Source Photonics. He was the Vice President of Datacom and Telecom at Fiberxon, and Sr. Director of System Engineering at Agility Communications, Inc. Rang-Chen holds a Ph. D. in Solid State Physics from University of Pennsylvania, and B. S. in Physics from Peking University.

PANEL II: STATE OF THE MARKET/INDUSTRY: 2014 IN REVIEW

Tuesday, 24 March
12:30 - 14:30

Moderator: Vladimir Kozlov; *CEO, LightCounting, USA*

PANEL DESCRIPTION:

A dedicated panel of industry experts will provide a deeper, more current understanding of the optical communications networks industry from the perspective of the top-tier analyst and finance communities. Are we still on track for recovery from the economic downturn or in a boom? Is there more M&A in the optical component and semiconductor IC space during the current market ups and downs? What are new emerging opportunities, innovations, and challenges? Can optical integration keep up with the pace of electronics development toward photonic-electronic convergence? What make sense and what does not, reality vs. myth? How do we leverage optical investment and business case studies? How sophisticated are the fast-growing geographic areas such as China, Brazil, and India? Join us at another great destination for just the right mix of market analysis, insights, and networking.

SPEAKERS:

Update on Investment in the Optical Communications Industry; Tom Hausken, *Senior Engineering & Applications Advisor, OIDA, USA*

Data Center Interconnect and LTE-A, Engines for Growth;Ron Kline, *Principal Analyst, Intelligent Networks, OVUM, USA*

The Promises of Silicon Photonics : Current Status and Future Trends; Hughes Metras, *VP, Strategic Partnerships, North America,CEA-LETI, France*

Technology meets Politics : The Story of Australia's National Broadband Network; Rod Tucker, University of Melbourne, Australia

Worldwide Optical Networking Market: Key Highlights, Trends & Drivers?; Dennis Ward, *Technical*

Analyst, ACG Research, USA

State of the Optical Transport System Equipment Market; Jimmy Yu, *Analyst, Microwave Transmission, Optical Transport, Dell'Oro Group, USA*

BIOGRAPHY:

Dr. Vladimir Kozlov is the founder and CEO of LightCounting an optical communications market research company. LightCounting was established in 2004 with an objective of providing in-depth coverage of market and technologies for high speed optoelectronic interfaces employed in communications. By now, the company employs a team of industry experts and offers comprehensive coverage of optical communications supply chain.Dr. Kozlov has more than 25 years of experience in optoelectronics, optical communications and market research. He also co-founded several other companies, including Fianium, LX Medical and Microtech Instruments, developing laser systems for medical applications.Dr. Kozlov held market analyst, product development and research staff positions at RHK Inc., Lucent Technologies and Princeton University. Dr. Kozlov holds several US patents and has numerous publications in the area of optoelectronics. He received M. Sc. at Moscow State University in Russia and Ph. D in Physics at Brown University in the United States.

With over 30 years in optoelectronics, **Dr. Hausken** focuses on industry activities at OSA—the Optical Society. This includes OIDA (the Optoelectronics Industry Development Associates, a trade association activity within OSA) where he held a position earlier in his career. For 13 years until 2012, Dr. Hausken led market research and strategy consulting for lasers, image sensors, and a range of other photonic products at Strategies Unlimited. He was also a telecom policy analyst at the U.S. Congressional Office of Technology Assessment, and held R&D and production positions at Alcatel and Texas Instruments in photonics and electronics. He has a PhD from the University of California at Santa Barbara, in optoelectronics.

Ron Kline is a Principal Analyst with Ovum's Intelligent Networks team. Ron has over 30 years of industry experience that includes 18 years working for a large North American service provider and 14 years as an industry analyst. Ron has an in-depth knowledge of network technology combined with a strong business-oriented approach to problem solving. He is responsible for the overall direction of Ovum's optical-packet networking research. Markets covered include optical transport, carrier Ethernet, mobile backhaul and data center interconnect. Ron specializes in DWDM, bandwidth management, aggregation, carrier Ethernet, microwave radio and transport SDN technologies used in both wireline and wirelessnetworking applications. Prior to becoming an analyst in 2000, Ron worked for Bell Atlantic (now part of Verizon) as senior member of the technical staff responsible for future optical network architectures, including bandwidth management, aggregation (SONET/MSPP), and the initial deployments of DWDM in the service provider's network. Ron has a wide variety of network transmission and switching equipment experience, and extensive knowledge of network control, management and operational support systems. Ron received a M.S. Telecommunications and Computing Management from NYU Polytechnic School of Engineering in 1997.

Hughes Metras works with CEA-LETI where he is VP in charge of Strategic Partnerships in North America. He is also a visiting staff at Caltech in the framework of the Alliance for Nanosystems VLSI where he is en charge of business development for the US region.In the framework of his present functions, he has been instrumental in establishing Leti's presence in the US as a key R&D player providing state of the art platforms and proposing services to bridge the gap between research of new

concepts and manufacturing. Hughes is very active in the field of silicon photonics through industry interactions, participation to workshop and conferences where he promotes Leti's silicon photonics 200 and 300 mm wafer scale prototyping capabilities for passive and active devices with a special emphasis on InP/Si laser integration. Previously, he was VP Marketing and Sales in charge of business development and strategic planning. He coordinated Leti's sales and marketing teams in the field of semiconductors (advanced CMOS as well as Heterogenous integration on 200/300 mm lines), imaging and photonics, biomedical technologies as well as telecommunications.
He benefits from a technical background in Physics engineering and holds an MBA from the University of Miami (Fl). Hughes is Base in Pasadena, Califonia

Rod Tucker is an Emeritus Professor at the University of Melbourne. He served on a government-appointed panel of experts that advised on the establishment of a national broadband access network in Australia. He is a Fellow of the IEEE, the Optical Society of America, the Australian Academy of Science, and the Australian Academy of Technological Sciences and Engineering. He has previously held positions at the Plessey Company, AT&T Bell Laboratories, Hewlett Packard Laboratories, and Agilent Technologies. Rod was Founding Director of the University of Melbourne's Institute for a Broadband-Enabled Society.

Dennis Ward with twenty-six years of experience in the datacom and telecom industries joined ACG Research as a principal analyst in Optical Networking, SDN and Internet Of Things. He has participated in the design, implementation, interoperability testing and QA Analysis of many device and system protocols. His experience allows for an insightful yet practical approaches to industry solutions and business models. Prior to joining ACG Mr. Ward has held various technical and management consulting positions in the USA and abroad. He has provided services to leading companies as Metaswitch Networks, Cisco Systems, Adaptive, NET, Sun Microsystems, Mitsubishi, CableLabs, Microsoft and Siemens to name a few. As an entrepreneur, he co-founded iThinkTest, Inc., a Test Engineering and Consulting firm. This firm successfully designed and implemented a suite of comprehensive protocol analyzers for the IP Communications, IMS and Packetcable networks. For example, the Flowcoder ™ products were used by CableLabs to certify many of the Softswitches and Application servers used in core MSO, Telco and MNO industries. This saved equipment and service providers such as Cedar Point, Siemens, Telcordia, Cisco, Comcast, Cablevision, AT&T and Sprint millions of dollars in protocol analysis and quality assurance. As an educator and BSEE graduate from M.I.T, Mr. Ward has trained many engineers at a University level in telecom and datacom disciplines

Jimmy Yu is responsible for the Optical Transport market research program at Dell'Oro Group. Mr. Yu originally joined Dell'Oro Group in 2001, and spent over four years as the primary analyst for Dell'Oro Group's Optical Transport program and built our coverage of the PON market. In 2006, Mr. Yu joined Spansion, a leader in flash memory solutions, where he was a Strategic Product Marketing Manager for Spansion's server memory subsystem product line. Prior to joining Dell'Oro Group in 2001, Mr. Yu worked for Deloitte Consulting in the strategy and operations group as a Management Consultant with a focus in the high-tech industry. Mr. Yu began his career in Northrop Grumman's space technology group, where he was a lead mechanical engineer developing satellite communication subsystems and components, such as transceivers. While at Northrop Grumman, he also developed advanced packaging approaches for millimeter wave RF semiconductors, circuit boards, fiber optics, and photonics. He is a recognized authority in the Optical Transport Market and has written articles in various industry magazines such as *Lightwave*. He is frequently quoted in publications such as *Bloomberg Businessweek, Converge! Network Digest, Dallas Business Journal, and Network World.* Mr. Yu is a frequent speaker at industry conferences and events, including Lightwave Optical Innovation Summit, OFC, OIDA, Photonics

Society, and the Next Generation Optical Networking and Packet Microwave and Backhaul conferences. Mr. Yu received a B.S. degree in Mechanical Engineering from University of California, Davis and an M.B.A. in General Management with an emphasis in Corporate Strategy and Finance from the University of Michigan.

PANEL III: WHAT'S NEW IN INTEGRATED PHOTONICS TECHNOLOGIES?

Tuesday, 24 March
15:00 - 17:00

Moderator: Mark Lutkowitz; *Principal, fibeReality, LLC, USA*

PANEL DESCRIPTION:

Highly integrated modules and devices have been one of the hottest topics at OFC. Thanks to the recent advances in photonics and integrated technologies, OEMs can offer smaller form factor and lower power solutions. We review the state of the art in photonic integration in optical communications. How does photonic integration address the emerging business needs in user applications? What are the novel integration concepts and what are the challenges in bringing them to production? Which forms of integration match specific demands within communication systems? What are the new and noteworthy products being commercialized today? Are there experiences to share from deployments?
This panel will explore the commercialization of components and subsystems and their applications across telecom and data center networks.

SPEAKERS:

Generic Photonic Integration Platform: Is It Possible?;Mark Earnshaw, *Director Photonic Subsystem Integration, Bell Labs, Alcatel-Lucent, USA*

Optical Packaging Challenges for Low-Cost, Data-Center Transceivers; Ken Jackson, *Product Marketing Director, Sumitomo Electric Device Innovations, USA*

Hybrid Integration, the Low-cost Scalable Way to Commercialize Silicon Photonics, III-Vs, and Your Favorite Device; Bardia Pezeshki, *President & Chief Executive Officer, Kaiam, USA*

Advanced DSP for High Speed Transmission with Integrated Photonics; Avi Shabtai, *Chief Executive Officer, MultiPhy, USA*

What is New in Integrated Photonics and Electronics Technologies; Siddharth Sheth, *VP Marketing, HSC, Inphi, USA*

Enabling integrated photonics technologies for Multi-Haul ROADM Optical Network Evolution; Yanjun Wang, *Coriant, USA*

BIOGRAPHY:

Mark Earnshaw is Principal, fibeReality, LLC, an independent market intelligence and consulting firm specializing in optical equipment and services in the telecommunications space. He has over three decades of experience in the sector and he is considered one of the most objective, no-nonsense demand-side analysts. With an intense concentration on primary research, Mark has been a consultant to some of the largest telecom companies in the world involving chips to full systems. While he was in college, Mark started his career at Northern Business Information, leaving as a Senior Analyst. He then established Trans-Formation, which specialized in transmission equipment markets. After 14 years at the helm, his company was purchased by CIR, where he became VP of Optical Networking Research. Subsequently, Mark was a co-founder in Telecom Pragmatics, which operated for nine years. More recently, Mark was Product Sales Strategist at PacketLight Networks. He excels at moderating panel discussions by keeping them lively and sparking debates among the participants.

Dr. Mark Earnshaw is Director of Photonic Sub-System Integration Research at Bell Labs, Alcatel-Lucent in Murray Hill, New Jersey. In 1999 he joined Bell Labs where he has worked on photonic integrated circuits including optical cross-connects and wavelength switching devices. His recent research work has focused on developing a hybrid integration platform for high-speed, parallel, wavelength division multiplexed transceivers. From 1994 to 1995, Dr. Earnshaw was at British Telecom Research Laboratories working on fiber amplifiers and lasers.

Dr. Kenneth Jackson has spent over 30 years in the fiber-optic communications field. He has held various research and development positions at IBM, JDSU, and EMCORE Corp involved in the development of serial and parallel fiber optic modules for enterprise interconnect applications. In the mid-1990s, Dr. Jackson was a key member of IBM's Rochester, Minnesota team that was largely responsible for the resurgence of 850nm laser-based transceivers for low-cost multimode fiber data links. In 2012 he joined Sumitomo Electric Device Innovations, USA where he is the Product Marketing Director for optical communications module and device products. Dr. Jackson has authored many journal articles and made numerous technical presentations at fiber-optic conferences. He holds five patents.

Dr. Pezeshki was previously the main founder of Santur Corporation (2000-2008), and acting as the President, Director, VP of Engineering, and Chief Technology Officer of the company at various times he developed the key ideas and managed their transition to manufacturing. These included the tunable laser that dominated the transition of long haul and metro networks from fixed wavelength lasers to tunable, and more recently the parallel transceiver that now leads the world in 100Gb/s Ethernet. Prior to Santur, Dr Pezeshki managed the Development group at SDL (now part of JDS Uniphase) and a similar group at IBM Research in Yorktown Heights. He obtained his Ph.D. from Stanford University and has approximately 30 patents and 100 peer reviewed publications and presentations.

Avi Shabtai is Chief Executive Officer of MultiPhy, a fabless semiconductor company providing cutting edge DSP based ICs at 100G speeds for Data Center connections. Avi has over 20 years of management experience in the telecommunications industry with expertise in semiconductors, systems and solutions. Before joining MultiPhy, he held Executive Business and R&D positions at Alvarion, Tiaris, Metalink and the Israeli Ministry of Defense. Avi holds a BSEE and MSEE from the Technion, Israel Institute of Technology and is an SMP Graduate of the Technion Institute of Management.

Siddharth Sheth brings with him more than 15 years of marketing, engineering and general

management experience in the networking and server infrastructure industry. At Inphi, Mr. Sheth heads up the network connectivity business leading the company's efforts in the cloud infrastructure and metro service provider segments. Prior to Inphi, Mr. Sheth was at NetLogic Microsystems (now Broadcom Corp.), where he held worldwide marketing responsibility for NetLogic's networking interconnect chips. While at NetLogic, he pioneered the company's 40G/100G product line and led NetLogic's entry into the mobile and cloud infrastructure markets. In 2001, Mr. Sheth was a founding team member of Aeluros, a mixed-signal networking IC company, where he held global marketing responsibility, helping make Aeluros a market leader until its successful acquisition by NetLogic in 2007. Mr. Sheth also spent many years at Intel Corp, where he held engineering design and management positions in the Pentium III microprocessor and network processor groups. Mr. Sheth is a regularly featured speaker at industry tradeshows and conferences, is a published author at ISSCC and other technical conferences and has an M.S.E.E from Purdue University.

Yajun Wang is a Sr. Principal Engineer at Coriant and currently responsible for DWDM ROADM Products Planning. He has been with Tellabs (Tellabs was acquired by Coriant in December 2014) since 2001 and has worked on DWDM optical transport system in a variety of roles including product planning, optical component technology development, new product introduction and manufacturing. Prior to Tellabs, he also worked at GE, Lucent technologies and Agere Systems. He received a BS from the University of Science and Technology of China, People's Republic of China and a Ph.D. from the University of Wisconsin-Madison, WI.

PANEL IV: MONETIZATION OF OPTICAL NETWORKS – NEED FOR NEW BUSINESS MODELS

Wednesday, 25 March
13:00 - 15:00

Moderator: Andrew Schmitt; *Principal Analyst,Infonetics Research, USA*

PANEL DESCRIPTION:

This panel will provide a very unique as well as provocative marketing and philosophical discussion about the ineffectiveness of the old paradigm of revenue generation based upon traffic demand as the market continually evolves to new business models that can no longer rest on selling fixed quantities of data like bits per second. What are the key secondary monetization opportunities (including some experimental in nature) for carriers. What are the principal technology enablers here? Why will service providers partnering with companies offering functionality specialties play a crucial role? How can customers best be accommodated for unbundled, immediate, and short-term bandwidth needs, such as a certain amount of capacity at a CDR, but allowing bursting at will to a higher speed without the penalty of committed rates? How has the apprehension of adversely affecting services delayed bandwidth on demand? How has the chronic problem of poor record keeping of available resources held up the advancement of open networking by incumbent operators? Is it possible to imagine a time in the distant future in which there will effectively be an infinite amount of broadband capacity in the world or will there always be a need for intelligence to free up constrained bandwidth?

SPEAKERS:

Bursting to a Hybrid Cloud for Services; John Adler, *General Partner, Silver Creek Ventures, USA*

Accelerate Revenue with One Marketplace; Ben Edmond, *Chief Revenue Officer, Global Capacity, USA*

Optical Network for Uncompressed High Definition Video Transmission; Wenbin Jiang, *Chief Technology Officer, Cosemi Technology, USA*

An Open SDN Enabled approach to Service Provider Monetization; Robert Keys, *Chief Technology Officer, BTI Systems, Canada*

Turning the Corner on Monetization; Eric Lampland, *President, Lookout Point Communications, USA*

The Death of Common Carriers and What This Means for Backhaul; Francis McInerney, *Managing Director, North River Ventures LLC, USA*

BIOGRAPHY:

Andrew Schmitt is an analyst focused on the optical network industry, leveraging over 20 years in the networking and communications industry including tenures at Vitesse Semiconductor, where he ran the carrier chipset unit, and Nyquist Capital, where he was a general partner at the investment consulting firm focused on the optical sector.

Mr. Adler joined Silver Creek Ventures as a General Partner in 2007. His areas of expertise include data and voice communications, enterprise software, semiconductors, and wireless applications. Mr. Adler has also served as a board member of the Texas Venture Capital Association, SMU Lyle Executive Board, and the SMU MBA Venture Fund. Prior to joining Silver Creek, Mr. Adler served as a Partner with InterWest, a leading diversified venture capital firm in information technology and life sciences. His current board participation includes Yvolver, Theatro, and Nimbix. Prior to InterWest Partners, Mr. Adler developed 17 years of operating experience in product management and engineering from Rockwell International, Alcatel, Monterey Networks and Cisco Systems. Mr. Adler received a Bachelor of Science in Electrical Engineering and MBA from Southern Methodist University and has authored or co-authored nine US patents.

Ben Edmond is Chief Revenue Officer at Global Capacity, with responsibility for all aspects of revenue generation including acquiring, designing, and delivering customer solutions. He has more than 15 years of experience in the telecommunications industry, encompassing broad expertise in the areas of sales, product management and service delivery. Prior to joining Global Capacity, Ben was President of Sales and Marketing at FiberLight, where he led a national carrier and enterprise sales team and conducted daily operations in customer and account development and service as well as implementation of product development. Prior to joining FiberLight, he owned Telecom Inventory, a consulting firm focusing on services for large enterprises requiring better access and use of telecommunications information. Ben's telecom experience includes eight years with Xspedius Communications (formerly ACSI), where he held several leadership positions. He holds a M.S. in International Business from St. Louis University and a B.S. in International Business & Finance from Northeastern University.

Throughout his 30 years career in photonics industry, **Dr Wenbin Jiang** has worked in companies spanning from telecom service provider to photonics device and equipment manufacturer. He was a founder of E2O Communications, which was later acquired by JDSU. Dr Jiang is an inventor of more than 90 US patents and an author of four book chapters and more than 50 peer reviewed technical papers.

Dr. Robert Keys brings over 20 years of communications engineering and leadership experience to his role as Chief Technology Officer. Prior to joining BTI Systems, Robert served as Chief Engineer for Bookham (now Oclaro), defining the company's technical roadmap and strategic investment requirements. Prior to Bookham, Robert held various influential roles in the development organization at Nortel, where he was responsible for the successful development and delivery of multiple optical products to market. Robert is a well-known authority in the optical industry, and is a frequently sought-after speaker. He has more than 12 patents granted in the area of optical communications. Robert has a Ph.D. & M.Sc. in Electronics and Electrical Engineering and a B.Sc. in Physics from the University of Glasgow.

Eric Lampland has been President of Lookout Point Communications, an independent consultancy, for over 17 years. He has been a network architect for over 35 years, specializing today in the development of fiber-to-the-home networks. Eric's work with public utilities and municipalities, individually small in scale and fiercely independent, has led to recent projects leveraging SDN/NFV emergent technologies advantaging transport aggregation and shared service level infrastructures. He was part of the design team at the University of Minnesota during the early construction of the Internet. Since then Eric has created companies and advised large and small firms on communications architecture and future trends. He has been an active member of several international standards forums.

Francis McInerney is Managing Director of North River Ventures LLC which shows companies how to scale profitably in an era of freefalling information costs and rapid Cloud Inflation. In 1976, Francis co-founded Northern Business Information, an information industry market research company. In 1988, McGraw-Hill Inc. made an unsolicited offer to buy the company. He has since raised over $250 million in commitments for several private equity and venture funds. He is a member of the Industry Council of London-based GMT. He was part of the GP of Denver-based Centennial Ventures Funds VI and VII to which be brought investors NBCU, NTT, DoCoMo, Harris, GE Capital, Bell Canada, Nortel, Alcatel-Lucent, 3Com, Crown Castle, Sony, and C2HM-Hill. In 1997, he formed Palo Alto-based incubator CenCom V with Panasonic, Bell Canada, Nortel, Vulcan Ventures, and Centennial Ventures. Today, he manages NRV's Zetabyte Scaler Project for major corporations. Francis has written six books on the impact of falling information costs on business organizations and profitability. He studied economics at the University of Toronto. In 2010, for his cash velocity management system, used to scale large companies profitably as information costs fall, Francis was awarded an honorary PhD by American Sentinel University.

Panel V: Intra-Data Center Interconnection Architectures and Challenges

Wednesday, 25 March
15:30 - 17:00

Moderator: Sudeep Bhoja, *Chief Technology Officer, Networking Interconnects, Inphi*, USA

PANEL DESCRIPTION:

Large 'scale out' data center operators have been looking for and are deploying various types of optical switching products inside their DCs. Many of these large providers have a growing interest to use higher bit rates and lower power photonic components for massive intra-data center connectivity. Some of these solutions exist today from conventional vendors. However, other products are being designed for specific uses, such as internal fiber management or higher bandwidth operation to manage the increasing VM load inside the data center. With non-standard or 'relaxed' specifications in this area, there may be an opportunity for optical vendors to address. They must understand the real requirements. This panel will tackle whether this is a niche market or an industry with the potential to push aside or replace conventional hardware for faster intra-data center transmission. The panel will answer a number of important questions. How much of a role will OTN switching play in these applications? To what extent can cost be driven out in intra-data center networking? How quickly can the optical industry expect advantages from the movement to a virtualization state? What will be the impact of the FC-PI-6 standard?

SPEAKERS:

Bandwidth Dilemma and Optical Challenges; Brad Booth, *Principal Engineer, Microsoft, USA*

Applying Optical Technology to the Data Center; Steven Hunter, *IBM Fellow, NCSU Adjunct Professor, IBM, USA*

Application Traffic Mobility Across the Data Center; Mans Jabal, *Principal Design Consultant, United Airlines, USA*

BaseT is dead in the data center; Tom Palkert, *System Architect , Molex, USA*

Future of VCSELs in Data Centers; Alka Swanson, *Principal, fibeReality, LLC, USA*

Enabling Software Defined Interconnection Layer for Application-driven Intra-Data Center Networks; Shan Zhong, *CoAnda Photonics, USA*

BIOGRAPHY:

Sudeep Bhoja is CTO for Networking Interconnects at Inphi and is currently developing higher order modulation PAM based physical layer products. He has worked on applied DSP, communications and Forward Error Correction in silicon PHYs for the last 20 years. Previously, he was Technical Director in the Infrastructure and Networking Group at Broadcom where he designed 10G DSP transceiver interconnect solutions. He was also Chief Architect at Big Bear Networks pioneering the industry leading 10G Electronic Dispersion Compensation (EDC) development. He has 24 patents in networking interconnects, has an M.S. in Electrical Engineering from Purdue University and a B.E. in Electrical Engineering from National Institute of Technology, Calicut, India.

Brad Booth develops next generation networking technologies in his role as part of Microsoft's networking strategic architecture team. He has helped initiate many Ethernet standards projects such as 25G Ethernet, Backplane Ethernet and 40 & 100 Gigabit Ethernet, and he served as chair for the

10GBASE-T standard and editor-in-chief of the 10 Gigabit Ethernet standard. Brad has also served as a director on the IEEE Standards Association Corporate Advisory Group. Currently, Brad serves as the Secretary for the 25G Ethernet Consortium, and he was the founder, president and chair of the board of the Ethernet Alliance and served as a director and VP of Technology for the 10 Gigabit Ethernet Alliance. Brad has worked for start-ups to Fortune 100 companies like Dell and Intel. He holds over a dozen patents in the networking field and is a senior member of the IEEE.

Steven Hunter began his IBM career in the Networking Division where he worked on a variety of networking products, technology, and standards. He later transitioned into IBM's x86 server organization where he was systems architect and CTO for IBM's BladeCenter and led industry activities to define server cluster standards and technology. Steve is an IBM Fellow and is continuously developing next generation system concepts, including high availability, power-efficiency, workload acceleration, cloud, and analytics. Steve has led key initiatives in IBM's Research organization and was most recently CTO of the PureFlex System. He's currently focused on defining IBM's Technical Strategy, is an Adjunct Professor at NC State University, and a Senior Member of IEEE. He holds patents spanning hardware and software technology, has published numerous papers, and has presented at a variety of conferences and symposiums. Steve is an ECE alumnus of Auburn (BS '84), NC State (MS '88), and Duke (PhD '97) Universities.

Mansour Jabalameli is a principal network architect at Prosoft Technology Group in Chicago. He has over 15 years of experience in the IT and telecommunications industry. His main focus is on data center architecture, network virtualization and service provider network design. He has his undergraduate degree from University of London and he holds three masters degrees in the areas of business administration (MBA), networking technologies and management (MS) from Sheffield Hallam University and information technology management (MS) from Robert Gordon University. In addition to his consulting background in Europe, Middle East and East Asia, he has worked on major projects for fortune 500 and Inc 500 companies such as Bank of Montreal, Marshall & Ilsley Corporation (M&I Bank), Northern Trust Bank, Harris Bank, United Airlines, BMO Financial Group, Citadel Hedge Fund Services (NTRS division), Global Success Solutions, Otterbase Inc, Lehman Brothers (NTRS division), Manpower USA, Experis IT and many more in North America.

Tom Palkert has done architecture/definition and design of high speed SERDES and optical modules for enterprise, telecom, storage, military and consumer products. He has been involved in many standardization efforts including Ethernet, Fibre channel, Infiniband, VESA, SFF and the Optical Internetworking Forum. His current work focuses on high speed electrical and optical interfaces for 100G to 1Tbit applications. Tom was editor of the 10GBase-KR specification, a past member of the OIF board of directors, chair of the OIDA silicon photonics alliance and is currently chair of the Fibre Channel T11.2 Physical Layer Task Group and vice chair of the OIF Physical and Link Layer (PLL) working group.

Dr. Alka Swanson is a Principal with fibeReality, LLC, an independent market intelligence and consulting firm specializing in optical equipment and services in the telecom/datacom space. She began her career as a Member of the Technical Staff at AT&T Bell Laboratories where she managed multiple optical device projects. Alka later became VP of Sales & Marketing of EPITAXX, and when it was purchased by JDSU in 1999, she became GM of the unit, managing over 1,000 employees. From 2003 to 2009, Alka took on several high-level executive roles at Princeton Lightwave, a producer of sensors and imaging InP subsystems as well as 3D time of flight imaging cameras. During her tenure, particularly as COO/CFO, PLI became a leader in key technologies for defense and security apps. In 2011, Alka became CEO of COGO Optronics, a supplier of next-generation solutions for high-speed optical networks. In 2013, TeraXion

bought the Canadian subsidiary of the firm. Alka received her PhD in Physics from Boston University.

Dr. Shan Zhong currently serve as the Technology Director in CoAdna Photonics, where he is responsible for defining and driving the strategic technology roadmap for WSSs and other agile optical components for ROADM application in next generation optical networking. Recently, he is taking the lead on the optical networking solution for next generation intra-data center networking. Before he joined CoAdna, he worked as the Principal Engineer in Photonics Group of CIENA Corporation from 2001 to 2011, where he was engaged in next generation optical networking product design and development. Before 2001, he worked in Tyco Electronics from 1998 to 2000, developing optical planar waveguide components for DWDM application. In 2000, he joined Sycamore Networks as Senior Optical Engineer, leading the effort on subsystem development for Sycamore's ultra long-haul DWDM transport product line. Dr. Zhong received his B.S. and Ph.D. degrees in electrical engineering from Tsinghua University, Beijing, China and University of Maryland, Baltimore County in 1992 and 2001, respectively. He is a Senior Member of IEEE Photonics Society. He has published tens of papers on technical journals and conferences. He holds 11 awarded U.S. patents and about 6 more on pending.

PANEL VI: DO CARRIERS REALLY WANT NETWORK CONVERGENCE OR MAINTAIN EQUIPMENT DIVERGENCE.

Thursday, 26 March
10:30 - 12:30

Moderator: Robert Doverspike; *Executive Director Research, AT&T Labs, USA*

PANEL DESCRIPTION:

Is there a difference between “New” service providers vs traditional ones from an architecture or technical standpoint. Convergence has been delayed because of turf wars between traditional transport and the data folks. It remains a layer over layer – IP, Ethernet, SONET/SDH,OTN implementation. There is concern Convergence can lead to gold boxes -- expensive, complex, high power. If Converged Equipment fails, a lot of diverse service customers can get affected. We will examine the different provider networks to discuss if there is movement toward combining the layers. If the stakes gets high enough there could finally be something that can legitimately be called convergence -- the virtualization of hardware and software in a significant way.

SPEAKERS:

SDN/Network Integration: A Service Provider's Perspective; Patrick Blesso, *Network Engineering Manager for Globenet, USA*

Answering the Service Provider Bandwidth vs. Cost Challenge: NG Optical and SDN/NFV Convergence; Richard Colter, *Director of Strategic Planning, Fujitsu Network Communications, USA*

SDN-Based Optics: Smaller, Faster, Cheaper and Intelligent?; Greg Gum, *BD Advisor, Acting COO, TITAN Photonics, USA*

Benefits of Interoperability, SDN, Undersea ROADMs and New Business Models to Converged

Networks Linked by Submarine Cable Systems Across Oceans; Edwin Muth, *Director of Product Line Management, TE Connectivity SubCom, USA*

Metro IP over DWDM Plug-and-Play; Jun Shi, *Senior Director Product Line Mangement, Juniper Networks, USA*

Layer Convergence in Non-Traditional Carriers: Services, Automation, and Intelligence; Scott T. Wilkinson, *Sr. Director Technical Marketing, MRV Communications Americas, Inc., USA*

BIOGRAPHY:

Robert Doverspike received his undergraduate degree from the University of Colorado and Masters and Ph.D. degrees from Rensselaer Polytechnic Institute (RPI). He began his career with Bell Labs and, upon divestiture of the Bell System, went to Bellcore (later called Telcordia). He returned to AT&T Labs (Research) where he is now Executive Director of Network Evolution Research. Dr. Doverspike has made extensive contributions to the field of optimization of multi-layered transmission and switching networks and pioneered the concept of packet transport in metro and long distance networks. He also pioneered work in spearheading the deployment of new architectures for transport and IP networks, network restoration, and integrated network management of IP-over-optical-layer networks and Software Defined Networking. He has over 1500 citations to his books and articles over diverse areas/publications such as Telecommunications, Optical Networking, Mathematical Programming, IEEE Magazine, IEEE Communications Society, Operations Research, Applied Probability, and Network Management. Dr. Doverspike holds many professional leadership positions and awards, such as INFORMS Fellow, IEEE Fellow, member of Optical Society of America (OSA), co-founder of the INFORMS Technical Section on Telecommunications, OFC Steering Committee, DRCN Steering Committee, and Associated Editor for JOCN (Journal of Optical Communications and Networking).

Patrick Blesso is an accomplished Manager with strong engineering and operations background and over 15 years in the telecommunications service providers industry, 12 of which working internationally in the submarine cable industry. Most recently, he is the network engineering manager for Globenet, a submarine cable system linking the Unites stated to South America (Colombia, Venezuela, Brasil) and Bermuda. Mr Blesso is currently responsible for the deployment of terrestrial DWDM routes linking major PoPs in various countries to the cable system, the deployments of all network platforms aimed for the delivery of transport (SDH, Carrier Ethernet), IP/MPLS services. His duties also extend to the development of new products aiming to diversify Globenet's product offering. Holds an MBA from the university of Manchester (U.K.), Bachelor and Masters degree in telecommunication engineering from Capitol college. A degree in Math & Physics from the polytechnic institute in the Ivory Coast.

Richard Colter, Director of Strategic Planning at Fujitsu Network Communications, is the architect of the Fujitsu's long term technology roadmap. Richard has broad experience in the design and planning of optical networks and network platforms. Over his 20 years in the telecommunications industry, he has held various leadership roles in the carrier and vendor space. Rich holds a BS in Electric Engineering from the University of Colorado.

Greg Gum joined Titan Photonics in 2014 as a Bd. Advisor and is currently the acting COO for the company. Prior to Titan, Greg was a Board Director for MINGOA Ltd., an Irish based software company acquired by Microsemi (Nasdaq: MSCC), Executive Director at USWEST/QWEST merged with CenturyLink (NYSE: CTL), and held senior management positions at Exalt Wireless, Telco Systems (LSE: BATM), ANDA

Networks (acquired by BATM), Ishoni Networks (acquired by Phillips Semiconductor), and Tsunami Ventures. He has a strong carrier operator, networking equipment, wireless, semiconductor and software background representing key perspectives on the communications ecosystem.

Edwin Muth is Director of Product Line Management at TE connectivity SubCom.
He joined TE Subcom in 2011 from his wireless consulting business. Prior to this he was a Senior Director at Infineon Technologies, LSI, and Agere Systems responsible for the IC and DSP designs. At Sychip, Inc, an advanced packaging and software wireless micro modules company spun off from Lucent, he was VP of Engineering. Prior to that he held various Engineering Director and manager positions in wireless hardware and satellite communications at AT&T/Lucent.

Jun Shi is a Senior Director of Product Line Management at Juniper Networks, with responsibility for Internet Core, Packet Optical, WAN SDN Controller and WANDL Network Simulation Tool business. He has more than 18 years of experience in Networking Industry. At Juniper, in addition to driving daily business, building up Core product portfolio and leading architecture evolution, he focuses on driving Packet Optical integration for Multilayer convergence, Telco Cloud, and WAN SDN controller for Network Virtualization and Multilayer Efficiency between Packet and Optical domain. Prior to joining Juniper, Jun worked in Cisco over 13 years, holding various positions across Sales, Software, TME and PLM, and in his role as PLM, he was responsible for IOS-XR software infrastructure, QoS, L2VPN, Ethernet Service, and fathered CRS Thin Core CRS FP40 and 140G CRS3, and led NCS Product Line Development. Before Cisco, he worked for China Telecom. Jun holds a MS degree in EE and double CCIE in SP and R&S.

Dr. Wilkinson has been involved in the telecommunications industry since 1996. In his role as Senior Director of Technical Marketing at MRV, he leads a team that operates as a bridge between the development and sales organizations, helping to evangelize MRV's suite of optical transport and carrier Ethernet solutions worldwide. Prior to MRV, Dr. Wilkinson was the Vice President for Product Management and System Engineering for Hitachi's North American telecommunications division, which developed and deployed a wide variety of technologies from the home to the network core. Before Hitachi, Dr. Wilkinson was with Parama Networks, a developer of industry-leading System-on-a-Chip solutions for SONET/SDH networks. He previously worked for Kestrel Solutions, a company developing Frequency Division Multiplexing equipment for low-cost, high speed fiber optics transmission systems. Dr. Wilkinson started his career with Fujitsu Network Communications in product management and planning for their SONET and DWDM products. Dr. Wilkinson earned his PhD in Electrical Engineering from the Georgia Institute of Technology in 1996, where his research focused on integrating semiconductor LEDs and VCSELs with silicon circuits and micro-machines (MEMS). He earned his B.E.E., also from Georgia Tech, in 1990.

PANEL VII: ARE CDNS LIGHTENING THE LOAD ON THE CORE AND METRO NETWORKS?

Thursday, 26 March
13:00 - 15:00

Moderator: Hans Jürgen Schmidtke; *VP Technology at Juniper Networks*

PANEL DESCRIPTION:

Local caching in the past has lightened the loads on core IP networks. With video distribution streaming from multiple sources today across peering sites, in order to maintain quality of experience, CDN infrastructure has been widely deployed and content increasingly distributed. Located in ISP data centers, colocation sites and Internet exchanges, CDN networks are being built by service providers, Akamai, Limelight, Netflix, and others. Selective peering arrangements are allowing OTT content to bypass some access networks. Is it lightening the load on core and metro networks, and if so, who is paying for the service? Are peering agreements being shuffled to adjust to the new traffic demands? Are connections being made to bypass some service providers to stream directly? If so, what does this mean for the future infrastructure builds and capital expenditures? On the other side of the coin, is the interest level increasing by traditional operators to go beyond just getting a managed solution, but actually partnering with the CDNs in order to gain greater efficiency in the transmission of bits in general? To what degree will CDNs be suffering with under-capacity issues in the future?

SPEAKERS:

Cisco perspective of CDN and IoTs; Mahbubul Alam , *GM & Head of Internet-of-Things and M2M Platform, Cisco, USA*

Network Efficiencies from Edge Caching and CDN; Frank Childs*, Director Product Marketing, Carrier Products, Akamai, USA*

Edge Platforms of the Future: Performance Meets Security; Joshua Motta, *CSO and Head of Special Projects, CloudFlare, USA*

China: Behind the Great Firewall Lie the Mysteries of the MIIT and ICP Licensing; Austin Robert Peterson, *Global Business Development, ChinaCache North America Inc., USA*

Improving Content Delivery with a CDN Through Middle-Mile Optimization; Jason Thibeault, *Senior Director of Marketing Strategy, Limelight Networks, USA*

Perspective of CDN at the Era of DT; Chongjin Xie, *Senor Director, Alibaba Group, USA*

BIOGRAPHY:

Hans-Juergen Schmidtke is Chief Architect for Converged Supercore at Juniper Networks located in Sunnyvale, Calif. In this role he is responsible for the architecture of the IP Converged Core and the Optical & Transport strategy and implementation of all Juniper's optical and transport related technologies. In his career he was Head of the Fixed Network Operator Business in North America for Nokia Siemens Networks located in Mountain View, Calif. Over the years at Nokia Siemens Networks and Siemens Communications, Inc., he has held positions in product management and general management in both Germany and the US. Dr. Schmidtke worked on various aspects of optical physics from advanced research, to product development, to real-world large-scale deployments. He studied physics at the University of Dusseldorf and at the Max-Planck Institute of Quantum Optics, and received

his PhD from the University of Wurzburg. Dr. Schmidtke is member of IEEE, OSA and the German Physical Society.

Mahbubul Alam is an experienced and innovative executive, with passion for creating new businesses and organizations. He is an industry-wide recognized leader with proven track record spanning product management, business development, gap analysis and marketing strategy, in multi-service router, switches, WLAN, IEEE 802.15.4 wireless communications protocols, cellular technologies such as 2G, 3G and 4G LTE, Femto-/Small- Cell, M2M, GPS, Connected Vehicle and Intelligent Transportation Systems. Over 15 years of tenure in senior leadership positions with continually increasing responsibility and profit & loss accountability while leading successful endeavors including entrepreneurial roles at Cisco. He demonstrated success in creating integrated, synergistic, growth focused organizations including developing strategic collaborations with diverse sets of eco-partners in commercial, academic, and international organizations. Prior to Cisco he was with Siemens Netherlands where he led Pan-European 3G Tiger team, GSM Railway project and advised Dutch law makers on cellular 2.5G/3G on mobile data privacy, parental control and lawful interception. With more than 10 publications in referred journal and conference proceedings, and numerous invited talks, panel participation, and keynote speeches. His blogs can be found at **http://www.myconnectedsociety.com**. He holds a Master's degree in Electrical Engineering, specialized in mobile and radar communication from Delft University of Technology, The Netherlands.

Frank Childs is Director of Product Marketing at Akamai. With over 20 years of leadership experience in marketing, product management, and business development, he has global marketing responsibility for Akamai's Carrier and Cloud Networking Solutions. Previously, he spent five years at PeerApp as VP Marketing and Business Development. Earlier in his career he was a partner at Pilot House Ventures, a VC firm with strong ties to the cable and telecom industries. He also held management roles at MCK Communications, AT&T, Ziff-Davis Publishing, and Shiva Corp. Frank holds a BS in Computer Science from WPI.

Joshua Motta (@joshuamotta) is CSO and Head of Special Projects at CloudFlare. Joshua is no stranger to technology companies and start-ups. In 1999 he exited a company to Microsoft, becoming the company's youngest hire. Joshua also worked in various technical capacities for Sprint and within Honeywell's aerospace division prior to attending The University of Chicago where he graduated Phi Beta Kappa. Prior to joining CloudFlare Joshua spent five years in venture capital, private equity and investment banking including positions at Francisco Partners, a global private equity firm focused on technology, and in Goldman Sachs' London based Investment Banking team where he advised technology, media and telecommunications companies in Europe, the Middle East and Africa.

Like the rest of the world, **Austin Peterson** had a few questions to ask about the Chinese superpower and its role in Southeast Asia. His experience there led him to the CDN industry, where his knowledge of industry trends, cultural, and legal affairs specific to China/APAC have helped to garner relationships and develop a distinct knowledge of the Chinese CDN industry. Austin Peterson is Global Business Development for ChinaCache North America, located in Los Angeles, CA. Prior to this, he established trade routes for the Electronics recycling industry between the US and South Africa, as well as developed distributor relationships all throughout SEA and India.

Jason Thibeault is the senior director of marketing strategy for Limelight Networks. In this role he helps direct Limelight's corporate messaging and positioning, develops whitepapers and e-books, blogs, and

evangelizes the Limelight solution offering to audiences around the world. He holds a B.A. in English from the University of California, Irvine Honors Program and a M.A. in English, with distinction, from California State University, Northridge. Jason is the co-author of the marketing thought-leadership book Recommend This! Delivering Digital Experiences People Want to Share (Wiley) and an inventor on a number of technical patents with Limelight Networks.

Dr. Chongjin Xie received his M.Sc. and Ph.D. degrees from Beijing University of Posts and Telecommunications, China in 1996 and 1999, respectively. From 1999 to 2001, he worked at Photonics laboratory, Chalmers University of Technology in Gothenburg, Sweden for one and half years to conduct post-doctorate research. He joined Bell Laboratories, Lucent Technologies in Holmdel, New Jersey, USA in 2001 and was a Distinguished Member of Technical Staff, doing research on optical communication systems and networks. He joined Alibaba Group in 2014 and currently is a senior director at Alibaba Infrastructure Service Lab, working on datacenter optics. Dr. Xie has authored and co-authored more than 190 journal and conference publications, and two book chapters. He is an associate editor of Journal of Lightwave Technology, and has served in many conferences as chairs, TPC chairs or TPC members. Dr. Xie is a senior member of IEEE and a Fellow of OSA

SERVICE PROVIDER SUMMIT TALKS

CARRIER'S VIEW ON FUTURE SDN/NFV DEPLOYMENT

KEYNOTE SPEAKER

Yukio Ito, *Senior Vice President of Service Infrastructure, NTT Communications Corporation, Japan*

NTT Com has successfully deployed SDN/OpenFlow technology into a commercial network since June 2012, first in the data center. Mr. ITO will provide insight into the experiences of deploying SDN/NFV to the carrier's commercial services and NTT's latest SDN architecture which aims to provide "The carrier cloud". "The carrier cloud" intends to provide a set of "operation and maintenance" features and advanced network security by integrating high-quality/high-reliability cloud and VPN. The audience will see mechanisms for reducing the cost of "operations and maintenance" for equipment that is the most important for carriers, by applying this SDN architecture.

In addition, we will discuss NTT Com technical development division's trial results for "transport SDN" which enables the expansion of applications using SDN over all the layers, including the optical transport layer.

BIOGRAPHY

Yukio Ito joined Nippon Telegraph and Telephone Public Corporation after graduating graduate school, having previously worked for the Switching System of PSTN and the Business Communication Network.

After the reorganization of NTT in 1999, he designed the architecture of the Transport Network of NTT Communications and introduced new technology in the Transport Network of NTT Communications. After June 2010, he had been in charge of engineering, construction and operation of the IP & L1, L2 backbone network in NTT Communications. He was in charge of the entire NTT Communications service infrastructure and was introducing SDN-OpenFlow technologies into NTT communications' Business

Network.

Since August 2014, he is responsible for Technology Development to strengthen cross-service technological development capability in accordance with NTT Communications'-wide business strategies.

Since December 2011, he has been a member of the Board of Open Networking Foundation.

PANEL I: VALUE AND COST OF MULTI-LAYER SDN

Moderator: Frank Effenberger,*Vice President and Fellow, Access Adv. Tech. at Futurewei Technologies, USA*

Panel Description:

Carriers are demanding to extend SDN concepts of network programmability to multi-vendor, multi-layer IP/optical networks, and leveraging it to simplify operations as well as optimize utilization of resources. While industry focus has been on enabling SDN for packet systems within the data center, many of the same concepts are being logically extended towards the converged packet-optical systems. The target here is to understand the real "value" and "cost" of SDN, and weigh the pros/cons against each other. With participation from vendors, network operators, and standard bodies, several key questions can be answered. Does SDN address the current pain-points of the network operators and what hurdles do they need to overcome? How does SDN integrate to the unique OSS/BSS of each service provider? Can bandwidth-on-demand applications be realized for the carriers? Does SDN have a role in closing the revenue-cost gap? Can it allow for a real multi-vendor, multi-layer network? Which vendors will have orchestrators that can manage other suppliers' equipment? How long will it take for standards to be developed for an open SDN? Can we avoid vendor lock-in? What are main challenges that suppliers are facing in building an SDN solution? Will NFV substantially slow down the introduction of SDN in public networks? To what extent will SDN be an enabler of an all-optical network?

SPEAKERS:

Enabling Multi-Layer SDN Management for Cloud Exchange Services; Casimer DeCusatis, *Assistant Professor, Marist College, USA*

Multi-Layer Network SDN Control: Case for Optical Layer; Rao Lingampalli, *Optical Network Architect, Equinix, USA*

Monetizing an SDN-Based Virtualized Network; Sanjay Nayak, *Senior Vice President for Corporate Development, PACNET, USA*

SDN: Look Under the Hood for a Quality Backbone Network; Shikhar Sarkar, *Director Product Marketing, Hibernia Networks, USA*

SDN and Multi-layer Optimization; Vishnu Shukla, *President, OIF, USA*

The Orchestration of Virtualization; Patrick Sims, *President and Chief Technology Officer, Lightcore Group, Inc., USA*

BIOGRAPHY:

After completing his doctoral work in 1995, **Dr. Effenberger** took a position with Bellcore (now Telcordia) where he analyzed all types of access network technologies, focusing on those that employed passive optical networks. He witnessed the early development of the FSAN initiative and the development of the APON standard. In 2000, he moved to Quantum Bridge Communications (now a part of Motorola), where he managed system engineering in their PON division. This work supported the development and standardization of advanced optical access systems based on B-PON and G-PON technologies. In 2006, he became director of FTTx in the advanced technology department of Futurewei Technologies. He remains heavily involved in the standards work, and is a leading contributor to the major PON standards in the ITU. He is now the rapporteur of Q2/15, which is the group charged with standardization of all optical access systems. In 2011, Frank was named to be one of the first Huawei Fellows, and was promoted to be Vice president of access networks research in Futurewei.

Dr. Casimer DeCusatis is an Assistant Professor in the Department of Computer Science and Mathematics, Marist College, Poughkeepsie, NY. His research with the New York State Center of Excellence for Cloud Computing and Analytics includes optical data networks, cybersecurity, and software-defined data center architectures. An IBM Distinguished Engineer Emeritus, he is also an IBM Master Inventor with over 150 patents, and recipient of several industry awards, including the IEEE Kiyo Tomiyasu Award, the Sigma Xi Walston Chubb Award for Innovation, the EDN Innovator of the Year Award, the Mensa Research Foundation Copper Black Award for Creative Achievement, the Penn State Outstanding Scholar Alumnus Award and Mark Luchinsky Memorial Lecture, and the IEEE/HKN Outstanding Young Electrical Engineer award (including a citation from the President of the United States and an American flag flown in his honor over the U.S. Capitol). He is co-author of more than 200 technical papers, book chapters, and encyclopedia articles, and editor of the Handbook of Fiber Optic Data Communication (now in its 4rd edition). He is a member of the IBM Academy of Technology and co-leader of the Academy study "Innovation Ecosystems". Dr. DeCusatis received the M.S. and Ph.D. degrees from Rensselaer Polytechnic Institute (Troy, N.Y.) in 1988 and 1990, respectively, and the B.S. degree magna cum laude in the Engineering Science Honors Program from the Pennsylvania State University (University Park, PA) in 1986. He is a Fellow of the IEEE, Optical Society of America, and SPIE (the international optical engineering society), a member of the Order of the Engineer, Tau Beta Pi, Eta Kappa Nu, Mensa, and various other professional organizations and honor societies (http://www.decusatis.net/casimer/); he was recognized as one of Sigma Xi's Distinguished Members during their 125th anniversary celebration. He is also Founder and Director of Hudson Valley FIRST Lego League (http://www.facebook.com/HudsonValleyFLL) which offers over 1,000 students each year the opportunity to pursue their interest in science and technology. His discussions on data networking are available on Twitter (@Dr_Casimer) or his monthly blog for the OFC Conference (http://www.ofcconference.org/en-us/home/about/ofc-blog/).

Rao Lingampalli is the Optical Network Architect at Equinix. His current role is network architecture and solutions development for inside and outside fiber plant including DWDM transport and switching systems and optical layer SDN for Equinix global data center networks. He has nearly 25 years of experience in optical and data network technologies, systems, networks, and services. His past experience includes R&D, systems engineering, technical sales and marketing, and product/program management at telecom service providers (MCI/WorldCom now part of Verizon) and optical system

vendors (Ciena, Fujitsu, and Calient Networks). He has about sixteen conference and trade journal publications to his credit in several optical technologies and networks. He holds Master of Engineering in Electrical Engineering with fiber optical communications specialization. He is currently pursuing his Jack Welch Executive MBA. He has active certifications in MEF-CECP, PMP, CCNA (R&S, Security), and CCDA.

Based in San Francisco, **Sanjay Nayak's** key focus is to identify, develop and manage strategic options, opportunities, partnerships and ecosystems for the company to accelerate business growth. Sanjay has over 14 years of experience in the telecommunication industry and prior to his current role, he was Vice President, Product Strategy & Management at Pacnet. Before joining Pacnet, Sanjay has held senior business development roles with Verizon Business and C&W in Australia. Sanjay holds an MBA from the University of Technology, Sydney and a BCOM in Commerce from Symbiosis International University.

With more than 18 years of experience in the telecom industry, **Shikhar Sarkar**, currently heads the Product Marketing team at Hibernia Networks, a fast growing provider of global network services such as IP, CDN, Ethernet, Video and Ultra Low Latency services. Shikhar is responsible for the marketing strategies, along with its execution and go to market activities including lead generation. In the past, Shikhar served in various product management and product innovation roles at Hi-Tech companies such as Lucent Technologies, Motorola, Tata Communications, and UTStarcom where he worked on a wide range of unified communication, mobile 3G and next generation networking technologies. Shikhar holds an MBA in Strategy and Finance from NYU, Stern School of Business, and a BS in Computer Science from NIT, India.

Vishnu Shukla is a Principal Technologist at Verizon. He has more than 25 years experience in optical network design and development, technology transfer and overall technology planning. His current responsibilities include development of the next generation network architecture, analyzing the current state-of-the-art technology trends and developments and evaluation of its strategic impact on Verizon. Vishnu contributes to the Verizon's participation in multi-disciplined standards concerning leading edge technologies. He holds a PhD from the University of Wales, U.K. and an MBA from Northeastern University, Boston. He is a member of IEEE and OSA.

Patrick Sims is focused in the growth industries of advanced IT, wireline and wireless communications, managed services sectors for SDN/analytics & NFV, smart grid, tele-health/medicine, Machine-to-Machine, and smart communities. His primary roles are to define the technical development strategy in access technologies, lead the technical direction for new product introduction, and ensure the sustainable development of the technical direction. Patrick's 35-year experiences include: CTO, Director of R&D, Product Management and Business Development, Design Engineering for Optical Networks, Wireless Backhaul, and DAS, and acts as an industry consultant to both equipment manufacturers and service providers within the global FTTx industry. Pat is a certified Passive Optical Network (PON) Designer and an RCDD, holds a Bachelor of Science Degree in Electrical Engineering from Florida A&M University, and has an MBA from the University of Florida. Pat is also one of the original team members responsible for establishing the FTTH Council.

PANEL II: PACKET OPTICAL: DOES THE BUMPY ROAD LEAD TO A PROMISING DESTINATION?

Natarajan 'Subu' Subrahmanyan; *Managing Director, Research Analyst, The Juda Group, USA*

PANEL DESCRIPTION:

The traditional packet optical transport is defined as carrier Ethernet with an integrated WDM interface with most of them based on 10G XFP or tunable SFP+ for metro and access networks. The newer generation packet optical solution has a packet box (router/switch) with integrated coherent 100G DWDM. In addition, the solution includes multi-layer, converged software.. This latest design provides a new network architecture for greater simplicity, lower cost, better resiliency, as well as higher flexibility and reliability. The panel will discuss a number of important matters. What is packet-optical convergence from the point of view of service providers? What are the main requirements from carriers, and the principal challenges to migrating to the new architecture? What will be the impact of software programmability and control? To what degree will packet optical quicken a shakeout of equipment vendors? What will be the projected breakdown of router vendors benefitting from the technology versus resistance from customers in some situations of being locked into a single vendor? Or will service providers still prefer the best-of-breed architectures?

SPEAKERS:

Ajay Govil, *Director of Network Architecture, XO Communications, USA*

Convergence without Compromise; Kile Griffith, *Transport Network Manager, Sprint, USA*

Surveying the Packet Optical Landscape; Jeff Jockman, *Director of Transport Strategy and Development, CenturyLink, USA*

Verizon's Next Gen Metro Network;David Templeton, *Manager of Optical Transport Planning, Verizon, USA*

Flexible Ethernet (FlexE) - Motivation and Approaches; Vijay Vusirikala, *Optical Network Architect, Google, USA*

BIOGRAPHY:

Natarajan 'Subu' Subrahmanyan, CFA is a Senior Managing Director and lead research analyst for communications equipment companies at The Juda Group, a division of Concept Capital Markets. Mr. Subrahmanyan's research focuses on leading networking, security and datacenter infrastructure companies. He has been featured on the Wall Street Journal's Best of the Street Analyst List, and ranked in the Institutional Investor polls. Mr. Subrahmanyan joined The Juda Group in 2003 prior to which he was lead research analyst for data and optical networking companies at Goldman Sachs. He holds an MBA from Vanderbilt University and a B.S in Electrical and Electronics Engineering from Anna University in Madras, India.

Jeff Jockman is Director of Transport Strategy and Development at CenturyLink, and is responsible for defining the architecture, design, and strategic direction for the CenturyLink Local, National and International transport networks. This includes the evaluation, selection and certification of ROADM, OTN and converged packet optical platforms. Jeff has over 15 years of experience in the Telecommunications industry, with a strong history in architecture, certification testing, planning and

engineering functions.

David Templeton is a manager of optical transport planning at Verizon. With 36 years of engineering and planning experience developing and deploying new technologies in metro networks, Dave has driven the evolution of Verizon's metro optical transport from SONET to ROADM resulting in over 5,000 ROADM network elements within Verizon. He is currently supporting the introduction of Verizon's next generation metro platform.

Vijay Vusirikala is currently an Optical Network Architect at Google, where is focused on solutions for scaling and optimizing Google's optical network covering client optics, metro optical, long haul and submarine links. Prior to Google, Vijay was at Infinera, Motorola and Sycamore Networks in senior marketing, business development and architecture roles working on optical networks and systems ranging from backbone core to access networks. Vijay has published extensively, spoken at numerous industry events, and holds several patents in optical devices and systems. He obtained a Ph.D from the University of Maryland, College Park in optoelectronic integration, and a BSEE from IIT, Madras in India.

OFC PRESS RELEASES

Title	Date
World-Class Optical Networking and Communications Event, OFC 2015, Concludes in Los Angeles	26 March 2015
"Light the Future: A Community Outreach Event" for Los Angeles Area Students Taking Place at OFC Celebrates International Year of Light	25 March 2015
Silicon Photonics Takes the Next Step Toward a High Bandwidth Future	16 March 2015
Largest-Scale Silicon Photonic Switch to be Presented at OFC 2015	11 March 2015
OFC 2015 to Host 550+ Exhibitors Featuring Innovative Advancements in Science	10 March 2015
Breakthrough Research, Innovating Keynote Presentations and Leading Edge Products at OFC 2015	18 February 2015
Paul Daniel Dapkus Wins 2015 John Tyndall Award	11 December 2014
Global Network Innovators Set to Deliver Keynote Talks at OFC 2015	10 November 2014

EXHIBITOR NEWS

Company	Title	Date

TeraView	TeraPulse 4000 – TeraView ships and delivers its first unit	26 March 2015
Macom	MACOM Debuts New 46Gbps Quad Channel Linear Modulator Driver for 400G Long Haul Applications	25 March 2015
Finisar	Finisar Post-Deadline Paper Presents New Research on 56 Gb/s Directly Modulated DFB Laser Technology at OFC 2015	25 March 2015
Macom	MACOM Extends Leading Optical Portfolio with New Dual Channel Linear Transimpedance Amplifier	25 March 2015
Macom	MACOM Extends Leading Optical Portfolio with New Dual Channel Linear Transimpedance Amplifier	25 March 2015
Macom	MACOM Introduces 10Gbps Burst Mode Laser Driver with Integrated Limiting Amplifier and Clock and Data Recovery for Next Generation Passive Optical Network	24 March 2015
Macom	MACOM Introduces VCSEL Driver and Transimpedance Amplifier with Integrated Clock and Data Recovery Chip-Set for 100Gbps Applications	24 March 2015
Polatis	Polatis and World Wide Technology Partner to Bring Best-in-Class Optical Networking Solutions to Enterprise, Government and Service Provider Customers	24 March 2015
Finisar	Finisar Introduces SFP28 and QSFP28 Optical Modules for High Port-Count 25G and 100G Data Center Applications	24 March 2015
Finisar	Finisar to Create the Industry's Broadest 200G Coherent Product Portfolio with New Products Announced at OFC	24 March 2015
Tektronix, Inc.	Tektronix Announces 70 GHz Real-Time Oscilloscope with Industry Best Signal Fidelity	24 March 2015
Tektronix, Inc.	Tektronix Announces 70 GHz Real-Time Oscilloscope with Industry Best Signal Fidelity	24 March 2015
Tektronix, Inc.	Tektronix Unveils 45 GHz Optical Modulation Analyzer for 400G Communications Testing	24 March 2015
Anritsu	Anritsu's Next-Generation Transport Tester Selected for Demonstrations	24 March 2015
Anritsu	Samtec to Demonstrate 28 Gbps FireFly™ with Anritsu	24 March 2015

Anritsu	Anritsu Company to be Part of OIF Technology Demonstration	24 March 2015
Xilinx	Xelic Announces 100G Staircase EFEC Core for FPGA Applications	24 March 2015
Lightip Technologies	Lightip launches TO-CAN based tunable laser TOSA at OFC2015	24 March 2015
PMC-Sierra, Inc.	PMC Enables 400G OTN Switching in Metro Networks	24 March 2015
Molex	Molex And Newly-Acquired Oplink To Demonstrate Innovative Transmission And Transport Solutions At OFC 2015	24 March 2015
CDFP	CDFP MSA Releases Rev. 3.0 Specifications for 400 Gbps Interoperable Hot Pluggable Modules	24 March 2015
II-VI Inc.	II-VI Incorporated to Exhibit at OFC 2015 and Showcase a Portfolio of Products to Enable High Bit Rate Transponders and Transceivers	24 March 2015
Teledyne LeCroy	PITTSBURGH, March 24, 2015 (GLOBE NEWSWIRE) – II-VI Incorporated (NASDAQ: IIVI), a leading provider of solutions for next generation optical networks, today announced that it will be exhibiting at the Optical Fiber Communications Conference (OFC 2015) in Booth #735, on March 24-26, 2015 in Los Angeles, California, where it will showcase a portfolio of amplification products to enable high performance, high bit rate (100, 200, 400 Gbps and beyond) optical transmission.	24 March 2015
Teledyne LeCroy	Chestnut Ridge, NY, March 24, 2015 — Teledyne LeCroy today announced significant enhancements to the two highest performance oscilloscope product lines in the company's portfolio. From the introduction of the 30 GHz WaveMaster 8 Zi in 2009 to the 100 GHz LabMaster 10 Zi available today, these award-winning oscilloscope platforms have advanced Teledyne LeCroy's technology leadership by aggressively pushing real-time bandwidth and sample rate boundaries. The new LabMaster 10 Zi-A delivers improved	24 March 2015
NeoPhotonics	NeoPhotonics Releases Dual Rate 100G CFP4 LR4 Transceivers	23 March 2015
Cross Fiber, Inc.	CrossFiber to Showcase Next-Generation Photonic Switches at OFC 2015	23 March 2015

Go!Foton	Go!Foton's PEACOC Ultra High Density Fiber Management Platform Granted US Patent #8,939,792	23 March 2015
Go!Foton	Go!Foton Completes GR & TPR Certification of 1.2mm & 900um LC Jumpers	23 March 2015
NTT Electronics	NTT Electronics Industry-First 20nm Low-Power Coherent DSP Now Shipping in Volume	23 March 2015
MicroCare Corporation	MicroCare Corp. Features New Fiber Optic Innovations at OFC 2015	23 March 2015
Finisar	Finisar Announces Technology Roadmap for Next Generation Multimode Fiber (MMF) Interfaces	23 March 2015
Macom	MACOM and Kaiam Corporation Demonstrate 400G Capability at OFC 2015 in Los Angeles	23 March 2015
Fujitsu	Fujitsu Solution Receives 2015 Lightwave Innovation Award Elite Score	23 March 2015
Source Photonics	Source Photonics announces production ramp and general availability of its market-leading 100G QSFP28 transceiver	23 March 2015
Macom	MACOM Demonstrates Industry's First Linear EML Driver for 400Gbs Applications	23 March 2015
Ranovus Inc.	OpenOptics MSA Consortium Releases the Industry's First WDM Specification for Intra Data Center Connectivity	23 March 2015
	NeoPhotonics to Demonstrate 16x16 Multicast Switch (MCS) Formed by Cascading Four Modular 4x16 MCSs	23 March 2015
NeoPhotonics	NeoPhotonics Releases Dual Rate 100G CFP4 LR4 Transceivers	23 March 2015
Light Brigade	Light Brigade Introduces New Online Training Modules	23 March 2015
RANOVUS Inc	OpenOptics MSA Consortium Releases the Industry's First WDM Specification for Intra Data Center Connectivity	23 March 2015
NeoPhotonics	NeoPhotonics to Demonstrate 16x16 Multicast Switch (MCS) Formed by Cascading Four Modular 4x16 MCSs	23 March 2015
Ironwood Electronics Inc.	27 GHz Bandwidth Socket for Xilinx FLGA2577 BGA Package	21 March 2015

OE Solutions	Live Demonstrations of 100G Discrete Multi-Tone Transceivers	20 March 2015
Solid Optics	SOLID OPTICS RELEASES REVOLUTIONARY MULTI-FIBER-TOOL FOR NETWORK PROFESSIONALS	20 March 2015
NeoPhotonics	NeoPhotonics Adds Micro-Integrated Coherent Receiver to Its Suite Of Products For 100G and 400G Coherent Transport	20 March 2015
OE Solutions	OE Solutions to Showcase New Mobile Backhaul/Fronthaul and Data Center Products at OFC 2015	20 March 2015
EMCORE	EMCORE to Demonstrate End-to-End DOCSIS 3.1 CATV Transmission Link at OFC 2015	19 March 2015
OE Solutions	OE Solutions to Showcase CSC LambdaRich™ Transceivers at OFC 2015	19 March 2015
Reflex Photonics	Reflex Photonics to show a live -40°C demonstration of its 120G LightABLE Embedded Optics during OFC 2015	19 March 2015
TE Connectivity (TE)	TE Connectivity Announces FullAXS Mini and MXC Connectors Demonstrates New Connectors at OFC 2015	19 March 2015
TE Connectivity (TE)	TE Connectivity Plans Major Presence at OFC 2015 with Product Demonstrations	19 March 2015
PETRA	PETRA demonstrates Low Power Silicon Photonics I/O Core and 25Gbps transmission over 300m MMF.	19 March 2015
Amphenol	Amphenol Fiber Optic Products to Exhibit their newest innovative products at OFC's Technical Conference	19 March 2015
Reichenbach International Inc.	Reichenbach International Inc. has developed new product	19 March 2015
Coriant	Coriant to Demonstrate End-to-End Packet Optical Transport Innovation at OFC 2015	19 March 2015
ElectroniCast Consultants	Fiber Optic Sensors Global Market Forecast	18 March 2015
ID Photonics	ID Photonics introduces automated BIAS Control for IQ-Mach Zehnder structures optimized for flexible Multi – Level modulation formats	18 March 2015

OE Solutions	OE Solutions and AimValley to Introduce IP OAM Smart SFP	18 March 2015
Tektronix	Tektronix Announces First Optical Test Solution for 100GBASE-SR4	18 March 2015
Microsemi	Microsemi to Demonstrate Leading-Edge Modulator Driver Amplifiers and Timing ICs for Optical Communication Networks at OFC 2015	17 March 2015
VPIphotonics Inc.	VPIphotonics announces a new product and live demos @ OFC 2015	17 March 2015
Device Technologies, Inc.	DTi Announces Release of Versatile Fast-Drop™ Rack Mount Fiber Array Panel	17 March 2015
Keysight Technologies, Inc.	Keysight Technologies Introduces Tunable Laser Source with Industry-Leading Tuning Repeatability	17 March 2015
Connected Fibers	Connected Fibers Introduces The Industry's First Intelligent Curing Oven, the 1CureTM , at OFC 2015	16 March 2015
ACT-Vision	ACT-Vision, distributor of LED and fiber optic systems will introduce RAYTELA fiber optic solutions by Toray to the U.S. market at OFC	16 March 2015
OSI Laser Diode, Inc.	OSI Laser Diode Introduces 1625 nm High-Power (350 mW, typical), Pulsed Laser Diode Module for Optical Testing	12 March 2015
Oclaro	Oclaro Brings Powerful Product Line-Up to OFC for Telecom, Enterprise and Data Center Applications	12 March 2015
Macom	MACOM to Showcase Extended Portfolio of Optical Communications Technology at OFC 2015	11 March 2015
Norland	NORLAND PRODUCTS INTRODUCES AN INTERFEROMETRIC GAME CHANGER	10 March 2015
Finisar	Finisar Introduces WaveShaper Optical Processor with Reprogrammable MxN Port Configuration	10 March 2015
ElectroniCast Consultants	Fiber Optic Circulators Global Market Analysis	9 March 2015
Mellanox® Technologies, Ltd.	OpenOptics MSA Founders Mellanox and RANOVUS Propose Wavelength Division Multiplexing Specifications to the Open Compute Project	9 March 2015

VLC Photonics S.L.	VLC Photonics introduces Multi-Project Wafer Standard Design Services	9 March 2015
Norland Products	NORLAND PRODUCTS OFFERS FREE SAMPLE OF FIBER RE- COATING ADHESIVE	9 March 2015
ProLabs	ProLabs Announces Two Strategic Appointments	9 March 2015
Coriant	Coriant Brings Packet Optical Transport Leadership and Innovation to the Metro Edge	6 March 2015
AppliedMicro	AppliedMicro to Showcase its Serial 40G PAM4 solution	6 March 2015
INNO Instrument	INNO Instrument's big launch in the US market: the next generation of fusion splicers	6 March 2015
inTEST Thermal Solutions	Optimize Design and Production Throughput with High-Speed Temperature Testing	6 March 2015
IPDiA Technologies	IPDiA Launches a 100nF/0402 60+GHz Silicon Capacitor for Ultra-broadband Systems	6 March 2015
MPB Communications	MPB Communications Introduces New Optical Line–enhancing Equipment	6 March 2015
MRSI Systems	MRSI Systems Announces a New System for the Assembly of Active Optical Cables	6 March 2015
SV Microwave	SV Microwave Announces a New Interconnect System	6 March 2015
Yokogawa Corporation of America	Yokogawa Corporation of America Releases New Multitasking, Modular OTDR with Capacitive Touchscreen	4 March 2015
Norland Products Inc.	NORLAND PRODUCTS INC NAMES NEW COO OF FIBER OPTIC DIVISION	4 March 2015
Suruga Seiki	The latest alignment platform which condensed our Advanced technology	3 March 2015
Fraunhofer Institute for Photonic Microsystems IPMS	OFC 2015: Fraunhofer IPMS to Present Li-Fi Technology for Real-Time Wireless Communication	2 March 2015

AFA Photonics Co., Ltd	AFA Photonics Co., Ltd., a new provider of Erbium Doped Fiber Amplifiers (EDFAs), announces PTDGC	2 March 2015
Oclaro	Oclaro Extends 100G Connectivity Leadership by Ramping	2 March 2015
ElectroniCast Consultants	Optical Isolators Global Market Trends	2 March 2015
AFA Photonics Co., Ltd	New Generation Erbium Doped Fiber Amplifier with PTDGC Technology	2 March 2015
Fraunhofer IPMS	OFC 2015: Fast Optical Power Control with Liquid Crystal Waveguides	2 March 2015
Fraunhofer IPMS	Fraunhofer IPMS to Present Li-Fi Technology for Real-Time Wireless Communication	2 March 2015
AFA Photonics Co., Ltd	The introduction of EDFAs integrated with PTDGC	2 March 2015
ElectroniCast Consultants	Planar Lightwave Circuit Splitters Market Forecast	27 February 2015
Ciena	Ciena Delivers New Capabilities for the Web-Scale World	25 February 2015
Optical Internetworking Forum	OIF Members Lead the Industry in 56G Interfaces and Pluggable Coherent Optics	24 February 2015
CenturyLink	CenturyLink successfully delivers terabit speeds in central Florida field trial	23 February 2015
KVH Co., Ltd	KVH and Ciena Run Successful 400 Gbps Field Trial – First in Japan	20 February 2015
Ironwood Electronics	Clamshell Spring Pin QFN Socket for Microchip's 10TDFN	16 February 2015

Presto Engineering	Presto Engineering Now an Approved Keysight Solutions Partner	16 February 2015
Yelo	Yelo announces NEW touch screen laser diode driver	16 February 2015
Gould Fiber Optics	Gould Fiber Optics Announces a New Product Offering:	1 February 2015
Gould Fiber Optics	Gould Fiber Optics Announces a New Product Offering:	1 February 2015
Gould Fiber Optics	Gould Fiber Optics: Expanding its Product Portfolio	1 February 2015
Ironwood Electronics	Burn-in test Socket for QFN74 with exposed pad	31 January 2015
Ironwood Electronics	30 GHz Bandwidth Socket for QFN34 Package	31 January 2015

SHORT COURSES

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SC101A: Hands-on Workshop on Fiber Optic Measurements and Component Testing
Caroline Connolly[1], Chris Heisler[1], Kevin Haddock [2], Tony Nicholson3; [1]OptoTest Corp., USA, [2] AFL Test & Inspection Division, USA, 3Connected Fibers, USA

SC101B: Hands-on Workshop on Fiber Optic Measurements and Component Testing
Caroline Connolly[1], Chris Heisler[1], Kevin Haddock [2], Loic Cherel3; [1]OptoTest Corp., USA, [2] AFL Test & Inspection Division, USA, 3Data-Pixel, France

SC102: WDM in Long-Haul Transmission Systems
Neal S. Bergano; TE Subcom, USA

SC105: Modulation Formats and Receiver Concepts for Optical Transmission Systems
Peter Winzer, Chandrasekhar Sethumadhavan; Bell Labs, Alcatel-Lucent, USA

SC114: Passive Optical Networks (PONs) Technologies
Frank J. Effenberger; Futurewei Technologies, USA

SC160: Microwave Photonics
Keith Williams, Vince Urick; NRL, USA

SC176: Metro Network: The Transition to Ethernet
Loudon Blair; Ciena Corp., USA

SC177: High-Speed Semiconductor Lasers and Modulators
John Bowers; Univ. of California at Santa Barbara, USA

SC178: Test and Measurement of High-Speed Communications Signals
Greg D. Le Cheminant; Keysight Technologies, USA

SC185: Hands-on Polishing, Inspection and Testing of Connectors
Phil Shoemaker1, Steve Baldo2, Loic Cherel3; 1Light Brigade Inc., USA, 2Seikoh Giken Co. Ltd., USA, 3Data-Pixel, France

SC203: 100 Gb/s and Beyond Transmission Systems, Design and Design Trade-offs
Martin Birk1, Benny Mikkelsen2; 1AT&T Labs, Res., USA, 2Acacia Communications, USA

SC205: Integrated Electronic Circuits and Signal Processing for Fiber Optics
Y. K. Chen, Noriaki Kaneda; Bell Labs, Alcatel Lucent, USA

SC208: Optical Fiber Design for Telecommunications and Specialty Applications
David J. DiGiovanni; OFS Labs, USA

SC210: Hands-on Polarization-Related Measurements
Danny Peterson1, Tasshi Dennis2, Brian Teipen3, Christine Tremblay4; 1Verizon Business, USA, 2NIST, USA, 3ADVA Optical Networking, USA, 4Ecole de Technologie Superieure, Univ. du Quebec, Canada

SC216: An Introduction to Optical Network Design and Planning
Jane M. Simmons; Monarch Network Architects, USA

SC217: Optical Fiber Based Solutions for Next Generation Mobile Networks
Dalma Novak; Pharad, LLC., USA

SC261: ROADM Technologies and Network Applications
Thomas Strasser; Nistica Inc., USA

SC266: Quantum Cryptography and Quantum Information
Richard Hughes1, Thomas Chapuran2; 1Los Alamos Natl. Lab, USA, 2Applied Communication Sciences, USA

SC267: Silicon Microphotonics: Technology Elements and the Roadmap to Implementation
Lionel Kimerling; MIT, USA

SC288: Fundamentals of Polarization, PDL, and PMD
Nick Frigo; US Naval Academy, USA

SC312: Parametric Preprocessing in Optical Networks
Stojan Radic; UCSD, USA

SC314: Hands-on Fiber Characterization for the Engineering of Long Haul and Metro Deployments
Daniel Peterson1, Christine Tremblay2; 1Verizon, USA, 2École de Technologie Supérieure, Univ. du Québec, Canada

SC325: Highly Integrated Monolithic Photonic Integrated Circuits
Chris Doerr; Acacia Communications, USA

SC327: Modeling and Design of Fiber-Optic Communication Systems
Rene-Jean Essiambre; Bell Labs, Alcatel-Lucent, USA

SC328: New Developments in Optical Transport Networking (OTN)
Stephen Trowbridge; Alcatel-Lucent, USA

SC341: OFDM for Optical Communications
Sander L. Jansen[1], Dirk van den Borne[2]; [1]ADVA Optical Networking, USA [2]Juniper Networks, Germany

SC347: Reliability and Qualification of Fiber-Optic Components
David Maack; Corning, USA

SC357: Circuits and Equalization Methods for Short Reach Optical Links
Alexander Rylyakov; Coriant, USA

SC359: Datacenter Networking 101
Cedric Lam, Hong Liu; Google, USA

SC369: Test and Measurement of Complex Modulated Optical Signals
Bernd Nebendahl, Oliver Funke; Keysight , Germany

SC372: Energy-Efficient Cloud Networks and Services
Rod S. Tucker, Kerry Hinton; Univ. Melbourne, Australia

SC373: Specialty Fiber Splicing and Interconnection
Andrew Yablon; Interfiber Analysis, USA

SC374: Cloud Computing and Dynamic Networks
George Clapp1, Douglas Freimuth2; 1AT&T Labs, USA, 2IBM, USA

SC384: Background Concepts of Optical Communication Systems
Alan Willner; Univ. of Southern California, USA

SC385: Fundamentals of Super Computing
John Shalf; NERSC, USA

SC386: The Evolution of Network Architecture Towards Cloud-centric Applications
Loukas Paraschis; Cisco Systems, Inc., USA

SC388: Wireless Backhaul
Stu Benington; Coriant GmbH, USA

SC389: Network Optimization
Dominic Schupke; Airbus Group Innovations, Germany

SC390: Introduction to Forward Error Correction
Frank Kschischang; Univ. of Toronto, Canada

SC392: Digital Coherent Optical Systems 1: Transceiver Technology and Performance
Maurice O'Sullivan; Ciena, Canada

SC393: Digital Coherent Optical Systems 2: Digital Signal Processing
Chris Fludger; Cisco Optical GmbH, USA

SC395: Hands On: Basic Modeling and Design of Coherent Fiber-Optic Communication Systems
Erich Gottwald, Harald Rohde; Coriant, Germany

SC408: Space-Division Multiplexing in Optical Fibers
Roland Ryf; Bell Labs, Alcate-Lucent

SC409: Safety in Fiber Optics: From Components to Systems
Larry Johnson, The Light Brigade1, USA

SC411: Multi-layer Interaction in the Age of Agile Optical Networking
Ori A. Gerstel; Sedona Systems, Israel, USA

SC420: Characterization of Components for Coherent Communication Systems New
Erich Gottwald, Harald Rohde; Coriant, Germany

SC421: SDN Control Plane for Photonic Systems Related Standards and Architectures New
Bernd Pruessing1, Karthik Sethuraman2; 1 Coriant, German; 2NEC Corporation of America, USA

SC423: Coherent Photonic Networks; Hardware, Software, and Applications New
Mark D. Feuer1; Maurice O'Sullivan2; 1CUNY College of Staten Island, USA; 2Ciena, Canada.

SC101A - Hands-on Workshop on Fiber Optic Measurements and Component Testing

Monday, 23 March
08:30 - 12:30

Short Course Level: Beginner

Instructor:

Caroline Connolly[1], Chris Heisler[1], Kevin Haddock [2], Tony Nicholson[3]; *[1]OptoTest Corp., USA, [2] AFL Test & Inspection Division, USA, [3]Connected Fibers, USA*

Short Course Description:

This Short Course focuses on the practical aspects of working with fiber optic components and instrumentation used to make optical performance characterization measurements. Four fully equipped stations are available for hands-on participation.

Rotation 1) Basic Component Testing—test and measurement techniques and latest issues involving single-mode and multimode fiber, cable and connectors including insertion loss, return loss, and visual fault location.

Rotation 2) Launch condition effects on multimode fibers. Launch conditions will be demonstrated and measured via near field, far field, and encircled flux methods. Includes demonstration and hands-on measurements with launch condition analyzer.

Rotation 3) Fiber Optic Test Overview and Tips – An overview on fiber optic testing including the importance of connector cleaning and inspection, measuring insertion loss and OTDR testing with tips on how to avoid commonly made testing errors.
Rotation 4) Interferometry measurements on single and multifiber connectors —understanding the measurements involved in characterizing a high quality fiber connection. Includes hands-on with an interferometer and an important discussion of the standards requirements.

Industry trends will be related in each rotation such as encircled flux requirements, high density connectivity, measurements important to the design and manufacture of optical components.

Short Course Benefits:

This course should enable you to:

- Explain the fundamental optical differences and applications of single-mode fiber (SMF) vs. multimode fiber (MMF), including the different fiber types and fiber sizes.
- Identify the different connector types and understand their specific performance features (i.e., E2000, FC, LC, Mil-Styles, MTP, SC, ST, etc.) plus the various end-face options (i.e. Expanded Beam, UPC and APC).
- Test connectors, cable assemblies, and fiber links for insertion loss (IL) and return loss (RL), while also understanding how these measurements can be affected by wavelength and launch conditions.
- Explain characterization measurements on passive optical components.
- Measure end face geometry and the importance that plays in a fiber connection.
- Make OTDR measurements and avoiding common pitfalls.

Short Course Audience:

This course is valuable to technicians, engineers, and managers interested in measurement and characterization of fiber optic components. Some familiarity with fiber optic test cables and equipment is assumed. Class size is limited to 16.

Instructor Biography:

Caroline Connolly is a Sales Director at OptoTest Corp. and has been involved with fiber optic test and measurements technologies and cable assemblies for more than 15 years. Her experience covers all areas of physical layer optical testing ranging from laboratory to field applications. Before joining OptoTest, she worked in various key sales positions at Rifocs Corp. Connolly holds a bachelor's degree in business management.

Chris Heisler has been in the fiber optics industry for over 4 years. For this duration he has worked at OptoTest Corp. as an Applications and Test Engineer where he has studied and researched fiber optic cable measurements with a focus on launch condition measurements and the various standards governing these measurements. Chris attended California Polytechnics San Luis Obispo where he received a B.S. in electrical engineering.

Tony Nicholson is currently the Director of Technology at Connected Fibers, a company focused on selling manufacturing and test equipment, components, consumables, and tools for optical cable assembly fabrication. Since 1984, Mr. Nicholson has worked in various positions for companies manufacturing and developing test equipment primarily for the fiber optic industry. For the last 16 years he has been involved in the manufacture, sales and support of interferometers for the fiber optic connector market and was on the technical advisory panel for the TIA during the draft of the first FOTP for measuring fiber optic connectors.

SC101B - Hands-on Workshop on Fiber Optic Measurements and Component Testing

Monday, 23 March
13:30 - 17:30

Short Course Level: Beginner

Instructor:

Caroline Connolly[1], Chris Heisler[1], Kevin Haddock [2], Loic Cherel[3]; [1]*OptoTest Corp., USA,* [2] AFL Test & Inspection Division*, USA,* [3]*Data-Pixel, France*

Short Course Description:

This Short Course focuses on the practical aspects of working with fiber optic components and instrumentation used to make optical performance characterization measurements. Four fully equipped stations are available for hands-on participation.

Rotation 1) Basic Component Testing—test and measurement techniques and latest issues involving single-mode and multimode fiber, cable and connectors including insertion loss, return loss, and visual fault location.

Rotation 2) Launch condition effects on multimode fibers. Launch conditions will be demonstrated and measured via near field, far field, and encircled flux methods. Includes demonstration and hands-on measurements with launch condition analyzer.

Rotation 3) Fiber Optic Test Overview and Tips – An overview on fiber optic testing including the importance of connector cleaning and inspection, measuring insertion loss and OTDR testing with tips on how to avoid commonly made testing errors.
Rotation 4) Interferometry measurements on single and multifiber connectors —understanding the measurements involved in characterizing a high quality fiber connection. Includes hands-on with an interferometer and an important discussion of the standards requirements.

Industry trends will be related in each rotation such as encircled flux requirements, high density connectivity, measurements important to the design and manufacture of optical components.

Short Course Benefits:

This course should enable you to:

- Explain the fundamental optical differences and applications of single-mode fiber (SMF) vs. multimode fiber (MMF), including the different fiber types and fiber sizes.
- Identify the different connector types and understand their specific performance features (i.e., E2000, FC, LC, Mil-Styles, MTP, SC, ST, etc.) plus the various end-face options (i.e. Expanded Beam, UPC and APC).
- Test connectors, cable assemblies, and fiber links for insertion loss (IL) and return loss (RL), while also understanding how these measurements can be affected by wavelength and launch conditions.
- Explain characterization measurements on passive optical components.
- Measure end face geometry and the importance that plays in a fiber connection.
- Make OTDR measurements and avoiding common pitfalls.

Short Course Audience:

This course is valuable to technicians, engineers, and managers interested in measurement and characterization of fiber optic components. Some familiarity with fiber optic test cables and equipment is assumed. Class size is limited to 16.

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Caroline Connolly is a Sales Director at OptoTest Corp. and has been involved with fiber optic test and measurements technologies and cable assemblies for more than 15 years. Her experience covers all areas of physical layer optical testing ranging from laboratory to field applications. Before joining OptoTest, she worked in various key sales positions at Rifocs Corp. Connolly holds a bachelor's degree in business management.

Chris Heisler has been in the fiber optics industry for over 4 years. For this duration he has worked at OptoTest Corp. as an Applications and Test Engineer where he has studied and researched fiber optic cable measurements with a focus on launch condition measurements and the various standards governing these measurements. Chris attended California Polytechnics San Luis Obispo where he received a B.S. in electrical engineering.

SC102 - WDM IN LONG-HAUL TRANSMISSION SYSTEMS

Monday, 23 March
08:30 - 12:30

Short Course Level: Beginner

Instructor:

Neal S. Bergano; *TE Subcom, USA*

Short Course Description:

Wavelength division multiplexing (WDM) technology used in long-haul transmission systems has steadily progressed over the past few years. Newly installed state-of-the-art transoceanic length undersea cable systems now have tens of terabit/s maximum capacity, while being flexible enough to have an initial deployed capacity at a fraction of the maximum. The steady capacity growth of these long-haul fiber-optic cable systems has resulted from many improvements in WDM transmission techniques and an increased understanding of WDM optical propagation. Important strides have been made in areas of new single-mode fibers, gain equalization, modulation formats, error correcting codes and coherent transponders that have made possible the demonstration of multi-terabit capacities over transoceanic distances. Next-generation systems and future upgrades of existing systems will benefit from new concepts emerging from system research.

This course will review the important issues regarding the use of WDM in long-haul transmission systems. Included will be an introduction to long-haul undersea cable transmission systems, the amplified transmission line, dispersion/nonlinear management, transmission formats, measures of system performance, forward error correction, the importance of polarization effects, experimental

techniques and results, a transmission line design example and future trends including coherent transponders.

Short Course Benefits:

- This course should enable you to:
- Explain the tradeoffs made in the design of an amplifier chain.
- Summarize the tradeoffs made in the selection of fiber types.
- Understand Q-factor.
- Discuss the concept of margin in fiber optic transmission systems.
- Identify the important polarization effects in long-haul transmission systems.
- Compare the different methods of performing long-haul transmission experiments.
- Discuss circulating loop experiments.
- Discuss the future trends in long-haul transmission systems.
- Gain insight into the optical propagation of data signals over long distances.

Short Course Audience:

This course is intended for the student who wants an understanding of how information is transmitted over long distances using fiber optic transmission lines, with emphasis on undersea cable transmission systems. This includes new entrants into the fiber optic field with an engineering background, engineers with fiber optics exposure, people in the fiber optic telecommunications industry, and fiber optic research and development management.

Instructor Biography:

Neal S. Bergano received the B.S. degree in electrical engineering from the Polytechnic Institute of New York, New York, and the M.S. degree in electrical engineering and computer science from the Massachusetts Institute of Technology, Cambridge, in 1981 and 1983. In 1981, he joined the technical staff of Bell Labs' undersea systems division. In 1992, he was named a Distinguished Member of the Technical Staff of AT&T Bell Labs, where he became an AT&T Technology Consultant in 1996 and AT&T Technology Leader in 1997. He is currently the Managing Director of the System Research and Network Development, TE Subsea Communications LLC, Eatontown, NJ. He holds 31 U.S. patents in the area of optical fiber transmission systems. His main research has been devoted to the understanding of how to improve the performance and transmission capacity of long-haul optical fiber systems, including the use of wavelength division multiplexing in optical amplifier based systems.

Mr. Bergano is a Fellow of the IEEE, the OSA, AT&T, and TE Connectivity. He served on the Board of Directors for the OSA from 2009 to 2011, and served on the Board of Governors for the IEEE Lasers and Electro-Optics Society from 1999 to 2001. He is a long-time volunteer and supporter of the OFC/NFOEC meeting, which includes General Chair and Technical Chair in 1999 and 1997, Chair of the steering committee from 2000 to 2002, and is currently the Chair of OFC/NFOEC's long-range planning committee. He is the recipient of the 2002 John Tyndall Award, for outstanding technical contributions to and technical leadership in the advancement of global undersea fiber-optic communication systems.

SC105 - Modulation Formats and Receiver Concepts for Optical Transmission Systems

Sunday, 22 March
09:00 - 13:00

Short Course Level: Advanced Beginner

Instructor:

Peter Winzer, Chandrasekhar Sethumadhavan; *Bell Labs, Alcatel-Lucent, USA*

Short Course Description:

The ever-increasing traffic demands in carrier networks, driven by emerging data-centric services and applications, have led to intense research and development in the area of high-capacity (several 10 Tbit/s), high-speed (beyond 100 Gb/s per wavelength) optical transport networks. In order to enable such high capacities and speeds over appreciable transmission distances (>1000 km), spectrally efficient yet impairment-tolerant transmission technologies have moved into the focus of optical communications research and have led to considerable innovation in modulation and detection strategies. This course gives an overview of modulation formats and multiplexing techniques for optical networking applications, both from a conceptually fundamental and from a state-of-the-art technological point of view. The discussed modulation formats include intensity modulation, phase modulation, and quadrature amplitude modulation; multiplexing techniques include wavelength division multiplexing (WDM), polarization division multiplexing (PDM), subcarrier multiplexing, discrete multi-tone (DMT), and orthogonal frequency division multiplexing (OFDM), and also introduce space division multiplexing (SDM) as the currently emerging research frontier, heavily discussed throughout the conference sessions. The course covers optical receiver design and optimization principles, both for direct-detection and digital coherent (intradyne) receivers, including some basic discussion of the underlying digital electronic signal processing (DSP) at both the receiver and the transmitter and coding techniques. Finally, the course highlights the interplay of modulation format, receiver design, and the wide variety of transmission impairments found in optically routed long-haul networks and points to latest research trends in optical modulation and multiplexing.

Short Course Benefits:

This course should enable you to:

- Identify key objectives of high-capacity and high-speed optically routed network design.
- Describe the basic concepts behind optical modulation and multiplexing techniques.
- Generate advanced optical modulation formats using state-of-the-art opto-electronic components and DSP.
- Explain the basic concepts of optical receiver design, including direct and coherent detection as well as related digital signal processing techniques.
- Recognize and discuss the interplay between modulation format, transceiver design, and transmission impairments.

- Get an insight into future trends in research and product commercialization of optical transport systems enabled by advanced modulation and multiplexing techniques, software-defined transceivers, and flexible WDM architectures.

Short Course Audience:

This advanced-beginner course is intended for a diverse audience including lightwave system researchers and engineers as well as opto-electronic subsystem designers. Some basic knowledge of optical modulation and detection technologies will help in better understanding the course but is not a prerequisite. Past attendees will find substantial updates to this course, which we continuously adapt to reflect the latest trends in research as well as in product development, and may hence find it useful to attend again.
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Instructor Biography:

Peter J. Winzer received his doctorate in electrical engineering/communications engineering from the Vienna University of Technology, Vienna, Austria, in 1998. His academic work, largely supported by the European Space Agency (ESA), was related to the analysis and modeling of space-borne Doppler wind lidar and highly sensitive free-space optical communication systems. In this context, he specialized in optical modulation formats and high-sensitivity receivers using coherent and direct detection. He continued to pursue this field of research after joining Bell Labs in 2000, where he focused on Raman amplification, optical modulation formats, advanced receiver concepts, as well as digital signal processing and multiplexing techniques for high-speed fiber-optic communication.

S. Chandrasekhar received a doctorate in physics from the University of Bombay, Bombay, India, in 1985. He joined Bell Labs, Lucent Technologies (formerly AT&T Bell Labs), Holmdel, New Jersey, in 1986. He has worked on III-V compound semiconductor devices such as photodetectors, heterojunction phototransistors, bipolar transitors (HBTs) and high-speed optoelectronic integrated circuits (OEICs), advanced receive-side digital signal processing, novel modulation formats, and high-speed DWDM optical networking systems. His current interests include coherent optical orthogonal frequency division multiplexed systems for high spectral efficiency transport and networking beyond 100Gb/s, multi-carrier superchannels, and software-defined transponders for efficient end-to-end optical networking. He is a Fellow of the IEEE and of the OSA.

SC114 - Passive Optical Networks (PONs) Technologies

Sunday, 22 March
09:00 - 13:00

Short Course Level: Advanced Beginner

Instructor:

Frank J. Effenberger; *Futurewei Technologies, USA*

Short Course Description:

PON systems have become the preeminent technology for broadband optical access networks. Over 100 million lines of PON-based access have been deployed around the world. However, there are multiple network types deployed today, and proposals for future systems are even more diverse. For this reason, it is important to understand the architectures and technologies that are used in PON, including their unique capabilities and trade-offs.

At the highest level, this short course reviews the major architectural variants of PON systems, including TDMA, WDMA, OFDMA, and hybrids of these. The commercially important implementations of these technologies will also be described, and their major application areas (FTTHome, FTTbuilding, etc.) will be described. The status of commercial deployments and interoperability of the equipment will be reviewed.

Additionally, the economic drivers for the entire PON value chain will be reviewed, including the factors that triggered deployments of the past, and what may cause evolutionary steps to the next generation. The integration of the PON technology into the larger broadband network will also be covered, including the larger network architecture, management, and regulatory framework.

The course will also contain a hypothetical case study of a PON deployment. This case will take the class through the decision-making processes involved, from initial business case construction, through technology selection, network design and implementation, and operations. This will hopefully be an interactive session that will build practical expertise in optical access.

Short Course Benefits:

This course should enable you to:

- Compare the capabilities and advantages of different PON technologies.
- Describe the practical limitations of real-world G-PON and EPON systems for broadband access.
- Explain the motivations behind the Full-Service-Access-Network initiative and the related IEEE P802.3 and P1904 projects.
- Identify the commercial issues surrounding fiber access, and how PON works to address these.
- List and compare the possible future evolution paths that PON technology may take.
- Begin to plan PON applications and deployments.

Short Course Audience:

This course is intended for engineers, network planners and product designers involved with broadband access and a need to understand passive optical networks.

Instructor Biography:

After completing his doctoral work in 1995, Dr. Effenberger took a position with Bellcore (now Telcordia) where he analyzed all types of access network technologies, focusing on those that employed passive optical networks. He witnessed the early development of the FSAN initiative and the development of the APON standard. In 2000, he moved to Quantum Bridge Communications (now a part of Motorola), where he managed system engineering in their PON division. This work supported the development and standardization of advanced optical access systems based on B-PON and G-PON technologies. In 2006,

he became director of FTTx in the advanced technology department of Futurewei Technologies. He remains heavily involved in the standards work, and is a leading contributor to the major PON standards in the ITU. He is now the rapporteur of Q2/15, which is the group charged with standardization of all optical access systems. In 2011, Frank was named to be one of the first Huawei Fellows, and was promoted to be Vice president of access networks research in Futurewei.

SC160 - MICROWAVE PHOTONICS

Monday, 23 March
13:30 - 17:30

Short Course Level: Advanced Beginner

Instructor:

Keith Williams, Vince Urick; *NRL, USA*

Short Course Description:

There has been significant progress in photonic components and technology applicable to microwave (analog) systems; several unique microwave functions have been implemented in the photonic domain. Along with or because of these technical advancements, there has been a slow, but expanding acceptance of photonics for microwave systems. This updated/revised Short Course will review some of the current capabilities and limitations of photonics as divided into four areas. They are: techniques and devices for generating microwave-modulated light, techniques and devices for detection, RF transmission links (distinguished from digital transmission systems), and microwave signal processing (including time-delay beamforming, downconverting, filtering and photonic analog-to-digital conversion). Emphasis will be placed on relating device operation to basic photonic subsystem performance and relating the photonic link and functions to comparable microwave techniques (e.g., link loss, noise figure, dynamic range and phase error). More recent technology advancements will also be incorporated.

Short Course Benefits:

This course should enable you to:

- Explain limitations of photonics and photonic devices for microwave systems.
- Identify promising technologies for analog system improvements.
- Discuss and relate analog and digital fiber optic system differences.
- Design optical systems for microwave applications.
- Identify and compare RF systems which may benefit from utilizing RF Photonics.

Short Course Audience:

The course attendee should have a basic understanding of lasers, photodetectors, and fiber optics. A bachelor's degree in engineering or the physical sciences or an equivalent level of experience would be necessary to understand the system design and application-need aspects of the course.

Instructor Biography:

Keith J. Williams received his B.S.E.E. degree from the University of Nebraska and the M.S. and Ph.D. degrees from the University of Maryland. His doctoral research was conducted on microwave p-i-n photodetector nonlinearities. Since 2000, he has been the head of the Photonics Technology Branch of the Naval Research Lab, Washington, D.C., where his research interests include microwave-optical devices, microwave fiber-optic links and systems and high current photodiodes.

Vincent J. Urick received the B.S. degree in physics from Bloomsburg University and the M.S. and Ph.D. degrees from George Mason University. His doctoral dissertation was on long-haul analog photonics. He has been conducting research and development of analog photonic systems and subsystems at the Naval Research Laboratory, Washington, DC since 2001, where he is presently the head of the Applied RF Photonics Section.

SC176 - Metro Network: The Transition to Ethernet

Monday, 23 March
09:00 - 12:00

Short Course Level: Advanced Beginner

Instructor:

Loudon Blair; *Ciena Corp., USA*

Short Course Description:

Metro networks are being stretched by new broadband services that are forcing the capacity of customer access links to increase by two to three orders of magnitude. Because service revenues are not growing in proportion to bandwidth, new network solutions are needed to dramatically lower the cost per unit bandwidth of the network infrastructure. Consequently, service providers almost universally are migrating from SONET/SDH to Ethernet for both equipment interfaces and the creation of a new packet transport layer. In this course, we consider the motivation for new service offerings for both residential and business environments and we analyze how these new services are changing the magnitude and pattern of traffic flows across the metro area. We then explore traffic projections at several key points in the metro network and estimate the required capacity of networking switches and transmission systems that will result from different service-mix scenarios. We will examine the mix of networking technologies that can be employed in the metro to yield a highly functional yet economic network solution. This will include an introduction to Carrier Ethernet and different implementation approaches to achieving carrier-grade performance as well as how Carrier Ethernet will operate in conjunction with other key network technologies including IP/MPLS, OTN and DWDM. With the anticipated dramatic growth in network capacity, the optical networking layer will play an increasingly important role in the metro network, both in enabling capacity scaling and in network reconfiguration. We discuss how the convergence of Carrier Ethernet and optical technologies is leading to the development of new packet-optical transport and switching systems. Applications of how packet-optical systems may be used in metro networks are explored using use cases.

Short Course Benefits:

This course should enable you to:

- • Describe how new services are changing metro network traffic characteristics.
- • Describe the impact that these new services will have on metro network traffic patterns and network equipment capacity in both aggregation and core metro networks.
- • Describe the meaning of Carrier Ethernet and discuss different implementation approaches.
- • Describe the key networking technologies used to build next generation metro networks, including DWDM, OTN, and IP/MPLS.
- • Discuss the role of Carrier Ethernet in new metro architectures and how it operates in combination with other key technologies.
- • Describe how packet and optical technologies are converging to form packet-optical transport and switching systems.
- • Discuss how packet-optical systems may be used in different metro application scenarios, including new cloud network architectures.

Short Course Audience:

This course is intended for network architects and planners from service providers, engineering and marketing staff to network equipment providers, technologists with an interest in the evolution of networks, industry analysts, and financial analysts.

Instructor Biography:

Loudon Blair is Senior Director of Network Architecture at Ciena. Since joining the company in 1997, he has performed several roles in the development of Ciena's optical networking products. He has also worked at Iridium, BT and Hitachi. He has been a long-term contributor to OFC/NFOEC and was general co-chair for OFC/NFOEC in 2008.

SC177 - High-Speed Semiconductor Lasers and Modulators

Sunday, 22 March
09:00 - 12:00

Short Course Level: Intermediate

Instructor:

John Bowers; *Univ. of California at Santa Barbara, USA*

Short Course Description:

Amplitude and phase modulation of light for transmission at 10, 40 and 100 Gbit/s is a critical problem for fiber-optic networks. We will review the basic concepts of optical modulators, with emphasis on electroabsorption modulators. The fundamental physics and design of modulators will be reviewed. The microwave characteristics of semiconductor lasers, important for high-speed digital and analog

applications, are presented. From the rate equations for electron and photon dynamics in the laser we derive fundamental limits to laser bandwidth. These limits include resonance limits, damping, transport effects and device parasitics. Methods to increase the bandwidth are illustrated with examples from literature, along with results showing the current state of the art. Finally, analog and large-signal modulation issues important for applications in communication systems are covered, including ringing, chirp, intensity noise and distortion.

Short Course Benefits:

This course should enable you to:

- • Compare different technologies.
- • Make informed decisions on the design of optical transmitters and their incorporation into optical networks.
- • Explain the performance of high-speed transmitters.

Short Course Audience:

Attendees should have some knowledge of semiconductor and device physics. A basic knowledge of laser operation is also needed.

Instructor Biography:

John E. Bowers is Director of the Institute for Energy Efficiency and the Kavli Professor of Nanotechnology in the Departments of Electrical and Computer Engineering and Materials at the University of California at Santa Barbara. He received his master's and doctorate degrees from Stanford University. He previously worked for Bell Labs and Honeywell. He is a member of the National Academy of Engineering and a Fellow of the IEEE, OSA and American Physical Society. He is a recipient of the IEEE/LEOS William Streifer Award and the OSA Holonyak Award. He has published nine book chapters, 500 journal papers, 700 conference papers and has received 52 patents.

SC178 - Test and Measurement of High-Speed Communications Signals

Monday, 23 March
08:30 - 12:30

Short Course Level:

Instructor:

Greg D. Le Cheminant; *Keysight Technologies, USA*

Short Course Description:

The ability to accurately characterize signals and waveforms is an essential element in the development and manufacturing of high-speed communications components and systems. This course will emphasize measurement tools and techniques to characterize signal quality and how well it is maintained when

transmitted through an optical system. It will focus on three measurement areas: bit-error-ratio (BER) analysis, oscilloscope waveform analysis with emphasis on the eye diagram and jitter analysis. The basics for each measurement type will be covered, gradually building to the more difficult aspects of measurements, including common measurement problems and their solutions. Results from tests performed on actual components and systems using BERTs, high-speed sampling oscilloscopes and jitter test sets will be presented. The course will emphasize research and development and manufacturing measurements of components and subsystems and will not discuss installation and maintenance test.

Short Course Benefits:

This course should enable you to:

- Determine the relationships between BER, eye-diagrams and jitter tests.
- Avoid common mistakes that degrade measurement accuracy.
- Define the relationship between Q-factor and BER.
- Identify ways to increase test efficiencies.
- Develop test strategies to verify compliance to industry standards.
- Compare the different approaches to characterizing jitter and recognize what the results imply in a systems context.

Short Course Audience:

This course is appropriate for engineers, technicians and scientists who have a basic or higher knowledge of high-speed communications systems and signals. A basic knowledge of common laboratory measurement instrumentation will be helpful.

Instructor Biography:

Greg LeCheminant holds B.S.E.E.T. (1983) and M.S.E.E. (1984) degrees from Brigham Young University. He began work for Agilent Technologies/Hewlett-Packard in 1985 as a microwave circuits manufacturing development engineer. Since 1989, he has been involved in the development of measurement tools and applications for high-speed digital communications signals and systems with an emphasis in optical transmission.

SC185 - Hands-on Polishing, Inspection and Testing of Connectors

Monday, 23 March
13:30 - 16:30

Short Course Level:

Instructor:

Phil Shoemaker[1], Steve Baldo[2], Loic Cherel[3]; *[1]Light Brigade Inc., USA, [2]Seikoh Giken Co. Ltd., USA, [3]Data-Pixel, France*

Short Course Description:

This course consists of three stand-alone segments that are supervised by fiber-optic experts specializing in each particular discipline. Each segment has specific tasks to be performed, measured and documented related to the specific tasks and includes both knowledge and skill (hands-on) components. The first segment, Fiber-optic Polishing, focuses on mass-production termination techniques that work with fiber optic connectors including SC, LC, and multifiber connector types with UPC and APC polishes. Learn how to achieve low insertion loss, low reflectance, optimum end-face geometry and improved production yields. The second segment, Fiber-optic End-face Inspection, explains the principles of microscopy and interferometry as they relate to the inspection and testing of fiber-optic plugs and termini. Hands-on demonstrations will show how microscopes and interferometers help to control the polishing process by checking for damage and measuring end-face geometry. The third segment, Connectorization Testing, reviews the test equipment used for attenuation and reflection testing after the polishing process is complete. The assemblies manufactured in the course are used in the testing to allow the course attendee to follow the production from assembly through testing processes.

Short Course Benefits:

- Benefit / Learning Objective 1: Measure optical attenuation measurements and expected variations at 1310/1550/1625nm.
- Benefit / Learning Objective 2: Measure optical return loss and define its relationship to connector polishes, polishing procedures and test methods.
- Benefit / Learning Objective 3: Identify contaminants, their cause, and how to resolve contamination issues with a variety of cleaning products.
- Benefit / Learning Objective 4: Identify and discuss the fundamentals of the polishing processes and their impact on attenuation and reflection.
- Benefit / Learning Objective 5: Identify and determine how to adjust variables that affect end-face geometry.
- Benefit / Learning Objective 6: Measure scratches using automatic analysis equipment.
- Benefit / Learning Objective 7: Apply the criteria for pass/fail in quality assurance programs and applications.
- Benefit / Learning Objective 8: Determine how the immediate feedback from the interferometer will help control the manufacturing process, creating higher performance terminations and increased production yields.

Short Course Audience:

This course is applicable to those involved with fiber optic terminations from the novice to production engineers and managers involved with laboratory, manufacturing, and field disciplines. A basic knowledge of fiber optics is expected.

Instructor Biography:

Since 1987, Light Brigade has instructed more than 50,000 attendees in its classes and special events that focus on fiber optic topics such as design, maintenance and testing, including topics such as OSP, networking, FTTx, DWDM and PMD. Since 1990, Light Brigade has provided a variety of special events at the OFC/NFOEC and CLEO conferences.

Seikoh Giken (SG) provides high performance interconnectivity solutions for network systems and chip

level applications. For networks and testing, Seikoh Giken provides premium patchcords (SMF and PMF), adaptors and attenuators. For manufacturers, SG manufactures ferrules, tunable connectors, polishing equipment, and films and photonic packaging technologies.

Data-Pixel is an international leader in technology for image-processing-based test and measurement equipment, since 2001. The fast company's growth has been primarily achieved by supplying the increasing metrology needs of the fiber optic industry for telecommunications with innovative solutions and superior customer support. Data-Pixel's subsidiary, RX-Solutions, develops X-Ray-based 3D scanning solutions (Industrial CT) systems and offers measurement services.

SC203 - 100 Gb/s and Beyond Transmission Systems, Design and Design Trade-offs

Sunday, 22 March
13:00 - 16:00

Short Course Level:

Instructor:

Martin Birk[1], Benny Mikkelsen[2]; *[1]AT&T Labs, Res., USA, [2]Acacia Communications, USA*

Short Course Description:

While in the past, higher bitrates were mainly driven by Service Provider's backbone networks, an interesting trend is appearing, where mobile users and data centers in rural areas are requesting high data rates at 100Gb/s outside core networks. This trend in turn has a large influence on the Transmission Systems, Hardware, Software and Design.
The first part of this course provides an overview of the drivers and applications of 100G transmission systems in backbone, regional and metro networks. It describes the requirements and expectations carriers will have to cost, power consumption, footprint, reliability, optical performance, and interoperability. We present practical design issues of 100G line-cards, and we critically review the availability and performance of the key building blocks. In particular, we discuss the technologies needed to implement different modulation formats, and the corresponding trade-off between complexity/cost of line-card implementations and the achievable fiber transmission distance. We will also look at future bitrates and technologies beyond 100Gb/s.

Short Course Benefits:

Identify key requirements and drivers for 100 Gbit/s applications.

- Describe the availability and performance of 100 Gbit/s key building blocks.
- Discuss 100 Gbit/s transmission limitations.
- Describe lessons learned from 100 Gbit/s field trials.
- Summarize 100 Gbit/s standards activities.

Short Course Audience:

The course is intended for engineers and technical managers who want an up-to-date overview of 100G transmission systems, including applications, line-card designs, and fiber transmission limitations. It was significantly updated in 2013, and past attendees may find it useful to take the course again. The course requires some understanding of basic optical transmission systems.

Instructor Biography:

Benny Mikkelsen is co-founder and CTO at Acacia Communications, where he is responsible for the design of 100 Gbit/s optical transport products. Before Acacia, he co-founded Mintera and earlier was with Bell Labs, Lucent Technologies, where his research included ultra high-speed optical transmission. He holds master's and doctorate degrees in electrical engineering from the Technical University of Denmark.

Martin Birk received his master's and doctorate degrees from Germany's University of Ulm in 1994 and 1999, respectively. Since 1999, he has been with AT&T Labs in New Jersey, working on high-speed optical transmission at data rates of 40Gbit/s and above.

SC205 - Integrated Electronic Circuits and Signal Processing for Fiber Optics

Sunday, 22 March
09:00 - 12:00

Short Course Level: Advanced Beginner

Instructor:

Y. K. Chen, Noriaki Kaneda; *Bell Labs, Alcatel Lucent, USA*

Short Course Description:

High speed electronics at 10-, 40-, 100-Gbit/s and beyond is a critical enabler for fiber-optic networks. We will review the basic functions of high speed lightwave circuits in optical terminals, with emphasis on physical layer transceiver electronics. The basic functions and architectures of these circuits will be reviewed. The high speed IC technologies and their implementation of these important high bit-rate digital and analog applications will be presented. The presentation materials include receiver front-ends including trans-impedance amplifiers and limiting amplifiers, clock-data recovery circuits including phase locked loop and digital phase detectors, SERDES such as electrical time-domain multiplexers, de-multiplexers and transmitter circuit such as driver amplifiers. Methods to enhance the performance and bandwidth are illustrated with examples from literature, along with results showing the current state of the art. A low-cost electronics solution such as FFE, DFE electronic front-end to equalize and mitigate optic fiber transmission impairments will be illustrated. The basic requirement, characteristics, and circuit topologies of emerging data converters technologies (ADC, DAC) for optical communications will be reviewed. As an increasingly important electronic component in today's optical communication, the course will cover the topics on digital signal processing for coherent optical transmission. The basic architectures, algorithms, and implementation techniques of digital signal processing in optical communication will be reviewed. The techniques for transmission mitigation and intradyne detection will be presented on single carrier and multi-carrier modulation formats with examples.

Short Course Benefits:

This course should enable you to:

- Describe the functions and performance of high-speed electronics for optic fiber terminals.
- Evaluate the design and implementation of physical layer electronic circuits.
- Describe commonly used circuit architectures.
- Compare the merits among different IC technologies.
- Justify advanced electronic equalization techniques.
- Compare implementation complexity of various DSP techniques for optical transmission.

Short Course Audience:

This course is intended for engineers, scientists or managers who must make or understand the choice of electronic circuits for optical transmission products or evaluate electronic solutions used in purchased products.

Instructor Biography:

Young-Kai Chen is a director of high speed electronics and optoelectronics research department at Bell Labs, Alcatel-Lucent. He received his doctorate in electrical engineering from Cornell University. He worked for General Electric Co. before joining Bell Labs. He is a Fellow of IEEE, a member of the National Academy of Engineering, and a recipient of the IEEE David Sarnoff Award. He has published three book chapters, more than 100 journal papers and more than 150 conference papers, and he has received 15 patents.

Noriaki Kaneda is member of technical staff at Bell laboratories, Alcatel-Lucent, Murray Hill, NJ. His Ph.D academic work included microwave photonics at the University of California, Los Angeles. Since he joined Lucent Technologies in 2000, he has worked on various topics regarding optical data formats including direct detection DPSK, digital coherent QPSK, coherent optical OFDM for the high bit rate optical transmission systems. His current research interest consists of high-speed digital signal processing in optical transmission systems.

SC208 - Optical Fiber Design for Telecommunications and Specialty Applications

Monday, 23 March
09:00 - 12:00

Short Course Level:

Instructor:

David J. DiGiovanni; *OFS Labs, USA*

Short Course Description:

Optical fiber design remains a robust field for innovation in both telecom and nontelecom applications. As worldwide bandwidth demand continues to grow, new fiber types and fiber-based components can increase speed, reduce cost and improve the bandwidth of communications networks. In addition, application-specific fiber can enable or benefit a wide array of functions such as simply transporting light between two points, amplifying light, processing signals, sensing environmental characteristics and even transporting particles. The tools available in adapting fiber to particular uses, whether for high speed communications or other applications, include a range of materials and dopants (glasses, polymers), the mechanics of the fiber (size, coatings, microstructure), waveguiding properties (index profile), and various fiber-based devices such as gratings and amplifiers. These tools have been used to establish an industry that continues to expand as photonics penetrates more and more applications.

This short course will discuss the many ways in which optical fiber design can be used in a wide range of applications and will review an array of current fiber technologies. We will consider the role and capabilities of materials, structures and waveguide design for both fiber and fiber-based photonic components. The focus will be on understanding the capabilities of fiber design and engineering with the goal of demonstrating the many opportunities available with novel optical fibers. Specific attention will be on the impact of transmission fiber design and properties for high-speed optical communication such as >100Gb/s transmission and coherent detection, space division multiplexing, designs for optical amplification and dispersion control; and the design of waveguides to produce effects such as enhanced nonlinearity and bandgap operation.

Short Course Benefits:

At the end of this course, participants will be able to:

- Understand how certain fiber attributes, like attenuation, modal area and dispersion can impact current and next-generation high speed communications technologies
- Describe the wide array of optical fibers available and discuss how their designs have been engineered for particular applications
- Compare the benefits of different materials in fiber design, including different glass dopants.
- Design simple fibers for various applications, such as amplifiers, dispersion compensators, sensors and component pigtails
- Determine whether particular applications can benefit from modified or novel optical fiber.
- Understand the potential offered by fiber engineering which may be exploited to improve existing applications or create new functions.

Short Course Audience:

This course is intended for the technical community seeking to understand the potential of optical fiber and waveguide design. Basic understanding of optical fiber properties is desirable though not required. The course will provide an understanding of the operating principles of fiber while also exploring the limits of waveguide and materials engineering. Specific designs for high speed transmission, optical amplification and dispersion compensation will be studied, among others.

Instructor Biography:

D.J. DiGiovanni received several engineering and mathematics degrees from Brown University, including a PhD in 1987. He joined Bell Laboratories in the Optical Fiber Research department in 1990 and has worked on various phenomena related to optical fibers for erbium-doped amplifiers, high power amplifiers and lasers and Raman amplification. He is now president of OFS Laboratories and continues to explore designs, fabrication and applications of specialty and transmission optical fibers and devices.

SC210 - Hands-on Polarization-Related Measurements

Sunday, 22 March
16:00 - 20:00

Short Course Level: Beginner

Instructor:

Danny Peterson[1], Tasshi Dennis[2], Brian Teipen[3], Christine Tremblay[4]; *[1]Verizon Business, USA, [2]NIST, USA, [3]ADVA Optical Networking, USA, [4]Ecole de Technologie Superieure, Univ. du Quebec, Canada*

Short Course Description:

In this Short Course you will measure the polarization-related parameters that are important to high-speed fiber optic communications. The course begins with a brief review of key polarization concepts and a short description of the course equipment and setups. The participants then divide into small groups and rotate among four lab stations. In Lab 1, you will control and measure the state and degree of polarization. You will also measure polarization cross-talk on polarization-maintaining fiber and create a polarization reference frame for absolute polarization measurements. Equipment for this lab includes a polarimeter, a DOP meter, various polarization controllers, and a polarization extinction ratio meter. Tasshi Dennis is the instructor. In Lab 2, you will measure the polarization dependent loss (PDL) of optical components (including filters) using the all-states and Mueller matrix PDL methods. You will also measure and correct for the polarization dependence of optical power meters and OSAs. Equipment for this lab includes a swept Mueller matrix setup, polarization controllers and scramblers, a PDL meter, an OSA and an optical power meter. Christine Tremblay is the instructor. In Lab 3, you will measure the polarization mode dispersion (PMD) of transmission paths with combinations of high-PMD fibers. The measurement methods used in this lab include Interferometry, wavelength scanning, polarization-OTDR, and Jones Matrix Eigenanalysis (JME). Danny Peterson is the instructor. In Lab 4, participants will explore the effects of PMD on a 100 Gb/s dual-polarization QPSK channel. Equipment for this lab includes a '100G' optical transponder, PMD source, polarization scrambler, polarimeter, and optical modulation analyzer. Brian Teipen is the instructor.

Short Course Benefits:

This course should enable you to:

- Operate a wide variety of polarization-related test equipment.
- Measure polarization dependent loss (PDL) using all-states and Mueller methods
- Measure polarization-mode dispersion (PMD) using Interferometric and JME methods

- Demonstrate the effect of PMD on high-speed digital signals and describe the technical difficulties associated with PMD compensation.
- Determine the outage probability in optical fiber transmission systems due to PMD-induced degradation.
- Measure polarization cross talk “in-line” and at the end of a polarization-maintaining (PM) fiber.
- Achieve optimum performance in PM fiber applications.
- Measure the polarization dependent response (PDR) of everyday test equipment and describe how to overcome PDRs by means of high-speed polarization scrambling.
- Describe/measure the system-level effects of polarization-related impairments on optical channels.

Short Course Audience:

This course is ideal for engineers, technicians and managers involved with optical fiber, components, and/or 8G/16G Fibre Channel, 10G SONET/SDH, or 10G/40G/100G Ethernet transmission interfaces.

Instructor Biography:

Tasshi Dennis received the Ph.D. in electrical engineering from Rice University. He is a staff scientist at NIST in the Optoelectronics Division working on high speed optical measurements. He is an OSA member.

Daniel Peterson is a distinguished member of the technical staff at Verizon. He is an internal advisor on optical technologies for Verizon's ULH network. He received a Ph.D. in electrical engineering from the University of Texas at Dallas. He is a senior member of IEEE.

Christine Tremblay, Ph.D., is a professor at the École de technologie supérieure, Université du Québec, where she set up the Laboratoire de technologies de réseaux, an advanced optical layer testbed for research on high- speed transmission technologies and network design, and established courses on optical communications. She is a member of OSA and IEEE.

Brian T. Teipen, Ph.D., researches advanced optical transport techniques for ADVA Optical Networking. Brian received the Bachelor of Science degree in physics at Indiana University in 1995, and his doctorate degree in electrical engineering at The University of Texas at Dallas in 2000. He is an IEEE and OSA member.

SC216 - An Introduction to Optical Network Design and Planning

Sunday, 22 March
13:00 - 16:00

Short Course Level: Beginner

Instructor:

Jane M. Simmons; *Monarch Network Architects, USA*

Short Course Description:

This course is an introduction to optical network design and planning for backbone, regional, and metro-core networks. A fundamental aspect of any optical network design is selecting the proper network equipment to maximize scalability and configurability, while minimizing cost. The course will discuss the role of network elements, such as ROADMs and multi-degree ROADMs, and address the benefits of equipment features such as 'colorless,' 'directionless,' 'contentionless,' and 'gridless.'

Routing and wavelength assignment (RWA) play an important role in the efficiency of ROADM-based networks. The course will cover RWA principles, including a discussion of some of the most relevant algorithms. This includes topics such as routing for cloud-computing applications and wavelength assignment in multi-line-rate networks. The role of regeneration and optical reach in network design will be discussed in some detail. Modeling for real-time network planning will also be covered.

The course will address current areas of research in optical networking, including: gridless and elastic networks, routing and spectrum assignment (RSA), network defragmentation, strategies to address fiber capacity limits, and Software Defined Networking (SDN).

Many of the principles of the course will be illustrated through an interactive design session with a commercial optical network design tool.

Short Course Benefits:

This course should enable you to:

- Compare O-E-O and optical-bypass technology.
- Compare the architectures of various optical network elements.
- Describe the colorless, directionless, contentionless, and gridless attributes of ROADMs.
- Describe the basics of routing traffic, including strategies for load balancing and protection.
- Describe the basics of wavelength assignment.
- Enumerate some of the networking principles as well as physical effects that determine where regeneration is required in a network.
- Enumerate the advantages and disadvantages of a gridless network
- Compare real-time vs. long-term network planning.

Short Course Audience:

This course is intended for network planners and architects in both carriers and system vendors who are involved in planning optical networks and selecting next-generation optical equipment. The discussion of networking elements and algorithms should be helpful to vendors who are developing optical systems, as well as to carriers who are modeling network evolution strategies. The course is introductory level, although a basic understanding of networking principles is assumed.

Instructor Biography:

Jane M. Simmons has been involved in the research and development of optical networks for more than 15 years. She founded Monarch Network Architects, which provides optical network architectural

services and design tools. From 1999 to 2002, she was the Executive Engineer for Network Architecture at Corvis Corp., and was named the Chief Network Architect in 2002. While at Corvis, she performed the network design and the link engineering for the Broadwing network, the first commercially deployed all-optical backbone network. Through pioneering algorithmic and architectural optimizations, she played a significant role in the adoption of all-optical networking in telecommunications networks. Prior to Corvis, Dr. Simmons worked at Bell Labs/AT&T Labs Research, where she conducted research on backbone, regional, and broadband access networks. She received a B.S., Summa Cum Laude, from Princeton University, and S.M. and Ph.D. degrees from MIT, all in Electrical Engineering. She is a Fellow of the IEEE and is the author of the textbook Optical Network Design and Planning, now in its second edition.

SC217 - Optical Fiber Based Solutions for Next Generation Mobile Networks

Sunday, 22 March
13:00 - 16:00

Short Course Level: Advanced Beginner

Instructor:

Dalma Novak; *Pharad, LLC., USA*

Short Course Description:

The convergence of optical and wireless networks continues to evolve, ever since the first proposals of extending wireless coverage areas using optical fiber links several decades ago. Today the use of fiber optic links in wireless networks is becoming ever increasingly pervasive. Applications where such converged optical/wireless network technology is employed include backhaul and fronthaul solutions for next generation mobile networks, indoor distributed antenna systems, as well as ultrabroadband, high frequency wireless networks capable of providing users with very high bandwidth services.
This short course presents an overview of optical fiber based solutions for next generation mobile networks. The associated system architectures and signal transport technologies that enable the implementation of integrated optical wireless networks will be discussed. The various technical challenges and issues that must be addressed for the successful integration of these networks, which encompass very different requirements and specifications, will also be presented. Topics to be covered include:
• Requirements for next generation mobile networks
• Optical fiber based architectures for emerging systems
• Relevant technologies, solutions and implementation approaches

Short Course Benefits:

This course should enable participants to:

• Understand the motivation for the integration of next generation mobile communication systems with optical fiber networks;
• Identify the technical challenges related to the application of photonics and optical networking

concepts to wireless communications;
• Understand and compare physical layer technologies that enable the integration of wireless and optical networks;
• Identify technologies that can improve the performance of integrated optical and wireless networks;
• Establish the trade-offs with alternative integrated network architectures

Short Course Audience:

This is an advanced beginner course for people working in either the optical or wireless telecommunication fields who wish to broaden their knowledge and learn how optical fiber solutions are playing a role in the realization of emerging integrated optical/wireless networks.

Instructor Biography:

Dalma Novak is VP of Engineering at Pharad, LLC; a high technology company located in MD developing advanced RF-over-fiber and antenna products. She is a Fellow of the IEEE and has over 20 years of experience working in the fields of optical and wireless telecommunications. Prior to Pharad she held positions at The University of Melbourne, Dorsal Networks, and Corvis Corporation. She received her PhD in Electrical Engineering in 1992. Dalma is the President of the IEEE Photonics Society for 2014-2015.

SC261 - ROADM Technologies and Network Applications

Monday, 23 March
13:30 - 16:30

Short Course Level: Advanced Beginner

Instructor:

Thomas Strasser; *Nistica Inc., USA*

Short Course Description:

In the past few years optical transmission platforms around the world have aggressively adopted Reconfigurable Optical Add-Drop Multiplexer (ROADM) technology. This technology is now firmly integrated into the product lines and roadmaps of transport systems and carriers with deployment of more than $1 billion of ROADM transport in the last year. This represents a groundbreaking commercial technology transformation of transparent optical routing displacing electrical grooming equipment for the first time on such a wide scale. Despite the commercial success, substantial confusion has surrounded this technology. This is largely because (a) the ROADM market is poorly defined since it may mean a subsystem or a system, neither of which have market-accepted minimum functionalities; (b) the lack of a clear market definition has been exploited to promote competing technologies driven by different commercial interests; and (c) there continues to be technology innovation that improves flexibility of these systems. This course will give a historical perspective of how this technology evolved, the numerous network benefits derived, and how those benefits depend on the functionality of the technology employed. Finally, the course will describe how these technologies are being integrated into

WDM systems and what types of networks most fully leverage the new capabilities to provide network value.

Short Course Benefits:

This course should enable you to:

- Describe the network level benefits of ROADM systems.
- Define the different ROADM technology approaches competing in the market.
- Summarize the functionality differences between competing ROADM technologies, including which are most likely to succeed in the long term and why.
- Compare the incremental cost of a ROADM to the network level savings it enables.
- Discuss the types of networks that most fully benefit from ROADM technology and why.
- Explain the contradictory statements made about ROADM in trade literature.

Short Course Audience:

Anyone interested in more fully understanding the functionalities and benefits of ROADMs, including students, researchers, engineers, managers, and executives involved in ROADM development, network design, network planning, and network operations

Instructor Biography:

Thomas A. Strasser received a doctorate from Cornell University designing periodic guided-wave devices and worked for three years at Eastman Kodak Research Labs and seven years at Bell Labs in Murray Hill, New Jersey. At Bell Labs his group invented and developed manufacturing for enabling technologies in the next-generation transmission platforms of AT&T and Lucent Technologies. He served for five years as the chief.

SC266 - Quantum Cryptography and Quantum Information

Sunday, 22 March
09:00 - 12:00

Short Course Level: Beginner

Instructor:

Richard Hughes[1], Thomas Chapuran[2]*; [1]Los Alamos Natl. Lab, USA, [2]Applied Communication Sciences, USA*

Short Course Description:

This course will describe the new and rapidly expanding field of quantum communications, which promises to revolutionize some aspects of communication networks. It will provide a view of an early application of quantum information and quantum communications, namely quantum cryptography and why it may be of interest for the OFC/NFOEC community. After a brief motivation as to "what is cryptography" and "What are the limitations with conventional cryptography," the course will provide a

high-level view of quantum cryptography and quantum key distribution. The course will provide a brief history of quantum cryptography from its inception to the present time and will walk through detailed examples of how the BB-84 QKD protocol works. The course will then turn to the realities of real-world light sources and photon detectors. The course will include both fiber and free space environments and will identify and summarize some of the major efforts worldwide in this area. Finally the course will describe recent “quantum hacking” research results, and will discuss how recent QKD network testbed results set the stage for quantum information systems for the future.

Short Course Benefits:

This course should enable you to:

- Identify benefits of quantum key distribution techniques.
- Determine free-space and fiber based applications.
- Describe single photon sources and compute their expected characteristics.
- Describe concepts of quantum entanglement.
- Determine appropriate networking applications for quantum communications.

Short Course Audience:

The audience may include optical networking and optoelectronic technology researchers with an interest in quantum communications, managers of research groups, and engineers who want a glimpse of a new and forward-looking technology. An undergraduate-level understanding of quantum mechanics is helpful.

Instructor Biography:

Richard J. Hughes is a Laboratory Fellow at the Los Alamos National Lab. He is co-principal investigator of projects in both free-space and optical fiber based quantum key distribution and holds two US patents in these areas. He obtained his doctorate from the University of Liverpool and has held positions at Oxford University, Queens College Oxford, Caltech, CERN, and the University of Oslo. His awards include the Los Alamos Distinguished Performance Award, Los Alamos Fellow's Prize, co-winner of an R&D Development 100 Award for "Free Space Quantum Cryptography," and co-winner of the European Union's Descartes Prize. He is an APS Fellow and has authored more than 150 scientific papers.

Thomas E. Chapuran is a Senior Scientist and Fellow at Applied Communication Sciences. He has served as co-principal investigator and Telcordia technical lead in experimental investigations of the compatibility of quantum key distribution with optical networking. He holds a doctorate in physics from the University of Illinois, and served on the faculty at the University of Pennsylvania. His research interests include quantum communications, quantum computing, optical network architectures, broadband access, and signaling and control for next-generation networks. He received Telcordia CEO Awards in 2000 and 2001 and has authored numerous papers in the fields of telecommunications and physics.

SC267 - Silicon Microphotonics: Technology Elements and the Roadmap to Implementation

Sunday, 22 March
17:00 - 20:00

Short Course Level: Beginner

Instructor:

Lionel Kimerling; *MIT, USA*

Short Course Description:

The optical components industry stands at the threshold of a major expansion that will restructure its business processes and sustain its profitability for the next three decades. This growth will establish a cost-effective platform for the partitioning of electronic and photonic functionality to extend the processing power of integrated circuits and the performance of optical communications networks. The traditional dimensional shrink approach to the scaling of microprocessor technology is encountering barriers in materials and power dissipation that dictate more distributed architectures. Before 2015 the performance requirements for this short link interconnection will cross the 10Mb/s.km threshold that dictates optical carrier utilization. This business direction will ignite a major change in leadership of the industry from information transmission (telecom) to information processing (computing, imaging); and it will open significant new markets with high-volume applications. Silicon microphotonics is a platform for the large-scale integration of CMOS electronics with photonic components. This course will evaluate the most promising silicon optical components and the path to electronic-photonic integration. The subjects will be presented in two parts: 1) Context: a review of the recently released Communications Technology Roadmap by the Industry Consortium of the MIT Microphotonics Center; and 2) Technology: case studies in High Index Contrast design for silicon-based waveguide, filter, photodetector, modulator, and laser devices. The objective of the course is to present an overview of the silicon microphotonic platform drivers and barriers in design, fabrication, packaging, and test.

Short Course Benefits:

This course should enable you to:

- Identify trends in the optical components industry.
- Explain the power of a standard platform.
- Discuss the benefits of electronic-photonic integration.
- Evaluate the latest silicon photonic devices.
- Summarize the findings of the Communications Technology Roadmap.

Short Course Audience:

This course is for executives and technologists in the optical components industry to include planners, engineers, and scientists participating in the optical components technology supply chain.

Instructor Biography:

Lionel Kimerling is the Thomas Lord Professor of Materials Science and Engineering at MIT. He was head of materials physics research at Bell Labs until 1990, when he joined MIT. He is currently Director of the MIT Materials Processing Center and its affiliate, the MIT Microphotonics Center, which he co-founded with 30 faculty members in 1997. Among his industry responsibilities were long-term reliability of semiconductor lasers, development of the first 1MB DRAM chip, and defect diagnostics and control for silicon IC manufacturing. His group's research has focused on silicon microphotonics, environmentally benign IC manufacturing, and solar electricity.

SC288 - FUNDAMENTALS OF POLARIZATION, PDL, AND PMD

Sunday, 22 March
13:00 - 17:00

Short Course Level:

Instructor:

Nick Frigo; *US Naval Academy, USA*

Short Course Description:

While polarization is one of the fundamental characteristics of light, it is only the advent of high-speed, long-haul transmission systems that has made polarization effects in the optical medium an important issue. This course begins with illustrations of wave propagation for different states of polarization (linear, circular, elliptical) and we introduce the common formalisms with interactive examples, showing the relationships between the Jones and Poincare/Stokes representations. Birefringence, a polarization-dependence for the speed of light in a medium, is introduced using these formalisms, emphasizing pictorial descriptions of the analytic methods. This permits us to cover special topics such as perturbations, polarization-maintaining fibers (PMF), polarization controllers, polarizers, polarization-dependent loss (PDL), splicing losses, and measurement issues in a unified manner. In-class demonstrations provide context to the main topics. After a brief review of phase and group velocity, we consider systems of concatenated birefringent fibers to introduce polarization mode dispersion (PMD), emphasizing pictorial representations. While the course is on fundamentals, in the last section we briefly address some of the ways in which PMD can impair transmission and several approaches to compensation and mitigation..

Short Course Benefits:

After taking this course you should be able to:

- Describe the major representations of polarization states
- Perform simple calculations of polarization evolution in birefringent media.
- Explain the mechanisms underlying PMF and estimate splice tolerances
- Discuss polarization-dependent loss sources and effects
- Explain the physical origin of PMD

- Describe the dominant effects of PMD on transmission systems

Short Course Audience:

The course is intended for engineers, technicians, and managers who would like a fundamental survey of polarization effects in devices or systems. The participant should have a basic understanding of how matrices multiply column vectors in order to follow the Jones formalism.

Instructor Biography:

Nicholas Frigo received a bachelor's degree from Claremont-McKenna College, and a Ph.D degree from Cornell University, both in Physics. He has worked at the Naval Research Laboratory, at Litton Industries, at AT&T Bell Laboratories, and at AT&T Research in optical propagation and polarization effects in fibers, fiber optic sensors, and optical networks. Since 2005 he has been teaching in the Physics Department at the US Naval Academy in Annapolis, MD.

SC312 - Parametric Preprocessing in Optical Networks

Monday, 23 March
13:30 - 16:30

Short Course Level:

Instructor:

Stojan Radic; *UCSD, USA*

Short Course Description:

With the introduction of coherent optical formats into mainstream transport links, signal conditioning and processing has migrated into the electronic backplane. However, an important class of functions is more efficiently served in photonic or hybrid (optical/electronic) domains. As an example, carrier stabilization can be performed more efficiently by using telecom-compatible frequency combs; channel mapping is simpler with all-optical converters; signal regeneration is more efficient with fast nonlinear devices than O/E/O modules. In addition to these, well recognized network functions, a new class of hybrid preprocessing operations have been identified for specific roles in transmission systems, data centers and cyber-defense architectures. For the first time, it is possible to perform a direct (line-rate) discrete Fourier / Hilbert channel decomposition, high-resolution and rate-invariant channel digitization, or nonlinear penalty cancellation. As a common characteristic, hybrid preprocessors take advantage of ultrawide photonic response, possess low dissipation but rely on electronic backplane for memory and more complex functions.

This course will introduce the basic elements necessary for construction of parametric preprocessing devices: fiber and monolithic platform physics; application specific design approaches; and measurement and characterization techniques. These principles will be used to illustrate practical implementation of hybrid photonics modules in diverse photonics systems. Specifically, its use in high capacity transmission and data center network will be discussed in detail.

Short Course Benefits:

This course should enable participants to:

- Design application-specific parametric preprocessors;
- Select device platform matching network function;
- Devise preprocessing architecture for typical network and data-center applications
- Build preprocessor modules such as channel converter, sampler, multicarrier conditioner or Fourier analyzer
- Measure and characterize device and preprocessing performance
- Design, build and characterize telecom-band frequency combs, AD converters, regenerators and band converters.

Short Course Audience:

Researchers and engineers interested in advanced signal processing, high performance transmission and dense data center architectures. Basic understanding of nonlinear optics and signal processing is sufficient for the course material. Past attendees of the course will find substantial updates and new information, and they are encouraged to attend again

Instructor Biography:

Stojan Radic graduated from The Institute of Optics in 1995 and has subsequently served in Corning and Bell Laboratories. He is presently a Professor and a Director of Systems Laboratory at University of California San Diego and California Institute for Telecommunications and Information Technology. Dr. Radic is a Fellow of the Optical Society of America and has served as editor with IEEE Photonics Technology Letters and Optics Express Journals. He serves or has served with Parametric Processing (IEEE), OFC (OSA/IEEE), OAA (OSA), APOC (OSA) and ECOC conferences. Prof. Radic has published 160 journals and has more than 200 conference presentations.

SC314 - Hands-on Fiber Characterization for the Engineering of Long Haul and Metro Deployments

Monday, 23 March
13:30 - 17:30

Short Course Level: Advanced Beginner

Instructor:

Daniel Peterson[1], Christine Tremblay[2]; *[1]Verizon, USA, [2]École de Technologie Supérieure, Univ. du Québec, Canada*

Short Course Description:

In this hands-on course you will measure all of the necessary fiber parameters for qualifying and engineering the optical fiber links of long haul and metro networks at a specified bit rate. The course will begin with a review of the basics of loss, reflectance, chromatic dispersion and polarization mode dispersion in optical fiber links, as well as the challenges in moving from 10G to 40G and 100G bit rates. Bit-rate dependent loss and dispersion limits will be calculated for fiber qualification purposes. Descriptions of the course equipment and experimental setups will follow. The participants will then divide into small groups and rotate among four lab stations. In Lab 1, participants will measure loss and optical return loss in optical fiber links using power meters and optical time-domain reflectometers (OTDR). In Lab 2, participants will measure the chromatic dispersion in optical fiber links using two different measurement techniques. The first one is the time-of-flight method and the second is the phase-shift method. Christine Tremblay is the instructor. In Lab 3, participants will measure the polarization mode dispersion (PMD) in optical links with combinations of high-PMD fibers using different measurement techniques: the interferometric method, the fixed analyzer method, the Stokes parameter evaluation method and the random-scrambling tunable POTDR method. Daniel Peterson is the instructor. The course will conclude with a review of the pros and cons for each method as well as an analysis of measurements results. Please note that the PMD portion of SC314 and SC210 overlaps in content.

Short Course Benefits:

This course should enable you to:

- Learn about transmission limits as a function of bit rate and application.
- Gain the knowledge to make decisions on when specific fiber testing is necessary dependent on the application.
- Measure polarization-mode dispersion (PMD) using Interferometric and JME methods.
- Measure chromatic dispersion (CD) using both time-of-flight (TOF) and phase-shift methods, and discuss CD compensation in mixed-fiber type mesh environments.
- Discuss the effect of PMD and chromatic dispersion on high-speed digital signals.
- Discuss the outage probability in optical fiber transmission systems due to PMD-induced degradation.
- Measure loss and characterize splices using optical time-domain reflectometry (OTDR).
- Describe the system-level effects of polarization-related impairments on long-haul optical transmission.

Short Course Audience:

This course is intended for engineers, technicians and managers involved with optical fiber, components or systems, including those that operate at or above 10 Gb/s.

Instructor Biography:

Daniel Peterson is a distinguished member of the technical staff at Verizon. He has directed the characterization of the ULH network fiber. He is an internal advisor on optical technologies and is responsible for specifying new optical fiber and characterization of older fiber for Verizon's ULH network. Peterson is also an adjunct professor at the University of Texas at Dallas. He received a Ph.D. (electrical engineering) from the University of Texas at Dallas.

Christine Tremblay is a professor at the École de technologie supérieure, Université du Québec. She set up the Laboratoire de technologies de réseaux, an advanced optical layer testbed for research on high-speed transmission, measurements and network design, and established courses on optical communications. She also held senior R&D and technology management positions at Nortel, EXFO and INO. She received a Ph.D. (optoelectronics) from the École Polytechnique de Montréal. She is a member of OSA and IEEE.

SC325 - Highly Integrated Monolithic Photonic Integrated Circuits

Monday, 23 March
08:30 - 12:30

Short Course Level:

Instructor:

Chris Doerr; *Acacia Communications, USA*

Short Course Description:

This course will discuss monolithic photonic integrated circuits (PICs) in InP, silicon, and related materials for optical communications. The course will start with optical waveguide fundamentals and move toward state-of-the-art devices comprising many elements monolithically integrated. Higher layers of PIC design will be stressed. A significant portion is devoted to PICs for advanced modulation formats and coherent detection.

Short Course Benefits:

This course should enable you to:

- Design optical waveguide structures.
- Simulate optical waveguide structures.
- Design complex photonic integrated circuits.
- Simulate photonic integrated circuits.
- Understand some of the device physics.
- Predict future abilities and costs of photonic integrated circuits.
- Debug problems in photonic integrated circuits.

Short Course Audience:

This course is intended for anyone who has basic electromagnetics knowledge (e.g., know Maxwell's equations but do not have them memorized) and basic optical communications knowledge (e.g., know what optical fiber is but do not have to know what 16-QAM is) but wants to learn more about photonic integrated circuits.

Instructor Biography:

Christopher R. Doerr earned a B.S. in aeronautical engineering and a B.S., M.S., and Ph.D. in electrical engineering from the Massachusetts Institute of Technology. Since joining Bell Labs in 1995, Doerr's research has focused on integrated devices for optical communication. He received the OSA Engineering Excellence Award in 2002. He is a Fellow of IEEE and OSA. He was Editor-in-Chief of IEEE Photonics Technology Letters from 2006-2008. He was an Associate Editor for the Journal of Lightwave Technology from 2008-2011. He was awarded the IEEE William Streifer Scientific Achievement Award in 2009. He became a Bell Labs Fellow in 2011. He joined Acacia Communications in 2011.

SC327 - Modeling and Design of Fiber-Optic Communication Systems

Monday, 23 March
13:30 - 17:30

Short Course Level: Advanced Beginner

Instructor:

Rene-Jean Essiambre; *Bell Labs, Alcatel-Lucent, USA*

Short Course Description:

The broad objective of this course is to provide a working knowledge of the numerous techniques and tools used to design the transport layer of advanced fiber-optic communication systems, from metropolitan to ultra-long haul systems. The primary focus is on providing a comprehensive overview of how to model propagation over optical fibers, with emphasis on the various fiber nonlinear effects involving signal and noise, for both singly-polarized and polarization-division-multiplexed signals. This includes a description of the techniques suitable for modeling nonlinear propagation of various advanced modulation formats in optically routed networks. The course also provides a comparative description of various optical amplification technologies, such as erbium-doped and Raman amplification, for different types of transmission lines. A description of the tools used to characterize system performance is covered in this course, including evaluations of optical signal-to-noise ratio (OSNR) penalties and Q-factors. In addition, the course presents an introduction to the issues faced when configuring the physical layer of optical networks, including ring and mesh network topologies. Finally, the course concludes with an overview of the ultimate capacity of the "fiber channel" that helps participants understand technological limits associated with increasing the capacity of fiber-optic communication systems.

Short Course Benefits:

This course should enable you to:

- Develop a functional understanding of the basic building blocks of fiber-optic communication systems.
- Learn the basic elements of optical transmission modeling.
- Develop a detailed understanding of how to model nonlinear transmission over fibers, especially how to navigate through the numerous pitfalls of nonlinear transmission modeling.

- Choose a suitable technique for modeling specific systems, such as systems using advanced modulation formats.
- Compare the performance of various amplification technologies.
- Understand the basic technical issues faced when configuring optical networks with complex topologies.
- Estimate the ultimate limit to fiber capacity.

Short Course Audience:

This course is intended for engineers and scientists working on fiber-optic transmission as well as those working on components and subsystems interested in developing an expertise at the transmission level. The course also addresses academic researchers and graduate students with basic knowledge on optical or digital communication interested in developing a detailed knowledge of fiber-optic transmission modeling and in understanding system implications of advanced technologies.

Instructor Biography:

René-Jean Essiambre is a Distinguished Member of the Technical Staff at Bell Labs, Alcatel-Lucent. He received his doctorate from Université Laval and studied at the University of Rochester before joining Lucent Technologies (now Alcatel-Lucent) in 1997. Essiambre is contributing to the design of advanced optical transmission systems, especially in relation to the management of fiber nonlinearities. His interests include modulation formats, detection and optimization techniques for the design of optically routed networks to increase capacity, optical transparency, and functionality of wavelength-division multiplexed communication systems. He is a recipient of the 2005 Engineering Excellence Award from OSA, where he is a fellow.

SC328 - New Developments in Optical Transport Networking (OTN)

Sunday, 22 March
09:00 - 12:00

Short Course Level: Beginner

Instructor:

Stephen Trowbridge; *Alcatel-Lucent, USA*

Short Course Description:

This course provides an introduction to revised ITU-T Recommendation G.709/Y.1331, Interfaces for the Optical Transport Network (OTN), focusing on new interfaces and capabilities for OTN in the first major revision of the standard since 2003. As DWDM networks have evolved, they have provided a common convergence layer for SONET/SDH, IP, and Ethernet traffic. The latest version of the standard helps move from a combination of point-to-point DWDM line systems and metro ROADM networks to a full, end-to-end managed network. The OTN hierarchy has been extended "at both ends," adding a new lower tier (ODU0) optimized for the transport of 1000GBASE-X (Gigabit Ethernet), and a new upper tier (ODU4) optimized for the transport of the new 100GBASE-R (100 Gigabit Ethernet) recently specified by

the IEEE P802.3ba project. Mapping is specified for the new 40GBASE-R (40 Gigabit Ethernet) signal into existing 40G transport using the currently deployed ODU3. OTN is being deployed by many operators for their next generation network builds. This course will cover the basic concepts of G.709, with specific emphasis on the recently added interfaces and capabilities. You will learn how IP, Ethernet, and SONET/SDH traffic can be carried by an international standard based digital wrapper solution. You will develop an appreciation for the flexibility provided in the latest OTN standards to transport a wide variety of client signals and to efficiently manage bandwidth.

Short Course Benefits:

This course should enable you to:

- Understand the concepts that form the basis for an OTN based on G.709
- Apply the capabilities of the OTN standards to manage client signals and wavelengths.
- Understand the mapping mechanisms used by OTN to transport major client signals.
- Utilize the new flexibility of the latest standard for efficient bandwidth management.
- Know where to look to find more information about G.709.
- Learn about the new interfaces provided in the latest revision of the standard.

Short Course Audience:

This course is intended for anyone who designs, operates, or supports metro and/or long haul optical networks and who need to understand the new interfaces and capabilities in ITU-T Recommendation G.709 and how they can be used.

Instructor Biography:

Dr. Stephen J. Trowbridge is a Consulting Member of Technical Staff (CMTS) at Alcatel-Lucent. He received his B.S. (EE&CS), M.S. (CS), and Ph.D. (CS) from the University of Colorado, Boulder. He joined Bell Laboratories–AT&T (now Alcatel-Lucent) in September 1977. He has been active in optical networking standardization since 1995. He is vice-chair of ITU-T TSAG, chairman of ITU-T Working Party 3/15 (responsible for OTN standards including G.709), chairman of the ATIS COAST-OHI working group, and a was a member of the IEEE P802.3ba editorial team.

SC341 - OFDM FOR OPTICAL COMMUNICATIONS

Sunday, 22 March
09:00 - 13:00

Short Course Level: Advanced Beginner

Instructor:

Sander L. Jansen[1], Dirk van den Borne[2]; *[1]ADVA Optical Networking, USA [2]Juniper Networks, Germany*

Short Course Description:

In this short course we will discuss the ins and outs of optical OFDM for next-generation optical transmission systems. The course will describe the principles of OFDM, and in detail explains the signal processing algorithms that are required for generation and detection of an OFDM signal. We describe the most relevant transmitter and receiver architectures to generate and detect an optical OFDM signal (both analogue and digital). In addition, optical OFDM implementation aspects such as the compensation of transmitter and receiver imperfections are addressed and the digital signal processing complexity trade-offs in various flavors of OFDM are explained.

The course includes as well a strong focus on the different application scenarios of OFDM, ranging from access applications and next-generation client interfaces to ultra-long haul transport. In particular, we discuss in detail on the role that OFDM can play in next-generation 400G/1T transport networks and explain the differences in signal processing between OFDM and single-carrier modulation. We describe as well the possible applications of DMT for next-generation client interfaces. Finally, the course will touch as well on the requirements and challenges when using OFDM for multi-mode propagation in future mode-division-multiplexed transmission systems.

The course should enable attendees to get a feel for the different concepts and implementations of optical OFDM and their application scenarios in different types of optical networks, including understanding the role that OFDM can play in optimizing the capacity of next-generation optical transport networks.

Short Course Benefits:

This course should enable you to:

- Describe the concept of orthogonal frequency division multiplexing (OFDM) and implementations such as discrete multi-tone (DMT).
- List different flavors of optical OFDM and detail the advantages and disadvantages of each method to generate an OFDM signal.
- Appreciate the design trade-offs of the cyclic prefix, FFT-size, etc. with respect to for instance the dispersion tolerance and oversampling.
- Explain the multi-input, multi-output (MIMO) technique that is required to equalize a polarization division multiplexed (PDM) or a mode division multiplexed signal.
- Describe concepts such as IQ imbalance mitigation and phase noise compensation.
- Illustrate the advantage that OFDM can bring in the generation of super channels for next-generation 400G/1T transport networks as well as future mode-division multiplexed transmission.
- Explain the influence of fiber nonlinearity on OFDM and describe methods to optimize the nonlinear tolerance of optical OFDM.
- Discuss different applications for optical OFDM from access to long-haul transmission in next-generation optical transport.

Short Course Audience:

This course is intended for engineers, researchers and technical managers who like to gain a better understanding of optical OFDM and its applications in next-generation optical transport networks. Apart

from the theory and concepts behind optical OFDM, the implementation and system design will be discussed in detail, such that the participants can obtain a good level of understanding for the different design trade-offs. Participants should have a basic knowledge in the field of fiber-optic transmission systems; no previous knowledge of OFDM is required. Past attendees of the course will find substantial updates and new information, and they are encouraged to attend again.

Instructor Biography:

Sander L. Jansen received his Ph.D. degree (with highest honors) in EE from the Eindhoven, University of Technology. Subsequently, Dr. Jansen worked as a post-doc at KDDI R&D Laboratories in Japan where he specialized in optical orthogonal frequency division multiplexing (OFDM), a broadband multi-carrier modulation method, for long-haul transmission systems. Whereas OFDM is a common modulation format in wireless communication systems it was at the time of his post-doc new for the optical communication community. From 2008 to 2012 he was project manager at Nokia Siemens Networks in Germany. In this position he was responsible for the specification, technical evaluation and selection of optical components. In addition he investigated and evaluated modulation formats for next generation 100GbE transmission systems and was responsible for forward looking topics in collaboration with several universities. Currently, Dr. Jansen is Director of Product Line Management at ADVA Optical Networking, Germany.
Dr. Jansen authored and co-authored 10+ patents, one book chapter and more than 100 refereed papers and conference contributions. He is an associate editor for the *PTL* and has served as a committee member on various conferences. He has received several awards including the Young Investigator award from the IEEE Photonics Society *"for pioneering contributions in optical OFDM for fiber-optic transmission systems"*.

Dirk van den Borne was born in Bladel, The Netherlands. He received the M.Sc. and Ph.D. degrees in electric engineering from the Eindhoven University of Technology, The Netherlands, in 2004 and 2008, respectively. During his Ph.D. research he focused on improvements in long-haul transmission systems using robust optical modulation formats and electronic impairment mitigation. As part of his Ph.D. studies he succeeded in the first demonstration of 100G transmission with coherent detection and digital signal processing, now the established industry standard for 100G transport. In 2008 he joined Nokia Siemens Networks, working as a R&D program manager responsible for the optical system performance of the DWDM portfolio. In 2012 he joined Juniper Networks, where he is now a solution architect for packet-optical transport.
He has spoken frequently at major industry events, authored and co-authored more than 100 peer-reviewed papers and conference contributions and holds several patents on optical communication. He is a member of the technical program committee of the Optical Fiber Conference (OFC) and previously served on the technical program committees of the IEEE photonics conference and summer topicals conference. He has received several awards including the telecommunication award from the royal Dutch engineering society (KIVI-NIRIA).

SC347 - Reliability and Qualification of Fiber-Optic Components

Monday, 23 March
08:30 - 12:30

Short Course Level:

Instructor:

David Maack; *Corning, USA*

Short Course Description:

Reliability and qualification of photonic components are two of the most important requirements for our modern telecommunication systems. They are one of a customer's first areas of intensive inquiry for a new supplier and potentially some of the biggest problems in deployed systems. An unreliable sub-component can bring down entire systems and, in the worst scenario, force recalls costing thousands of times the original components price. This can also lead to substantial financial liabilities and highly strained customer-vendor relationships.

This course is a rewrite of prior courses on these subjects by this author in response to a maturing technology, a changing business environment and specific requests by former attendees. The new course will provide a similar body of knowledge, but concentrate more on an expanded view of reliability, less on the mechanics of qualification and attempt to give the attendee a more intuitive understand of both subjects. There will be a higher focus on the methodologies of both for various families of components, some discussions on failure analysis and its tools, helpful charts and rules of thumb, differences between the two.

Short Course Benefits:

This course will enable the attendee to:

- Learn the importance, tools, methodologies, mathematics and benefits of reliability programs
- Understand the requirements, tests, benefits and limitations of qualification programs
- Learn the strategic and tactical differences between qualification testing and reliability modeling.
- Review the multitude of roles, contributions, tools and functions of a reliability group
- Discuss and learn what constitutes a complete qualification program and get the author's interpretation of the "letter of the law" for the most popular standards
- See charts comparing different qualification standards
- Determine why and when reliability testing and modeling needs to be done.
- Understand the limitation of both reliability modeling and qualification testing.
- Learn how to establish appropriate reliability tests and gather meaningful data.
- Learn the ways to calculate the reliability of a device using accelerated testing data.
- Find information on standards, components, reliability software and other reference materials.

Short Course Audience:

This course is intended for a general audience including non-technical persons with no particular background except an interest in or need for knowledge of reliability and qualification of photonic components. It is meant to impart valuable information to audiences of all levels.

Instructor Biography:

David Maack has 40 years of technical and management experience in photonics with the last 16 years in qualification and reliability of passive and active photonic components. Currently, he is the reliability manager for the Components and Systems Group at Corning, Inc. in Corning, NY. He is the past chairman of the IEC TC86B Working Group 5 writing standards for passive fiber optic components, has participated in multiple Telcordia GR rewrites, and is the author of numerous papers. He a bachelor's degree in physics, a bachelor's degree in nuclear science and a master's degree in business administration.

SC357 - Circuits and Equalization Methods for Short Reach Optical Links

Monday, 23 March
13:30 - 16:30

Short Course Level:

Instructor:

Alexander Rylyakov; *Coriant, USA*

Short Course Description:

Short reach (or computercom interconnect) links are defined as communication links found inside a single (possibly large) computer, reaching distances of up to several 100's of meters. They are typically used in an environment featuring high integration levels (many thousands and tens of thousands of links) and high total aggregated bandwidth requirements (100's of Tb/s and more). The key performance parameters for short links are power efficiency, density, bandwidth, and cost. Many existing system and circuit solutions found in long haul (telecom or datacom) links are often not applicable to a short reach situation as being too bulky, too expensive or dissipating too much power. At the same time, at short distances the optical I/O is always in a direct competition with purely electrical wireline solutions, further driving the need for high power efficiency at high total aggregated bandwidth. To stay competitive, both optical and wireline links use highly specialized front-end circuits and equalization methods.

The main focus of the course will be on circuits for VCSEL-based multi-mode and for Silicon Photonics single-mode optical short reach links in the context of highly parallel, high bandwidth applications. For completeness, circuit topologies and performance parameters will be compared to corresponding wireline transceiver solutions.

We will start with outlining the basics of channel properties and communication techniques. We will then review the most common front-end I/O circuit topologies used in both optical and electrical short reach interconnects and compare their overall efficiencies. Typical transmitter and receiver architectures for both electrical and optical links will be presented, with discussion of basic functionality and performance requirements for each of the building blocks. We will outline the similarities as well as the differences between the key front-end components (e.g., VCSEL driver vs wireline driver vs Silicon Photonic modulator driver), and their effect on the overall link performance. We will compare SiGe bipolar and CMOS technologies in terms of performance, power dissipation, area and cost. The review will also include a brief discussion of the high-speed digital MUX/DEMUX (serializer/deserializer) circuits

and the CDR (clock and data recovery) function. Full link power efficiency examples will be presented for several optical and wireline links, together with a discussion of scaling trends.

Equalization is an absolute necessity for electrical links due to severe bandwidth limitations of wireline channels, but optical solutions can also greatly benefit from equalization, even at short reach. We will discuss the most commonly used equalization methods:

• continuous-time linear equalizer (CTLE, often used on both sides of the link)
• feed-forward equalizer (FFE, typically employed in the transmitter pre-emphasis)
• decision-feedback equalizer (DFE, commonly present in the receiver)

High-level descriptions of several topologies of FFE transmitters and DFE receivers will be presented, together with a discussion of tradeoffs involved when selecting one equalizer over another, or using both. We will conclude with discussion of several recently published results demonstrating the benefits of equalization for short reach optical links.

Short Course Benefits:

This course should enable you to:

- Outline overall transceiver architectures of typical wireline and optical short reach links
- Explain functionality and performance requirements of all key front-end I/O building blocks
- Evaluate and compare the efficiencies of wireline and optical short reach interconnects
- Compare SiGe bipolar and CMOS circuits for short reach optical and electrical links
- Understand and compare equalization techniques (CTLE, FFE, DFE)
- Discuss benefits and tradeoffs of equalization
- Make an educated choice between an optical and electrical solution for short reach interconnect

Short Course Audience:

This course is for anyone interested in learning the basic transmitter and receiver circuit architectures for both optical and electrical short reach interconnects. The course will help gain the insight into the main tradeoffs involved in choosing between the optical and electrical links, as well as the integrated circuit topologies and technologies used in the transceiver circuits. The overview of advanced equalization techniques will be also of interest to audience already familiar with the basics of short reach interconnect.

Instructor Biography:

Alexander Rylyakov received the M.S. degree in physics from Moscow Institute of Physics and Technology in 1989 and the Ph.D. degree in physics from State University of New York at Stony Brook in 1997, where he worked on the design and testing of superconductor integrated circuits based on Josephson junctions. In 1999 he joined the IBM T.J. Watson Research Center as a research staff member, working on the design and testing of high-speed digital and mixed-signal communication circuits for optical and channel-limited wireline communications. Many of those circuits, implemented in various generations of CMOS and SiGe bipolar, are now used in IBM products and several of them have

established performance records in their respective technologies. Dr. Rylyakov's current research interests are in the areas of digital phase-locked loops for communication and microprocessor clocking, high-speed low power transceivers and equalization for wireline and optical communication, and integrated circuits for silicon photonics. He has published over 80 papers and has 20 patents issued, 48 filed.

SC359 - DATACENTER NETWORKING 101

Sunday, 22 March
09:00 - 12:00

Short Course Level: Beginner

Instructor:

Cedric Lam, Hong Liu; *Google, USA*

Short Course Description:

This introductory course starts with a review of the network transformations resulted from the rise of Internet computing applications. We then review the architectural structures of warehouse-scale computers (WSCs) and the networking technologies used to implement WSC datacenters. This course covers both intra-datacenter and inter-datacenter networks, the challenges facing datacenter operators in the next 3 to 4 years, the need for energy efficient datacenter networking technologies, and the desirable optical networking technologies to sustain the growth of Internet computing applications.

Short Course Benefits:

This course should enable you to:

- Define warehouse-scale computer (WSC) and describe its structure
- Describe the engineering principles and philosophies behind scalable mega-datacenter infrastructures
- Compare different datacenter cluster topologies and switching technologies.
- Compare the differences and similarities between traditional telecommunication networks and booming data-communication networks
- Identify the challenges for intra-datacenter and inter-datacenter communications
- Select suitable optoelectronic interconnect technologies
- Explain the roles of optics in transmission, multiplexing and switching
- Identify designs to realize energy efficient data networks

Short Course Audience:

This course is beneficial to optoelectronic engineers, fiber optic transceiver designers and optical transmission engineers who would like to understand the requirements of datacenter networking. It also benefits network engineers with the knowledge of high-speed optical communication technologies

used to realize various datacenter network applications. For network planners and architects, this course provides outlooks in optical network technology developments in the next 3 to 4 years.

Instructor Biography:

Cedric F. Lam is currently Optical Network Architect at Google. Before joining Google, he worked at OpVista Inc. as chief system architect, responsible for the development of an ultra-dense WDM transport system with integrated ROADM functionality. Prior to OpVista, Cedric was senior technical staff member at AT&T Labs-Research. His research covers broadband optical transport and access networks architectures, optical signal modulation and transmission, passive optical network, HFC, etc. His current focus is in FTTH and optical networking technologies for data center applications. Cedric received B.Eng. in Electrical and Electronic Engineering from the University of Hong Kong with First Class Honors and PhD. in Electrical Engineering from UCLA.

Hong Liu is a Member of Technical Staff at Google Platform Advanced Technology, where she is involved in the system architecture and interconnection for large-scale computing platforms. Her research interests include interconnection networks, high speed signaling, photonic integrated circuit, and optical metro design. Prior to joining Google, Hong was a Member of Technical Staff at Juniper Networks, where she was principally involved in the architecture and design of high-end physical interface cards, network routers, and multi-chassis switches, including Juniper's flagship core router T640, edge routers M7i/M10i/M120, world's first OC768 line card and world's very first switch-matrix TX640. Hong received her Ph.D. in Electrical Engineering from Stanford University.

SC369 - Test and Measurement of Complex Modulated Optical Signals

Monday, 23 March
13:30 - 16:30

Short Course Level: Advanced Beginner

Instructor:

Bernd Nebendahl, Oliver Funke; *Keysight , Germany*

Short Course Description:

This course will provide solid understanding how complex modulated optical signals are created and how the signal quality of complex modulated signals with an emphasis to widely used real time detection can be quantified. A significant part of the course explains how to improve the transmitter signal quality if given constellation diagram distortions are observed. By understanding the concept of EVM and its relation to BER, SNR, and Q factor engineers and decision makers will get a profound knowledge base to decide for the best test strategy for their characterization applications.

Short Course Benefits:

Attendees of this course will be able to:

- Compare the quality of various transmitters through the use of EVM measurements
- Determine the relationships between EVM, BER, and Q-factor
- Compare the different techniques used for complex modulation analysis and determine which provide optimum results for a given measurement scenario
- Relate details of constellation diagrams to specific device and/or measurement system impairments
- Identify the root causes of measurement degradation and uncertainty
- Develop test strategies to validate the accuracy of test results

Short Course Audience:

This short course is intended for engineers who start to work or already have experience in manufacturing and development of transmitters, links and receivers operating with complex modulated signals. Attendees should be aware of basic concepts of optical transmission and polarization of light. Research and manufacturing managers as well as technical buyers will get a profound background in order to make optimal decision for their test and measurement needs. Students will extend their knowledge in complex signal analysis to setup optimal test concepts.

Instructor Biography:

Oliver Funke
Product Manager, Keysight Technologies

Oliver joined Keysight Technologies in 1992 (formerly Agilent Technologies/Hewlett Packard) as Engineer of the Optical Communication Measurement Division. Oliver has worked in various R&D projects, including low noise OTDR receiver, optical power meter, coherent optical all parameter test and lightwave component analyzer in various positions from engineer to project lead. In 2006 he joined product marketing. He is now responsible as Product Manager for coherent transmission test.
Oliver has a degree in Communication Theory from the Technical University in Munich.

Bernd Nebendahl
Project Lead, Keysight Technologies

Bernd is currently with Keysight Technologies, formerly Agilent Technologies which he joined 2000 as Engineer of the Optical Communication Measurement Division. Bernd has worked in various R&D projects, including tunable external cavity lasers, optical attenuators, coherent optical all parameter testers, distributed temperature sensing and the optical modulation analyzer in positions from optics designer to project lead. He currently focuses on all topics around coherent transmission.
Bernd received a diploma and a PhD in physics, both from University of Stuttgart.

SC372 - Energy-Efficient Cloud Networks and Services

Sunday, 22 March
17:00 - 20:00

Short Course Level:

Instructor:

Rod S. Tucker, Kerry Hinton; *Univ. Melbourne, Australia*

Short Course Description:

This short course will provide an introduction and overview of energy efficiency in communications networks. The course will look at trends (past and future), challenges and opportunities presented by the evolution to energy-efficient telecommunications.
Course components are:

- Growth of ICT and its power consumption
- Sustainability implications of ICT growth
- Modelling network power consumption
    - Sales and inventory based models
    - Network-design-based model
    - Transaction-based model
    - Important parameters: PUE, peak vs average access speed, dimensioning for growth, redundancy, protection and replacement
- Power consumption modelling of networks
    - Access networks: Wireless, PON, FTTN, HFC and Point-to-Point
    - Edge and Metro networks
    - Core networks: Terrestrial and submarine
- Power consumption of equipment
    - IP Routers (edge and core)
    - Switches (Ethernet, MPLS and TDM)
    - Cross connect, add/drop multiplexer
    - Multi-layer switches (GMPLS)
    - Transmission systems
    - OLTs and ONUs
    - Equipment for cloud services
- Equipment power consumption trends
    - Time evolution
    - Traffic load dependence
- Bringing it all together
    - Future trends and directions
    - Identifying leverage points for improvements in energy efficiency
- Improving energy efficiency using:
    - Architectures
    - Protocols
    - Technologies
- What is attainable
    - Lower theoretical limits on power consumption
    - How close can we get to these limits?: Network control, management and monitoring
- Overview of global activities in green networking
    - GreenTouch
    - Carbon Trust
    - GreenGrid

- GeSI
- ITU, EU & others

Short Course Benefits:

This course should enable participants to:

- Compare networks from the perspective of energy efficiency.
- Compute an estimate of the energy efficiency of network equipment, designs and architectures (in Joules/bit).
- Explain the principles of energy efficiency in telecommunications networks
- Identify key factors and leverage points for improving the energy efficiency future networks
- Describe the key determinants of network energy efficiency

Short Course Audience:

Telecommunications engineers, managers, policy makers, researchers and educators.
A basic knowledge of telecommunications networks and equipment will be advantageous. Little or no knowledge of energy efficiency issues in telecommunications networks is required.

Instructor Biography:

Rodney S. Tucker (M'76–SM'81–F'89) is a Laureate Professor at the University of Melbourne. He is Director of the University of Melbourne's Centre for Energy-Efficient Telecommunications (CEET). He is a Fellow of the Australian Academy of Science, a Fellow of the Australian Academy of Technological Sciences and Engineering, a Fellow of the Optical Society of America, and a Fellow of the IEEE. He is currently Vice-President, Publications of the IEEE Photonics Society.

Kerry Hinton received a PhD from the University of Newcastle Upon Tyne, U.K., in 1984. He worked at the Telstra Research Laboratories, Australia, for 21 years researching analytical and numerical modelling of optical systems, ASONs and monitoring in all-optical networks. In 2006, he joined the University of Melbourne, undertaking research into the energy efficiency of the Internet, communications technologies and networks as a member of the Centre for Energy Efficient Telecommunications (CEET).

SC373 - Specialty Fiber Splicing and Interconnection

Sunday, 22 March
13:00 - 16:00

Short Course Level: Advanced Beginner

Instructor:

Andrew Yablon; *Interfiber Analysis, USA*

Short Course Description:

The recent emergence of a diversity of optical fiber designs and applications has made optical fiber interconnection more challenging even as it has become more important. Effective interconnection of optical fibers is critical for all applications, including traditional telecom links, optical fiber sensors, and high-power fiber amplifiers and sources.

This course provides an introduction to all aspects of optical fiber interconnection, and compares the benefits and disadvantages of fusion splices, fiber connectors, and free space optics. Performance metrics and their measurement are introduced, including optical loss, reflectance, mode conversion, polarization crosstalk, and tensile strength. Special issues relevant to field deployment, factory production, and laboratory environments are all covered. An overview of equipment for fusion splicing as well as for fiber preparation and splice packaging is presented. Special fusion splicing strategies and fu`sion splice optimization are reviewed. Practical approaches for interconnection specialty fibers, including multimode, single-mode, dispersion managed, rare-earth-doped, large effective area, multi-core, high-power, polarization-maintaining, non-silica, and microstructured fibers are all discussed. Proof testing and long term mechanical reliability of fusion splices are addressed. A numerical approach for modeling fusion splicing is presented.

Short Course Benefits:

This course will enable you to:

- Improve the quality of your fusion splices
- Compare competing interconnection technologies
- Select equipment for optical fiber interconnection
- Estimate interconnection performance
- Test and measure optical fiber interconnections
- Avoid problems with splice reliability
- Evaluate and apply special fusion splicing strategies

Short Course Audience:

This course is intended for engineers and scientists who are concerned about the problem of optical fiber interconnection and are looking for practical solutions to their problems. This course presupposes a familiarity with contemporary optical fibers and their theory of operation.

Instructor Biography:

Andrew D. Yablon is President of Interfiber Analysis, an optical fiber test & measurement company. Dr. Yablon previously worked at Bell Labs, OFS Labs, and Vytran Corp and has consulted widely on optical fiber interconnection. He wrote the monograph Optical Fiber Fusion Splicing, is listed as an author on numerous peer-reviewed journal articles and conference publications, and holds 18 US Patents. He is a Senior Member of the OSA, was chair of the Optical Fiber Subcommittee for OFC/NFOEC 2010, and also teaches a fusion splicing course at SPIE Photonics West.

SC374 - Cloud Computing and Dynamic Networks

Monday, 23 March
09:00 - 12:00

Short Course Level: Beginner

Instructor:

George Clapp[1], Douglas Freimuth[2]; *[1]AT&T Labs, USA, [2]IBM, USA*

Short Course Description:

Cloud computing is playing an increasingly prominent role as providers offer more complete and robust services and as enterprises adopt the technology into their IT infrastructure. Cloud computing lowers the total cost of computing through large pools of resources that are shared across many clients and managed as a single entity. Virtualization is a key enabler that creates a logical version of a physical resource such as a computer or storage device and permits the resource to be allocated to different users as demands change. Networks are essential resources in cloud computing, just as essential as computers and storage devices, but unlike virtual computers and storage, cloud providers have treated their networks between data centers as static resources over which they had little control. This model is changing rapidly as new network technologies and services emerge. The optical control plane has enabled agile, intelligent and autonomous networks that can rapidly provision new services, and carriers are deploying them to offer dynamic services. The Research & Education community is also offering dynamic network services and integrating them into cloud computing for large scale experiments.

This course is an introduction to cloud computing and to the emerging dynamic network services. The course will describe cloud computing infrastructures and technologies such as virtualization and cover the different dynamic network technologies and services, describing how they can be virtualized and integrated into cloud computing. It will also describe sample cloud applications and how they can make use of the new services.

Short Course Benefits:

This course will enable you to:

- Identify and describe the key technologies that underlie cloud computing
- Describe the network within the data center and how it is virtualized and managed by the cloud provider
- Describe the key technologies that underlie dynamic network services
- Describe and compare the different dynamic network services either presently offered or under development by carriers and the Research & Education community
- Describe how the dynamic network services can be virtualized and integrated into cloud management systems
- Discuss sample cloud applications and how they can benefit from the dynamic network services

Short Course Audience:

This course is intended for planners and architects of both networks and data centers who are involved in designing networks both between and within data centers. The course will also be helpful to system vendors who wish to understand the emerging requirements of cloud and network service providers for dynamic network services. The course is at an introductory level but some familiarity with data network architecture and protocols is assumed.

Instructor Biography:

George H. Clapp is a researcher working at AT&T Laboratories on the design and the control and management of optical networks, focusing on the development of dynamic network services. He previously worked at Telcordia Technologies and Ameritech, which was the first Regional Bell Operating Company to offer Internet Access in 1994 and created one of four Network Access Points (NAPs) for the National Science Foundation (NSF). George participated in the Internet Engineering Task Force (IETF), where he chaired working groups that defined the transport of IP over the data services of public carriers.

Douglas M. Freimuth is a Senior Technical Staff Member in the Enterprise Networking group at the IBM T.J. Watson Research Center where he has focused on the research, design and development of server networking technologies. He is a co-author of the IO Virtualization (IOV) specifications in the PCI SIG. He has also participated in the Distributed Management Task Force (DMTF) for activities related to deployment of Virtual Machines and cloud networks. Doug has 60+ disclosures and patents in the domain of enterprise networking, and has also published related papers, developed products and contributed to open source.

SC384 - Background Concepts of Optical Communication Systems

Sunday, 22 March
09:00 - 13:00

Short Course Level:

Instructor:

Alan Willner; *Univ. of Southern California, USA*

Short Course Description:

Optical communication systems have provided ever-increasing data transmission capacities, and there is a set of core concepts that are fundamental to understanding many of the crucial technical areas. The OFC/NFOEC conference has numerous courses teaching advanced topics that require some basic prior knowledge of these core concepts. The intent of this short course is to provide key background information to enable attendees to subsequently take more advanced courses as well as to enhance the attendee's understanding of technical sessions throughout the conference.

An attendee will obtain an overview of the field that concentrates on a number of specific topics, including:

1. Introduction to optical systems (point-to-point links, reconfigurable networks, line/client, switching techniques)
2. Communications concepts (SNR, ISI, BER, PRBS, eye diagrams, link budget, data standards)
3. Channel multiplexing techniques (time, wavelength, subcarrier, space, polarization)
4. Fiber-based data-degrading effects (loss, chromatic dispersion, polarization-mode dispersion, polarization-dependent loss)
5. Amplifiers (EDFA and Raman, gain flattening, gain transients)
6. Nonlinear effects, dispersion management and fiber types
7. Modulation formats, capacity and data constellations (OOK, PSK, DPSK, QAM, OFDM)
8. Direct and coherent detection schemes
9. Mitigating data impairments: optical (tunable compensators) and electronic (DSP, FEC)
10. Basics of lightwave system modeling

Short Course Benefits:

This course should enable you to:

- Understand basic concepts of an optical communication system.
- Identify different types of modulation and multiplexing formats.
- Compute a simple optical power budget.
- Explain key differences between direct and coherent detection systems.
- Attend more advanced OFC short courses and understand better the conference technical sessions.

Short Course Audience:

This introductory course is intended for an audience with at least some technical background in engineering, physics or related disciplines, and is ideally suited for engineers who want to learn more about optical fiber communication systems. The audience should gain valuable knowledge enabling them to take more advanced courses as well as understand better the conference technical sessions.

Instructor Biography:

Alan Willner (Ph.D., Columbia) worked at AT&T Bell Labs and Bellcore, and he is the Sample Chaired Professor of Engineering at USC. He received the Int'l Fellow of U.K. Royal Society of Engineering, NSF Presidential Faculty Fellows Award from White House, Packard Foundation Fellowship, Fulbright Foundation Senior Scholars Award, OSA Forman Eng. Excellence Award, IEEE Photonics Society Eng. Achievement Award and Distinguished Lecturer Award, USC University-Wide Outstanding Teacher Award, and Eddy Best Technical Paper Award from Pennwell. He is an IEEE, OSA, and SPIE Fellow. He was co-chair of National Academies Committee on Harnessing Light II, president of IEEE Photonics Society, OSA Science and Engineering Council co-chair, Optics Letters editor-in-chief, Journal of Lightwave Technology editor-in-chief, IEEE JSTQE editor-in-chief, CLEO general co-chair, and OFC steering/program committee member.

SC385 - FUNDAMENTALS OF SUPER COMPUTING

Sunday, 22 March
13:00 - 16:00

Short Course Level: Beginner

Instructor:

John Shalf; *NERSC, USA*

Short Course Description:

A large change in the computing world has started in the last few years: not only are the fastest computers parallel, but nearly all computers will soon be parallel, because the physics of semiconductor manufacturing will no longer let conventional sequential processors get faster year after year, as they have for so long (roughly doubling in speed every 18 months for many years). So all programs that need to run faster will have to become parallel programs. (It is considered very unlikely that compilers will be able to automatically find enough parallelism in most sequential programs to solve this problem.) This will be a huge change not just for science and engineering but the entire computing industry, which has depended on selling new computers by running their users' programs faster without the users having to reprogram them. At the same time increasingly fast-paced, digital world has produced an ever-growing volume of petabyte-sized datasets, and terabytes of new, unstructured data arrive daily. As the desire to ask more detailed questions about these massive streams has grown, parallel software and hardware have only recently begun to enable complex analytics for Big Data. This talk will also compare and contrast the performance of systems from Intel, NVIDIA, IBM, Cray, and Cloud/MapReduce platforms. Real-world examples in this tutorial include challenging problems such as climate models, finding new materials, and analyzing large genomic data sets, and discuss areas where photonic technologies might make a big difference in future application performance.

Short Course Benefits:

• Understand how new computing technologies enable real-world applications
• Understand trends in high performance computing architecture
• Describe innovative technologies on the horizon, such as hybrid memory, optical interconnects, multicore processors and accelerators, and petascale supercomputers.
• Compare technologies and solutions for real-world applications such climate modeling, biological sciences, and materials discovery
• Point to opportunities for dramatic improvements in performance for data-movement limited applications

Short Course Audience:

This lecture is designed to introduce students how to use parallel computers to efficiently solve challenging problems in science and engineering, where very fast computers are required either to perform complex simulations or to analyze enormous datasets. The lecture is intended to be useful for students from different backgrounds. The presenter has a strong track record of presenting similar

tutorials to academic and industrial audiences, and this material will be accessible by researchers, implementers, innovators, and executives.

Instructor Biography:

John Shalf is Chief Technology Officer at NERSC. His background is in electrical engineering: he spent time in graduate school at Virginia Tech working on a C-compiler for the SPLASH-2 FPGA-based computing system, and at Spatial Positioning Systems Inc. (now ArcSecond) he worked on embedded computer systems. John first got started in HPC at the National Center for Supercomputing Applications (NCSA) in 1994, where he provided software engineering support for a number of scientific applications groups. While working for the General Relativity Group at the Albert Einstein Institute in Potsdam Germany, he helped develop the first implementation of the Cactus Computational Toolkit, which is used for numerical solutions to Einstein's equations for General Relativity and which enables modeling of black holes, neutron stars, and boson stars. He also developed the I/O infrastructure for Cactus, including a high performance self-describing file format for storing Adaptive Mesh Refinement data called FlexIO. John joined Berkeley Lab in 2000 and has worked in the Visualization Group, on the RAGE robot, which won an R&D100 Award in 2001, and led international high performance networking teams to win to consecutive SciNET bandwidth challenges in 2001-2002. He is a member of the DOE Exascale Steering committee, and is a co-author of the landmark "View from Berkeley" paper as well as the DARPA Exascale Software Report. He currently leads the NERSC Advanced Technology Group (ATG) that leads projects in exascale technology research such as CoDEx (CoDesign for Exascale), and the LBNL Green Flash project (http://www.lbl.gov/cs/html/greenflash.html) that seeks to develop energy efficient scientific computing systems using manycore and embedded technologies.

SC386 - The Evolution of Network Architecture Towards Cloud-centric Applications

Monday, 23 March
13:30 - 16:30

Short Course Level: Advanced Beginner

Instructor:

Loukas Paraschis; *Cisco Systems, Inc., USA*

Short Course Description:

This short course reviews the current and emerging “cloud-centric” service delivery models, and evaluates the functional characteristics, and challenges in the associated network architectures. It then focus on the interplay among important and promising photonics technologies, and converged IP and WDM architectures that have increasingly been adopted to address the transport network needs.

The increasing availability of fast and reliable network connectivity has enabled applications to transition to an Internet based service delivery model, commonly referred to as “cloud”. The underlying infrastructure consists of data-centers of massive computing, and storage resources. Networking is crucial in interconnecting, and optimizing the cost-performance, of the “cloud infrastructure”. As a result the interconnection of datacenters is one of the largest contributors to the increased traffic

demands in the traditional transport networks. Consequently, the structure of the Internet has been changing towards flatter, more densely interconnected networks, with consequences for traditional optical transport, routing, traffic engineering, and security. We will first analyze the functional characteristics and challenges of these networks, and review the current and emerging applications that motivated these networks to scale leveraging IP, MPLS, and DWDM transport. We will particularly discuss how the new, high-bandwidth, predominantly video related, applications (including IPTV, ideoon- demand, peer-to-peer, and videoconferencing), often with diverse quality-of-service requirements, are increasingly motivating a fundamental shift in services from circuits to packets, giving rise to the most significant evolution of transport networks in recent history. The course will then focuses on the current and future converged Packet and DWDM transport. We will identify the unique network requirements, design challenges, and desired future hardware and software features of these interdata- center interconnection architectures, and their components. We will also review the significant advancements in optical technologies, system, standards, and the improvement in capital and operational cost, including density, or power. Finally, we will attempt to evaluate the interplay among the intra and inter data-center networking architectures, system design, and the enabling photonics technology and packaging innovations. Future network evolution, like SDN and NfV, emerging standards, and related research topics will also be discussed.

Short Course Benefits:

This short course will enhance the audience understanding of the interplay between network architectures, systems, and IP and photonics technology innovation in the actual evolution (past, current and future) of the public and private cloud-centric network infrastructure.

Short Course Audience:

This short course is intended for researchers, and students in the fields of photonics technologies, and optical networking that wish to obtain an industry perspective, and also industry professionals that wish to have a network architecture and system level analysis of the networking evolution, with a particular focus on the implications of cloud-centric service delivery models.

Instructor Biography:

Loukas (Lucas) Paraschis is senior architect for next-generation networks in cisco's Americas service provider team, responsible for the network evolution, technologies, business models, and market development in service providers, large enterprise, and public sector infrastructure. Prior to his current role, Loukas worked as an R&D engineer, product manager, technical leader, and BDM in optical networking and core routing, and completed graduate studies at Stanford University (PhD applied physics 1999, MS EE 1998). He has (co)authored more than 100 peer-reviewed publications, invited, and tutorial presentations, a book, two book chapter, and two patents, and has been associate editor for the Journal of Optical Communication and Networks, guest editor of the Journal of Lightwave Technology, chair of multiple conference organizing committees, Fellow of the OSA, senior member of the IEEE, and was an IEEE Photonics Society Distinguished Lecturer (2009). Loukas was born in Athens, Greece, where he completed his undergraduate studies.

SC388 - WIRELESS BACKHAUL

Sunday, 22 March
17:00 - 20:00

Short Course Level: Intermediate

Instructor:

Stu Benington; Coriant GmbH*, USA*

Short Course Description:

Mobile broadband traffic is one of the major network drivers in the industry, and mobile service revenue continues to increase in importance to network operators' business models. It can even be said that mobility is becoming a feature rather than a discrete service offering as all forms of communication (voice, video and data) are becoming mobile to a large extent.

This presents operators with both a challenge and an opportunity. The challenge is to ensure that their networks can accommodate the requirements associated with a competitive mobility service offering as 2G and 3G networks evolve to 3G+ and 4G. At the same time, they must strike a balance between investing for the future and ensuring that their capital investment generates an appropriate ROI.

This course will explore the mobility service trends, the network requirements in accommodating them, the technologies that can and will be employed, and the associated incremental services that operators can add in ways that leverage these network investments. The area of particular focus will be Wireless Backhaul given its importance in effectively meeting the requirements that new mobile services will bring, and the quality of experience expectations that users will have.

The course will place an emphasis on the role of optical technology on wireless backhaul, and the benefits it brings in areas such as bandwidth requirements, latency, security, and potential for FMC extensions. It will also delve into the network topology changes as LTE and 4G become more prominent, and the implications for backhaul infrastructure.

Short Course Benefits:

This course will enable participants to do the following:

- Describe wireless backhaul architectures, technologies, and business issues
- Explain how services are changing the mobile telecommunications landscape and driving backhaul network requirements
- Determine the best methodology for optimal backhaul design

Short Course Audience:

This course is intended for technical participants (network design, architecture, optical technology, etc) who are looking to gain a better understanding of mobile infrastructure. It is also intended for

management, marketing, and other non-engineering job functions who have some technical knowledge but are looking to deepen their knowledge in wireless backhaul and optical applications for mobility.

SC389 - Network Optimization

Monday, 23 March
08:30 - 12:30

Short Course Level: Beginner

Instructor:

Dominic Schupke; *Airbus Group Innovations, Germany*

Short Course Description:

Network optimization is an integral part of planning and operating networks, in order to achieve high cost efficiency while meeting manifold service requirements. On the one hand, new approaches such as Software-Defined Networking (SDN), Virtualization, and Cloud Computing enable network operators to realize extremely optimized network solutions. On the other hand, networks are concurrently innovated by new network technologies and by changing operational requirements.

Examples for new technologies are multilayer networks with hybrid packet-optical switching and optical networks with flexible spectrum usage. Network optimization needs also to address emerging operational issues, such as increasing capacities (e.g., 100G->400G->...), demand robustness, configuration flexibility, energy efficiency, and new services (e.g., data centers).

The course aims to introduce network optimization concepts and provides a toolset that forms a basis for solving concrete optimization tasks. The course firstly summarizes network and traffic modeling for network optimization and planning. Necessary optimization fundamentals are then presented, including Linear Programming (LP), Mixed-Integer Programming (MIP), and heuristics. Representative approaches to solve routing, wavelength assignment, dimensioning, topology design, resilience problems, etc. are covered in detail. The course also includes online implementations of optimization examples.

Short Course Benefits:

This course will enable you to:

- Describe the process for optimizing a network using optimization software
- Formulate linear optimization models for network problems
- Explain the differences between the various modeling approaches
- Discuss the pros and cons of solving approaches (heuristics, branch-and-bound algorithms, …)
- Identify key parameters influential in modeling complexity, solving time, and computation results

Short Course Audience:

The course requires only basic knowledge in mathematics (calculus and linear algebra), communication networks, and programming (recursions, iterations, …)

Instructor Biography:

Dominic Schupke is with Airbus Group Innovations, Munich, Germany and had previously positions at NSN, Siemens, and Munich University of Technology (TUM). He received his Dipl.-Ing. degree from RWTH Aachen in 1998 and his Dr.-Ing. degree from TUM in 2004. He has over 15 years experience in the area of transport networks, especially in their design and optimization. Since April 2009 he has instructed the course "Network Planning" at TUM.

SC390 - Introduction to Forward Error Correction

Monday, 23 March
08:30 - 12:30

Short Course Level: Beginner

Instructor:

Frank Kschischang; *Univ. of Toronto, Canada*

Short Course Description:

Error-control coding, the technique of adding redundancy in controlled fashion to transmitted data so as to correct errors introduced by noise or other channel impairments, is a key component of modern optical communication systems. This course introduces basic concepts in coding and information theory: channel models and channel capacity (the Shannon limit), encoders and decoders (hard-decision and soft-decision), linear block codes and convolutional codes, code rate and overhead, Hamming distance, net coding gain, generator matrices, parity-check matrices, syndromes, polynomials, and finite fields. Specific families and constructions of error-correcting codes will be described, including Hamming codes, Reed-Solomon codes, BCH codes, product codes, concatenated codes, turbo codes, and low-density parity-check codes. Techniques for combining coding with higher-order modulation (such as 16-QAM) will also be described. After completion of this course, students will be prepared for the more advanced course SC391: FEC Technology in Optical Communications.

Short Course Benefits:

This course should enable participants to:

- define the key parameters of an error-correcting code
- explain the system-level benefits provided by FEC
- convert between generator-matrix and parity-check-matrix descriptions of a code
- encode and decode a binary Hamming code
- encode a cyclic code using a generator polynomial
- describe the key parameters of Reed-Solomon codes
- combine two or more codes into a product-code or concatenation

- describe iterative decoding methods for low-density parity-check codes

Short Course Audience:

This course is intended for systems engineers, system operators and managers who need to understand the costs and benefits in applying physical-layer error-control coding in a communications link, and those who wish to prepare themselves for the more advanced course SCxxx. No previous background in information theory or algebra is assumed.

Instructor Biography:

Frank R. Kschischang is a Tier-I Canada Research Chair and Professor of Electrical and Computer Engineering at the University of Toronto, where he has been a faculty member teaching graduate courses in coding theory and information theory since 1991. Prof. Kschischang has received numerous awards both for his teaching and for his research, including the 2006 University of Toronto Faculty of Applied Science and Engineering Teaching Award and the 2010 IEEE Communications Society and Information Theory Society Joint Paper Award (for a paper on error-control in network coding). Prof. Kschischang served as the 2010 President of the IEEE Information Theory Society. Prof. Kschischang is an inventor of "staircase codes," a family of spatially-coupled product codes well-suited for applications in optical transport networks.

SC392 - Digital Coherent Optical Systems 1: Transceiver Technology and Performance

Monday, 23 March
08:30 - 12:30

Short Course Level: Beginner to advanced beginner (basic understanding of topic is necessary to follow course material)

Instructor:

Maurice O'Sullivan; *Ciena, Canada*

Short Course Description:

Coherent optical transmission is a commercial solution which supports capacity growth in reconfigurable WDM networks at 40 Gb/s and higher capacity. Its implementation follows on available CMOS technology that is capable of digital signal processing (DSP) capacities of multiple terabits per second and co-integration with analog to digital (ADC) and digital to analog (DAC) conversion as well as forward error correction (FEC) functions. Coherent transmission uses the measured optical field envelope which comprises amplitude, phase and polarization. Compared to intensity modulation –direct detection (IMDD), this richer set of measurements allows better use of the available optical spectrum for data transmission i.e. higher spectral efficiency. Measurement of the field instead of just intensity predisposes coherent systems to signal equalization and recovery in the electronic domain. This course examines implementation aspects of electric field transmitters, coherent receivers and the role of transmit and receive DSP for channel equalization and data recovery. The dependence of performance

upon the dispersion map and on composition of the wavelength division multiplexed (WDM) spectrum are addressed.

Short Course Benefits:

This course should enable you to:

- Understand optical field amplitude, phase, polarization and intensity
- Distinguish IMDD from coherent detection and field modulation
- Understand the role of DSP in standard coherent transmission
- Gain exposure to electro-optic technologies used for coherent transmission
- Learn standard implementations of electric field transmitters and coherent receivers
- Estimate Q and BER for BPSK, QPSK and 16 QAM modulations
- Anticipate relative performances of coherent phase modulated channels vs. dispersion map and WDM channel spectrum

Short Course Audience:

This course is intended for those interested in the workings and estimates of performance of commercial coherent solutions in a multi-span amplified WDM system. It is recommended to its audience as pre-requisite to SC393.

Instructor Biography:

For more than 25 years Maurice O'Sullivan has contributed to the design and manufacture of optical fiber and, mostly, the highest capacity long line transmission equipment of its day with emphasis on layer 0. Recent examples include a 40 Gb/s and 100 Gb/s coherent transceiver products. He holds a PhD in Physics from the University of Toronto.

SC393 - Digital Coherent Optical Systems 2: Digital Signal Processing

Monday, 23 March
13:30 - 16:30

Short Course Level: Intermediate

Instructor:

Chris Fludger; Cisco Optical GmbH, USA

Short Course Description:

Digital signal processing (DSP) has always been an intrinsic component of optical communications, albeit for simple modulation techniques, framing and coding. The development of high-speed ADCs and DACs, and the increase in data processing power of CMOS ICs has enabled the implementation of complex signal processing techniques for signal modulation and demodulation. Combined with revived interest in coherent detection, algorithms have been implemented to increase the channel capacity and

compensate for network impairments such as chromatic dispersion and PMD.

This course follows on from the introduction course to coherent transceivers (SC392) and takes a more in-depth view of the DSP building blocks and their implementation in a high-speed ASIC.

Parallel filter structures in the time and frequency domain will be identified and compared. The constituent sub-blocks, such as signal shaping and CD compensation filters, polarisation compensation filters, frequency, carrier and clock recovery will be analysed. Complexity and implementation trade-offs will be discussed, along with their relative importance for different field applications.

Since the coherent receiver must compensate for the optical channel, estimation of parameters such as CD and PMD can be performed. Channel parameter estimation methods will be explained.

Techniques to enable flexible capacity and the implications for the network will be explained. In addition, the course will describe methods for performing non-linear compensation, their effectiveness and relative complexity.

Next generation coherent transceivers must be cost-effective, flexible, spectrally efficient and highly tolerant to impairments in the channel. This course explains the enabling technology, practical design aspects and future research.

Short Course Benefits:

This course should enable you to:

- Describe the principle building blocks in a coherent optical transceiver.
- Explain the function of frequency and time-domain filters and their advantages and disadvantages.
- Explain the implementation of pulse shaping and CD filters.
- Describe techniques for frequency and carrier phase estimation
- Summarize the importance of clock recovery and describe clock recovery methods.
- Describe the components of polarization tracking filters.
- Explain how channel parameter estimation may be performed in coherent transceivers.
- Explain the options for achieving flexible capacity including implications for the network.
- Quantify the effectiveness and complexity of non-linear compensation.

Short Course Audience:

This course is intended for individuals having an intermediate knowledge of digital lightwave transmission systems. The introductory course (SC392) is recommended a prior knowledge. It will be of value for industrial professionals (system designers, managers) who need to understand the different components in digital coherent transceivers, as well as for researchers who are new to the field.

Instructor Biography:

Chris Fludger has developed three generations of coherent optical transceivers at Cisco Optical GmbH (formally CoreOptics) where he specializes in System Design and Digital Signal Processing. He has

received Master's and Doctorate degrees in electronic engineering from Cambridge University, UK. Previously, at Nortel Networks he has worked on electronic signal processing, advanced modulation techniques and Raman amplification.

SC395 - Hands On: Basic Modeling and Design of Coherent Fiber-Optic Communication Systems

Sunday, 22 March
09:00 - 13:00

Short Course Level: Advanced Beginner and Intermediate

Instructor:

Erich Gottwald, Harald Rohde; *Coriant, Germany*

Short Course Description:

Within the course the building blocks for a simulation system for a coherent fiber optical communication system will be developed and implemented in a hands-on manner. The instructors will present the methodology and basic code skeletons which will then be used by the participants to implement a basic simulator in Matlab. After a general introduction into the modeling of optical transmission systems and into different established modulation formats specific topics like the modeling of a receiver, including both the optics and the demodulation part, will be covered. The target is a simulator which approaches real system as close as possible with minimum efforts. Effects due to limited bandwidths or phase distortions by dispersion and nonlinear effects in the transmission chain, noise sources and BER estimation are included. Due to the limited time, topics like PMD or EDFAs will not be covered.

As a communication system is simulated in order to analyze and to optimize it, virtual measurement instruments form an important part of a simulator. A number of virtual instruments like electrical spectrum analyzers, optical spectrum analyzers, constellation diagrams and eye diagram generators will be developed within the course.

The main part of the course will concentrate on the numerical simulation. However, a few topics in a coherent optical transmission system can be covered analytically to minimize simulation efforts and to get a better understanding of basic interdependencies.

Short Course Benefits:

This course should enable participants to:

- Design and program a simulator for a coherent optical transmission system, based on Matlab.

Short Course Audience:

This course is targeted for Researchers and students who want to learn how to build a simulation tool for coherent optical transmission systems. Familiarity with Matlab is a pre-requisite as well as a basic knowledge of transmission system related mathematics, e.g. Fourier transforms. Basic communication theory knowledge is also required.

The participants shall bring their own laptop computers, including a Matlab installation. Participants without a computer or without Matlab can follow the instructions and the tutoring part of the short course but might be idle during the hands on parts.

Instructor Biography:

Erich Gottwald joined Siemens Central Research Labs for Communication Technology in 1985 and worked on coherent optical transmission systems. With the up-coming of EDFAs he switched to WDM systems in 1991 and, as suitable commercial simulation tools were not available at that time, developed a simulation tool for nonlinear fiber optical transmission systems which was the basis for dimensioning the first WDM 8/16 channel 10 Gb/s optical systems offered by Siemens in the late 90th. In the last years, together with Harald Rohde, he developed a very detailed simulation tool for the coherent system under development which includes every effect and impairment the instructors could think of.

Harald Rohde simulated photonic transmission system since he joined Siemens in 2001 after his PhD in physics. After using commercial simulation tools for many years, those tools turned out to be insufficient for the special needs of the development of a coherent optical access system so he started to implement own tools. Together with Erich Gottwald, he developed a very detailed simulation tool for the coherent system under development which includes every effect and impairment the instructors could think of.

SC408 - Space-Division Multiplexing in Optical Fibers

Monday, 23 March
13:30 - 17:30

Short Course Level:

Instructor:

Roland Ryf; *Bell Labs, Alcate-Lucent*

Short Course Description:

This course provides the background and the principles necessary to understand the transmission of multiple optical signal channels over a single optical fiber by using spatially diverse light paths (space-division multiplexing).
The course teaches methods and techniques to design and model the propagation of light beams carrying multiple spatial channels in optical fibers, free-space couplers, splitters, wavelength-selective switches, and mode converters. A special emphasis is placed on the description of the optical elements as multiple-input- multiple-output-port devices by applying the mathematical framework of linear system theory and experimental methods to measure the complete transfer matrix of the components

are presented.
The course builds up from simple components to complete transmission systems and basic multiple-input multiple-output digital signal processing techniques required to recover the transmitted signals are reviewed. Strategies to minimize the complexity of digital signal processing, like differential group-delay compensation or intentional introduction of strong coupling between the light paths are presented and discussed and compared to experimental long distance transmission results.
The course is heavily based on real life examples; in particular it covers following topics: coupled and uncoupled multi-core fibers, multimode fibers with step-index, depressed-cladding and graded index profiles, ring-core fibers, phase-plate-based mode couplers, spot-based couplers, 3D-waveguide and photonic lantern based couplers, distributed Raman amplification, Erbium doped fiber amplifiers, and wavelength selective switches for multimode and multi-core fibers.

Short Course Benefits:

This course should enable participants to:

- Compare space-division multiplexing to other multiplexing techniques, and list key advantages and potential fields of application
- Design optical components that support multiple modes and explain how the basic design differs from single-mode components
- Measure components with multiple-input and/or multiple-output ports and extract key parameters like mode-dependent loss and differential group delay
- Discuss strategies to reduce the complexity of the receiver digital signal processing in space-division multiplexed transmission
- Describe digital signal processing techniques to calculate bit-error rate and multiple-input multiple-output impulse responses from raw receiver data
- Summarize key advantages and limitations of different fiber designs
- Explain the origin of coupling or cross-talk between light paths or modes in multi-mode and multi-core fibers
- List the key principles used to build mode-couplers and how the loss scales as function of modes

Short Course Audience:

This course is intended for engineers, scientists, managers, technicians and students who want to understand space-division multiplexing in optical fibers. No specific previous knowledge of optics is assumed and only basic math knowledge in linear algebra and differential equations is suggested. By the end of the course, these techniques will allow the design and analysis of simple space-division multiplexed systems.

Instructor Biography:

Dr. Roland Ryf is a member of technical staff in Advanced Photonics Research at Bell Laboratories, Alcatel-Lucent, Holmdel, NJ, where he is working on the optical design and prototyping of optical microelectromechanical systems (MEMS) and liquid crystal on Silicon (LCOS) based devices. Most recently he has been working on mode couplers for space-division multiplexing (SDM) and record-breaking demonstration of optical multiple-input multiple-output (MIMO) long distance transmission experiments in multi-core and multi-mode fibers.

SC409 - Safety in Fiber Optics: From Components to Systems

Monday, 23 March
09:00 - 12:00

Short Course Level:

Instructor:

Larry Johnson, *The Light Brigade[1], USA*

Short Course Description:

This session serves a primer on the safety elements and concerns of anyone working with fiber optic communication systems, lasers, optical amplifiers, and optical fibers. The content includes visual safety based on ANSI and IEC laser standards for fiber optic communication systems. It also includes physical safety for handling optical fibers and chemicals, and work area safety.

This session will help attendees to develop and implement a fiber optic safety program at their workplace. In today's workplace, job safety has never been more important. Workplace injuries can take an enormous toll in terms of lost quality of life, operating costs of business, and decreased profitability.

Short Course Benefits:

This course should enable you to:

- Attendees will be able to identify the various ANSI and IEC classifications of laser categories as defined by the ANSI and IEC laser safety standards.
- Attendees will be able to identify the laser types used in fiber optic communication systems and the potential safety concerns associated with each.
- Attendees will be able to identify the types of optical amplifiers used in fiber optic communication systems and the potential safety concerns involved at different power levels.
- Attendees will be able to describe the difference between APR and APS in fiber optic communication systems.
- Attendees will be able to apply the properties of DWDM with the associated power levels of optical amplifiers.
- Attendees will be able to identify potential problem areas where skin and possible eye punctures can occur and what remedies are available to minimize potential occurrences.
- Attendees will be able to explain the various types of test, measurement, and inspection equipment and their limitations with high-powered laser transmitters.
- Attendees will be able to develop a list addressing safety concerns towards the development of a fiber optic safety program as it pertains to fiber optic outside plant installations.

Short Course Audience:

This course is designed for those from an advanced beginner level. This is applicable to safety officers, supervisors, managers, and technicians who work with lasers, chemicals, fiber, transmission systems, and outside plant installations. For safety officers, the goal is to enhance or develop a safety program that addresses potential safety issues and concerns.

Instructor Biography:

Larry Johnson has been active in fiber optics since 1977. As Fiber Optic Specialist at Tektronix he wrote fiber optic standards and developed fiber optic test equipment. Since 1986, when he founded The Light Brigade, he has written fiber optic training courses, books, and designed a multitude of certification programs. In 2001, he was identified as a Luminary of the fiber optics industry for his role in fiber optic training. He has written content on fiber optic safety and was a contributor to the ANSI Z136.2 Fiber Optic Communications Safety standard. Since 2000, his passion has been archiving the history of fiber optics.

SC411 - Multi-layer Interaction in the Age of Agile Optical Networking

Sunday, 22 March
17:00 - 20:00

Short Course Level: Advanced Beginner

Instructor:

Ori A. Gerstel; Sedona Systems, Israel*, USA*

Short Course Description:

Optical networks are becoming more agile through the use of ROADMs, control planes, and more recently, SDN. However much of value from such agility can only be achieved if the optical layer interacts with the client layer – be it an OTN layer, a packet-transport layer or an IP layer. Without such interaction, the optical layer cannot assess the impact of new client layer links, and therefore cannot add new connections; It can also not reoptimize or reroute existing connections without losing client layer traffic. Using such interaction, the network can quickly move optical capacity to where it is needed by the client layer, instead of today's approach, of over-provisioning static client links to address different scenarios. Applications that make use of such multi-layer interactions range from combined IP-optical restoration, through router bypass and network reoptimization, to disaster recovery. We will review these applications and the role that each layer plays in enabling them.

The interactions between the layers are varied: from hardware integration (e.g., IPoDWDM), through multi-layer control plane technologies (UNI, GMPLS), to centralized intelligence via network management, PCE and SDN tools. We will review the impact of each of these interactions on the network and understand the cost savings that can be achieved and how they can be quantified. In this context we will also review the pros and cons of using distributed control planes vs. centralized SDN control and how the two can be harmonized to create a more optimal solution. We will briefly also review emerging control plane standards – such as extensions to GMPLS UNI, OSPF, BGP-LS, PCEP, Openflow, Netconf/YANG and others.

Special focus will be given to how IP and optical networks are planned today, and how combining the planning processes and taking the above multi-layer interactions into account enables significant savings in the network.

Short Course Benefits:

This course should enable you to:

- Describe IP layer behaviors which affect multi-layer networking
- Explain types of multi-layer interactions (physical integration, control plane, SDN, mgmt plane)
- Define multi-layer functionality (restoration, reoptimization of various kinds, disaster recovery,…)
- Quantify the value for multi-layer functionality
- Describe the interaction between IP layer protection and optical restoration
- Explain how multi-layer interaction affects the planning process
- Understand how elastic flexgrid networking benefits from multi-layer interaction
- Discuss possible centralized/distributed control plane architectures and their pros/cons

Short Course Audience:

The audience for this course includes system and network architects and engineers in network operators and equipment vendors, as well as researchers wanting to understand realistic methodologies for modeling multi-layer networks. The course assumes some familiarity with optical network architectures and basic understanding of the role of higher layer networks and how they connect to the optical layer.

Instructor Biography:

Dr. Ori Gerstel is the founder of SDN Solutions – a consulting company specializing in of SDN and multi-layer networking. Until the end of 2013, Ori was a Principal Engineer at Cisco, where he was responsible for driving the architecture of router-transport integration. Before joining Cisco in 2002, Ori held senior architecture positions at Tellabs and Nortel, where he architected the first mesh optical network and the first fully switched optical network respectively. He started his work in optical networking at IBM, where the first commercial DWDM system was developed. For his contribution, he was awarded the grade of IEEE Fellow (2008) and OSA Fellow (2014).

Ori published over 90 papers in the main international conferences and journals in the field, as well as several book chapters. He holds over 35 granted patents on optical networks, and a similar number of pending patents. He served as conference committee member and co-chair of several communication conferences and has been regularly invited to teach short courses and attend panels. He also serves as editor-in-chief for the primary journal for optical networking (JOCN) and as a steering committee member for the OFC/NFOEC conference. Ori holds a Ph.D. degree from the Technion.

SC420 - Characterization of Components for Coherent Communication Systems NEW

Sunday, 22 March
17:00 - 20:00

Short Course Level: Advanced beginner and Intermediate

Instructor:

Erich Gottwald, Harald Rohde; *Coriant, Germany*

Short Course Description:

Coherent fiber optic communication systems have been widely used in the long haul networks for many years. As they enter the shorter reach network domains, more and more cost sensitive components are becoming available. Requirements differ significantly between components used in coherent systems and in systems using amplitude modulation with direct detection.

This short course provides an in-depth overview of the requirements of common components for coherent communication systems and presents measurement methods of key parameters. Specifically, this course will discuss main laser characteristics and their influence on coherent communication systems; different types of modulators and their suitability for coherent systems; and coherent receivers, their properties and their effects on the overall transmission performance. Main measurement techniques as well as their advantages and disadvantages will be discussed.

As many key properties can only be extracted from measured data by extensive signal processing, measurement methods and accompanying Matlab /Octave scripts will be demonstrated. The respective algorithms and sample Matlab / Octave code will also be provided.

Short Course Benefits:

The course enables the participants to:

- Understand the properties of key optical components for coherent communication systems.
- Measure those properties and to evaluate the results in the right context
- Gain a better understanding of component specifications and can specify components themselves

Short Course Audience:

targets researchers and system designers who want to get a better insight into the depths of component properties and to understand the properties' interdependencies.

Instructor Biography:

Erich Gottwald joined Siemens Central Research Labs for Communication Technology in 1985 and worked on coherent optical transmission systems. He began to work on WDM systems in 1991 and developed the simulation tool for nonlinear fiber optical transmission systems which was the basis of Siemens's first commercial WDM 8/16 channel 10 Gb/s optical systems in the late 90s. In the last years, together with Harald Rohde, he developed an extensive simulation tool for coherent system, which includes every effect and impairment the instructors could think of. Currently, one of his main tasks is the characterization of components for Coriant's coherent communication systems.

Together with Harald Rohde, he received the Fiber to the Home Council Innovations Award 2011 for his work on Ultra Dense DWDM coherent access systems. He has more than 70 publications and holds more than 50 patents.

Harald Rohde worked on simulation of photonic transmission systems since he joined Siemens in 2001 after receiving his PhD in physics. He started to develop and implement his own tools after years of frustration of using commercial simulation tools, which are insufficient for the special needs of the development of a coherent optical access system. Together with Erich Gottwald, he developed a very detailed simulation tool for the coherent system, which includes every effect and impairment the instructors could think of. Currently, he is working on the specification and verification of components for coherent optical communication systems. Together with Erich Gottwald, he received the Fiber to the Home Council Innovations Award 2011 for his work on Ultra Dense DWDM coherent access systems. He has more than 70 publications and holds more than 50 patents.

SC421 - SDN Control Plane for Photonic Systems Related Standards and Architectures

NEW

Monday, 23 March
09:00 - 12:00

Short Course Level: Beginners, with basic understanding in telecommunications and OSS/BSS systems

Instructor:

Bernd Pruessing[1], Karthik Sethuraman[2]; [1] *Coriant, German;* [2]*NEC Corporation of America, USA*

Short Course Description:

The course will give an overview of the current status of SDN with a special focus on Transport SDN and requirements derived from photonic systems. It will cover an overview about current SDN related activities in standardization and explain architectures as well as open source projects.
From business point of view the course will introduce SDN use cases and the business value.

SDN Introduction

- What is SDN?
- Where did SDN come from?
- Why do we need SDN?
- What is different in SDN versus NMS or OSS/BSS?

SDN Overview

- SDN for packet networks
- SDN for transport networks
- Specific requirements for the different transport layers

SDN Architectures

- SDN and standardization
- Overview of SDN architectures & interfaces
- Distributed versus centralized network control
- Network virtualization & abstraction
- SDN, NMS, GMPLS interworking
- SDN and optical network planning
- Multi-layer management
- SDN, NFV and their relation

SDN and open Source

- SDN open source projects
- What does open source mean for real customer deployments?
- Multi-vendor integration via open source projects

SDN Use Cases & Business

- General SDN Use Cases
- Public SDN projects
- What does SDN mean for the existing networks?
- SDN Benefits & Challenges
- Network Migration
- SDN and new business models

Short Course Benefits:

This course will enable you to:

- Explain SDN as a new technology
- Summarize the current state of SDN in the market
- Compare SDN architecture with general NMS/OSS/BSS architectures
- Determine the value of open source projects
- Identify the value of SDN technology for your company

Short Course Audience:

This course is valuable to engineers, technicians and managers interested in a general understanding of SDN with a special focus on transport networks. The course will help to understand SDN from a technology as well as a business related perspective. It will introduce you to the technology of SDN architectures, interfaces and standards and also look at the business aspects of use cases, business value and operational changes.

Instructor Biography:

Bernd Pruessing is Head of Business Development SDN at Coriant. He has over 25 years of experience in the field of telecommunications. With a strong technical background, Bernd drives new ideas together with customers and partners as well as Coriant's R&D to bring advanced products and solutions to market.His current role focuses on SDN technologies and uses case for optical transport networks.Bernd has a degree in Electrical Engineering and background in Business Administration. He holds several patents and has received an award of the Professor- Doehrer-Foundation.

Karthik Sethuraman is Software Architect for IP Optical Development at NEC Corporation of America. He has over 12 years of experience in architecting and designing management and control software for TDM, WDM and packet transport networks. Karthik has been driving SDN for transport for past couple of years and is actively involved in concept and business development at NEC as well as standardization of the technology in ONF and OIF. Karthik has a degree in Computer Science and Engineering and spent his early career in AI research.

SC423 - COHERENT PHOTONIC NETWORKS; HARDWARE, SOFTWARE, AND APPLICATIONS NEW

Sunday, 22 March
13:00 - 16:00

Short Course Level: Advanced Beginner

Instructor:

Mark D. Feuer1; Maurice O'Sullivan2; 1CUNY College of Staten Island, USA; 2Ciena, Canada

Short Course Description:

This course examines hardware and software approaches for coherent photonic networking, including reconfigurable wavelength-routed networks, elastic networks, and software-defined networks (SDNs). Key concepts of photonic networking, including ROADMs (reconfigurable optical add/drop multiplexers), wavelength continuity, and virtual topology are introduced, as are the key benefits and characteristics of coherent optical transmission. The network value of ROADM features such as colorless and directionless add/drop are evaluated through the use of the routing power metric. Building upon that foundation, we explore how coherent systems enhance ROADM node architecture, facilitate spectral efficiency and enable impairment monitoring and compensation through digital signal processing. Network contention, including both inter-node and intra-node contention, is addressed, and various mitigation approaches, including contentionless ROADM designs, are compared. The benefits and challenges of flexible grid networks and software-defined optical transceivers are outlined: although these two innovations are complementary, one does not necessarily imply the other. We will discuss network scenarios that exploit either one or both together, considering full connections that span both long-reach (line-side) and short-reach (client-side) segments. Techniques for optical performance monitoring (OPM) will be discussed, along with OPM's role in photonic network management. We examine the role of wavelength grooming/network defragmentation, and discuss the mechanisms for its implementation. Applications of reconfigurable photonic networks are categorized in terms of their required reconfiguration speed, and technologies

appropriate to each speed regime are identified. Finally, future research directions, including reconfigurable space-division-multiplexing and coherent access networks, are introduced.

Short Course Benefits:

This course should enable you to:

- Define key concepts in photonic networking, including colorless and directionless optical add/drop
- Compare ROADM node designs for coherent and direct-detection systems
- Identify methods by which coherent transmission can enhance spectral efficiency
- List alternatives for contention management
- Explain the benefits and challenges of flexible-grid networks and software-defined optical transceivers
- Discuss the role of network defragmentation in photonic networks
- Compare approaches for optical performance monitoring in coherent and direct-detection networks.
- Identify switching speed requirements of various reconfigurable network services
- Anticipate future network developments in coherent photonic networks.

Short Course Audience:

This course is intended for those interested in flexible coherent optical networks, including network operators, system and subsystem builders, and purchasers of optical network services. Some familiarity with optical network concepts and operation is assumed, as is basic knowledge of coherent optical transmitters and receivers (see for example SC932).

Instructor Biography:

Mark D. Feuer has more than 30 years of experience industrial research at Bell Labs, AT&T Labs, and JDS Uniphase Corp., and is an internationally recognized authority in technologies for photonic networking. He is currently an Associate Professor at the College of Staten Island, a campus of the City University of New York.

For more than 25 years Maurice O'Sullivan has contributed to the design and manufacture of optical fiber and, mostly, the highest capacity long line transmission equipment of its day with emphasis on layer 0. He holds a PhD in Physics from the University of Toronto

INVITED SPEAKERS

TRACK D - OPTICAL COMPONENTS, DEVICES AND FIBER

D1: ADVANCES IN DEPLOYABLE OPTICAL COMPONENTS, FIBERS, AND FIELD INSTALLATION EQUIPMENT

- Atsushi Aratake; *NTT Device Innovation Center, Japan*
  Field Reliability of Silica-based PLC Splitter for FTTH
- Mike Hughes; *US Conec Ltd., USA*
  Multi-fiber Connector Technologies

- Masaki Kotoku; *NTT Device Innovation Center, Japan*
  Compact InP-based Optical Modulator for 100-Gb/s Coherent Pluggable Transceivers
- Daniel Mahgerefteh; *Finisar Corporation, USA*
  Techno-Economic Comparison of Silicon Photonics and Multimode VCSELs
- Fumito Nakajima; *NTT Device Innovation Center, Japan*
  High-Speed Avalanche Photodiode for 100-Gbit/s Ethernet
- Kazuhiro Takizawa; *Fujikura Ltd., Japan*
  Splice-on Connectors: Design, Application and Development Trend
- Akio Tanabe; *Furukawa Electric, Japan*
  The Latest Fusion Splicing Technologies and Applications to FTTx Deployment

D2: PASSIVE OPTICAL DEVICES FOR SWITCHING AND FILTERING

- Joel Carpenter; *University of Sydney, Australia*
  LCOS Based Devices for Mode-division Multiplexing
- Uriel Levy; *Hebrew University of Jerusalem, Israel*
  Atomic Cladding Waveguide
- Jean-François Morizur; *CAILabs, France*
  Efficient Mode-selective Mode Couplers Based on Multi-plane Light Conversion
- Wolfram Pernice; *Karlsruhe Institute of Technology, Germany*
  Diamond-integrated Optomechanical Circuits
- Joyce Poon; *University of Toronto, Canada*
  Integrated Photonic Devices and Circuits
- Richard Soref; *University of Massachusetts System, USA*
  Mid-infrared Photonics
- Ming Wu; *University of California Berkeley, USA*
  Large-Port-Count MEMS Silicon Photonics Switches
- Steven Yerolatsitis; *University of Bath, UK*
  Tapered Mode Multiplexers for Single Mode to Multi Mode Fiber Mode Transitions

D3: ACTIVE OPTICAL DEVICES AND PLATFORMS FOR PHOTONIC INTEGRATED CIRCUITS

- Thomas Baehr-Jones; *California Institute of Technology, USA*
  Silicon Photonics Systems - Nonidealities and Nonlinearities
- Frederic Boeuf; *STMicroelectronics, France*
  Recent Progress on Silicon Photonics R&D and Manufacturing on 300mm Wafer Platform
- Joe Campbell; *University of Virginia, USA*
  Avalanche Photodiodes
- Shigeru Kanazawa; *NTT Device Innovation Center, Japan*
  EADFB Laser Array for 400 GbE and Beyond
- Christian Koos; *Karlsruhe Institute of Technology KIT, Germany*
  Silicon-organic Optoelectronics
- Bert Jan Offrein; *IBM Research GmbH, Switzerland*
  Silicon Photonics for the Data Center
- Petter Westbergh; *Chalmers Tekniska Hogskola, Sweden*
  High Speed and High Temperature operation of VCSELs

- Lars Zimmermann; *Technische Universität Berlin, Germany*
  BiCMOS Silicon Photonics Platform

D4: FIBER AND PROPAGATION PHYSICS

- Gilberto Brambilla; *University of Southampton. UK*
  Selective Excitation of High Order Modes in Few Mode Fibres Using Optical Microfibres
- Nicolas Fontaine; *Alcatel-Lucent Bell Labs, USA*
  Characterization of Space-Division Multiplexing Fibers Using Swept-wavelength Interferometry
- Lars Grüner Nielsen; *OFS Fitel Denmark, Denmark*
  Recent Advances in Low DGD Few-mode Fibre Design, Fabrication, Characterization and Experiments
- Brian J. Mangan; *OFS Laboratories, USA*
  Single Mode Hollow Core Photonic Crystal Fibers
- Tanya Monro; *University of Adelaide, Australia*
  New Trends in Fiber Based Sensors
- Luca Palmieri; *University of Padova, Italy*
  Modal Dispersion Properties of Few Mode Spun Fibers
- Yoshinori Yamamoto; *Sumitomo Electric Industries Ltd., Japan*
  Low Loss and Low Nonlinearity Fibers for Long Haul Transmission

D5: FIBER-OPTIC DEVICES AND SENSORS

- Shaif-Ul Alam; *University of Southampton, UK*
  Recent Progress in the Development of Few Mode Fiber Amplifier
- Fabrizio Di Pasquale; *Scuola Superiore Sant Anna di Pisa, Italy*
  Advanced Coding Techniques for Long-range Raman/BOTDA Distributed Strain and Temperature Measurements
- Julien Fatome; *CNRS University of Burgundy, France*
  All Optical Polarization Control for Telecom Applications
- Jason Moore; *NASA Langley Research Center, USA*
  Shape Sensing using Multi-core Fiber
- Karsten Rottwitt; *Technical University of Denmark, Denmark*
  Challenges in Higher Order Mode Fiber Raman Amplifiers
- Motohide Tamura; *National Astronomical Observatory Japan, Japan*
  Extra-solar Planets Exploration using Frequency Comb

TRACK S - PHOTONIC SYSTEMS AND SUBSYSTEMS

S1: ADVANCES IN DEPLOYABLE TRANSMISSION SUBSYSTEMS AND SYSTEMS

- Andreas Bisplinghoff; *Cisco Optical GmbH, Germany*
  Cycle Slip Tolerant, Differentially Encoded Aware, Soft-Decision FEC
- Annika Dochhan, *ADVA Optical Networking SE, Germany*
  Solutions for 80km DWDM Systems
- Kiyoshi Fukuchi; *NEC Corporation, Japan*
  Practical Techniques for Nonlinear Compensation and Mitigation

- Mitsunori Fukutoku; *NTT Network Innovation Laboratories, Japan*
  Next Generation ROADM Technology and Applications
- Jonas Geyer; *Acacia Communications, Inc., USA*
  Practical Implementation of Higher Order Modulation Beyond 16-QAM
- Lukas Kull; *IBM Research - Zurich, Switzerland*
  Challenges in Implementing High-speed, Low power ADCs
- Bruno Lavigne; *Alcatel-Lucent France, France*
  Practical Aspects of 200G Deployment
- Toshiya Matsuda; *NTT Network Service Systems Laboratories, Japan*
  Operational Issues Facing Commercial Raman Amplifier System: Safety Measures and System Designs
- Glenn Wellbrock; *Verizon Communications Inc., USA*
  The True Value of Flexible Networks

S2: PHOTONIC SUBSYSTEMS FOR DIGITAL SYSTEM APPLICATIONS

- Pierre-Alexandre Blanche; *University of Arizona, USA*
  Fast Non-blocking NxN Opitcal Switch Using Diffractive MOEMS
- Brandon Collings; *JDSU, USA*
  Advanced ROADM Technologies and Architectures
- Yuping Huang; N*orthwestern University, USA*
  Sub-systems for Gb/s Quantum Communications
- Klaus Petermann; *Technische Universität Berlin, Germany*
  Phase-sensitive Optical Processing in Silicon Waveguides
- Thomas Richter; *Fraunhofer Heinrich-Hertz Institut, Germany*
  Generation of Ultra-dense Superchannels using Frequency Conversion in Optical Fibers
- Dries Van Thourhout; *Ghent University, INTEC, Belgium*
  Photonics Subsystems for Optical Packet/Burst Switches Based on Heterogeneous SOI and III-V integration
- Andreas Wiberg; *University of California San Diego, USA*
  Photonic Analog-to-digital Conversion

S3: RADIO-OVER-FIBER, MICROWAVE PHOTONICS, FREE-SPACE, AND ANALOG APPLICATIONS

- Guillermo Carpintero; *Universidad Carlos III de Madrid, Spain*
  Integrated Photonic Transceivers for mm-wave Transmission
- Paolo Ghelfi; *CNIT, Italy*
  Fully Photonics-based Radar Demonstrator: Concept and Field Trials
- Ampalavanapilla Nirmalathas; *University of Melbourne, Australia*
  Photonic Assisted Gigabit Wireless
- Michel Poulin; *TeraXion Inc., Canada*
  Optically Phase-locked Lasers for RF Photonics Applications
- Chris Roeloffzen; *Universiteit Twente, Netherlands*
  Integrated Optical Beamformers
- Juan Jose Vegas Olmos; *Technical University of Denmark, Denmark*
  Reconfigurable Radio-Over-Fiber Networks

- Hejie Yang; *Corning Incorporated, USA*
  Optical Solutions for Mobile Access

S4: DIGITAL ELECTRONIC SUBSYSTEMS AND TRANSCEIVERS

- Sercan Arik; *Stanford University, USA*
  MIMO DSP Complexity
- Liang Dou; *Fujitsu Research and Development Center, China*
  Advanced Digital NL Distortion Compensation
- Chao Lu; *Hong Kong Polytechnic University, Hong Kong*
  Optical Performance Monitoring in DSP-based Coherent Optical Systems
- Jeremie Renaudier; *Alcatel-Lucent France, France*
  1Tb/s Transceivers
- William Shieh; *University of Melbourne, Australia*
  Linearization of Optical Channels with Stokes Vector Direct Direction
- Nebojsa Stojanovic; *Huawei Technologies Co., Ltd., China*
  Clock Recovery in Coherent Optical Receivers

S5: DIGITAL TRANSMISSION SYSTEMS

- Do-Il Chang; *Xtera Communications Inc., USA*
  Unrepeatered High-speed Transmission Systems
- Vittorio Curri; *Politecnico di Torino, Italy*
  HFA Optimization for NyWDM Tranmission
- Toshiaki Koike-Akino; *Mitsubishi Electric Research Labs, USA*
  Coded Modulation Design for Finite-Iteration Decoding and High-Dimensional Modulation
- Takayuki Mizuno; *NTT Network Innovation Laboratories, Japan*
  Dense Space Division Multiplexed Transmission over Multi-core and Multi-mode Fiber
- Danish Rafique; *Coriant GmbH & Co. KG, Germany*
  Fiber Nonlinearity Compensation: Practical Use Cases and Complexity Analysis
- Mark Shtaif; *Tel-Aviv University, Israel*
  The Dynamics of Nonlinear Distortion in Long-haul Transmission System
- Henk Wymeersch; *Chalmers Tekniska Hogskola, Sweden*
  On the Use of Factor Graphs in Optical Communications
- Fatih Yaman; *NEC Laboratories America Inc., USA*
  Bi-directional Transmission to Reduce Linear and Nonlinear Crosstalk

TRACK N - NETWORKS, APPLICATIONS, AND ACCESS

N1: ADVANCES IN DEPLOYABLE NETWORKS AND APPLICATIONS

- Michael Freiberger; *Verizon Communications Inc., USA*
  In-network Experiences with Installing OTN Switched Metro Core Optical Systems
- John Hollingsworth; *IBM TJ Watson Research Center, USA*
  Opportunities for Bandwidth-on-Demand between Large Datacenters
- Itsuro Morita; *KDDI R&D Laboratories, Japan*
  Network Control and Virtualization for Cloud and Mobile Services from Carrier's Point of View

- Toshikazu Sakano; *NTT Network Innovation Laboratories, Japan*
  Movable and Deployable ICT Resource Unit (MDRU) and Resilient Photonic Network
- Yutaka Takita; *Fujitsu Labs. Ltd., Japan*
  Agile Network Re-optimization Supporting Seamless Service Migration
- Vijay Vusirikala; *Google, USA*
  Google's Vision of the Next-gen Optical Network

N2: DYNAMIC SOFTWARE CONTROLLED AND MULTILAYER NETWORKS

- Dean Bogdanovic; *Juniper Networks Inc., USA*
  Autonomic Agent for Transport Networks
- Mazen Khaddam; *Cox Communications, Inc., USA*
  The Benefits of Optimization in Multilayer SDN Transport Networks
- Reza Nejabati; *University of Bristol, UK*
  SDN and NFV Convergence a Technology Enabler for Abstracting and Virtualising Hardware and Control of Optical Networks
- Vishnu Shukla; *Verizon Communications Inc., USA*
  SDN Transport Architecture and Challenges
- Atsushi Takahara; *NTT Device Innovation Center, Japan*
  Software-Defined, Virtualized Networking and Beyond 100G

N3: NETWORK ARCHITECTURES, TECHNO-ECONOMICS, AND DESIGN TRADEOFFS

- Gordon Brebner; *Xilinx, USA*
  Programmable Hardware for High Performance "Softly" Defined Networking
- Konstantinos Christodoulopoulos; *Department of Computer Engineering and Informatics, University of Patras, Greece*
  Elastic Bandwidth Allocation Algorithms
- Stéphane Gosselin; *Orange Labs, France*
  Fixed and Mobile Convergence: Which Role for Optical Networks?
- Matthias Gunkel; *Deutsche Telekom AG Laboratories, Germany*
  Elastic Black Link for Future Vendor Independent Optical Networks
- Hiroshi Hasegawa; *Nagoya University, Japan*
  Large Scale Optical Cross-connect: Architecture, Performance Analysis, and Feasibility Demonstration
- Rosanna Pastorelli, *Cisco Systems, Inc., Italy*
  Network Planning Strategies for Flexible Optical Networks
- João Santos; *Coriant Portugal, Portugal*
  Evaluating the Potential for Spectrally-Efficient Super-Channel Formats in Brownfield Networks with Legacy Services
- Marco Schiano; *Telecom Italia Lab, Italy*
  Flexible Node Architectures for Metro Networks

N4: OPTICAL ACCESS SYSTEMS AND WIRELESS BACKHAUL NETWORKS

- Silvio Abrate; *Istituto Superiore Mario Boella, Italy*
  Silicon Photonics and FDMA PON: Insights from the EU FP7 FABULOUS project

- Romain Brenot; *Alcatel-Thales III-V Laboratory, France*
  Demystification of Self-seeded WDM Access
- David Hillerkuss; *ETH Zurich, Switzerland*
  Software-defined Transceivers for Dynamic Access Networks
- Noriko Iiyama; *NTT Access Network Service Systems Laboratories, Japa*n
  Advanced DSP for Optical Access Networks: Challenges and Opportunities
- Jesper Jensen; *DTU Fotonik, Denmark*
  VCSELs for Coherent PON
- Fumio Koyama; *Tokyo Institute of Technology, Japan*
  Energy Efficient Tunable Light Sources for Next Generation Flexible Access Networks
- Thomas Pfeiffer; *Alcatel-Lucent, Germany*
  Next Generation Mobile Fronthaul Architectures
- Josep Prat; *Universitat Politecnica de Catalunya, Spain*
  Technologies for a Cost-effective Coherent udWDM-PON
- Keiji Tanaka, *KDDI R&D Laboratories, Japan*
  Next-Generation Optical Access Networks for C-RAN

DSN6: Optical devices, subsystems, and networks for Datacom and Computercom

DSN6: OPTICAL DEVICES, SUBSYSTEMS, AND NETWORKS FOR DATACOM AND COMPUTERCOM

- Stuart Elby; *Infinera Corporation., USA*
  Migration Services to the Cloud and its Impact upon the Carrier Network
- Frank Flens; *Finisar Corporation, USA*
  Optical Transceiver Packaging
- David Lariviere; *Columbia University, USA*
  Technology Trends to Speed up the Delivery of Wall Street Data
- David Maltz; *Microsoft, USA*
  SDN and Routing Strategies for Cloud-Scale Data Center Traffic
- Cyriel Minkenberg; *IBM Research, Switzerland*
  Optical Networking for Data-Centric Systems
- Matthew Sysak; *Intel Corporation, USA*
  Intel®'s Silicon Photonics on an Advanced Manufacturing Platform
- Ryo Takahashi; *NTT Device Innovation Center, Japan*
  Data Center Networks based on Optical Packet Switching with Flow Control
- Jason Taylor; *Facebook Inc., USA*
  Facebook's Data Center Infrastructure: OpenCompute, Disaggregated Rack, and Beyond

TUTORIAL SPEAKERS

Track D - Optical Components, Devices and Fiber

D1: ADVANCES IN DEPLOYABLE OPTICAL COMPONENTS, FIBERS, AND FIELD INSTALLATION EQUIPMENT

- **Raman Amplification: An Enabling Technology for High-Capacity, Long-Haul Transmission**
  Wayne Pelouch
  Xtera Communications Inc, USA

D2: PASSIVE OPTICAL DEVICES FOR SWITCHING AND FILTERING

- **Femtosecond Laser Inscribed Waveguides for New Optical Circuit Applications**
  Peter Herman
  University of Toronto, Canada

D3: ACTIVE OPTICAL DEVICES AND PLATFORMS FOR PHOTONIC INTEGRATED CIRCUITS

- **Silicon Photonics**
  John E. Bowers
  University of California Santa Barbara, USA

D4: FIBERS AND PROPAGATION PHYSICS

- **Propagation Effects in SDM Fibers**
  Antonio Mecozzi
  University of L'Aquila, Italy
- **Multicore Fiber Technology**
  Kunimasa Saitoh
  Hokkaido University, Japan

D5: FIBER-OPTIC DEVICES AND SENSORS

- **Biomedical Fiber Optic Sensor Applications**
  Alexis Mendez
  MCH Engineering, LLC, USA

TRACK S - PHOTONIC SYSTEMS AND SUBSYSTEMS

S1: ADVANCES IN DEPLOYABLE TRANSMISSION SUBSYSTEMS AND SYSTEMS

- **Design Trade-offs in Practical ASIC Implementations**
  Oscar E. Agazzi
  ClariPhy Communication, Inc., USA

  Power Efficient Implementation of Soft-Decision FEC
  Sameep Dave
  ViaSat Inc., USA

S2: PHOTONIC SUBSYSTEMS FOR DIGITAL SYSTEM APPLICATIONS

- **Phase Sensitive Amplifiers and their Applications**
  Francesca Parmigiani
  University of Southampton, UK

S3: RADIO-OVER-FIBER, MICROWAVE PHOTONICS, FREE-SPACE, AND ANALOG APPLICATIONS

- **Visible Light Communication**
  Harald Haas
  University of Edinburgh, Scotland

S4: DIGITAL ELECTRONIC SUBSYSTEMS AND TRANSCEIVERS

- **Optical Coherent Communication Technology**
  Kazuro Kikuchi
  University of Tokyo, Japan
- **Role of Information Theory in Coherent Optical Transmission Systems**
  Frank Kschischang
  University of Toronto, Canada

S5: DIGITAL TRANSMISSION SYSTEMS

- **High-Capacity Submarine Transmission Systems**
  Alexei N. Pilipetskii
  TE SubCom, USA
- **400G and 1Tb/s Single-carrier Systems**
  Gregory Raybon
  Alcatel-Lucent Bell Labs, USA

TRACK N - NETWORKS, APPLICATIONS, AND ACCESS

N1: ADVANCES IN DEPLOYABLE NETWORKS AND APPLICATIONS

- **SDN Control of Packet-over-optical Networks**
  Guru Parulkar; *Stanford University, USA* and Tom Tofigh; *AT&T Labs, USA*

N2: DYNAMIC SOFTWARE CONTROLLED AND MULTILAYER NETWORKS

- **Control Architectures for Multi-layer Networking: Distributed, centralized, or something in between?**
  Ori Gerstel;
  Sedona Systems, Israel

N3: NETWORK ARCHITECTURES, TECHNO-ECONOMICS, AND DESIGN TRADEOFFS

- **Ethernet and OTN: 400G and beyond**
  Steve Trowbridge
  Alcatel-Lucent, USA

N4: OPTICAL ACCESS SYSTEMS AND WIRELESS BACKHAUL NETWORKS

- **OFDM for Optical Access**
  Christian Ruprecht and Johannes von Hoyningen-Huene
  Christian-Albrechts Universität zu Kiel, Germany

DSN6: OPTICAL DEVICES, SUBSYSTEMS, AND NETWORKS FOR DATACOM AND COMPUTERCOM

DSN6: OPTICAL DEVICES, SUBSYSTEMS, AND NETWORKS FOR DATACOM AND COMPUTERCOM

- **High Speed Circuits for Optical Communications**
  Alexander Rylyakov
  IBM TJ Watson Research Center, USA

WORKSHOPS

OFC Workshops provide opportunities to discuss and debate the latest technologies.

Workshop topics are controversial in nature and meant to be highly interactive, amongst both the speakers and the audience. The format of each session is determined by the organizers. In the past, many workshops have consisted of a series of short presentations (5 to 10 minutes) from people involved in the field followed by a panel discussion driven by questions from the audience.

The workshops provide an interactive learning environment and are open to all conference registrants. Like invited and tutorial speakers, workshop topics and organizers are chosen through a highly selective nominations process.

DO SMALL, LARGE, AND MEGA DATA CENTERS NEED ADVANCED PHOTONICS TECHNOLOGY?

Monday, March 23, 2015
9:00 AM - 12:00 PM

Organizer:

Rich Baca; *CommScope, Inc., USA*; Nicola Calabretta; *Technische Universiteit Eindhoven, Netherlands*; Mark Feuer; *CUNY College of Staten Island, USA*; Adel Saleh; *University of California Santa Barbara, USA*

Description:

In today's data centers (DC), photonics technology is largely limited to point-to-point, fiber-optic links interconnecting servers, storage devices and electronic packet switches. This workshop will examine and debate how (and whether) the flexibility, security, scalability, cost, and energy efficiency of DC of various sizes would benefit from advanced photonics technology (e.g., PIC or silicon photonics integration, WDM or SDM technology, optical circuit switching, optical burst or packet switching, photonic processing, etc.). Will the fundamental architecture of the DC change? Should photonics-switching-based solutions support SDN control? While the answers to these questions may depend on the DC size, is it possible to identify common photonic technologies besides those of today's point-to-

point links that could benefit DC of all sizes? Or will solutions be fragmented with some choosing the status quo?

Speakers:
Future Data Centers Don't Need Photonics, Unless ..., Al Davis; *HP Laboratories, USA*

Can Optical Switches Penetrate into Future Datacenter Networks?,
Harm Dorren; *Eindhoven University of Technology, Netherlands*

Small is Copper and Large is Optical, Scott Kipp; *Brocade, USA*

Why DC Network Requires OCS as well as OPS, Ken-Ichi Kitayama; *Osaka University, Japan*

The Value of Photonics in Next-gen Data-center Networks, Beyond Optical Interconnects, Loukas Paraschis; *Cisco, USA*

Overwhelming Economic Benefits of the Use of Optical Circuit Switches in Data-Center Networks, Atiq Raza; Calient Technologies, USA

The Growing Role of Optics in Data Centers: Next Generation Requirements and Vision for Advanced Photonics, Katharine Schmidtke; Facebook, USA

Enabling Highly Programmable Optical Data Centres, Dimitra Simeonidou; University of Bristol, UK

Format: The workshop will bring panelists having the full gamut of data center perspectives to present their opinions. Panelist presentations will be limited to a few slides each to allow for a rich follow-up participation by the audience. In addition to asking questions of the panelists, audience members are encouraged to present their own opinions, which can include one slide submitted to the organizers in advance of the workshop.

FLEXIBLE OPTICAL NETWORK, TECHNOLOGY IS READY, BUT...

Sunday, March 22, 2015
3:30 PM - 6:30 PM

Organizer:

Tiejun (T.J.) Xia; *Verizon, USA*; Alan Pak Tao Lau, *Hong Kong Polytechnic University, Hong Kong*; Steve Plote, *BTI Systems, USA*

Description:

Colorless and Directionless (CD) and even Contentionless (CDC) ROADM designs are getting mature; flexible spectrum arrangement is standardized; path adaptive and bit-rate adaptive transceivers are rolling out; and concept of elastic optical network is well received. However, are the network operators ready to take full advantages of the next generation

routing/bandwidth/data-rate flexible optical layer functions? If the answer is “Yes”, what are the main drivers and applications and where are the first implementations? If the answer is “No”, what are the crucial hurdles and hesitations? Do we still need more technical advances to enable a higher degree of flexibility and make elastic optical network even more attractive? This workshop has a full spectrum of panelists, including network operators, system manufacturers, component developers and academics to answer questions you may have in this field, whether they are technical or economical.

Speakers:
Flexible Network: Technology is Ready, Deployment is on the Way, Yiran Ma; China Telecom, China

Use Cases for Practical and Fully Managed CD and CDC Deployments, Robert Keys; BTI, USA

Agile Photonic Switching Applications, Glenn Wellbrock; Verizon, USA

Dynamic Optical Layer, Juan Pedro Fernández-Palacios Giménez; Telefonica, Spain

Leveraging CDC ROADMs to Address Unpredictable Network Growth, Satyajeet Ahuja; Facebook, USA

CDC ROADM with Minimum EDFAs, Winston Way; Neophotonics, USA

Application of the CDC ROADM-based WDM Network, Noboru Yoshikane; KDDI, Japan

SILICON PHOTONICS: IS IT STILL IN HYPE OR ON ITS WAY TO THE FIELD?

Sunday, March 22, 2015
3:30 PM - 6:30 PM

Organizer:

Daniel Kuchta; *IBM T. J. Watson Res. Center, USA*; Ken Morito; *PETRA/Fujitsu Labs., Japan;* Jonathan Klamkin; *Boston University, USA*; Po Dong; *Bell Labs, Alcatel Lucent, USA*

Description:

WDM and large-scale integration are often perceived as technology advantages for silicon photonics over VCSELs and other photonic technologies. However, after intensive developments from both universities and companies, there still exist significant challenges to implement silicon photonics as a low-cost, or even low power, solution for optical communications. Fabrication variations and thermal issues, which are often overlooked for silicon photonics, may be a significant obstacle for WDM and dense integration. Although silicon photonics is gearing to make a major impact on telecommunications, there are few

examples demonstrating true scalability of this technology where WDM and/or closely spaced integrated channels are operating simultaneously and it is not clear that this technology will reach the level of performance demanded by data centers and high performance computing. Other significant technical challenges include low-cost laser integration, efficient and compact modulators, low-loss optical I/O, and polarization-insensitive receivers. Another issue is the lack of standardization of the silicon photonics platform. Currently, there are too many platforms and technologies: various silicon on insulator (SOI) substrates, diverse light source solutions, different optical I/Os, dissimilar wavelength bands, and different packaging. As an example consequence, incompatible MSAs are applied to the same 100GbE CLR4 application.

This workshop will attempt to answer the following questions:

- Will fabrication variations and thermal issues kill WDM silicon photonic transceivers? Can DWDM or even CWDM be realized in monolithic silicon photonic circuits?

- Can on-chip lasers perform at high temperature, low power and low cost? Is the requirement for packaging or hybridization of lasers on silicon too expensive?
- Is large scale electronic-photonic integration a pipe dream given thermal crosstalk and power dissipation issues?
- Expectations are that Silicon Photonics technology will be compact and low power but the current solutions are far from this. What will it take to realize large scale integration with high channel density and good signal integrity? Can 2.5D or 3D packaging help in this regard?
- For what applications can silicon photonics realistically compete with current solutions? Mega datacenters, coherent, backplanes, chip-to-chip?

Speakers:
Kenji Sato; *NEC, Japan*
Greg Fish; A*urrion Inc., USA*
Chris Doerr; *Acacia Communications Inc., USA*
Chris Cole; *Finisar Corporation, USA*
Arlon Martin*; Mellanox, USA*
Matt Traverso; *Cisco, USA*

Format:
The workshop is intended to be interactive with the audience. To stimulate discussion there will be presentations from at least 6 panelists from Industry. After the third panelist and the last panelist, a volunteer from the audience will be selected to contribute a 5 minute rebuttal or counter point to the conversation.

ARE THERE LIMITS TO HIGH-SPEED INTERFACE RATES?

Monday, March 23, 2015
9:00 AM - 12:00 PM

Organizer:

Sebastian Randel; *Alcatel-Lucent Bell Labs, USA*; The'linh Nguyen; *Finisar Corporation, USA;* Ali Ghiasi; *Ghiasi Quantum LLC, USA*; Michael Sprenger; *Optical Technologies CableLabs, USA*; Takashi Saida; *NTT Photonics Laboratories, Japan*

Description:

In this workshop, we will discuss how emerging applications are driving the need for higher interface speeds and if there are any fundamental limits that might limit the doubling of I/O BW every 4-5 years. We will bring together key players from industry and academia to cover a wide range of application areas:

<=100m ComputerCom (Switch and processor modules)
<=1km Intra Data Centers
<=10km Short Reach Interconnects
<=100km Medium Reach
<=1000km Metro Networks
>=1000km Long-Haul Networks

Even though the above application scenarios dictate considerably different space/price/power requirements, they are all concerned with finding the right trade-off between parallelism, serial bandwidth, and advanced modulation/equalization.

For example, currently being discussed in the field of short reach interconnects industry is he right approach towards 100G in CFP2/CFP4 and QSFP28 modules. Proposals include 4x25G NRZ and 50 Gb/s NRZ, plus Higher Order Modulation (HOM) based on 50 GB/s PAM-4, 100 Gb/s PAM4, or 100 Gb/s DMT. What if we look even further ahead: are there limits for 400G/1T links? The winner will probably be the solution that offers the best tradeoff between component cost, power, and parallelism. What are the trade-offs in terms of integration technologies (stay with pluggable module, one board optics PIC, or integrate PIC into ASIC)? How much can we improve thermal designs?

In long-haul, coherent 100G is already widely applied on a single carrier and 400G/1T superchannels have been demonstrated. The question arises whether 1Tb/s single carrier systems, i.e., systems where 1 Tb/s is generated using a single PDM-I/Q-modulator, will ever become commercial reality? Can we allow for even higher-order modulation formats with an improved link design (better fibers, Raman amplifiers, cabling and connector techniques)?

In intra DC and on-board applications; VCSEL arrays with a large spatial multiplex are already widely used with speeds moving from 10 Gb/s to 25 Gb/s. As we move from 25 Gb/s NRZ to 50 Gb/s NRZ or HOM, integration densities could be limited by crosstalk between lanes. The question arises whether we can increase serial speeds to 50 Gb/s and beyond while keeping the integration densities. As we migrate from NRZ to HOM, how will the TOSA and driver that is integrated with linear interface maintain high density?

Speakers:

How Server Designs will Change as Interface Bandwidth Demands Continue to Increase, Dan Dreps; *IBM, USA*

Breaking the Chip I/O Barrier using On-chip Parallel Optics: The Enabler for Multi Petabit Scale Data Center, Kobi Hasharoni; C*ompass EOS, USA*

VCSEL for Data Rates Beyond 28Gb/s, Jim Tatum; *Finisar, USA*

Silicon Photonics with Hybrid Integration for Optical Interconnect, Yasuhiko Arakawa; *The Univ. of Tokyo/PETRA, Japan*

Need for Speed - from Data-Centers to Long-Haul, Wendy Zhao; *Google, USA*

DSP Techniques Leverage Moore's Law to Cost Effectively Scale Datacenter Interconnects, Sudeep Bhoja; *InPhi, USA*

Is APD the Future?: How to Break through Responsivity-Bandwidth Limit of Optical Receivers, Masahiro Nada; *NTT, Japan*

Enabling Cost Effective Terabits Connectivity for Intra- Data Center optical links using with Quantum Dot Laser and Silicon Photonics Technologies, Jeff Hutchins; *Ranovus, Canada*

Increasing the Network Bandwidth with PSM4 and 100 Gb/s PAM4, Brian Welch; *Luxtera, USA*

A/D and D/A Converters for Future Generations of Multicarrier Optical Networks, Ian Dedic; *Fujitsu, UK*

Towards Terabit/s Serial Optical Interfaces, Greg Raybon; *ALU, USA*

Optical Superchannels to extend beyond 100 Gb/s, Steve Grubb; *Infinera, USA*

Format: Speaker slots will be in the range of 15 minutes where each speaker should leave at least 50% of his or her time for discussions.

ARE ACCURATE REAL-TIME PLANNING TOOLS FOR PHYSICAL-LAYER SYSTEM PERFORMANCE POSSIBLE?

Sunday, March 22, 2015
3:30 PM - 6:30 PM

Organizer:

Annalisa Morea; *Bell Labs, Alcatel Lucent, USA;* Fabrizio Forghieri; *Cisco, Italy*; Oleg Sinkin; *TE SubCom, USA;* Robert Doverspike; *AT&T, USA*

Description:

This workshop is aimed to contrast recent results on modeling techniques for fiber transmission and stimulate discussion on their application to DWDM coherent dynamic meshed networks.

Models based on Gaussian Noise approximation of the nonlinear interaction have recently proven to be a reliable performance estimator for coherent systems over dispersion-uncompensated links. Such models can accurately reproduce experimental results with drastically faster computation times, and be used in network planning tools where the feasibility of connections has to be quickly assessed during dynamic traffic provisioning or restoration.

Different modeling approaches and their application to manage real-time dynamic networks will be discussed and compared, with the objective to determine if this is indeed the last missing piece to the puzzle of DWDM Software Defined Networks.

Part I: Is Accurate and Fast Modeling of Nonlinear Propagation forDWDM Coherent Systems finally possible?

In Part I, analytical models of fiber transmission for fast performance evaluation will be compared and their trade-offs between accuracy and complexity/computational speed will be discussed. Experimental verification and comparison vs. “classic” split-step numerical simulations to assess accuracy and application to “legacy” dispersion-managed transmission systems will also be discussed.
Part I of this workshop will address the following topics:

- How come that when we share information with each other we end up exchanging “white noise”? How can different modulation schemes be accounted for?

- Theories are elegant on paper. Do they get ugly in real applications? Are there tricks to address practical issues (e.g. gain shape evolution, mixed fibers, Raman amplification, signal-ASE four wave mixing,…) or are they deal breakers?

- How can we model DSP algorithms, SD-FEC and transponders without being privy to the chip manufacturers' secrets?

- Are new analytical models accurate and general enough to replace full numerical simulations? Will split-step simulations ever have a chance for "real-time" applications using parallel graphics computing?

- Is there a "right way" to model fiber transmission for real-time applications? Can we converge to a standard modeling approach?

Speakers:
Antonio Mecozzi; *Universita' dell'Aquila, Italy*
Lee Richardson; *TE SubCom, USA*
Pierluigi Poggiolini; *Politecnico di Torino, Italy*
Paolo Serena; *Universita' di Parma, Italy*

Part II: How to use/apply Physical Layer Modeling in Network Design and Real-time Network Management?

Planning tools can be divided into two categories: off-line and on-line. Off-line planning tools are used to dimension a network before its deployment; thus an accurate physical estimator is needed, to avoid network over-dimensioning, excessive regenerator requirements, and achieve cost-efficient networks. On-line planning tools, instead, are used in automatically reconfigurable networks thanks to GMPLS- or SDN-based control and management functions. In this scenario the main constraint is the connection set-up time and requests for diverse paths. Part II of this workshop will address the following topics:

- Are there models that can be used in real time applications (i.e. for restoration/upgrade/dynamic networking)? If so, are they accurate enough?
- How do Gaussian models cope with the heterogeneity of a mesh network?
- How do real-time propagation models adapt to a mesh environment?
- Are there specific requirements for standardization to allow alien wavelength and agnostic (vendor-independent) network management and performance monitoring?
- Can assessment of optical loss/impairment characteristics for wavelength assignment and regenerator placement be performed in real time for provisioning of links between ROADMs, as well as circuits that transit these ROADM links?
- Will future SDN capability be useful to more dynamically calculate circuit paths and satisfy needs for diverse path calculations in carrier networks? Note that Shared Risk Link Group (SRLG) (e.g., fiber span) information is almost universally maintained by carriers offline inventory systems - not computable by vendor products.

Speakers:
Rosanna Pastorelli; *Cisco Systems, Italy*
Vladimir Grigoryan; *Ciena, USA*

Pete Magill; *Coriant, USA*
Xiang Zhou; G*oogle, USA*
Jean-Luc Augé; *Orange Labs, FT, France*
Achim Autenrieth; *ADVA, Germany*
Akira Hirano; *NTT Labs, Japan*

WHERE WILL THE REAL VALUE OF SDM RESEARCH BE REALIZED FIRST? WILL IT BE IN TELECOM OR NON-TELECOM APPLICATIONS?

Monday, March 23, 2015
9:00 AM - 12:00 PM

Organizer:

Thierry Taunay; *OFS Laboratories, USA*; Kazuhide Nakajima; *Nippon Telegraph & Telephone Corp, Japan*; Victor Kopp; *Chiral Photonics Inc. , USA*; *David Neilson; Bell Labs, Alcatel-Lucent, USA*

Description:

In recent years, space division multiplexing (SDM) technology has been widely explored through numerous research activities and has seen significant technical advances. Based on these research achievements, several new concepts have been proposed for telecom and non-telecom applications.

In this workshop we will discuss the possible applications or developments based on SDM and its technologies, in support of telecom/datacom and also non-telecom applications, with the goal of identifying the best possible use of these technologies and how they compare with existing alternative technologies. Potential topics include:

- Applications of few/multi-mode fibers (MDM, imaging, sensors)
- Applications of multicore fibers (SDM, 3D shape sensing, position sensors)
- SDM switch designs and their application in optical networks
- Applications and value proposition of multichannel amplifiers
- Adiabatic mode-couplers for single mode performance for multimode fibers, mode MUXs, astronomy, pump-laser combiners

This workshop will attempt to answer the following questions:

- What are the advantages/disadvantages of using SDM technology?
- Is there an economical advantage in using SDM technology?
- How will SDM technology evolve in the telecom and non-telecom fields?
- When will SDM technology be really needed?
- Which subsystem is likely to be the hardest obstacle for the widespread adoption of SDM technologies?
- Are there any SDM technology components that are common to both telecom and non-telecom applications?

- Are the SDM technologies developed for telecom and non-telecom complementary?
- Are any standardization efforts necessary for the applications?

PART I: APPLICABILITY OF SDM TECHNOLOGIES FOR TELECOM AND NON-TELECOM FIELDS

Application and Expectation for SDM Technologies, David Richardson; *University of Southampton, UK*
SDM Technology for Super Computer/LAN Network, Marc A. Taubenblatt; *IBM, USA*
SDM Fibers in High-capacity Inter-datacenter Networks, Vinayak Dangui; *Google, USA*
SDM Media for Sensing Application, Brian J Soller; *Luna Innovations Incorporated, USA*

PART II: TECHNICAL ASPECTS OF SDM TECHNOLOGIES FOR REAL APPLICATION

FBG and SDM Technologies for Non-telecom Application, Patrick Hon Man Chan; *NASA, USA*
SDM Technologies for Real Application, Ton Koonen; *Technische Universiteit Eindhoven, Netherlands*
SDM Technologies Required for Real Use in Telecom Network, Takashi Matsui; *NTT, Japan*
Development of SDM Fibers, Doug Butler; *Corning Inc., USA*

BEYOND THE HYPE: HOW REALISTIC ARE CLAIMS OF BENEFITS FROM SDN CONTROL IN CARRIER METRO NETWORKS?

Monday, March 23, 2015
9:00 AM - 12:00 PM

Organizer:

Mehran Esfandiari; *AT&T Corp., USA;* Dominique Verchere; *Bell Labs, Alcatel-Lucent, France*

Description:

The Packet/Optical Metro networks are undergoing challenging evolutions to support the requirements of existing and emerging cloud services. These services require many infrastructure deployments of servers and storage capabilities as “datacenters” in the network Central Offices. Furthermore, in today’s metro carrier infrastructures, the data switching networks (i.e. IP/MPLS, Ethernet) and the optical transport networks (i.e. OTN including WSS and ROADM) are installed, interconnected, and manually provisioned. They are mostly controlled independently.

Software Defined Networking (SDN) proposes to integrate the network control functions and to centralize their execution in order to remotely control heterogeneous node equipments. Many in the industry claim that SDN can drive down costs by automating much of the packet forwarding and optical-transmission provisioning processes in carrier metro networks and enable adding new services.

This workshop will challenge the speakers to address the following:

- What are the drivers for SDN control deployments in carrier metro networks?

- Compare SDN control and management functions to existing distributed control plane, centralized network management.
- How realistic is a unified multi-layer data model allowing the control and provisioning of services?
- Which SDN functionality is effectively implemented today? How are the SDN promises realizable for future cloud services?
- How can we quantify the gains of current/future SDN control solutions? Can SDN provide any real capital or operations cost savings?
- How does SDN interwork with current OSS/BSS? How to migrate operational networks towards SDN control - how does SDN get a foothold? Are there roadmaps for increasing SDN functionality in carrier grade networks?
- What are the next steps the R&D community should envision for missing/still to be developed SDN features?

Speakers:
Application-based Network Operations (ABNO/IETF) approach for carrier Software Defined Networking, Juan Pedro Fernandez-Palacios Gimenez; *Telefónica I+D, Spain*

NFV and Transport SDN Orchestration: Possible Use Cases and Issues Toward Commercialization, Wataru Imajuku; *NTT Network Innovation Laboratories, Japan*

The Potential of SDN for Planning and Provisioning Carrier Metro Networks, Bob Doverspike; *AT&T Labs, USA*

Flexible Service Programming in Access and Metro Networks: Examples and Use-cases, Andreas Gladisch; *Deutsche Telekom AG T-Labs; Germany*

SHORT REACH OPTICAL NETWORKS HIGHLY SYNERGISTIC OR DIFFERENT WORLDS?

Sunday, March 22, 2015
3:30 PM - 6:30 PM

Organizer:

Peter Vetter; *Bell Labs, Alcatel-Lucent, USA;* David Piehler; *Fields and Waves, USA*; Anna Tzanakaki; *University of Bristol, UK;* Neda Cvijetic; *NEC Labs America, USA*

Description:

In this workshop, we will discuss commonalities and differences of short reach optical technologies for access, mobile fronthaul/backhaul, data center, and in-building networks. Emerging short reach applications require high speed with low latency and low power consumption at an exceptionally low cost. It is well known that volume drives cost reduction. Are these requirements sufficiently common to consider similar system and/or device approaches? Or are the requirements for these short-reach application spaces irreconcilable with common technology platforms?

Topics to be discussed:

- What architectures drive technical requirements for high-speed access networks, mobile Xhaul, data center, and in-building networks?
- Are there opportunities for common high-speed modulation (e.g. PAM, DMT, OFDM) and multiplexing (e.g. wavelength, space, fiber-direction) techniques in these different short reach applications?
- Will innovation in high-speed PON access technology find new uses in mobile Xhaul, data centers, or even in building LAN?
- Will SDN control in data centers also cause a paradigm shift for the flexible configuration of access and other networks?
- Will radio fronthauling use the same digital or analog approaches for the access or in-building networks?
- Monolithic or hybrid optical integration was long ago predicted to be critical to economic success of (high-volume, low-cost) access networks. Today discrete, TO-can technology dominates the single-mode short-reach optics. Will any of these applications lead to an end of TO-can domination?
- Can common component technologies be leveraged to drive volumes? Can advances in the performance for data center and mobile benefit the optical access or in building space? Which application has the dominate volumes and pull the others along?

PANEL 1: ARCHITECTURE AND REQUIREMENT PERSPECTIVE ON SHORT REACH OPTICAL NETWORKS

Datacenter Architectures, Laurent Schares; *IBM, USA*
Datacenter Architectures and Optical Technology Requirements, Craig Thompson; *Finisar, USA*
Access Network for High Speed Applications and Mobile Xhaul, Philippe Chanclou; *Orange Lab, France*
Access Network for 5G xHaul - Architectures and Optical Technology Requirements, Fabio Cavaliere; *Ericsson, Italy*
Building Network Architectures and Requirements, Mike Sauer; *Corning, USA*

PANEL 2: TECHNOLOGY PERSPECTIVE ON SHORT REACH OPTICAL NETWORKS

DMT for High-speed Networks in Access and Data Centers, Tomoo Takahara; *Fujitsu, Japan*
Advanced Modulation Formats for 100G and Beyond Short-reach Optical Networks, Jose Estaran; *DTU, Denmark*
Fronthaul: Analog RoF or Generic Digital Short Reach Technology?, Ton Koonen; T*U Eindhoven, Netherlands*
Role of SDN and switching technologies across short-reach segments, Kostis Kanonakis; *NEC Labs, USA*
Commonalities in Non-planar Component Technologies: Opportunity to Drive the Volumes?, Mitch Fields; *Avago, USA*

HIGH CAPACITY, SCALABLE AND ENERGY-EFFICIENT NETWORKS: AN ACHIEVABLE GOAL OR AN OXYMORON?

Monday, March 23, 2015
9:00 AM - 12:00 PM

Organizer:

Kerry Hinton; *University of Melbourne, Australia;* Rod Tucker; *University of Melbourne, Australia*

Description:

Demands for increasing network bandwidth and constraints on CAPEX and OPEX are pushing the need for improved network flexibility, scalability, and energy efficiency. But can all of these goals be achieved simultaneously? Will the a move to software-defined networking, network function virtualisation and advanced modulation and switching formats lead to poorer energy efficiency? Will increasing energy costs drive up OPEX to a point where network growth becomes constrained? The goal of this workshop is to explore the tradeoffs between scalability, capacity, flexibility and energy consumption in advanced optical networks.

Some issues:

- Will software-defined networking and network function virtualisation impact the energy consumption of the network?
- Packet switching is a key enabler of network scalability, but it is not energy efficient. Is it possible to move away from packet switching, but retain its flexibility and scalability?
- Advanced modulation formats with high spectral efficiency have poorer energy efficiency than simpler formats. Will this become a problem in future networks?
- Access networks and in-home networks are significantly less energy efficient than optical core networks. Can optical technologies be used to improve the energy efficiency of networks close to the user?
- The move toward load proportionality (equipment idle power close to zero) continues to be a challenge. What are the prospects of load proportionality in optical network equipment?
- As use-phase energy efficiency improves, embodied energy becomes increasingly significant. What opportunities are there to improve embodied energy efficiency of optical network equipment?

Speakers:
Virtualization and the Impact on Network Power Efficiency, Vishnu Shukla; *Verizon, USA*
Energy Efficiency Improvements for Optical Access Networks Studied in GreenTouch, Prasanth Anthapadmanabhan; *Alcatel-Lucent, USA*
The Challenging Road to Load Proportionality, Mario Pickavet; *University of Gent, Belgium*
Long-term Prediction of Energy Consumption of the Internet and a Road to the Ultimate Optical Path Network, Kiyo Ishii; *AIST, Japan*
How SDN Can Improve the Cost, Energy Consumption and Scale of Packet Networks, Ore Gerstel; *Sedona Systems, Israel*
Energy-efficiency in Communication Networks: Have we Overlooked the Embodied Energy, Chien Chan; *University of Melbourne, Australia*

PANELS

The panels provide an interactive learning environment and are open to all conference registrants. Like invited and tutorial speakers, panel topics and organizers are chosen through a highly selective nominations process.

FTTH Indoor Optical Fiber Installation Technologies

Thursday, March 26, 2015
8:00 AM - 10:00 AM

Organizer:

Robert Lingle; OFS, USA

Description:

Moderator: John George; *OFS, USA*

Fiber is moving inside both homes and office buildings in the current wave of Gigabit PON roll out. The conflicting goals of fast installation for labor savings and aesthetics inside the home or office have brought indoor installation technologies to the forefront of practical fiber optics technology. This panel will explore both carrier experience and requirements as well as available solutions.

Speakers:
David Chen; *Verizon, USA*
Robert Mapes; *AT&T, USA*
Philippe Chanclou; *Orange Labs, France*
Kiyoshi Omoto; *NTT Access Service Systems Laboratories, Japan*

Optics in Access: Technology and Standards

Tuesday, March 24, 2015
2:00 PM - 4:00 PM

Organizer:

Frank Effenberger; *FutureWei Technologies, Inc., USA*

Description:

Optical access has become a mainstream component of operators' networks, and they are also being stretched to perform new roles and serve new applications. NG-PON2's standardization is nearing completion, while next generation EPON is just starting this process. In addition to the active electronics part of the network, new techniques are being applied to the passive infrastructure. PON technology is being used to back-haul traffic from very high speed copper systems, and now it seems likely that wireless front-haul will be a major push in the market. Coaxial networks are also being merged with PON systems to bring about various types of distributed architecture. This panel brings together leaders from across the industry to review both where we are now in terms of technologies and their standardization, and what might be coming next.

Speakers:

Jun-ichi Kani; *NTT Access Service Systems Laboratories, Japan*
Osman Gebizlioglu; *Huawei Technologies Co., Ltd., USA*
Philippe Chanclou; *Orange Labs, France*
Curtis Knittle; *CableLabs, USA*

TUNABLE AND PROGRAMMABLE MODULATION FORMAT TRANSCEIVERS

Tuesday, March 24, 2015
4:30 PM - 6:30 PM

Organizer:

Steve Plote; *BTI Systems, USA*; Alan Pak Tao Lau; *Hong Kong Polytechnic University, Hong Kong*

Description:

Moderator: Alan Pak Tao Lau; *Hong Kong Polytechnic University, Hong Kong*

ROADM flexible grid spectrum arrangements are standardized. We have options for adaptive modulation techniques to be path adaptive. Bit-rate adaptive transceivers are rolling out. The concept of elastic optical networks is being well received. Are the network operators ready to take full advantages of the bandwidth/data-rate flexible optical layer functions? Do we need/Can we achieve a higher degree of flexibility at the physical layer?

Speakers:

Signal Processing ASICs: Ready and Able, Norman L. Swenson; *ClariPhy, USAF*

ROADM networks are undergoing a generational transition with the simultaneous introduction of the route and select architecture, Colorless, Directionless (CD) and optionally Contentionless (CDC), Brandon Collings; *JDSU, USA*

The Keys to Freedom… …or Living off the Grid, David W. Boertjes; *Ciena Corporation, Canada*

Flexible optical network: Technology is Not Ready, Darli Augusto de Arruda Mello; *University of Campinas, Brazil*

Network Optimization at the Physical Layer, Steve Joiner; *Finisar, USA*

Flexible Transceivers for Next Generation Elastic Optical Network, David V. Plant; *McGill University, Canada*

Path to Flexible Optical Networking for 100G and Beyond, Zhensheng Jia; *ZTE, USA*

SYMPOSIA

BEYOND THE GOLD BOX: THE FUTURE OF INTEGRATED OPTICS

Wednesday, 25 March
08:00 - 17:30

Organizers: Christopher Cole; Finisar Corporation, USA; Robert Lingle; OFS, USA; Chris Fludger; Cisco Optical GmbH, Germany; Clint Schow; IBM T.J. Watson Res. Ctr., USA

The on-going explosion of data and the need to move and process it efficiently demands ever greater amounts of optical I/O at every level. A special symposium at OFC 2015 will focus on how packaging and integration may be used to lower cost for different applications in the network. A consistent theme will be a focus on optimizing the integration of optics and electronics as a path to dramatically reduce the cost of traditional “gold box” optical modules. This symposium tackles the topic of packaging and integration technologies, targeting high capacity optical transport for line-side, client-side and inter- and intra- data centre applications.

A dynamic line up of invited speakers will illustrate the challenges and propose solutions to achieve the next generation of optimized optical interfaces.

Plan on attending and being a part of this exciting new field at OFC 2015!

PART I: LINE-SIDE TECHNIQUES TO MOVE BEYOND THE GOLD-BOX

Line-side applications are also demanding integrated pluggable optics as a means of thermal separation of "hot" ASICs and sensitive optical components with the added benefit of adding and replacing optical interfaces on-demand. Whilst long-haul traditionally demands the highest levels of performance, Metro DWDM applications have a greater emphasis on cost. Which packaging and device technologies are suitable for line-side applications (e.g. InP, SiP) and how can DSP be used to facilitate their use?

Beyond CFP2 ACO, Ian Betty; *Ciena,* USA.

Device Technologies for Integrated Packaged Transceivers, Robert Griffin; *Oclaro, Inc., USA*

Impact of Pluggable Analog Coherent Optics Modules on Line Card Architecture and DSP Functionality, Thomas Duthel; *Cisco Systems, Inc. USA*

Integrated Devices for Metro Applications, Michael Eiselt; *ADVA Optical Networking AG, Germany*

Integrated Devices for High-Performance Optical Links, Merhdad Ziari; *Infinera Corporation, USA*

Future Narrow Linewidth Lasers, Toshikazu Mukaihara; *Furukawa Electric Co., Japan*

PART II: DATA CENTER OPTICAL TECHNIQUES TO MOVE BEYOND THE GOLD-BOX

Within data center servers, will the next generations of optics move from the backplane to be embedded close to chip modules or even all the way onto chip packages? How should next-generation optical devices be developed to address density and thermal challenges that will arise as integration levels increase? Integrated pluggable optical interfaces have been used extensively in client applications. Enabling technologies and modulation techniques for client-side applications will be discussed with the target of deploying cost-effective links of up to 2-km through component and packaging reduction.

InP Photonic Integrated Circuits for High Efficiency Pluggable Optical Interfaces, Yuliya Akulova; *JDSU, USA*

High Bandwidth Transceivers Using Heterogeneous Integration on Silicon, Greg Fish; *Aurrion Inc, USA*

Silicon Photonics … With The Photons, Alfredo Viglienzoni; *Skorpios, Inc., USA*

Photonic Packaging in High-Throughput Microelectronic Assembly Lines for Cost-Efficiency and Scalability, Tymon Barcwicz; *IBM Research, USA*

Embracing Diversity – Interconnecting Different Materials and Components for the Lowest $/Gb, Bardia Pezeshki; *Kaiam, USA*

PART III: DATA CENTER CIRCUITS AND DSP TECHNIQUES TO MOVE BEYOND THE GOLD-BOX

Circuit Design Techniques For High Bit Rate and High Density Optical Interconnects, The'Linh Nguyen; *Finisar Corporation, USA*

Low-Power MOS-Capacitor Based Silicon Photonic Modulators and CMOS Drivers, Mark Webster; *Cisco Systems, Inc., USA*

Deploying DSP in Optical Transceiver Modules, Vipul Bhatt; *Inphi, USA*

Can Discrete Multi-Tone Reduce the Cost for Short Reach Systems?, Tomoo Takahara; *Fujitsu Laboratories Ltd., Japan*

Investigation of 50 GBd PAM-4 Electrical Interfaces for 2km Data Center Interconnects, Edward Frlan, *Semtech, USA*

ENABLING THE CLOUD: UNLEASHING THE CAPABILITIES OF EMERGING FLEXIBLE OPTICAL TRANSPORT THROUGH SDN AND NFV

Monday, 23 March
13:30 - 18:00

Organizers: Clint Schow; IBM T.J. Watson Res. Ctr., USA; Dimitra Simeonidou; University of Bristol, UK; Marina Thottan; Alcatel-Lucent Bell Labs, USA

Software Defined Networking (SDN) is becoming an established trend in operation and management of today's networks from Data Centre (DC) to Telecomm Infrastructures. Network Functions Virtualisation (NFV) is another emerging trend that has been recently introduced to reinforce the evolution of network services. Enabling SDN and NFV to support optical networks can provide a new open framework that can potentially facilitate network virtualisation, application specific network slicing at the optical layer as well as coordination and orchestration of higher layers and applications with the optical layer.

In parallel with the two aforementioned trends, programmable network technologies are rapidly emerging, which can utilise plugable photonics and electronics and synthesise on demand hardware platforms . These new technology capabilities will provide a framework for hosting various network functions at the transport layer and if combined with SDN and NFV can create a very unique and attractive solution that allows full application programmability of the optical networks.

This symposium will attempt to shed light on potentials and benefits of combined SDN, NFV and programmable hardware as the basis of an emerging framework for optical infrastructure evolution for telecommunication and cloud service providers. It brings together leading experts from industry and research to discuss solutions for extending SDN and NFV frameworks, protocols and new functions in optical data plane technologies such as programmability within context of data center, metro and core networks.

PART I SPEAKERS:

ONF: Applying SDN to Optical Transport, Dan Pitt; *ONF, USA*

Implementing SDN Controlled Flexible Optical Transport at AT&T, the Next Steps, Mehran Esfandiari; *AT&T, USA*

Architecting the Next Generation DCN for Flexibility and Scale with Optics and SDN, Katherine Barabash; *IBM, Israel*

Towards a Common Network Orchestration Protocol for Multi-tenant Multi-domain Optical Networks with Heterogeneous Control and Data Planes Technologies, Raul Munoz; *CTTC, Spain*

PART II SPEAKERS:

Emerging Open Technology and Optics for the Next Generation Mega Data Centers, Yuval Bachar; *Facebook, USA*

How Server Designs Will Change as Interface Bandwidth Demands Continue to Increase, Daniel Dreps; *IBM, USA*

Programmable Hardware in Software Defined Networking, Gordon Brebner; Xilinx Inc., USA

SDN Control of a Coherent Open Line System, Jeff Cox; *Microsoft, USA*

FUTURE OF BROADBAND ACCESS

Thursday, 26 March
13:00 - 17:30

Organizers: Neda Cvijetic; NEC Laboratories America, USA; Junichi Kani; NTT Access Service Systems Laboratories, Japan; Peter Vetter; Alcatel-Lucent, USA; Antonio Teixeira, Aveiro University, Portugal

This symposium will examine the trends and technologies poised to shape the future of broadband access. Key drivers, including 5G mobile, Internet of Things (IoT), and universal/unlimited access initiatives, as well as their potential ramifications on future broadband access will be discussed. From the technology perspective, presentations will delve into the competing options for the access segment, including a summary of the latest advances in fiber, copper, and wireless technologies. Important operational aspects affecting access networks will also be examined.

PART I: FUTURE OF BROADBAND ACCESS: TRENDS AND DRIVERS

Application Drivers and Trends for Future Broadband Access, Tomoaki Yoshida; *NTT Corporation, Japan*

Internet Connectivity for the World's 60% Unconnected Population, Hamid Hemmati; *Facebook Inc., USA*

Operational Issues in Access Networks: Past, Present, and Future, David Payne; *CTVR Trinity College* Dublin, *Ireland*

FTTx Migration Challenges to Giga-bps Hyper-connectivity Networking Infrastructure, Bongtae Kim; *Electronics & Telecom Rsrch Inst., South Korea*

PART II: FUTURE OF BROADBAND ACCESS: TECHNOLOGIES

DOCSIS 3.1® Technology and Hybrid Fiber Coax for Multi-Gbps Broadband, Dan Rice; *CableLabs, USA*

Copper is the New Black for Ultra Broadband Networks, David Eckard; *Alcatel-Lucent Bell Labs, USA*

Access Network Transformation Options for Gbps Broadband, George Ginis; *Assia Inc., USA*

Net Neutrality and Broadband Access: What Does the Future Hold?, To Be Determined

SPECIAL SESSION ON THE SOCIETAL, BUSINESS, AND TECHNICAL IMPACT OF NET NEUTRALITY

Thursday, 26 March
13:00 - 15:00

Organizers: Pat Iannone; Bell Labs, USA; Rich Linke; Aluben Research LLC, USA

Network neutrality-related regulatory decisions, or the lack thereof, will impact not only the business landscape for internet service providers (ISPs), content providers, and application innovators, but will have a profound effect on the user experience. Less widely publicized is the impact these decisions will have on optical network technologies and architectures. This symposium will illuminate the fundamental issues around net neutrality and the potential impact of various proposals.

SPEAKER:

Scott Jordan; *Federal Communications Commission, USA*

Kurt Opsahl; *Electronic Frontier Foundation, USA*

Special Symposium on Fiber Optic Parametric Amplifiers: A Tribute to the Research of Prof. Michel Marhic

Thursday, 26 March
15:30 - 17:30

Organizers: Periklis Petropoulos; University of Southampton, UK; Kenneth K. Y. Wong; University of Hong Kong, Hong Kong; Shu Namiki, AIST, Japan

Prof. Michel Marhic was one of the most dedicated researchers in the theory and applications of fiber optical parametric amplifiers. After learning that Prof. Marhic passed away suddenly and unexpectedly in August 2014, we were honored to organize a special session in recognition of his world-leading work in this area. Anyone, especially those who knew Prof. Marhic, are cordially asked to join this session and share their memories and research works. The session will celebrate the progress on fiber optic parametric amplifiers, a field that has benefitted so much from Prof. Michel Marhic's contributions.

SPEAKERS:

Kenneth K. Y. Wong; The University of Hong Kong, Hong Kong
Prem Kumar; *Northwestern University, USA*
Colin McKinstrie; *Applied Communication Sciences, USA*
Youichi Akasaka; *Fujitsu Laboratories of America, USA*
Katsumi Uesaka; *Sumitomo, USA*
Stojan Radic; *UCSD, USA*
Peter Andrekson; *Chalmers University of Technology, Sweden*
Periklis Petropoulos; *University of Southampton, UK*
Shu Namiki; *AIST, Japan*
Nick Doran; *Aston University, UK*