Room 102	Room 120	Room 121	Room 122	Room 123	Room 124

Details on all Workshops (both Sunday and Monday) can be found on pages 9-13

12:00–13:30 Lunch *(on your own)*

13:30–15:30
M2A • QAM
Presider: Xiang Zhou; Google, USA

M2A.1 • 13:30 ***Top-Scored***
Implementation of 64QAM at 42.66 GBaud Using 1.5 Samples per Symbol DAC and Demonstration of up to 300 km Fiber Transmission, Fred Buchali[1], Axel Klekamp[1], Laurent Schmalen[1], Drenski Tomislav[2]; [1]*Alcatel-Lucent Bell Labs, Germany;* [2]*Fujitsu Microelectronic Europe, Germany.* We demonstrate 400Gbit/s data generation using 64QAM at 42.66 GBaud with a reduced oversampling ratio of 1.5 Sample/symbol including digital Nyquist filtering and spectral pre-emphasis. Even at 24% FEC overhead a successful transmission over 300 km ULAF has been shown.

M2A.2 • 13:45 ***Top-Scored***
High-Speed Optical 64QAM Signal Generation Using InP-based Semiconductor IQ Modulator, Nobuhiko Kikuchi[1], Riu Hirai[1], Yuki Wakayama[2]; [1]*Central Research Lab., Hitachi Ltd, Japan;* [2]*Central Research Lab., Hitachi Ltd, Japan.* The use of InP-based IQ modulator for ultra-high speed precise 28-GBaud 64QAM signal generation (336 Gbit/s with polarization multiplexing) is experimentally demonstrated using digital modulator non-linearity compensation techniques, for the first time to our knowledge.

13:30–15:00
M2B • Network Planning
Presider: Zeljko Bulut; Coriant, USA

M2B.1 • 13:30
Network Planning Strategies for Next-Generation Flexible Optical Networks, Rosanna Pastorelli[1], Gabriella Bosco[2], Antonino Nespola[3], Stefano Piciaccia[1], Fabrizio Forghieri[1]; [1]*Cisco Photonics, Italy;* [2]*DET, Politecnico di Torino, Italy;* [3]*Istituto Superiore Mario Boella, Italy.* Using well-established results on non-linear propagation modeling in coherent optical links, two different approaches for network performance optimization are addressed and compared in terms of performance maximization and robustness to dynamic changes in the network.

M2B.2 • 13:45
Pre-Deployment of Regenerators in DWDM Networks and the Impact of Mismatches between Planning and Operation, João Pedro[1,2]; [1]*Research & Technology, Coriant Portugal, Portugal;* [2]*Instituto Superior Técnico, Instituto de Telecomunicações, Portugal.* Pre-deploying regenerators is vital for fast service provisioning in long-haul networks. This paper compares regenerator placement strategies exploiting different degrees of network and traffic information and assesses their sensitivity to planning and operation conditions mismatches.

13:30–15:00
M2C • Coded Modulation I
Presider: Takashi Sugihara; Mitsubishi Electric Corporation, Japan

M2C.1 • 13:30
Achievable Rates for Four-Dimensional Coded Modulation with a Bit-Wise Receiver, Alex Alvarado[1], Erik Agrell[2]; [1]*Department of Engineering, Univ. of Cambridge, UK;* [2]*Department of Signals and Systems, Chalmers Univ. of Technology, Sweden.* We study achievable rates for four-dimensional (4D) constellations for spectrally efficient optical systems based on a (suboptimal) bit-wise receiver. We show that PM-QPSK outperforms the best 4D constellation designed for uncoded transmission by approximately 1 dB. Numerical results using LDPC codes validate the analysis.

M2C.2 • 13:45
Rate-Adaptive Coding for Direct-Detection of Discrete Multi-Tones, Chen Chen[1], Mahdi Zamani[1], Zhuhong Zhang[1], Chuandong Li[1]; [1]*Huawei Technologies Canada, Canada.* we demonstrate the rate-adaptive coding can improve the capacity of a 100-Gbps direct-detection DMT system. A new loading algorithm is proposed to incorporate rate-adaptive coding into water-filling.

13:30–15:30
M2D • Radio-over-Fiber I
Presider: Michael Sauer; Corning Incorporated, USA

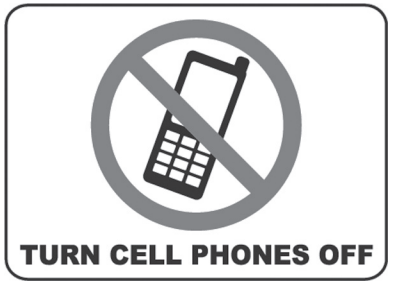
M2D.1 • 13:30 **Invited**
Ultra High-Speed Fiber Wireless Transport, Tetsuya Kawanishi[1]; [1]*National Inst of Information & Comm Tech, Japan.* This paper describes high-speed data transmission based on combination of optical fiber and radio-wave links, which would enable low-latency transfer and agile deployment capability, where broadband radio signal waveforms can be transferred by radio-on-fiber technology.

13:30–15:30
M2E • DC 100 Gb/s and Beyond Transmission
Presider: Loukas Paraschis; Cisco Systems, Inc., USA

M2E.1 • 13:30 **Invited**
The innovations and future needs of WDM transport for inter-data-center interconnections, Bikash Koley[1]; [1]*Google, USA.* Abstract not available

13:30–15:15
M2F • Low Loss and Hollow Core Fibers
Presider: Liang Dong; Clemson Univ., USA

M2F.1 • 13:30 **Invited**
Ultralow Loss Fiber Advances, Masaaki Hirano[1]; [1]*Sumitomo Electric Industries Ltd, Japan.* Recent realization of ultralow loss pure-silica-core fibers having 0.15dB/km and their manufacturability will be discussed. The fibers have appropriately enlarged Aeff decided from viewpoint of analytically developed fiber figure-of-merit depending on transmission distances.



Room 125	Room 130	Room 131	Room 132	Room 133

Details on all Workshops (both Sunday and Monday) can be found on pages 9-13

12:00–13:30 Lunch *(on your own)*

13:30–15:00
M2G • Photodetectors
Presider: Shinji Matsuo; NTT Photonics Laboratories, Japan

M2G.1 • 13:30
A High-Power and High-Linearity 50 GHz Waveguide Photodiode Module, Efthymios Rouvalis[1], Philipp Müller[1], Sascha Fedderwitz[1], Dirk Trommer[1], Jens Stephan[1], Andreas Steffan[1], Günter Unterbörsch[1]; [1]*u2t Photonics AG, Germany.* We demonstrate a high-responsivity (0.52 A/W) and high-linearity 50 GHz photodiode module based on an MMI-Splitter and a 4×PD-Array with +3.5 dBm RF-power at 50 GHz and an OIP3 of >25 dBm at 40 GHz.

M2G.2 • 13:45
High-speed InGaAs photodetectors with low dark current selectively grown on SOI substrate, Yu Geng[1], Shaoqi Feng[1], Kei May Lau[1], Andrew W. Poon[1]; [1]*Hong Kong Univ. of Sci. & Tech., Hong Kong.* We report selective growth of high crystalline quality InGaAs photodetectors (PDs) with optimized InP/GaAs buffers on patterned SOI substrates by MOCVD. Both waveguide and normal-incidence PDs show low dark current and high-speed performance.

13:30–15:30
M2H • Cloud
Presider: Motoyoshi Sekiya; Fujitsu Lab America, USA

M2H.1 • 13:30 Tutorial
Optical Network Requirements for Cloud, Douglas Freimuth[1]; [1]*Cloud Networking, IBM TJ Watson Research Center, USA.* The cloud computing model's acceptance is accelerating and the network is an essential enabler. This tutorial will describe the cloud computing model and relate the requirements of dynamic cloud networks for carrier NFV and large enterprise cloud networks.

Douglas M. Freimuth is a Senior Technical Staff Member and Master Inventor in the Cloud Networking group at the IBM T.J. Watson Research Center where he has focused on the research, design and development of cloud 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 and cloud networking, and has also published related papers, developed products and contributed to open source.

13:30–15:00
M2I • High-Speed Access
Presider: Jorg Elbers; ADVA Optical Networking AG, Germany

M2I.1 • 13:30 Invited
Discrete Multi-Tone for 100 Gb/s Optical Access Networks, Tomoo Takahara[1], Toshiki Tanaka[1], Masato Nishihara[1], Yutaka Kai[1], Lei Li[2], Zhenning Tao[2], Jens Rasmussen[1]; [1]*Fujitsu Laboratories Ltd, Japan;* [2]*Fujitsu R&D Center, China.* Discrete Multi-Tone (DMT) is an attractive technology for short reach optical transmission systems. We have reported several results on transmission experiments using DMT. In this paper we review this technology and these experimental results.

Presentations selected for recording are designated with a . Access these by visiting www.ofcconference.org and clicking on the View Presentations button.

13:30–15:00
M2J • Amplifiers for SDM I
Presider: Radan Slavik; Optoelectronics Research Centre, Univeristy of Southampton, United Kingdom

M2J.1 • 13:30
Design and characterization of Few-Mode Fiber amplifiers, Laurent Bigot[1]; [1]*PhLAM/IRCICA, CNRS, France.* This tutorial will focus on the modeling and characterization of optical amplifiers based on few-mode erbium-doped fiber. The general equations used to describe multimode amplification will be reviewed and measurement techniques will be revisited.

13:30–15:30
M2K • Optical Switching
Presider: Milos Popovic; University of Colorado Boulder, USA

M2K.1 • 13:30 *Top-Scored*
A 204.8 Tbps Throughput 64x64 Optical Cross-Connect Prototype that Allows C/D/C Add/Drop, Kensuke Takaha[1], Yojiro Mori[1], Hiroshi Hasegawa[1], Ken-ichi Sato[1], Toshio Watanabe[2]; [1]*Department of Electrical Engineering and Computer Science, Nagoya Univ., Japan;* [2]*NTT Photonics Laboratories, NTT Corporation, Japan.* We fabricate a subsystem modular 64x64 OXC with C/D/C add/drop capabilities. Its throughput reaches 204.8 Tbps at the channel speed of 40 Gbps. Transmission experiments verify the performance of the prototype.

M2K.2 • 13:45 *Top-Scored*
Monolithic 50x50 MEMS Silicon Photonic Switches with Microsecond Response Time, Sangyoon Han[1], Tae Joon Seok[1], Niels Quack[1], Byung-Wook Yoo[1], Ming C. Wu[1]; [1]*Electrical Engineering and Computer Science, Univ. of California, Berkeley, USA.* We report on 50x50 MEMS-actuated silicon photonic switches with 16V switching voltage and microsecond switching time. 2,500 MEMS cantilever 1x2 waveguide switches have been integrated on 9mmx9mm chips

M2A • QAM—Continued

M2A.3 • 14:00 *Top-Scored*
Generation of a Digitally Shaped 55-GBd 64-QAM Single-Carrier Signal Using Novel High-Speed DACs, Sebastian Randel[1], Stephen Corteselli[1], Peter J. Winzer[1], Andrew Adamiecki[1], Alan Gnauck[1], S. Chandrasekhar[1], Anna Bielik[2], Lars Altenhain[2], Tobias Ellermeyer[2], Ulrich Dümler[2], Henning Langenhagen[2], Rolf Schmid[2]; *[1]Bell Laboratories, Alcatel-Lucent, USA; [2]Micram Microelectronic GmbH, Germany.* We present a novel 2-channel arbitrary waveform generator (AWG) prototype, generating complex signal constellations with 6-bit digital-to-analog conversion (DAC) of up to 72 GS/s at a 6-dB bandwidth of 23 GHz. We generate a 55-GBd root-raised cosine shaped single-carrier 64-QAM signal.

M2A.4 • 14:15
Parallel and Pipelined Decision-Directed Phase Recovery for 64-QAM in the Presence of Sinusoidal Tones, Wing-Chau Ng[1], An T. Nguyen[1], Simon Ayotte[2], Chul Soo Park[1], Leslie Rusch[1]; *[1]Universite Laval, Canada; [2]TeraXion, Canada.* We experimentally investigate the impact of sinusoidal laser phase on parallel and pipelined decision-directed phase recovery in a 5 Gbaud 64-QAM system, including the effects of frequency offset compensation and equalization.

M2B • Network Planning—Continued

M2B.3 • 14:00
Simulations of Traffic Growth in a ROADM Network with a Growing Topology, Mark D. Feuer[1], Sheryl L. Woodward[2], Inwoong Kim[3], Paparao Palacharla[3], Xi Wang[3], Qiong Zhang[3], Daniel Bihon[4]; *[1]CUNY - College of Staten Island, USA; [2]AT&T Labs - Research, USA; [3]Fujitsu Laboratories of America, USA; [4]Fujitsu Network Communications, USA.* We explore challenges faced when deploying a new technology to serve a large network. Our simulations demonstrate the benefits of having an optical layer that can be reconfigured as the technology's footprint grows over time.

M2B.4 • 14:15
Optical Super-Channels in Long-Haul Network Architectures, Steven Clarke[1], Serge Asselin[1], Arash Vakili[1]; *[1]Network Planning, Ciena Corporation, Canada.* Network efficiency is compared for 500Gb/s super-channel and 100Gb/s single-wavelength systems. Results show that exclusively using 500Gb/s systems requires 1.7x to 2.6x more network capacity for the same service demands and introduces network scalability concerns.

M2C • Coded Modulation I—Continued

M2C.3 • 14:00 **Invited**
Transmission Performance of Coded Modulation Formats in a Wide Range of Spectral Efficiencies, Jin-Xing Cai[1], Hussam G. Batshon[1], Hongbin Zhang[1], Matt Mazurczyk[1], Oleg Sinkin[1], Dmitri Foursa[1], Alexei Pilipetskii[1]; *[1]TE SubCom, USA.* We experimentally study the performance of coded-modulation formats based on Nyquist-spectrally-shaped mQAM constellations with spectral efficiencies from 2.4 to 8.0 bits/s/Hz, and demonstrate that the relative performance in uncompensated links depends only on their respective OSNR sensitivity.

M2D • Radio-over-Fiber I—Continued

M2D.2 • 14:00
5-bit/s/Hz 50-Gbps W-band Optical/Wireless System Employing Single-Sideband Single-Carrier Modulation, Chun-Hung Ho[1], Yu-Hsuan Cheng[1], Hou-Tzu Huang[1], Chun-Ting Lin[1], Chia-Chien Wei[2], Sien Chi[1]; *[1]Inst. of Photonic System, National Chiao Tung Univ., Taiwan; [2]Department of Photonics, National Sun Yat-sen Univ., Taiwan.* We experimentally demonstrate W-band radio-over-fiber system employing single-sideband single-carrier modulation with lower PAPR than OFDM. Up to 50-Gbps wireless transmission with the highest spectral efficiency of 5-bit/s/Hz at 103GHz can be achieved over 25-km fiber.

M2D.3 • 14:15
Seamless W-Band Radio-to-Optical Signal Conversion with Direct IQ Down-Converter, Atsushi Kanno[1], Pham Tien Dat[1], Toshiaki Kuri[1], Iwao Hosako[1], Tetsuya Kawanishi[1], Yuki Yoshida[2], Ken-ichi Kitayama[2]; *[1]National Inst. of Information and Communications Technology, Japan; [2]Osaka Univ., Japan.* Seamless conversion from millimeter-wave radio signals to optical baseband signals was demonstrated using a direct IQ down-converter. Hybrid optical and millimeter-wave signal transmission was performed using a conventional digital-coherent receiver, without any special algorithms.

M2E • DC 100 Gb/s and Beyond Transmission—Continued

M2E.2 • 14:00
400GbE Demonstration Utilizing 100GbE Optical Sub-Assemblies and Cyclic Arrayed Waveguide Gratings, Yoshiyuki Doi[1], Takaharu Ohyama[1], Toshihide Yoshimatsu[1], Shunichi Soma[1], Manabu Oguma[1]; *[1]NTT Photonics Laboratories, NTT Corporation, Japan.* We propose a 16 x 25-Gb/s WDM configuration with cyclic AWGs as a realistic solution for 400-Gb/s Ethernet, which utilizes 100GbE optical sub-assemblies. A 10-km error-free transmission with our proposed approach demonstrates its technical feasibility.

M2E.3 • 14:15
100 Gb/s Uncooled DWDM using Orthogonal Coding for Low-cost Datacommunication Links, Johannes von Lindeiner[1], Jonathan D. Ingham[1], Adrian Wonfor[1], Jiannan Zhu[1], Richard V. Penty[1], Ian White[1]; *[1]Electrical Engineering Division, Univ. of Cambridge, UK.* We demonstrate a 10 x 10 Gb/s uncooled DWDM system using orthogonal coding on adjacent carriers, assuming the use of a monolithically integrated sources. A power saving of 72% is expected over traditional WDM.

M2F • Low Loss and Hollow Core Fibers—Continued

M2F.2 • 14:00
Large Aeff Pure-Silica-Core Fiber with Low Similar Splice Loss for Terrestrial Transmission Lines, Yoshinori Yamamoto[1], Yuki Kawaguchi[1], Masaaki Hirano[1]; *[1]Sumitomo Electric Industries, Ltd., Japan.* We demonstrate that pure-silica-core fiber with Aeff of 110 μm2 exhibits low span loss including plural similar splices, which will contribute to high OSNR in hybrid Raman/EDFA-amplified systems.

M2F.3 • 14:15
Low-Loss Low-Latency Transmission Over Single-Mode Hollow Core Fiber at 10 and 120 Gb/s, Vitaly Mikhailov[1], John M. Fini[1], Linli Meng[1], Brian Mangan[1], Jeffrey W. Nicholson[1], Robert S. Windeler[1], Eric M. Monberg[1], Frank V. DiMarcello[1], Paul S. Westbrook[1]; *[1]OFS Laboratories, USA.* We present a single-mode hollow-core fiber with loss of 5.7 dB/km for low latency transmission. We demonstrated penalty-free transmission over 1 and 300 m at 10 Gb/s and 120 Gb/s without optimization of launch conditions.

Room 125

M2G • Photodetectors—Continued

M2G.3 • 14:00
80GHz Balanced Photodetector Chip for Next Generation Optical Networks, Patrick Runge[1], Gan Zhou[1], Angela Seeger[1], Klemens Janiak[1], Jens Stephan[2], Efthymios Rouvalis[2], Dirk Trommer[2]; *[1]Photonic Components, Fraunhofer Heinrich-Hertz Inst., Germany; [2]u2t Photonics, Germany.* We demonstrate a balanced 80GHz pin-photodetector chip with excellent responsivity, dark current and polarisation dependent loss. The device focuses on next generation optical networks with 56/64Gbaud and operates in C-band and L-band.

M2G.4 • 14:15
First Demonstration of Silicon-Based Parallel-Fed Travelling-Wave Photodetector Array (TWPDA), Xianshu Luo[1], Junfeng Song[1], Qing Fang[1], Xiaoguang Tu[1], Lianxi Jia[1], Tsung-Yang Liow[1], Mingbin Yu[1], Patrick Guo-Qiang Lo[1]; *[1]Inst. of Microelectronics, Singapore.* We demonstrate the first silicon-based parallel-fed travelling-wave photodetector array (TWPDA). Impedance-matched travelling-wave electrode is designed considering periodic loading effect. The demonstrated up to 4-channel TWPDAs show >10GHz 3-dB bandwidths and ~0.75A/W responsivity using 30μm-length PDs.

Room 130

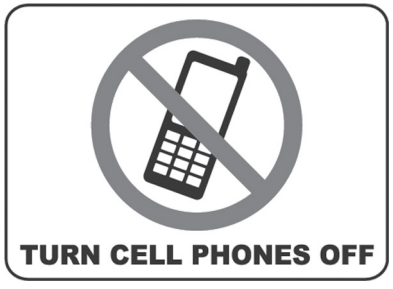
M2H • Cloud—Continued

Room 131

M2I • High-Speed Access—Continued

M2I.2 • 14:00
Experimental Demonstration of 100 Gbps Optical DMT Transmission Combined with Mobile Data Signal, Masato Nishihara[1], Toshiki Tanaka[1], Tomoo Takahara[1], Lei Li[2], Zhenning Tao[2], Jens Rasmussen[1]; *[1]Fujitsu Laboratories Ltd., Japan; [2]Fujitsu R&D Center, China.* We experimentally demonstrated transmission of optical discrete multi-tone (DMT) signal combined with mobile data signal over 10-km SMF. Combined DMT signal and LTE signal achieved capacity larger than 107Gbps and EVM smaller than 8%, respectively.

M2I.3 • 14:15
30km Downstream Transmission Using 4×25Gb/s 4-PAM Modulation with Commercial 10Gbps TOSA and ROSA for 100Gb/s-PON, Hong G. Zhang[1], Shengmeng Fu[1], Jiangwei Man[1], Wei Chen[1], Xiaolu Song[1], Li Zeng[1]; *[1]Fixed Network Research Department, Huawei Technologies Co., Ltd., China.* We proposed a novel 100Gb/s PON scheme using 4-PAM modulation with commercial low-cost 10Gbps TOSA/ROSA compatible with 40Gb/s TWDM-PON. Experimental results show that with EQ compensating bandwidth limitation and CD, 30km transmission is available.



Room 132

M2J • Amplifiers for SDM I—Continued

Presentations selected for recording are designated with a . Access these by visiting www.ofcconference.org and clicking on the View Presentations button.

Room 133

M2K • Optical Switching—Continued

M2K.3 • 14:00
High-speed and Compact Non-blocking 8×8 InAlGaAs/InAlAs Mach-Zehnder-Type Optical Switch Fabric, Hiroki Kouketsu[1], Shoko Kawasaki[1], Noriaki Koyama[1], Akiko Takei[2], Takafumi Taniguchi[2], Yuichi Matsushima[3], Katsuyuki Utaka[1]; *[1]Faculty of Science and Engineering, Waseda Univ., Japan; [2]Central Research Laboratory, Hitachi Ltd, Japan; [3]Green Computing System Research Organization, Waseda Univ., Japan.* A high-speed and compact non-blocking 8×8 InAlGaAs/InAlAs Mach-Zehnder-type optical switch (MZ-OS) fabric consisted of twenty eight 2×2 MZ-OS elements were successfully fabricated. It is expected to operate with switching times of less than 2.5ns.

M2K.4 • 14:15
Chip-level 10-Gbit/s optical interconnects using 1 × 2 polymer vertical splitter on silicon substrate, Chin-Ta Chen[1], Po-Kuan Shen[1], Teng-Zhang Zhu[1], Chia-Chi Chang[2], Shu-Shuan Lin[1], Mao-Yuan Zeng[1], Chien-Yu Chiu[1], Hsu-Liang Hsiao[3], Hsiao-Chin Lan[3], Yun-Chih Lee[3], Yo-Shen Lin[4], Mount-Learn Wu[1]; *[1]Department of Optics and Photonics, National Central Univ., Taiwan; [2]Optical Sciences Center, National Central Univ., Taiwan; [3]Centera Photonics Inc., Taiwan; [4]Department of Electrical Engineering, National Central Univ., Taiwan.* The chip-level 10-Gbit/s optical interconnects with the BER better than 10-12 using the 1 × 2 polymer vertical splitter, which is composed of a polymer waveguide and three silicon 45° reflectors is demonstrated.

M2A • QAM—Continued

M2A.5 • 14:30
Multicarrier Offset-QAM Modulations for Coherent Optical Communication Systems, Jessica Fickers[1], Amirhossein Ghazisaeidi[2], Massimiliano Salsi[2], François Horlin[1], Philippe Emplit[1], Gabriel Charlet[2]; [1]*Universite libre de Bruxelles, Belgium;* [2]*Alcatel Lucent Bell Labs, France.* We study the performance of multicarrier offset modulation and root-raised-cosine shaped multicarrier modulation with aggregate 32.5 GBd symbol rate and show that offset modulation is preferable for non-zero rolloff factors.

M2A.6 • 14:45 ***Top-Scored***
Experimental Performance of 4D Optimized Constellation Alternatives for PM-8QAM and PM-16QAM, Henning Buelow[1], Xiaofeng Lu[2], Laurent Schmalen[1], Axel Klekamp[1], Fred Buchali[1]; [1]*Bell Labs, Alcatel-Lucent, Germany;* [2]*LHFT, MAOT, Univ. Erlangen, Germany.* Sensitivity and reach of soft-decoded PM-8QAM was improved by 1.2-dB and 35%, respectively, by moving to a 64 point 4D constellation and iterative decoding. Replacing PM-16QAM by 256 4D points led to 0.3-dB gain only.

M2B • Network Planning—Continued

M2B.5 • 14:30 **Invited**
Network Virtualization, Aihua Guo[1]; [1]*ADVA Optical Networking Inc., USA.* Network virtualization is introduced to optical networks to enable the offering of logical network resources. This paper examines virtualization practices for optical networks and optical constraint abstractions for computing virtual overlay networks.

M2C • Coded Modulation I—Continued

M2C.4 • 14:30 **Invited**
Four-Dimensional Modulation Formats for Long-Haul Transmission, Pontus Johannisson[1], Martin Sjödin[1], Tobias A. Eriksson[1], Magnus Karlsson[1]; [1]*Photonics Laboratory, Chalmers Univ. of Technology, Sweden.* A number of four-dimensional modulation formats are described theoretically and from an implementation point of view. The requirements for digital signal processing and the trade-off between spectral efficiency and receiver sensitivity is discussed.

M2D • Radio-over-Fiber I—Continued

M2D.4 • 14:30
Robust 71-76 GHz Radio-over-Fiber Wireless Link with High-Dynamic Range Photonic Assisted Transmitter and Laser Phase-Noise Insensitive SBD Receiver, Andreas Stohr[1], Oleg Cojucari[2], Frederic van Dijk[3], Guillermo Carpintero[4], Tolga Tekin[5], Stephane Formont[6]; [1]*Universität Duisburg-Essen, Germany;* [2]*ACST GmbH, Germany;* [3]*III/V-Lab, France;* [4]*UC3M, Spain;* [5]*Technische Universität Berlin, Germany;* [6]*Thales Systems Aeroportes, France.* A robust radio-over-fiber wireless link system for use in wireless extension and mobile backhaul applications is presented. The wireless link operates at 71-75 GHz E-band carrier frequencies and can transmit up to 2.5 Gbps.

M2D.5 • 14:45
Demonstration of 24-Gb/s Carrierless Amplitude and Phase Modulation (CAP) 64QAM Radio-over-Fiber System over 40-GHz Mm-wave Fiber-Wireless Transmission, Junwen Zhang[1,2], Xinying Li[1], Jiangnan Xiao[1], Gee-Kung Chang[3], Fan Li[2]; [1]*Fudan Universitiy, China;* [2]*ZTE (TX) Inc, USA;* [3]*Georgia Inst. of Technology, USA.* A novel CAP-ROF system based on multi-level carrier-less amplitude and phase modulation (CAP) 64QAM with high spectrum efficiency is demonstrated. The 24-Gb/s CAP-64QAM signal is successfully transmitted over 40-km SSMF and 1.5-m 38-GHz wireless link.

M2E • DC 100 Gb/s and Beyond Transmission—Continued

M2E.4 • 14:30 ***Top-Scored***
O-band 400 Gbit/s Client Side Optical Transmission Link, Tianjian Zuo[1], Anna Tatarczak[2], Miguel Iglesias[2], Jose Estaran[2], Jesper Bevensee Jensen[2], Qiwen Zhong[1], Xiaogeng Xu[1], Idelfonso Tafur[2]; [1]*Transmission Technology Research Department, Huawei Technologies Co.Ltd., China;* [2]*DTU Fotonik, Department of Photonics Engineering, Technical Univ. of Denmark, Denmark.* We present an O-band 400 Gbit/s optical client side Ethernet link with 40 km SSMF reach employing four LAN-WDM lanes, MultiCAP modulation and direct detection.

M2E.5 • 14:45
Towards 100 Gbps over 100m MMF using a 850nm VCSEL, Miguel Iglesias Olmedo[1,3], Anna Tatarczak[1], Tianjian Zuo[2], Jose Estaran[1], Xiaogeng Xu[2], Idelfonso Tafur[1]; [1]*DTU Fotonik - Department of photonics engeniering, Technical Univ. of Denmark, Denmark;* [2]*Transmission Technology Research Department, Huawei Technologies Co., Ltd, China;* [3]*Optics division, Royal Inst. of Technology (KTH), Sweden.* Employing MultiCAP signaling, successful 70.4 Gbps transmission over 100m of OM3 MMF using off-the-shelf 850 nm VCSEL with 10.1 GHz 3-dB bandwidth is experimentally demonstrated indicating the feasibility of achieving 100 Gbps with a single 25 GHz VCSEL.

M2F • Low Loss and Hollow Core Fibers—Continued

M2F.4 • 14:30
Understanding Wavelength Scaling in 19-Cell Core Hollow-Core Photonic Bandgap Fibers, Yong Chen[1], Natalie V. Wheeler[1], Naveen Baddela[1], John Hayes[1], Seyed Reza Sandoghchi[1], Eric Numkam Fokoua[1], Meng Li[1], Francesco Poletti[1], Marco Petrovich[1], David J. Richardson[1]; [1]*Optoelectronics Research Centre, Univ. of Southampton, UK.* First experimental wavelength scaling in 19-cell core HC-PBGF indicates that the minimum loss waveband occurs at longer wavelengths than previously predicted. Record low loss (2.5dB/km) fibers operating around 2μm and gas-purging experiments are also reported.

M2F.5 • 14:45
Accurate Loss and surface mode modeling in Fabricated Hollow-core Photonic Bandgap Fibers, Eric Rodrigue Numkam Fokoua[1], Seyed Reza Sandoghchi[1], Yong Chen[1], Natalie V. Wheeler[1], Naveen Baddela[1], John Hayes[1], Marco Petrovich[1], Francesco Poletti[1], David J. Richardson[1]; [1]*Optoelectronics Research Centre, Univ. of Southampton, UK.* We present a method to reconstruct the cross-sectional profile of fabricated hollow-core photonic bandgap fibers from SEM images. For the first time, numerical simulations show a good agreement with measured loss and surface mode position.

Room 125

M2G • Photodetectors—Continued

M2G.5 • 14:30
Ultra-Small Butt-Joint Ge Photodetector Featuring Self-Aligned In-situ Doping and CMP-Free Novel CVD Process, Makoto Miura[1,2], Junichi Fujikata[1,2], Masataka Noguchi[1,2], Yasuhiko Arakawa[1,3]; *[1]Inst. for Photonics-Electronics Convergence System Technology (PECST), Japan; [2]Photonics Electronics Technology Research Association (PETRA), Japan; [3]Inst. of Industrial Science, Univ. of Tokyo, Japan.* Ultra-small butt-joint germanium photodetector featuring self-aligned in-situ doping was realized with drastically decreased process number based on novel CVD method. The photodetector showed prominently increased 3 dB bandwidth at zero bias (35 GHz).

M2G.6 • 14:45
Waveguide Ge/Si Avalanche Photodetector with a Unique Low-Height-Profile Device Structure, Tsung-Yang Liow[1]; *[1]Inst. of Microelectronics, Singapore*. We present a SACM waveguide Ge/Si APD capable of 25 Gb/s operation at 1.3 μm, with a unique low-height-profile structure which enables low dark current. A maximum sensitivity improvement of ~9 dBm can be obtained.

Room 130

M2H • Cloud—Continued

M2H.2 • 14:30
Cloud Service Embedding in Software-Defined Flexible Grid Optical Transport Networks, Ankitkumar Patel[1], Zilong Ye[1], Philip N. Ji[1]; *[1]NEC Laboratories America Inc, USA.* We design network hypervisor applications to embed cloud demands in flexible grid transport networks for the first time. The designed applications can embed at least 15% more cloud demands than the baseline approach.

M2H.3 • 14:45 Invited
Survivability in Virtualized Networks, Dominic Schupke[1], Burcu Barla[1,2], Marco Hoffmann[1]; *[1]Nokia Siemens Networks, Germany; [2]Technische Universität München, Germany.* Future highly-reliable cloud and network services demand for survivability architectures covering network and IT infrastructures. We propose corresponding design models and evaluate them.

Room 131

M2I • High-Speed Access—Continued

M2I.4 • 14:30 *Top-Scored*
80 km IM-DD Transmission for 100 Gb/s per Lane Enabled by DMT and Nonlinearity Management, Weizhen Yan[1], Lei Li[1], Bo Liu[1], Hao Chen[1], Zhenning Tao[1], Toshiki Tanaka[2], Tomoo Takahara[2], Jens Rasmussen[2], Drenski Tomislav[3]; *[1]Fujitsu R&D Center, China; [2]Fujitsu Laboratories Ltd., Japan; [3]Fujitsu Semiconductor Europe GmbH, Germany.* 117Gb/s single wavelength and polarization IM-DD transmission over 40km SMF is first enabled by DMT. With an SOA, 101Gb/s over 80km is demonstrated. The nonlinearity management through parameter optimization and digital compensation is discussed.

M2I.5 • 14:45 *Top-Scored*
Experimental Demonstration of 448-Gbps+ DMT Transmission over 30-km SMF, Toshiki Tanaka[1], Masato Nishihara[1], Tomoo Takahara[1], Weizhen Yan[2], Lei Li[2], Zhenning Tao[2], Manabu Matsuda[3], Kazumasa Takabayashi[3], Jens Rasmussen[1]; *[1]Fujitsu Limited, Japan; [2]Fujitsu R&D Center, China; [3]Fujitsu Laboratories Ltd., Japan.* We have experimentally demonstrated 469-Gbps transmission over 30-km SMF using DMT on a LAN-WDM system for 400-Gbps Ethernet. Only four directly modulated lasers and direct detectors as optical devices were necessary to achieve the results.

Room 132

M2J • Amplifiers for SDM I—Continued

M2J.2 • 14:30
First Demonstration of Cladding Pumped Few-moded EDFA for Mode Division Multiplexed Transmission, EE Leong Lim[1], Yongmin Jung[1], Qiongyue Kang[1], Tim C. May-Smith[1], Nicholas H. L. Wong[1], Robert Standish[1], Francesco Poletti[1], Jayanta K. Sahu[1], Shaiful Alam[1], David J. Richardson[1]; *[1]Univ. of Southampton, UK.* We report the first experimental demonstration of a cladding pumped FM-EDFA supporting 4 mode groups. The modal gains are measured to be >20dB between 1540nm-1570nm with modal differential gain of ~4dB among the mode groups.

M2J.3 • 14:45
Cladding-pumped Er/Yb-doped Multi-Element Fiber Amplifier for C+L band Operations, Saurabh Jain[1], Tim C. May-Smith[1], Jayanta K. Sahu[1]; *[1]Univ. of Southampton, UK.* A cladding-pumped multi-element fiber comprising 4-Er/Yb-doped signal fibers and one multimode pump fiber has been used to demonstrate a C+L split-band amplifier. The signal fibers were cascaded to provide >20dB gain over 80nm bandwidth.

Room 133

M2K • Optical Switching—Continued

M2K.5 • 14:30 Invited
What devices do data centers need?, Cedric F. Lam[1], Hong Liu[1], Ryohei Urata[1]; *[1]Google, USA.* We discuss the trend in fiber optic technology developments to fulfill the scaling requirements of datacenter networks.

Papers are available online for download. Visit www.ofcconference.org and click on the Download Digest Papers button.

M2A • QAM—Continued

M2A.7 • 15:00
Training-Aided PDM 64-QAM Transmission with Enhanced Fiber Nonlinearity Tolerance, Chen Zhu[1], Liang B. Du[2], An V. Tran[3], Arthur J. Lowery[2], Efstratios Skafidas[1]; [1]*Victoria Research Lab, NICTA, Electrical and Electronic Engineering, Univ. of Melbourne, Australia;* [2]*CUDOS, Electrical and Computer Systems Engineering,, Monash Univ., Australia;* [3]*Center for Technology Infusion, La Trobe Univ., Australia.* We show that fiber nonlinearity compensation of just the training sequence improves the nonlinearity-limited performance of training-aided m-QAM systems. Experimental results demonstrate transmission performance improvement by 0.4 dB for a 120-Gb/s 64-QAM 800-km system.

M2A.8 • 15:15
Multi-Stage CPE Algorithms for 64-QAM Constellations, Syed M. Bilal[1], Chris R. Fludger[2], Gabriella Bosco[1]; [1]*DET, Politecnico di Torino, Italy;* [2]*Cisco Optical GmbH, Germany.* We propose and analyze a multi-stage architecture for carrier phase-estimation in 64-QAM systems, based on the cascade of several feed-forward elementary blocks. We outline the beneficial effect of increasing the number of elementary blocks.

Presentations selected for recording are designated with a ▶. Access these by visiting www.ofcconference.org and clicking on the View Presentations button.

M2D • Radio-over-Fiber I—Continued

M2D.6 • 15:00 ***Top-Scored***
150-km 103-GHz Direct-Detection OFDM-RoF System Employing Pilot-aided Phase Noise Suppression, Hou-Tzu Huang[1], Wan-Ling Liang[1], Chia-Chien Wei[2], Chun-Ting Lin[1], Sien Chi[1]; [1]*Inst. of Photonic System, National Chiao-Tung Univ., Taiwan;* [2]*Department of Photonics, National Sun Yat-sen Univ., Taiwan.* Pilot-aided phase noise suppression (PPNS) is employed to demonstrate distance- and linewidth-insensitive 103-GHz DD-OFDM-RoF systems. With 10.3-MHz linewidth, PPNS lowers BER of −6-dBm signal from >10-2 to <10-3 over 150-km fiber and 2-m wireless transmission.

M2D.7 • 15:15
Full-duplex bidirectional transmission of 10-Gb/s millimeter-wave QPSK signal in E-band optical wireless link, Yuan Fang[1], Jianjun Yu[1], Junwen Zhang[1,2], Jiangnan Xiao[1]; [1]*Fudan University, China;* [2]*ZTE Corporation, USA.* We proposed and experimentally demonstrated full-duplex bidirectional transmission of 10-Gb/s millimeter-wave QPSK signal in E-band optical wireless link with coherent detection and digital signal processing for emergency communication.

M2E • DC 100 Gb/s and Beyond Transmission—Continued

M2E.6 • 15:00
Real-Time Demonstration of 100Gbps Class Dual-carrier DDO-16QAM-DMT Transmission with Directly Modulated Laser, Xin Xiao[1], Fan Li[1]; [1]*ZTE (TX) Inc, USA.* Real-time 100Gbps dual-carrier DDO-16QAM-DMT transmission and reception is successfully demonstrated at a record line. The measured BER after 20-km LEAF is less than the SD pre-FEC limit of 2×10-2.

M2E.7 • 15:15
A Low-Cost 100GE Optical Transceiver Module for 2km SMF Interconnect with PAM4 Modulation, Jiangwei Man[1], Wei Chen[1], Xiaolu Song[1], Li Zeng[1]; [1]*Fixed Network R&D Department, Huawei, China.* With the introduction of PAM4 modulation, a novel 100GE optical transceiver module has been proposed using the low-cost 4x10Gbps DML TOSA and PIN ROSA. 4x25Gbps PAM4 signal transmission has been demonstrated over 2km SMF on-line with -11dBm sensitivity and 4dB link margin.

M2F • Low Loss and Hollow Core Fibers—Continued

M2F.6 • 15:00
First Investigation of Longitudinal Defects in Hollow Core Photonic Bandgap Fibers, Seyed Reza Sandoghchi[1], Tao Zhang[1], John P. Wooler[1], Naveen Baddela[1], Natalie V. Wheeler[1], Yong Chen[1], Gregory T. Jasion[1], David R. Gray[1], Eric Numkam Fokoua[1], John Hayes[1], Marco Petrovich[1], Francesco Poletti[1], David J. Richardson[1]; [1]*Optoelectronics Research Centre, Univ. of Southampton, UK.* To improve yield in fabricated HC-PBGFs we have studied morphology and longitudinal evolution of occasional, undesired defects causing localized loss. The short spatial and temporal duration of the defects seems indicative of residual preform contaminations.

15:30–16:00 Coffee Break, *South, Exhibit Halls A, B, C, North, Exhibit Hall D*

M2H • Cloud—Continued

Join the conversation.
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M2H.4 • 15:15
Disaster-Aware Dynamic Content Placement in Optical Cloud Networks, Sifat Ferdousi[1], Massimo Tornatore[4,2], Biswanath Mukherjee[4], M. Farhan Habib[4], Ferhat Dikbiyik[1,3]; *[1]Department of Electrical and Computer Engineering, Univ. of California Davis, USA; [2]Department of Electronics and Informatics, Politecnico di Milano, Italy; [3]Sakarya Univ., Turkey; [4]Department of Computer Science, Univ. of California Davis, USA.* Content placement in cloud networks should be resilient to data loss due to disaster-driven failures. We propose a disaster-aware dynamic content placement scheme to reduce the expected content loss while satisfying resource constraints and QoS.

M2K • Optical Switching—Continued

M2K.6 • 15:00
On-Chip Optical Interconnects Integrated with Laser and Photodetector Using Three-Dimensional Silicon Waveguides, Po-Kuan Shen[1], Chin-Ta Chen[1], Chia-Hao Chang[1], Chien-Yu Chiu[1], Chia-Chi Chang[2], Hsiao-Chin Lan[3], Yun-Chih Lee[3], Mount-Learn Wu[1]; *[1]Department of Optics and Photonics, National Central Univ., Taiwan; [2]Optical Sciences Center, National Central Univ., Taiwan; [3]Centera Photonics Inc., Taiwan.* A whole on-chip optical interconnects integrated with laser, photodetectors, driver IC, and amplifier IC is experimentally demonstrated. A 10-Gbps error-free data transmission is achieved as driving current of laser is 10 mA.

M2K.7 • 15:15
Electronic Two-Dimensional Beam Steering for Integrated Optical Phased Arrays, Behrooz Abiri[1], Firooz Aflatouni[1], Angad Rekhi[1], Ali Hajimiri[1]; *[1]Electrical Engineering, California Inst. of Technology, USA.* This paper presents electrical beam steering in an integrated 4x4 2D optical phased array (OPA) on a silicon on insulator (SOI) process enabling fast and repeatable beam steering for next generation projection, tracking, and imaging.

15:30–16:00 Coffee Break, *South, Exhibit Halls A, B, C, North, Exhibit Hall D*

Room 102

16:00–18:00
M3A • FEC and Modulation
Presider: Gabriella Bosco; Politecnico di Torino, Italy

M3A.1 • 16:00 Invited
Energy Efficient FEC for Optical Transmission Systems, Laurent Schmalen[1]; [1]*Bell Laboratories, Alcatel-Lucent, Germany.* We give an overview about different options for energy efficient FEC realizations in future optical communication systems. We especially highlight different options for realizing energy efficient decoders for higher order modulation formats.

Room 120

16:00–18:00
M3B • Multi-layer Networks
Presider: Ronald Skoog; Applied Communication Sciences, USA

M3B.1 • 16:00 *Top-Scored*
Minimizing resource protection in IP over WDM networks: Multi-layer Shared Backup Router, Arturo Mayoral López de Lerma[1], Victor Lopez[1], Ori Gerstel[2], Eleni Palkopoulou[2], Juan-Pedro Fernández-Palacios[1], Oscar Gonzalez de dios[1]; [1]*Core Networks, Telefonica I+D, Spain;* [2]*Cisco, Israel.* This work compares two resilience strategies on multi-layer network dimensioning: dual-plane protection and Multi-Layer Shared Backup Router. Latter provides a significant reduction (up to 24%) on the required IP equipment in comparison with current approach.

M3B.2 • 16:15
Optimization of Light-path Configuration Order in IP over WDM Networks using Fast Traffic Matrix Estimation, Shohei Kamamura[1], Daisaku Shimazaki[1], Hiroki Mori[1], Koji Sasayama[1], Yuki Koizumi[2], Shin'ichi Arakawa[2], Masayuki Murata[2]; [1]*NTT, Japan;* [2]*Osaka Univ., Japan.* We propose an algorithm for determining light-path configuration order to minimize the reconfiguration time from a disrupted state to a suboptimal state. It computes a near-optimal solution within one minute on a 1000-node network.

Room 121

16:00–17:45
M3C • Fiber Nonlinearity Mitigation & Compensation
Presider: Fabrizio Forghieri; Cisco, Italy

M3C.1 • 16:00
Exceeding the Nonlinear-Shannon Limit using Raman Laser Based Amplification and Optical Phase Conjugation, Ian Phillips[1], Mingming Tan[1], Marc F. Stephens[1], Mary McCarthy[1], Elias Giacoumids[1], Stylianos Sygletos[1], Pawel Rosa[1], Simon Fabbri[1], Son T. Le[1], Thavamaran Kanesan[1], Sergei K. Turitsyn[1], Nick J. Doran[1], Paul Harper[1], Andrew D. Ellis[1]; [1]*Aston Inst. of Photonic Technologies, Aston Univ., UK.* We demonstrate that a combination of Raman laser based amplification and optical phase conjugation enables transmission beyond the nonlinear-Shannon limit. We show nonlinear compensation of 7x114Gbit/s DP-QPSK channels, increasing system reach by 30%.

M3C.2 • 16:15
Fiber Nonlinearity Compensation of an 8-channel WDM PDM-QPSK Signal using Multiple Phase Conjugations, Hao Hu[2,1], Robert M. Jopson[1], Alan Gnauck[1], Mihaela Dinu[1], S. Chandrasekhar[1], Xiang Liu[1], Chongjin Xie[1], Marc Montoliu[3,1], Sebastian Randel[1], Colin McKinstrie[1]; [1]*Alcatel-Lucent Bell Labs, USA;* [2]*DTU Fotonik, Technical Univ. of Denmark, Denmark;* [3]*Universitat Politècnica de Catalunya (ETSETB), Spain.* We demonstrate compensation of fiber nonlinearities using optical phase conjugation of an 8-channel WDM 32-Gbaud PDM QPSK signal. Conjugating phase every 600 km in a fiber loop enabled a 6000 km transmission over TrueWave fiber.

Room 122

16:00–18:00
M3D • Radio-Over-Fiber II
Presider: Andreas Stohr; Universität Duisburg-Essen, Germany

M3D.1 • 16:00
84-Gbps 64-QAM 2 × 2 MIMO RoF System at 60 GHz Employing Single-Sideband Single-Carrier Modulation, Chun-Ting Lin[1], Chun-Hung Ho[1], Hou-Tzu Huang[1], Yu-Hsuan Cheng[1]; [1]*Inst. of Photonic System, National Chiao Tung Univ., Taiwan.* 2×2 MIMO RoF system employing single-sideband single-carrier modulation is experimentally demonstrated. Compared with OFDM, it has lower PAPR. The highest 84-Gbps data rate within 7-GHz unlicensed band at 60 GHz can be achieved.

M3D.2 • 16:15
LTE Advanced Carrier Aggregation Supporting Fully Standard 3GPP MIMO by Optical Polarization Multiplexing, Maria Morant[1], Roberto Llorente[1], Josep Prat[2]; [1]*Nanophotonics Technology Center, Universitat Politècnica de València, Spain;* [2]*Signal Theory and Communications Department, Universitat Politècnica de Catalunya, Spain.* LTE-A carrier aggregation investigation demonstrates successful 2x2 MIMO Pol-Mux RoF transmission of five LTE-A carriers modulated in 16QAM in 25 km, three LTE-A carriers in 75 km and an LTE carrier in 100 km SSMF.

Room 123

16:00–18:00
M3E • Datacom Switching Architectures
Presider: Odile Liboiron-Ladouceur; McGill Univ., Canada

M3E.1 • 16:00 Tutorial
Scalable Computing Systems with Silicon Photonic Enabled Data Movement, Keren Bergman[1]; [1]*Columbia Univ., USA.* As future computing systems aim to realize Exascale performance the challenge of energy efficient data movement rather than computation is paramount. Silicon photonics has emerged as perhaps the most promising technology to address these challenges by providing ultra-high bandwidth density communication capabilities that is essentially distance independent. This tutorial will explore the design of silicon photonic interconnected architectures and their impact on the system level performance.

Keren Bergman is the Charles Batchelor Professor and Chair of Electrical Engineering at Columbia University where she also directs the Lightwave Research Laboratory (http://lightwave.ee.columbia.edu/). She leads multiple research programs on optical interconnection networks for advanced computing systems, data centers, optical packet switched routers, and chip multiprocessor nanophotonic networks-on-chip. Dr. Bergman holds a Ph.D. from M.I.T. and is a Fellow of the IEEE and of the OSA. She has authored and co-authored over 350 publications in leading journals and conferences including a current book entitled: Photonic Network-on-Chip

Continued on page 68

Room 124

16:00–18:00
M3F • Multimode and Few-Model Fibers
Presider: Scott Bickham; Corning Incorporated, USA

M3F.1 • 16:00 Invited
MMF for High Data Rate and Short Length Applications, Ming-Jun Li[1]; [1]*Corning Incorporated, USA.* We review recent developments in multimode fiber for high data rate and short reach applications and discuss new trends in multimode fiber to increase system data rate and reach length and for consumer applications.

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Room 125

16:00–17:45
M3G • High Speed Transmitters and Receivers
Presider: Larry Coldren; Univ. of California Santa Barbara, USA

M3G.1 • 16:00 Invited
High Density Optical Interconnects for High Performance Computing, Fuad E. Doany[1]; [1]*International Business Machines Corp, USA.* High Performance Computing systems with > 105 optical links are deployed today.Chip-scale optical transceivers for next generation systems can simultaneously achieve high bandwidth and high density while minimizing power and cost.

Room 130

16:00–18:00
M3H • Optical Networks and Virtualization
Presider: Angela Chiu; AT&T Labs, USA

M3H.1 • 16:00
Survivable Virtual Infrastructure Mapping over Transport Software-Defined Networks (T-SDN), Zilong Ye[1,2], Ankitkumar Patel[1], Philip Ji[1], Chunming Qiao[2]; [1]*Optical, NEC Labs of America, USA;* [2]*Computer Science, SUNY-Buffalo, USA.* An algorithm is proposed to map virtual infrastructures with survivability over T-SDN for the first time. The algorithm improves the traffic-carrying capacity of networks by provisioning at least 13% more demands than the baseline algorithms.

M3H.2 • 16:15
Heterogeneous Bandwidth Provisioning for Virtual Machine Migration over SDN-Enabled Optical Networks, Uttam Mandal[1], M. Farhan Habib[1], Shuqiang Zhang[1], Pulak Chowdhury[1], Massimo Tornatore[2,1], Biswanath Mukherjee[1]; [1]*Computer Science, Univ. of California Davis, USA;* [2]*Department of Electronics and Information, Politecnico di Milano, Italy, Italy.* Virtual machine migration in cloud-computing environments is an important operational technique, and requires significant network bandwidth. We demonstrate that heterogeneous bandwidth (vs. homogeneous bandwidth) for migration reduces significant resource consumption in SDN-enabled optical networks.

Room 131

16:00–18:00
M3I • NG-PON2 Technologies
Presider: Derek Nesset; British Telecom, UK

M3I.1 • 16:00 Invited
Optical Component Technology Options for NGPON2 Systems, Robert Murano[1]; [1]*Photop Aegis, Inc., USA.* We review NGPON2 system architectures and compare the viability of available component technologies to meet challenges at the OLT, ONU and wavelength multiplexing and demultiplexing nodes, and propose an alternative to discrete transceiver/multiplexer OLT architectures.

Thank you for attending OFC. Look for your post-conference survey via email and let us know your thoughts on the program.

Room 132

16:30–17:45
M3J • High Power Lasers, Components and Sensors
Presider: Kazi Abedin; OFS Laboratories, USA

M3J.1 • 16:00 Invited
Withdrawn

Room 133

16:00–18:00
M3K • Multiplexer for Space-Division Multiplexing
Tsung-Yang Liow; Inst. of Microelectronics, Singapore

M3K.1 • 16:00
Compact Multi-core Fiber Fan-out with GRIN-lens and Micro-lens Array, Osamu Shimakawa[1]; [1]*Sumitomo Electric Industries, Ltd., Japan.* A multi-core fiber fan-out composed of a GRIN-lens and a micro-lens array has been proposed. A seven-core fan-out was fabricated and confirmed the coupling loss between the fan-out and SM-fiber agreed with the optical design.

M3K.2 • 16:15
All-Fiber Mode Division Multiplexer optimized for C-band, Kyung Jun Park[1], Kwang Yong Song[2], Byoung Yoon Kim[1], young Kie Kim[3]; [1]*Physics, KAIST, Republic of Korea;* [2]*Physics, Chung-Ang Univ., Republic of Korea;* [3]*KS phtonics, Republic of Korea.* We demonstrate the excitation of all of the higher-order modes in a few-mode fiber using mode-selective couplers made by taper-polish method. We also demonstrate the C-band optimized mode division multiplexer using cascaded mode selective couplers.

M3A • FEC and Modulation—Continued

M3A.2 • 16:30
Multi-dimensional Permutation Modulation Aiming at Both High Spectral Efficiency and High Power Efficiency, Shota Ishimura[1], Kazuro Kikuchi[1]; [1]*Univ. of Tokyo, Japan.* We analyze the performance of multi-dimensional permutation modulation formats. With the increase in the dimension of modulation, their spectral efficiencies can approach the Shannon limit even when their power efficiencies are kept high.

M3A.3 • 16:45
Cycle Slip-Mitigating Turbo Demodulation in LDPC-Coded Coherent Optical Communications, Toshiaki Koike-Akino[1], Keisuke Kojima[1], David Millar[1], Kieran Parsons[1], Yoshikuni Miyata[2], Wataru Matsumoto[2], Takashi Sugihara[2], Takashi Mizuochi[2]; [1]*MERL, USA;* [2]*MELCO, Japan.* We show that an iterative demodulation with soft-decision feedback information from FEC decoder can efficiently mitigate cycle slips. With 3% pilot insertion, the turbo QPSK demodulation achieves 1.05 dB gain even in the presence of frequent cycle slips.

M3B • Multi-layer Networks—Continued

M3B.3 • 16:30 **Invited**
Metro Transport Architectures for the Future, Wendell Liu[1]; [1]*AT&T Services, INC, USA.* Metro transport network architectures for the future need to support dynamic connectivity management with switching technologies at different levels that can be controlled via a programmable interface to meet the faster and bigger changes.

M3C • Fiber Nonlinearity Mitigation & Compensation—Continued

M3C.3 • 16:30
WDM Transmission of 3x1.12-Tb/s PDM-16QAM Superchannels with 6.5-b/s/Hz in a 162.5-GHz Flexible-Grid using only Optical Spectral Shaping, Luis Carvalho[1], Claudio Floridia[1], Carolina Franciscangelis[1], Victor Parahyba[1], Edson P. da Silva[1], Neil G. Gonzalez[1], Julio Oliveira[1]; [1]*CPqD, Brazil.* We demonstrated the transmission of 3x1.12-Tb/s superchannels (5x224-Gb/s PDM-16QAM) in 162.5-GHz flexible-grid, 6.5-b/s/Hz SE, using only optical spectral shaping, over SSMF-EDFA link. A maximum reach of 600-km with 3-ROADM passes was obtained employing nonlinear compensation.

M3C.4 • 16:45
Adaptive Digital Back-Propagation for Optical Communication Systems, Antonio Napoli[1], Maxim Kuschnerov[1], Chien-Yu Lin[2], Bernhard Spinnler[1], Marc Bohn[1], Danish Rafique[1], Vincent A. Sleiffer[3], Bernhard Schmauss[2]; [1]*R&D, Coriant GmbH, Germany;* [2]*Inst. of Microwave and Photonics (LHFT), Univ. of Erlangen (FAU), Germany;* [3]*COBRA Inst., Eindhoven Univ. of Technology, Netherlands.* We propose an adaptive digital back-propagation method (A-DBP) to self-determine unknown fiber nonlinear coefficient gamma. Performance is experimentally verified with 10×224-Gb/s POL-MUX-16QAM over 656km. Optimal DBP performance without knowledge of gamma, is obtained by A-DBP.

M3D • Radio-Over-Fiber II—Continued

M3D.3 • 16:30
Centralized Optical Pre-coding for Multi-cell MIMO in Millimeter-wave Radio-over-Fiber System, Lin Cheng[1], Cheng Liu[1], Ming Zhu[1], Jing Wang[1], Gee-Kung Chang[1]; [1]*Georgia Inst. of Technology, USA.* We propose a system design for millimeter-wave MIMO communications. Based on centralized optical pre-coding enabled by RoF, multi-cell MIMO is successfully demonstrated to enhance system capacity by exploiting the spatial multiplexing gain.

M3D.4 • 16:45
Digital Multi-Channel Post-Linearization for Uplink in Multi-Band Radio-Over-Fiber Systems, Yinqing Pei[1], Jianqiang Li[1], Kun Xu[1], Yitang Dai[1], Ji Yuefeng[1], Jintong Lin[1]; [1]*Beijing Univ of Posts & Telecom, China.* A digital multi-channel post linearization technique is proposed for the uplink of multi-band RoF systems. With all linearization functions located in the central office, >12dB ACLR reduction is demonstrated in a two-band RoF system.

M3E • Datacom Switching Architectures—Continued

Design; published by Springer. Dr. Bergman currently serves as the co-Editor-in-Chief of the IEEE/OSA Journal of Optical Communications and Networking.

M3F • Multimode and Few-Model Fibers—Continued

M3F.2 • 16:30
Low-DMGD 6-LP-Mode Fiber, Pierre Sillard[1], Denis Molin[1], Marianne Bigot-Astruc[1], Hélène Maerten[1], Dennis van Ras[2], Frank Achten[2]; [1]*R&D, Prysmian Group, France;* [2]*Prysmian Group, Netherlands.* We report the design and the fabrication of a low-DMGD 6-LP-mode fiber adapted to strongly-coupled mode-division-multiplexed systems that allows to multiply the capacity by a tenfold factor.

M3F.3 • 16:45
Six-LP-mode transmission fiber with DMD of less than 70 ps/km over C+L band, Takayoshi Mori[1], Taiji Sakamoto[1], Masaki Wada[1], Takashi Yamamoto[1], Fumihiko Yamamoto[1]; [1]*NTT Corporation, Japan.* A low DMD trench assisted GI-fiber supporting six-LP-mode propagation is proposed. We successfully fabricated a transmission fiber with a total absolute DMD of less than 70 ps/km within the C+L band for six-LP-mode operation.

Room 125

M3G • High Speed Transmitters and Receivers—Continued

M3G.2 • 16:30 Invited

Reliability of VCSELs for >25Gb/s, Jim Guenter[1], Bobby Hawkins[1], Robert Hawthorne[1], Gary Landry[1]; [1]*Finisar Corporation, USA*. The next individual-channel VCSEL (Vertical Cavity Surface Emitting Laser) node for data communications is 25 Gbps or higher. Providing the required reliability becomes ever more challenging as the speeds increase, but possible with proper design.

Room 130

M3H • Optical Networks and Virtualization—Continued

M3H.3 • 16:30

Effective Virtual Optical Network Embedding Based on Topology Aggregation in Multi-Domain Optical Networks, Sangjin Hong[1], Jason P. Jue[1], Qiong Zhang[2], Xi Wang[2], Hakki C. Cankaya[3], Qingya She[3], Motoyoshi Sekiya[2]; [1]*Computer Science, Univ. of Texas at Dallas, USA;* [2]*Fujitsu Laboratories of America, USA;* [3]*Fujitsu Network Communications, USA*. We present an efficient algorithm for mapping a virtual optical network topology onto a physical multi-domain optical network with the objective of minimizing the total network link cost.

M3H.4 • 16:45 *Top-Scored*

Dynamic Multi-domain Virtual Optical Networks Deployment with Heterogeneous Control Domains, Ricard Vilalta[1], Raul Muñoz[1], Ramon Casellas[1], Ricardo Martínez[1], Shuping Peng[2], Mayur Channegowda[2], Tasos Vlachogiannis[2], Reza Nejabati[2], Dimitra E. Simeonidou[2], Xiaoyuan Cao[3], Takehiro Tsuritani[3], Itsuro Morita[3]; [1]*CTTC, Spain;* [2]*High-Performance Networks Group, Univ. of Bristol, UK;* [3]*KDDI R&D Laboratories Inc., Japan*. We propose a resource broker to dynamically provision multi-domain VON across heterogeneous control (GMPLS, OpenFlow) domains and transport (OPS, EON) technologies. Experimental evaluation has been performed in an international testbed across Spain, UK and Japan.

Room 131

M3I • NG-PON2 Technologies—Continued-

M3I.2 • 16:30

Outage probability due to Stimulated Raman Scattering in GPON and TWDM-PON coexistence, Vittorio Curri[1], Stefano Capriata[2], Roberto Gaudino[1]; [1]*DET, Politecnico di Torino, Italy;* [2]*Telecom Italia, Italy.* TWDM-PON (ITU-T G.989) may induce relevant extra-attenuation on coexistence with GPON due to Raman nonlinearity. We give a compact theoretical framework to study this problem considering polarization statistical effects, leading to outage probability characterization.

M3I.3 • 16:45 *Top-Scored*

Beyond 5dB Nonlinear Raman Crosstalk Reduction via PSD Control of 10Gb/s OOK in RF-Video Coexistence Scenarios for Next-Generation PON, Akihiro Tanaka[1], Neda Cvijetic[1], Ting Wang[1]; [1]*NEC Laboratories America Inc, USA*. We present the first experimental verification of nonlinear Raman crosstalk mitigation via PSD control of 10 Gb/s OOK using simple RF filtering. Beyond 5dB crosstalk suppression is achieved without bandwidth expansion after 25-km SSMF transmission.

Room 132

M3J • High Power Lasers, Components and Sensors—Continued

M3J.2 • 16:30 Invited

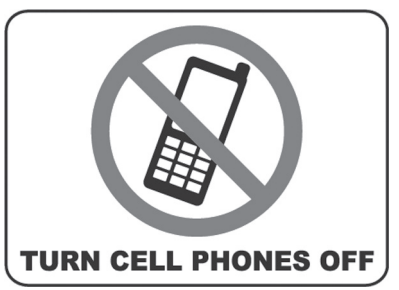
Techniques to detect and stop fiber fuses, Kenji Kurokawa[1]; [1]*Electrical and Electronic Engineering, Kitami Inst. of Technology, Japan*. The fiber fuse phenomenon will pose a real danger to optical communication systems constructed with conventional single-mode fiber in the future. I describe techniques to actively and/or passively terminate fiber fuses.

Room 133

M3K • Multiplexer for Space-Division Multiplexing—Continued

M3K.3 • 16:30 Invited

Couplers for Multicore Fibers and 3D Waveguide Technology, Nicholas Psaila[1]; [1]*Optoscribe, UK*. Components for Space-Division-Multiplexing fabricated using laser inscribed 3D waveguides are presented and discussed. Fan-outs for coupling to multicore fibre, Photonic Lanterns for coupling to multimode fibre, and advanced SDM integration platform capabilities are demonstrated.



M3A • FEC and Modulation—Continued

M3A.4 • 17:00
Comparison of Quaternary Block-Coding and Sphere-Cutting for High-Dimensional Modulation, David Millar[1], Toshiaki Koike-Akino[1], Sercan O. Arik[1,2], Keisuke Kojima[1], Kieran Parsons[1]; *[1]Mitsubishi Electric Research Labs, USA; [2]Department of Electrical Engineering, Stanford Univ., USA.* We propose quaternary block coded high-dimensional modulation formats and compare them to spherical lattice-cut and hybrid modulation formats. Noise tolerance and transmission performance are simulated for spectral efficiencies ranging between those of DP-QPSK and DP-8QAM. Similar performance to sphere-cutting is attained with lower DAC resolution.

M3A.5 • 17:15 ***Top-Scored***
Experimental Demonstration of 24-Dimensional Extended Golay Coded Modulation with LDPC, David Millar[1], Toshiaki Koike-Akino[1], Robert Maher[2], Domanic Lavery[2], Milen Paskov[2], Keisuke Kojima[1], Kieran Parsons[1], Benn Thomsen[2], Seb J. Savory[2], Polina Bayvel[2]; *[1]Mitsubishi Electric Research Labs, USA; [2]Optical Networks Group, Univ. College London (UCL), UK.* We experimentally demonstrate ultra-long haul transmission of 24-D extended Golay coded modulation with LDPC. Compared with LDPC coded DP-BPSK, an increase of 15% in reach was shown, with a 3 dB increase in launch power margin at a transmission distance of more than 16,000 km.

M3B • Multi-layer Networks—Continued

M3B.4 • 17:00
Leverage G.808.3 Shared Mesh Protection and Best Effort SRLG GMPLS Protection in Multi-layer Networks, Yuxin (Eugene) Dai[1], Wei Dai[2]; *[1]Network Architecture, Cox Communications, USA; [2]Department of Computer Engineering, Univ. of California, Santa Barbara, USA.* With core networks going up to 100Gb/s, multiple-layer network protection becomes increasingly important. Optimizing ITU-T G.808.3 Shared Mesh Protection at the transport layer with best effort SRLG GMPLS protection at L2/L3 and survivability are studied.

M3B.5 • 17:15
Operational Expenditures savings in IP/MPLS over DWDM networks by Multi-layer restoration, Beatriz de la Cruz Miranda[1], Oscar Gonzalez de dios[1], Victor Lopez[1], Juan-Pedro Fernández-Palacios[1]; *[1]Telefonica I+D, Spain.* Multi-layer restoration enhances recovery in multiple failure scenarios and can relax the urgency of the reparation of damaged network equipment. This work analyses the operational expenditures (OpEx) savings obtained with multi-layer restoration.

M3C • Fiber Nonlinearity Mitigation & Compensation—Continued

M3C.5 • 17:00 **Invited**
256 Gb/s PM-16-QAM Quasi-Single-Mode Transmission over 2600 km using Few-Mode Fiber with Multi-Path Interference Compensation, Sui Qi[1], Zhang HongYu[2], John D. Downie[3], William A. Wood[3], Jason E. Hurley[3], Snigdharaj Mishra[4], Alan Pak Tao Lau[1], Chao Lu[5], Hwa-Yaw Tam[1], Ping-kong Alexander Wai[5]; *[1]Electrical Engineering, The Hong Kong Polytechnic Univ., Hong Kong; [2]Tyndall National Inst., Univ. College cork, Ireland; [3]Corning Incorporated, USA; [4]Corning Incorporated, USA; [5]Electronic and Information Engineering, The Hong Kong Polytechnic Univ., Hong Kong.* We experimentally demonstrate 256 Gb/s PM-16-QAM transmission up to 2600 km by using 100-km spans of few-mode fibers (FMF) operating in quasi-single-mode (QSM) transmission and using a DD-LMS algorithm to compensate multi-path interference (MPI).

M3D • Radio-Over-Fiber II—Continued

M3D.5 • 17:00
Experimental Investigation on Multi-Dimensional Digital Predistortion for Multi-Band Directly-Modulated Radio-Over-Fiber Systems, Hao Chen[1], Jianqiang Li[1], Kun Xu[1], Yitang Dai[1], Feifei Yin[1], Jintong Lin[1]; *[1]Beijing Univ of Posts & Telecom, China.* Multi-dimensional digital predistortion technique is experimentally investigated for multi-band directly-modulated radio-over-fiber sytems, in terms of nonlinearity order, memory length, oversampling rate, carrier frequency dependence, and RF input power tolerance.

M3D.6 • 17:15
Ultra-High-Speed Fiber-Wireless-Fiber Link for Emergency Communication System, Xinying Li[1], Zizheng Cao[2], Junwen Zhang[1,3], Fan Li[3], Gee-Kung Chang[4]; *[1]Fudan Univ., China; [2]Eindhoven Univ. of Technology, Netherlands; [3]ZTE (TX) Inc, USA; [4]Georgia Inst. of Technology, USA.* We propose and experimentally demonstrate fiber-wireless-fiber link suited for emergency situation. The proposed system has throughput comparable with fiber-optic communication. Capacity of 109.6 Gb/s over two spans of 80-km SMF and 2x2 MIMO is demonstrated.

M3E • Datacom Switching Architectures—Continued

M3E.2 • 17:00
Fast Dynamic Wavelength and Path Scheduling in a Monolithic 8×8 Switch, Qixiang Cheng[1], Patty Stabile[2], Abhinav Rohit[2], Adrian Wonfor[1], Richard V. Penty[1], Ian White[1], Kevin Williams[2]; *[1]Univ. of Cambridge, UK; [2]Eindhoven Univ. of Technology, Netherlands.* The control plane is implemented for the first time to allow scheduling and power leveling in a monolithic 8×8 space and wavelength selective cross-connect. 16 dynamic data connections are established within 16μs.

M3E.3 • 17:15
OPTOPUS: Optical Backplane for Data Center Switches, Michael R. Tan[1], Paul Rosenberg[1], Georgios Panotopoulos[1], Moray Mclaren[3], Wayne Sorin[1], SAGI MATHAI[1], Lennie Kiyama[1], Joseph Straznicky[1], David Warren[2]; *[1]Hewlett Packard Labs, USA; [2]Hewlett Packard Company, USA; [3]Hewlett Packard Labs, UK.* An all optically connected data center switch with a Multi-Bus Optical Backplane is demonstrated. The broadcast bus is based on a multimode zig-zag star coupler capable of 1:6 optical broadcast on 12 multi-mode GI fiber channels.

M3F • Multimode and Few-Model Fibers—Continued

M3F.4 • 17:00 **Invited**
Fibers supporting OAM and their applications, Siddharth Ramachandran[1]; *[1]Boston Univ., USA.* We describe optical fibers that can generate, and stably propagate over km-distances, light beams that possess orbital angular momentum. We review applications of such fibers in areas ranging from telecommunications to nanoscale microscopy.

Room 125

M3G • High Speed Transmitters and Receivers—Continued

M3G.3 • 17:00
Up to 64-QAM Modulation of a Silicon-Ring-Resonator-Modulator, Giovanni Beninca de Farias[1], Sylvie Menezo[1], Olivier Dubray[1], Delphine Marris-Morini[2], Laurent Vivien[2], Andre Myko[1], Benjamin Blampey[1]; *[1]CEA-Leti, France; [2]Institut d'Electronique Fondamentale, France.* The multi-level modulation of a Silicon-Ring-Resonator-Modulator (Si-RRM) is demonstrated for the first time: an up-to-64-Quadrature Amplitude Modulation (QAM) is made possible due to the use of a highly linear modulation span.

M3G.4 • 17:15
High-Speed Silicon-Organic Hybrid (SOH) Modulators with 230 pm/V Electro-Optic Coefficient Using Advanced Materials, Robert Palmer[1], Sebastian Koeber[1], Markus Woessner[1], Delwin L. Elder[2], Wolfgang Heni[1], Dietmar Korn[1], Hui Yu[3,4], Matthias Lauermann[1], Wim Bogaerts[3], Larry R. Dalton[2], Wolfgang Freude[1], Juerg Leuthold[1,5], Christian Koos[1]; *[1]Inst.s IPQ and IMT, Karlsruhe Inst. for Technology, Germany; [2]Department of Chemistry, Univ. of Washington, USA; [3]IMEC, Photonics Research Group, Ghent Univ., Belgium; [4]Department of Information Science and Electronic Engineering, Zhejiang Univ., China; [5]Electromagnetic Fields Laboratory, Swiss Federal Inst. of Technology (ETH), Switzerland.* We report on record-high electro-optic coefficients of up to 230 pm/V in silicon slot waveguide modulators. The modulators allow for low drive voltage at 40 Gbit/s at a device length of only 250 µm.

Room 130

M3H • Optical Networks and Virtualization—Continued

M3H.5 • 17:00 Invited
Towards Software Defined Autonomic Terabit Optical Networks, Julio Oliveira[1], Juliano Oliveira[1], Marcos Siqueira[1], Rafael Scaraficci[1], Marcos Salvador[1], Leonardo Mariote[1], Neil G. Gonzalez[1], Luis Carvalho[1], Fabian Van't Hooft[1], Giovanni Santos[1], Eduardo C. Magalhaes[1], João Januario[1]; *[1]CPqD, Brazil.* This paper presents an Optical SDN architecture and implementation enabled for virtual optical networks, supporting adaptive and cognitive algorithms to enhance QoT. The paper also shows experimental results of a software-defined autonomic flexible transponder.

Papers are available online for download. Visit www.ofcconference.org and click on the Download Digest Papers button.

Room 131

M3I • NG-PON2 Technologies—Continued-

M3I.4 • 17:00 Invited
Burst-mode Electronic Dispersion Compensation, Peter Ossieur[1], Stefano Porto[1], Cleitus Antony[1], Anil Jain[1], Denis Kelly[1], Nasir Quadir[1], Giuseppe Talli[1], Paul Townsend[1]; *[1]Photonic Systems Group, Tyndall National Inst., Univ. College Cork, Ireland.* We demonstrate burst-mode electronic dispersion compensation to support the upstream transmission in hybrid DWDM-TDMA PONs. It is shown how fast tap adaptation is feasible within the short preamble at the start of each burst.

Room 132

M3J • High Power Lasers, Components and Sensors—Continued

M3J.3 • 17:00
Advanced Optical Pulse Signal Profiling using Distributable "Optical Pulse Ruler", Tsuyoshi Konishi[1], Tomotaka Nagashima[1], Takuya Murakawa[1]; *[1]Osaka Univ., Japan.* We propose and demonstrate advanced optical pulse signal profiling using a high-nonlinear optical fiber, which works as a distributable "optical pulse ruler". Additionally, we assess its profiling performance by comparison with conventional instruments.

M3J.4 • 17:15
128km fully-distributed high-sensitivity fiber-optic intrusion sensor with 15m spatial resolution, Fei Peng[1]; *[1]UESTC, China.* An ultra-long phase-sensitive optical time domain reflectometry (Φ-OTDR) that can achieve high-sensitivity intrusion detection over 128 km fiber with high spatial resolution of 15 m is presented, which is the longest Φ-OTDR reported to date.

Room 133

M3K • Multiplexer for Space-Division Multiplexing—Continued

M3K.4 • 17:00
Ultrafast Laser Fabrication of 3D Photonic Components in Flexible Glasses, Sheng Huang[1], Mingshan Li[1], Kevin P. Chen[1], Sean M. Garner[2], Ming-Jun Li[2]; *[1]Univ. of Pittsburgh, USA; [2]Corning Inc., USA.* We demonstrated flexible photonics lightwave circuits in glasses. The waveguide was written in ≤100um thick Corning® Willow® Glass by a spatially and temporally shaped femtosecond ultrafast laser beam with 0.11dB/cm loss at 1550nm. T

M3K.5 • 17:15
57 Channel (19x3) Spatial Multiplexer Fabricated using Direct Laser Inscription, Paul Mitchell[1,2], Graeme Brown[1], Robert R. Thomson[2], Nicholas Psaila[1], Ajoy Kar[2]; *[1]Optoscribe Ltd., UK; [2]Inst. of Photonics and Quantum Sciences, Heriot Watt Univ., UK.* We present a 57 channel spatial multiplexer consisting of 19 separate 3-port photonic lanterns arranged in a hexagonal array. An average insertion loss of 0.92 dB was measured across all ports with 0.1 dB uniformity.

Room 102

M3A • FEC and Modulation—Continued

M3A.6 • 17:30
Staircase Rate-Adaptive LDPC-Coded Modulation for High-Speed Intelligent Optical Transmission, Yequn Zhang[1], Ivan B. Djordjevic[1]; [1]*Univ. of Arizona, USA*. We propose staircase rate-adaptive LDPC-coded modulation that is suitable for high-speed intelligent optical transmission. Compared with shortening of LDPC codes, larger coding gain can be obtained and error floor can also be effectively mitigated.

M3A.7 • 17:45
A Simple and High-Performance Method for Combining Soft-Decision FEC with Differential Encoding in 100 Gbps Dual-Polarization QPSK System, Julie Karaki[2], Raphaël Le Bidan[2], Erwan Pincemin[1]; [1]*France Telecom, France;* [2]*Signal & Communications Department, Telecom bretagne, France*. By a joint design of FEC and modulation, we demonstrate that it is possible to associate strong SD-FEC and differentially-encoded QPSK systems with negligible coding gain penalty and minor modifications in existing transceivers. The resulting system is robust to cycle slips.

Room 120

M3B • Multi-layer Networks—Continued

M3B.6 • 17:30 Invited
Considerations for multi-layer network optimization, John Leddy[1]; [1]*Comcast Corporation, USA*. Abstract Not Available

Room 121

M3C • Fiber Nonlinearity Mitigation & Compensation—Continued

M3C.6 • 17:30
Spectrally-efficient Dual Phase-Conjugate Twin Waves with Orthogonally Multiplexed Quadrature Pulse-shaped Signals, Tsuyoshi Yoshida[1], Takashi Sugihara[1], Kazuyuki Ishida[1], Takashi Mizuochi[1]; [1]*Mitsubishi Electric Corporation, Japan*. We propose a novel nonlinearity mitigation technique which can double the spectral efficiency of a phase-conjugate twin wave by diplexing the twin waves. Simulation shows a Q improvement of 1.2 dB from conventional DP-QPSK transmission.

Room 122

M3D • Radio-Over-Fiber II—Continued

M3D.7 • 17:30 *Top-Scored*
Antenna Polarization Diversity for 146Gb/s Polarization Multiplexing QPSK Wireless Signal Delivery at W-band, Xinying Li[1], Junwen Zhang[1,2], Fan Li[2], Jiangnan Xiao[1]; [1]*Fudan Univ., China;* [2]*ZTE (TX) Inc, USA*. We experimentally demonstrate a novel W-band integrated optical-wireless system based on antenna polarization diversity, which can realize 80-km SMF-28 transmission and 2-m 2×2 MIMO wireless delivery for up to 39-Gbaud (146 Gb/s) PDM-QPSK signal at W-band.

M3D.8 • 17:45
Error-Free and Laser-Phase-Noise-Insensitive Optical Coherent Transmission of Uplink Radio-over-Fiber signal, Toshiaki Kuri[1], Takahide Sakamoto[1], Guo Wei Lu[1], Tetsuya Kawanishi[1]; [1]*National Inst. of Information and Communications Technology, Japan*. Laser-phase-noise-insensitive optical coherent transmission of a radio-over-fiber signal with two-tone local light and digital signal processing technique is experimentally demonstrated. The estimated BER of less than 10e-9 is successfully achieved after 20-km-long fiber-optic transmission.

Room 123

M3E • Datacom Switching Architectures—Continued

M3E.5 • 17:30
Gain Effect on the Scalability of SOA-based Optical Space Switches, Peicheng Liao[1], Chunshu Zhang[1], Xi Lu[1], Mehrdad Mir Shafiei[1], Cerutti Isabella[2], Nicola Andriolli[2], Odile Liboiron-Ladouceur[1]; [1]*Dept. of Electrical and Computer Eng., McGill Univ., Canada;* [2]*Scuola Superiore Sant'Anna, Italy*. Scalability is assessed by propagating WDM packets through multiple SOAs using a loop. Experimental results show that high SOA gain is more energy-efficient for single-stage space switch while low gain enhances the scalability of multi-stage architectures.

M3E.6 • 17:45
Hybrid Photonic Ethernet Switch for Datacenters, Hamid Mehrvar[1]; [1]*Huawei Technology Canada, Canada*. We demonstrate a photonic packet switch using a hybrid photonics-electronic approach. It uses compression, scrambling and packet size discrimination to allow for the photonic switching of native Ethernet frames.

Room 124

M3F • Multimode and Few-Model Fibers—Continued

M3F.5 • 17:30
Effect of random linear mode coupling on intermodal four-wave mixing in few-mode fibers, Yuzhe Xiao[1,2], Sami Mumtaz[1], Rene-Jean Essiambre[2], Govind P. Agrawal[1]; [1]*The Inst. of Optics, Univ. of Rochester, USA;* [2]*Bell Laboratories, Alcatel-Lucent, USA*. We study numerically intermodal four-wave mixing (IM-FWM) in few-mode fibers including both birefringence fluctuations and random linear coupling. We find that linear mode coupling reduces idler power by 3.5 dB for non-degenerate IM-FWM.

M3F.6 • 17:45
Experimental Evaluation of Mode Conversion Ratio at Splice Point for Two-Mode Fibers and its Simulated Effect on MIMO Transmission, Ryo Maruyama[1], Nobuo Kuwaki[1], Shoichiro Matsuo[1], Kiminori Sato[1], Masaharu Ohashi[2]; [1]*Fujikura.ltd, Japan;* [2]*Osaka Prefecture Univ., Japan*. We evaluate experimentally mode conversion ratio at a splice point (Cs) for two-mode fibers. We clarify the precise connection with an offset value which are required for suppressing the degradation due to Cs by simulation.

Room 125

M3G • High Speed Transmitters and Receivers—Continued

M3G.5 • 17:30
Exploring the limits of high-speed receivers for multimode VCSEL-based optical links, Nicolas Dupuis[1], Daniel Kuchta[1], Fuad E. Doany[1], Alexander V. Rylyakov[1], Jonathan Proesel[1], Christian Baks[1], Clint L. Schow[1], Sanh Luong[2], Chuan Xie[2], Li Wang[2], Shenghong Huang[2], Kenneth Jackson[2], Neinyi Li[2]; [1]*IBM T.J. Watson Research Center, USA;* [2]*Sumitomo Electric Device Innovations USA, USA.* We present complete characterizations of multimode GaAs photodetectors for high-speed VCSEL-based optical links and compare SiGe receiver IC performances in a 62Gbps back-to-back link for different photodiode designs.

Room 130

M3H • Optical Networks and Virtualization—Continued

M3H.6 • 17:30
Wireless-DataCenter Backhaul over Hardware Virtualized Flexible Optical Network, Bijan Rahimzadeh Rofoee[1], Georgios S. Zervas[1], Yan Yan[1], Shuping Peng[1], Reza Nejabati[1], Anna Tzanakaki[2], Dimitra E. Simeonidou[1]; [1]*Electrical and Electronic, Univ. of Bristol, UK;* [2]*Network Design and Services Group, Athens Information Technology, Greece.* Architecture design extensions for Time Shared Optical Network (TSON) are proposed for mobile backhaul. It introduces higher rates, flexible sub-lambda or lambda modes of operation, and dynamic memory allocation facilitating infrastructure virtualization and reprogramming.

M3H.7 • 17:45
Virtual Network Reconfiguration in Optical Cloud Substrates, Hao Bai[1], Feng Gu[2], Kaile Liang[2], Mahshid Rahnamay-Naeini[2], Samee Khan[3], Majeed Hayat[2], Nasir Ghani[1]; [1]*USF, USA;* [2]*UNM, USA;* [3]*NDSU, USA.* This paper studies reconfiguration design for cloud-based virtual network services mapped over optical substrates. A novel scheme is proposed to improve resource efficiency and its results are analyzed versus some existing strategies.

Room 131

M3I • NG-PON2 Technologies—Continued-

M3I.5 • 17:30 *Top-Scored*
Demonstration of 10Gb/s burst-mode transmission using a linear burst-mode receiver and burst-mode electronic equalization, Stefano Porto[1], Cleitus Antony[1], Giuseppe Talli[1], Daniel Carey[1], Peter Ossieur[1], Paul Townsend[1]; [1]*Tyndall National Inst., Univ. College Cork, Ireland.* Using burst-mode electronic dispersion compensation and a linear burst-mode receiver, we achieved >100km reach at 15dB loud/soft ratio. Gear shifted least mean squares adaptation limits the number of training bits in the preamble to 250.

M3I.6 • 17:45
A bi-directional semiconductor optical amplifier acting simultaneously as upstream pre-amplifier and downstream booster in low cost NG-PON2 optical line terminations, Rene Bonk[1], Wolfgang Poehlmann[1], Harald Schmuck[1], Thomas Pfeiffer[1]; [1]*Bell Labs Germany, Alcatel-Lucent Germany, Germany.* We experimentally demonstrate a bi-directional SOA for simultaneous upstream pre-amplification and downstream boosting in NG-PON2 OLT applications. Signal performance, output power, burst ratio and back-reflection tests indicate its feasibility for mid-class power budgets of NG-PON2.

Room 132

M3J • High Power Lasers, Components and Sensors—Continued

M3J.5 • 17:30
Fast Pump-Power-Independent Brillouin Fiber Optic Sensor, Avi Motil[1], Orr Danon[1], Yair Peled[1], Moshe Tur[1]; [1]*Tel Aviv Univ., Israel.* A fast and distributed Brillouin sensor, which is immune to pump power variations is presented. 120Hz strain vibrations are measured over 50m fiber with >1kHz sampling rate, demonstrating immunity to >5dB pump power variations.

Room 133

M3K • Multiplexer for Space-Division Multiplexing—Continued

M3K.6 • 17:30
Orbital-Angular-Momentum Mode (De) Multiplexer: A Single Optical Element for MIMO-based and non-MIMO-based Multimode Fiber Systems, Giovanni Milione[1,4], Hao Huang[3], Martin Lavery[2,4], Alan Willner[3], Robert R. Alfano[1,4], Thien An Nguyen[1,4], Miles J. Padgett[2,4]; [1]*Physics, City College of New York, USA;* [2]*Physics and Astronomy, Univ. of Glasgow, UK;* [3]*Electrical Engineering, Univ. of Southern California, USA;* [4]*New York State Center for Complex Light, USA.* A mode (de)multiplexer in a basis of OAM modes for MIMO-based and non-MIMO-based multimode fiber systems is experimentally demonstrated which via a single optical element can (de)multiplex and generate individual modes with potential scalability

M3K.7 • 17:45
Experimental Demonstration of Basic Functionalities for 0.1-THz Orbital Angular Momentum (OAM) Communications, Long Zhu[1], Xuli Wei[1], Jian Wang[1], Zhongqi Zhang[1], Zhuoyu Li[1], Han Zhang[1], Shuhui Li[1], Kejia Wang[1], Jinsong Liu[1]; [1]*Wuhan National Laboratory for Optoelectronics, China.* By designing and fabricating 3D printed spiral phase plates (SPPs), we demonstrate basic functionalities for terahertz (THz) orbital angular momentum (OAM) communications, including the generation, detection, conversion, multicasting and manipulation of OAM at 0.1 THz.

Room 102	Room 120	Room 121	Room 122	Room 123	Room 124

08:00–10:00 Tu1A • Plenary Session

10:00–17:00 Exhibition and Show Floor, *Exhibit Halls A, B, C (South) & Hall D (North) (coffee service from 10:00–10:30)*

11:00–14:00 Unopposed Exhibit-Only Time, *Exhibit Halls A, B, C (South) & Hall D (North) (concessions available)*

12:00–14:00 Poster Preview, *Exhibit Hall South*

14:00–16:00
Tu2A • RF Photonic Devices

Presider: Leif Johansson; Univ. of California Santa Barbara, USA

Tu2A.1 • 14:00
Integrated Silicon-Organic Hybrid (SOH) Frequency Shifter, Matthias Lauermann[1], Claudius Weimann[1], Alexander Knopf[2], Delwin L. Elder[3], Wolfgang Heni[1], Robert Palmer[1], Dietmar Korn[1], Philipp Schindler[1], Sebastian Koeber[1], Luca Alloatti[1], Hui Yu[4,5], Wim Bogaerts[4], Larry R. Dalton[3], Christian Rembe[2], Juerg Leuthold[1,6], Wolfgang Freude[1], Christian Koos[1]; *[1]Inst.s IPQ and IMT, Karlsruhe Inst. of Technology (KIT), Germany; [2]Polytec GmbH, Germany; [3]Department of Chemistry, Univ. of Washington, USA; [4]IMEC, Photonics Research Group, Ghent Univ., Belgium; [5]Department of Information Science and Electronic Engineering, Zhejiang Univ., China; [6]Electromagnetic Fields Laboratory, Swiss Federal Inst. of Technology (ETH), Switzerland.* We demonstrate a waveguide-based frequency shifter on the silicon-organic hybrid (SOH) platform, enabling frequency shifts up to 10 GHz. Spurious side-modes are suppressed by more than 23 dB using temporal shaping of the drive signal.

14:00–15:45
Tu2B • Field Trial Demonstrations and Modulation Formats

Presider: Richard Younce; Tellabs, USA

Tu2B.1 • 14:00
Transmission of 400G PM-16QAM Channels over Long-Haul Distance with Commercial All-Distributed Raman Amplification System and Aged Standard SMF in Field, Tiejun J. Xia[1], Glenn A. Wellbrock[1], Ming-Fang Huang[2], Shaoliang Zhang[2], Yue-Kai Huang[2], DO-IL CHANG[3], Sergey Burtsev[3], Wayne Pelouch[3], Edwin Zak[3], Hector dePedro[3], William Szeto[3], Herve Fevrier[3]; *[1]Verizon Communications, Inc., USA; [2]NEC Laboratories, Inc., USA; [3]Xtera Communications, Inc., USA.* Transmission of eight dual-carrier 400G PM-16QAM channels over 1,504-km aged SSMF in field is demonstrated with high-coding-gain FEC and commercial all-distributed-Raman amplification system. The result shows 16QAM can be used for deployed long-haul fiber networks.

14:00–15:45
Tu2C • New Devices in NGPON Networks

Presider: Susumu Kinoshita; Fujitsu Laboratories Ltd., Japan

Tu2C.1 • 14:00
Multi-service OFDM Uplink Transmission in Full-Duplex FTTx Systems Using RSOA-based WDM-PON Architecture, Truong An Nguyen[1], Kim Lefebvre[1], Leslie Rusch[1]; *[1]Electrical and Computer Engineering, Center d'Optique, Photonique et Laser, Canada.* We experimentally demonstrate, for the first time, the transmission of multi-service analog OFDM WiFi uplink signal along with OOK downlink signal over 20 km of single mode fiber in a full-duplex RSOA-based WDM-PON fiber-to-the-x system

14:00–15:45
Tu2D • Amplifiers for SDM - II

Presider: Peter Krummrich; Universitat Dortmund, Germany

Tu2D.1 • 14:00 Invited
Multicore EDFA for Space Division Multiplexing by Utilizing Cladding-pumped Technology, Yukihiro Tsuchida[1], Masateru Tadakuma[1], Ryuichi Sugizaki[1]; *[1]Furukawa Electric Co., Ltd., Japan.* Amplification characteristics of double-clad multicore EDFA are reviewed. Cladding-pumping configuration, which has possibilities for reducing power consumption and downsizing, is demonstrated.

14:00–16:00
Tu2E • Ring Resonators

Presider: Jurgen Michel; Massachusetts Inst. of Technology, USA

Tu2E.1 • 14:00
Experimental Demonstration of Silicon-Bbased Metallic Whispering Gallery Mode Disk Resonators and Their Thermo-Tuning, Fei Lou[1], Lars Thylen[1,2], Lech Wosinski[1]; *[1]Kungliga Tekniska Hogskolan, Sweden; [2]Hewlett-Packard Laboratories, USA.* Si-based metallic whispering gallery mode disks with 0.5 μm and 1 μm radii are theoretically analyzed and experimentally demonstrated. Estimated Purcell factor is around 127±42. Thermo-tuning of the device is also presented.

14:00–16:00
Tu2F • DSP-Based Optical Access

Presider: Jun-ichi Kani; NTT Access Service Systems Laboratories, Japan

Tu2F.1 • 14:00 Invited
Digital Coherent Technology for Long-Reach Optical Access, Domanic Lavery[1], Seb J. Savory[1]; *[1]Univ. College London, UK.* This semi-tutorial paper outlines the potential advantages afforded by digital coherent receivers in long-reach optical access networks. Low complexity DSP algorithms are discussed which relax the optical complexity requirements of a coherent receiver.

Room 125	Room 130	Room 131	Room 132	Room 133

08:00–10:00 Tu1A • Plenary Session

10:00–17:00 Exhibition and Show Floor, *Exhibit Halls A, B, C (South) & Hall D (North) (coffee service from 10:00–10:30)*

11:00–14:00 Unopposed Exhibit-Only Time, *Exhibit Halls A, B, C (South) & Hall D (North) (concessions available)*

12:00–14:00 Poster Preview, *Exhibit Hall South*

14:00–16:00 Tu2G • OFDM I

Presider: William Shieh; Univ. of Melbourne, Australia

Tu2G.1 • 14:00
Experimental Study of Weighted Inter-frame Averaging Based Channel Estimation for CO-OFDM System, Paikun Zhu[1], Juhao Li[1], Hui Zhao[1], Cheng Zhang[1], Yue Liu[1], Yuping Zhao[1], Yongqi He[1], Zhangyuan Chen[1]; [1]*State Key Laboratory of Advanced Optical Communication Systems and Networks, Peking Univ., China.* We propose an efficient channel estimation method based on weighted inter-frame averaging for CO-OFDM system. Up to 2.4 dB error vector magnitude improvement compared with traditional methods is shown by a PDM-16QAM CO-OFDM experiment.

14:00–16:00 Tu2H • Tunable Lasers & Comb Sources

Presider: Yuliya Akulova; JDSU, USA

Tu2H.1 • 14:00 Tutorial
Widely tunable semiconductor lasers, Michael Larson[1]; [1]*JDSU, USA.* Widely tunable semiconductor lasers have become a mainstay for metro and long-haul transmission. This tutorial addresses the unifying principles underlying the plethora of device architectures in use today, with focus on monolithic integration to meet demanding application requirements.

Michael C. Larson is an R&D manager at JDSU in Milpitas, CA, overseeing source laser development. He holds a bachelor of engineering from Harvey Mudd College, and M.S. and Ph.D. in electrical engineering from Stanford

Continued on page 77

14:00–16:00 Tu2I • Symposium on Enabling the Cloud: Datacenter as a Network I

Presider: George Clapp, AT&T, USA; Hong Liu, Google, USA; Laurent Schares, IBM, USA

Tu2I.1 • 14:00 Invited
Scaling Bottlenecks in Data Center Networks, David Maltz; *Microsoft, USA.* Building cost-efficient cloud data centers means putting more and more servers on the same sites, and this stresses the ability to build cost-efficient fiber plants and networks to connect them. With lifespan of a server being 3 years while fiber can be good for 10 years or more, designs must be future proof. Given the scale of the networks, reducing fiber density, optimizing installation time, and automating validation of the built plant is key. This talk will describe the challenges Microsoft has faced in building cloud scale data centers and how improvements in optical technology can unlock the next steps.

14:00–15:45 Tu2J • High Capacity Transmission Using SDM

Presider: Chongjin Xie; Alcatel-Lucent Bell Labs, USA

Tu2J.1 • 14:00 Invited
Petabit/s Transmission Using Multicore Fibers, Akihide Sano[1], Takara Hidehiko[1], Takayuki Kobayashi[1], Yutaka Miyamoto[1]; [1]*NTT Network Innovation Laboratories, Japan.* Recent developments in high capacity transmission technologies based on multi-core fiber are reviewed. Propagation-direction interleaving with dual-ring structure 12-core MCF is promising for suppressing inter-core crosstalk and enables spectrally-efficient long-haul transmission.

14:00–16:00 Tu2K • Nonlinear Effects in Optical Fibers

Presider: Moshe Tur; Tel-Aviv Univ., Israel

Tu2K.1 • 14:00 Tutorial
Methods For Mapping of Local Fiber Characteristics With Sub-Molecular Accuracy, Eugene Myslevets[1]; [1]*Univ. of California San Diego, USA.* A technique for selective localization of four-photon mixing (FPM) is described. The new technique relies on localized counter-colliding power transfer and is capable of mapping transverse geometry, dispersion, stress and birefringent properties in fiber-based devices.

Evgeny Myslivets received the B.S. degree in physics (94–99) from the Belarusian State University, Minsk, Belarus, in 1999. His graduation was followed by position of principal

Continued on page 77

Show Floor Programming

11:00–12:00
Network Components in FTTx Systems, *Expo Theater Programming III*
For more details, see page 43

11:00–12:30
OIDA Review of Roadmaps for the Optical Communications Market and NPI Overview, *Expo Theater II Programming*
For more details, see page 41

■ **MarketWatch**
12:00–14:00
Panel I: State of the Industry, *Expo Theater I Programming*
For more details, see page 37

12:30–14:00
Advancing Optical Solutions in Cloud Computing, Communications and Networking, *Expo Theater III Programming*
For more details, see page 43

13:30–16:30
The Future of the Metro Core: A New and Innovative Approach to Delivering a Scalable, Yet Simplified, Metro Core Network, *Expo Theater II Programming*
For more details, see page 41

14:30–15:15
Panel: 100G Single Lamba Optics, *Expo Theater III Programming*
For more details, see page 43

15:15–16:00
Snapshot on 400GE Standardization, *Expo Theater III Programming*
For more details, see page 43

Room 102

Tu2A • RF Photonic Devices—Continued

Tu2A.2 • 14:15
Rapidly Reconfigurable RF Arbitrary Waveform Synthesis using a CMOS Silicon Photonic Chip, Jian Wang[1], Fuwan Gan[2], Ben Niu[1], Hao Shen[1], Daniel E. Leaird[1], Andrew M. Weiner[1], Minghao Qi[1,2]; *[1]Electrical and Computer Engineering, Purdue Univ., USA; [2]Shanghai Inst. of Microsystem and Information Technology, Chinese Academy of Sciences, China*. We demonstrate nanosecond-reconfigurable RF waveforms with a time-domain synthesis method using a silicon photonic chip. The waveform is modulated by a synchronized silicon electro-optic intensity modulator embedded in the pulse shaper.

Tu2A.3 • 14:30
A Compact Optically Driven Travelling-Wave Radiating Source, Steven Bowers[1], Behrooz Abiri[1], Firooz Aflatouni[1], Ali Hajimiri[1]; *[1]Electrical Engineering, California Inst. of Technology, USA*. A compact silicon-photonics optically driven mm-wave radiator uses a multi-port driven travelling-wave antenna driven by 8 silicon photodiodes with -3dB bandwidth of 25GHz to produce -9.7dBm EIRP at 180GHz.

Room 120

Tu2B • Field Trial Demonstrations and Modulation Formats—Continued

Tu2B.2 • 14:15
150 x 120 Gb/s Field Trial over 1,504 km using All-Distributed Raman Amplification, DO-IL CHANG[1], Sergey Burtsev[1], Wayne Pelouch[1], Edwin Zak[1], Hector dePedro[1], William Szeto[1], Herve Fevrier[1], Tiejun J. Xia[2], Glenn A. Wellbrock[2]; *[1]Xtera Communications, USA; [2]Verizon, USA*. An all-distributed Raman system is demonstrated to support high order modulation formats with coherent digital processing. We report the transmission of 150 channels x 120 Gb/s over 1,504 km field fiber with 5 dB Q margin.

Tu2B.3 • 14:30
Real-Time Gridless 800G Superchannel Transport Field Trial over 410km Using Coherent DP-16 QAM, Yu Rong Zhou[1], Kevin Smith[1], Roger Payne[1], Andrew Lord[1], Glenn Whalley[1], Tex Bennett[2], Eric Maniloff[2], Savchenko Alexander[2], David Boymel[2]; *[1]BT, UK; [2]Ciena Corporation, USA*. We report the first successful trial of real-time gridless 800G super-channel over a 410km DCM-less, EDFA-only fibre link using production grade DP - 16QAM, demonstrating 4.76b/s/Hz spectral efficiency, stable error free performance and robust PMD tolerance.

Room 121

Tu2C • New Devices in NGPON Networks—Continued

Tu2C.2 • 14:15
Development of Si photonics technology: Ge/Si avalanche photodiode for PON applications, Mengyuan Huang[1], Pengfei Cai[1], Liangbo Wang[1], Tuo Shi[1], Wang Chen[1], Su Li[1], Guanghui Hou[1], Ching-yin Hong[1], Dong Pan[1]; *[1]SiFotonics Technologies Co., Ltd., USA*. We accomplished the first mass-production of Ge/Si avalanche photodiode (APD) for FTTx applications in a standard CMOS foundry. Our APDs satisfy sensitivity requirements of 10G PON (both OLT and ONU sides) applications within -5°C~75°C.

Tu2C.3 • 14:30 **Invited**
Gain-Controlled Optical Amplifier Technologies for Long-Reach and High-Splitting-Ratio PON Systems, Masamichi Fujiwara[1]; *[1]NTT Access Network Service Systems Laboratories, NTT Corporation, Japan*. We describe gain-controlled optical amplifier technologies that allow service providers to flexibly locate PON repeaters in a long-reach PON system and accommodate many more users through high splitting ratios.

Room 122

Tu2D • Amplifiers for SDM - II—Continued

Tu2D.2 • 14:30 **Invited**
Challenges of Few Mode Amplifiers, Massimiliano Salsi[1]; *[1]Alcatel-Lucent Bell Labs, France*. We review recent experimental demonstrations of amplifiers for spatial division multiplexed optical transmission systems. We present an analysis of the existing and of the future few-mode erbium doped fiber amplifiers for an increasingly larger number of modes.

Room 123

Tu2E • Ring Resonators—Continued

Tu2E.2 • 14:15
Air-suspended High-Q Ring Microcavities with Scatterer-Avoiding "Wiggler" Supermode Fields, Yangyang Liu[1], Milos Popovic[1]; *[1]Department of Electrical, Computer, and Energy Engineering, Univ. of Colorado at Boulder, USA*. We demonstrate air-suspended high-Q ring resonators based on multimode Bloch matching and resultant scatterer-avoiding "wiggler" supermode field. Device designs are fabricated in silicon-on-insulator and undercut to form air-suspended structures with measured Q's up to 139,000.

Tu2E.3 • 14:30
An SOI Based Polarization Insensitive Filter for All-optical Clock Recovery, Jinghui Zou[1], Yu Yu[1], Weili Yang[1], Zhao Wu[1], Mengyuan Ye[1], Guanyu Chen[1], Xinliang Zhang[1]; *[1]Wuhan National Lab for Optoelectronics, China*. We propose and fabricate an SOI based polarization diversity scheme consisting of two 2D grating couplers and a micro ring resonator. Based on this scheme, all-optical polarization insensitive clock recovery has been demonstrated successfully.

Room 124

Tu2F • DSP-Based Optical Access—Continued

Tu2F.2 • 14:30
Extended TWDM-PON demonstration up to 100 km and 35 dB ODN loss on Burst-Mode Coherent Reflective PON, Stefano Straullu[1], Fabrizio Forghieri[3], Gabriella Bosco[2], Valter Ferrero[2], Roberto Gaudino[2]; *[1]ISMB Istituto Superiore Mario Boella, Italy; [2]Electronics and Telecommunications, Politecnico di Torino, Italy; [3]CISCO Photonics, Italy.* We demonstrate the upstream path for a TWDM-PON on up to 100 km installed fibers, 35 dB ODN loss and 4 wavelengths, using burst-mode self-coherent OLT receiver and reflective ONU transmitters without tunable lasers.

Tu2G • OFDM I—Continued

Tu2G.2 • 14:15
Enhanced Dispersion Tolerance of Coherent Offset-QAM OFDM over Conventional OFDM, Jian Zhao[1], Andrew D. Ellis[2]; [1]*Tyndall National Inst., Ireland;* [2]*Aston Inst. of Photonic Technology, Aston Univ., UK.* We experimentally demonstrate 38-Gbit/s offset-16QAM OFDM over 840km without guard interval, and numerically show that 112-Gbit/s PDM offset-QPSK OFDM achieves 23% increase in net capacity over conventional OFDM under the same transmission reach.

Tu2G.3 • 14:30 *Top-Scored*
Demonstration of Software-defined Multiband OFDM with Low-complexity Phase Noise Compensation, Xi Chen[1], Jiayuan He[1], Di Che[1], William Shieh[1]; [1]*Univ. of Melbourne, Australia.* We demonstrate low-complexity phase noise compensation for a software-defined multiband OFDM system. Experimental results show that laser phase noise up to 1 MHz can be compensated for 114.8-Gb/s 16-QAM signals after 480-km SSMF transmission.

Tu2H • Tunable Lasers & Comb Sources—Continued

University. He got his start in tunable lasers at Stanford conducting pioneering work in MEMS-tunable VCSELs. At Hitachi Central Research Laboratory, he demonstrated the first GaInNAs-based long wavelength VCSEL, and he researched multi-wavelength VCSEL arrays at Lawrence Livermore National Laboratory. Since 2000 he has developed widely tunable semiconductor laser products, first at Agility Communications and thereafter as part of JDSU. He received the Young Scientist Award, International Symposium on Compound Semiconductors, 2003, for contributions in tunable lasers and long wavelength VCSELs.

Tu2I • Symposium on Enabling the Cloud: Datacenter as a Network I—Continued

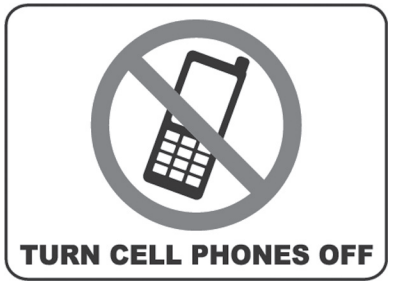
Tu2I.2 • 14:30 Invited
Data Center Networking: A Brave New World, Dinesh Dutt, *Cumulus Networks, USA.* Data centers are changing the way networking is done. When the revolution is over, the landscape will be as altered as the server landscape was when the Lintel tsunami swept aside the vertically integrated server market of the late 90s. In this talk, we'll explore the ideas that underpin these changes, ideas that include modern network architectures, network overlays and network management.

Tu2J • High Capacity Transmission Using SDM—Continued

Tu2J.2 • 14:30 Invited
Long-Haul Transmission Using Multi-core Fibers, Hidenori Takahashi[1], Koji Igarashi[1], Takehiro Tsuritani[1]; [1]*KDDI R&D Laboratories Inc., Japan.* We review recent progress of long-haul transmission over 6,000 km using multicore fiber (MCF) repeatered with multicore (MC)-EDFA. The capacity-distance product has been increased from 177 Pbit/s·km to 1.03 Ebit/s·km.

Tu2K • Nonlinear Effects in Optical Fibers—Continued

modeling engineer at VPI Photonics (2000-2005). In 2010, he received Ph.D. degree from the University of California San Diego. Currently, he is senior researcher with California Institute of Telecommunications and Information Technologies (CALIT2) where he leads effort on new fiber technologies. His research interests include nonlinear optics, optical signal processing, optical measuring techniques, high-speed optical communications, and numerical methods.



Show Floor Programming

13:30–16:30
The Future of the Metro Core: A New and Innovative Approach to Delivering a Scalable, Yet Simplified, Metro Core Network, *Expo Theater II Programming*
For more details, see page 41

14:30–15:15
Panel: 100G Single Lamba Optics, *Expo Theater III Programming*
For more details, see page 43

15:15–16:00
Snapshot on 400GE Standardization, *Expo Theater III Programming*
For more details, see page 43

Room 102

Tu2A • RF Photonic Devices—Continued

Tu2A.4 • 14:45 Invited

High-Power Microwave Photodiodes, Andreas Beling[1]; [1]*Electrical and Computer Engineering, Univ. of Virginia, USA*. The talk reviews modified uni-traveling carrier photodiodes that are capable of delivering high RF output power levels of >1 Watt. Discrete photodiodes, balanced detectors, photodiode arrays, and waveguide photodiodes are discussed.

Room 120

Tu2B • Field Trial Demonstrations and Modulation Formats—Continued

Tu2B.4 • 14:45 *Top-Scored*

400Gb/s Real-time Trial Using Rate-adaptive Transponders for Next Generation Flexible-grid Networks, ANNACHIARA PAGANO[1], Emilio Riccardi[1], Marco Bertolini[2], Vitaliano Farelli[2], Tony Van De Velde[3]; [1]*TELECOM ITALIA, Italy;* [2]*ALCATEL-LUCENT ITALY, Italy;* [3]*ALCATEL-LUCENT FRANCE, France*. We demonstrate real-time transmission using a 400G rate-adaptive transponder in metro regional Telecom Italia multivendor legacy environment. Transmission over G.652 and G.655 fibers was successfully achieved with 5.33 b/s/Hz of spectral efficiency.

Tu2B.5 • 15:00 Invited

Field Trial of Direct-Detection and Multi-Carrier based 100G Transceiver, Kwangjoon .. Kim[1], Hwan Seok Chung[1], Sun Hyok Chang[1], Jyung Chan Lee[1], Jong Hyun Lee[1]; [1]*ETRI, Republic of Korea*. Modulation format plays a critical role for 100G transmission, and there have been extensive works on searching suitable modulation format. We review direct detection based formats, and introduce DC-DQPSK based 100G transceiver for metro networks.

Room 121

Tu2C • New Devices in NGPON Networks—Continued

Tu2C.4 • 15:00

Comparison of Downstream Transmitters for High Loss Budget of Long-Reach 10G-PON, Zhengxuan Li[1], Lilin Yi[1], Weisheng Hu[1]; [1]*Shanghai Jiao Tong Univ., China*. A comparison among different transmitters was made by evaluating the sensitivities under various launch powers and reaches. Experimental results indicate that directly-modulated laser based transmitters provide higher loss budget for long reach 10G-PON.

Room 122

Tu2D • Amplifiers for SDM - II—Continued

Tu2D.3 • 15:00

1.7 μm Band Optical Fiber Amplifier, Makoto Yamada[1], Hirotaka Ono[2], Jun Ono[3]; [1]*Department of Electrical & Information Systems, Osaka Prefecture Univ., Japan;* [2]*NTT Photonics Laboratories, Japan;* [3]*Anritsu Devices Co., Ltd, Japan*. We realize for the first time a 1.7 μm band fiber amplifier. The maximum gain of 22.5 dB and the noise figure of 6.2 dB were achieved at the signal wavelength of 1700 nm.

Room 123

Tu2E • Ring Resonators—Continued

Tu2E.4 • 14:45

Wavelength Locking of a WDM Silicon Microring Demultiplexer using Dithering Signals, Kishore Padmaraju[1], Lian-Wee Luo[2], Xiaoliang Zhu[1], Madeleine Glick[3], Raj Dutt[3], Michal Lipson[2], Keren Bergman[1]; [1]*Columbia Univ., USA;* [2]*Cornell Univ., USA;* [3]*APIC Corporation, USA*. A control system utilizing dithering signals is used to demonstrate wavelength locking of WDM channels by a microring filter array. Data measurements verify that the dithering mechanism has a near-negligible effect on filtered data channels.

Tu2E.5 • 15:00

10-Gb/s BPSK link using Silicon Microring Resonators for Modulation and Demodulation, Qi Li[1], Yang Liu[2], Kishore Padmaraju[1], Ran Ding[2], Dylan F. Logan[3,4], Jason J. Ackert[3], Andrew P. Knights[3], Tom Baehr-Jones[2,7], Michael Hochberg[5,6], Keren Bergman[1]; [1]*Electrical Engineering, Columbia Univ., USA;* [2]*Electrical & Computer Engineering, Univ. of Delaware, USA;* [3]*Engineering Physics, McMaster Univ., Canada;* [4]*Ranovus Inc, Canada;* [5]*Inst. of Microelectronics, Singapore;* [6]*Electrical & Computer Engineering, National Univ. of Singapore, Singapore;* [7]*EastWest Photonics PTE LTD, Singapore*. We demonstrate the first binary-phase-shift-keying (BPSK) link based on silicon microring resonators, with an operational bit-rate at 10 Gb/s. Bit-error-rate measurements and eye diagrams are used to compare the link's performance with conventional BPSK modulation and demodulation techniques.

Room 124

Tu2F • DSP-Based Optical Access—Continued

Tu2F.3 • 14:45

A Long Reach IM/DD OFDM-PON Using Super-Nyquist Image Induced Aliasing and Code-Division Multiplexing, Changjian Guo[1], Longling Dai[1]; [1]*South China Normal Univ., China*. An 83.2-km, 20-Gb/s QPSK CDM-OFDM-PON is experimentally demonstrated. The reachable distance is extended from less than 40 km to 90 km using super-Nyquist image induced aliasing. CDM-OFDM is shown to outperform conventional OFDM signals in IM/DD systems.

Tu2F.4 • 15:00

Comparison of Rx-DSP-Structures in Experimental OFDMA-PON Uplink Transmission System, Johannes von Hoyningen-Huene[1], Helmut Griesser[2], Michael H. Eiselt[3], Christian Ruprecht[1], Werner Rosenkranz[1]; [1]*Chair for Communications, Univ. of Kiel, Germany;* [2]*ADVA Optical Networking SE, Germany;* [3]*ADVA Optical Networking SE, Germany*. We compare a DSP with a common FFT and a DSP with individual FFTs to receive the experimental OFDMA uplink transmission with four individually modulated ONUs in terms of timing mismatch robustness.

Room 125

Tu2G • OFDM I—Continued

Tu2G.4 • 14:45
Fast Wavelength Switching DP-OFDM Transceiver in a 5-Node 800km Coherent OBS Network, Robert Maher[1], Hou-Man Chin[1], Manoj Thakur[1], Domanic Lavery[1], Polina Bayvel[1], Seb J. Savory[1], Benn C. Thomsen[1]; [1]*Electrical and Electronic Engineering, Univ. College London, UK.* Fast wavelength switching OFDM transceiver enables the coherent reception of 2-burst channels within a 1dB penalty after 800km transmission. Burst detection and variable path-history compensation are performed using inherent OFDM synchronization symbols and cyclic prefix.

Tu2G.5 • 15:00
Pre-Amplified 64-QAM-OFDM Modulation of a Colorless Laser Diode for 30 Gbit/s Transmission with Enhanced SNR, Cheng-Ting Tsai[1], Min-Chi Cheng[1], Gong-Ru Lin[1]; [1]*National Taiwan Univ., Taiwan.* A directly-modulated colorless laser diode based pre-amplified 64-QAM-OFDM transmission at 30Gbit/s is demonstrated with optimized SNR of 21.6 dB and EVM of 8.3 % to provide spectral efficiency of 6 bit/sec/Hz and BER of $<2.5\times10^{-3}$.

Room 130

Tu2H • Tunable Lasers & Comb Sources—Continued

Tu2H.2 • 15:00
Narrow Linewidth Tunable Light Source Integrated with Distributed Reflector Laser Array, Go Kobayashi[1], Kazuaki Kiyota[1], Tatsuya Kimoto[1], Toshikazu Mukaihara[1]; [1]*Optical Devices Dept. Fitel Photonics Laboratory, Furukawa Electric Co., Ltd., Japan.* We demonstrated tunable light source integrated with 12 DR laser array and SOA, for the first time. We could report single-mode operation (SMSR>43dB) and narrow linewidth less than 185kHz over 40nm C-band range.

Room 131

Tu2I • Symposium on Enabling the Cloud: Datacenter as a Network I—Continued

Tu2I.3 • 15:00 Invited
The State of OpenFlow, Guido Appenzeller; *Big Switch Networks, USA.* OpenFlow is a protocol that has risen to prominence in a very short period of time. However despite the tremendous interest, few OpenFlow production deployments in the data center exist today. In this talk, we review OpenFlow deployments, examine the challenges of the current OpenFlow development model, and present our perspective and what needs to change for OpenFlow to become ubiquitous.

Room 132

Tu2J • High Capacity Transmission Using SDM—Continued

Tu2J.3 • 15:00 Invited
Ultra-high Capacity Transmission with Few-mode Silica and Hollow-core Photonic Bandgap Fibers, Vincent A. Sleiffer[1], Paolo Leoni[2], Yongmin Jung[3], Haoshuo Chen[1], Maxim Kuschnerov[4], Shaiful Alam[3], Marco Petrovich[3], Francesco Poletti[3], Natalie V. Wheeler[3], Naveen Baddela[3], John Hayes[3], Eric Numkam Fokoua[3], David J. Richardson[3], Lars E. Gruner-Nielsen[5], Yi Sun[5], Huug Waardt, de[1]; [1]*Technische Universiteit Eindhoven, Netherlands;* [2]*Universität der Bundeswehr München, Germany;* [3]*Optoelectronics Research Centre, UK;* [4]*Coriant R&D GmbH, Germany;* [5]*OFS, Denmark.* We review the capacity records achieved using mode division multiplexing in few mode fiber and hollow core photonic bandgap fibers. Currently the MDM capacity record for both fiber types is 73.7 Tb/s, whereas per wavelength 960 Gb/s is achieved.

Room 133

Tu2K • Nonlinear Effects in Optical Fibers—Continued

Tu2K.2 • 15:00 Invited
Dispersion Fluctuation Invariant Fibers, John M. Fini[1], Lars E. Gruner-Nielsen[2]; [1]*OFS Laboratories, USA;* [2]*OFS, Denmark.* Improved nonlinear fiber designs have recently demonstrated intrinsically stable phase-matching. They remove dispersion variation limits, enabling efficient devices, for example a low-threshold oscillator tunable across wavelengths from 1.7-2.1 microns.

Show Floor Programming

13:30–16:30
The Future of the Metro Core: A New and Innovative Approach to Delivering a Scalable, Yet Simplified, Metro Core Network, *Expo Theater II Programming*
For more details, see page 41

14:30–15:15
Panel: 100G Single Lamba Optics, *Expo Theater III Programming*
For more details, see page 43

15:15–16:00
Snapshot on 400GE Standardization, *Expo Theater III Programming*
For more details, see page 43

Room 102

Tu2A • RF Photonic Devices—Continued

Tu2A.5 • 15:15
Strong Enhancement in Saturation Power of Sub-THz Photodiode by Using Photonic Millimeter-Wave Femtosecond Pulse Generator, Jhih-Min Wun[1], Yi-shiun Chen[2], Cheng-Hung Lai[1], Hao-Yun Liu[2], Chen-Bin Huang[2], Ci-Ling Pan[3,2], Jin-Wei Shi[1]; *[1]Dept. of Electrical Engineering, National Central Univ., Taiwan; [2]Inst. of Photonics Technologies, National Tsing-Hua Univ., Taiwan; [3]Dept. of Physics, National Tsing-Hua Univ., Taiwan.* A photonic MMW femtosecond pulse-generator has been demonstrated. Using it, we achieve strong (6.4 dB) saturation-power enhancements, which result in +3.9 dBm maximum output of UTC-PD at 160 GHz, as compared to that under sinusoidal excitation.

Tu2A.6 • 15:30
A Photonic Integrated Fractional Hilbert Transformer With Continuous Tunability, Jianping Yao[1], Weilin Liu[1], Ming Li[1], Robert Guzzon[2], Erik Norberg2[2], Larry A. Coldren[2]; *[1]Univ. of Ottawa, Canada; [2]ECE, UCSB, USA.* A continuously tunable fractional Hilbert transformer based on a photonic integrated chip in an InP-InGaAsP material system consisting of semiconductor optical amplifiers and current injection phase modulators is proposed and experimentally demonstrated.

Room 120

Tu2B • Field Trial Demonstrations and Modulation Formats—Continued

Tu2B.6 • 15:30
Cost-effective Next Generation Mobile Fronthaul Architecture with Multi-IF Carrier Transmission Scheme, Seung-Hyun Cho[1], Heuk Park[1], Hwan Seok Chung[1], Kyeong-Hwan Doo[1], Sang Soo Lee[1], Jong Hyun Lee[1]; *[1]Optical Internet Department, Electronics and Telecommunications Research Inst., Republic of Korea.* We proposed a cost-effective next generation mobile fronthaul architecture with multi-IF carrier transmission scheme and investigated the system performances under various IF carrier operating conditions.

Room 121

Tu2C • New Devices in NGPON Networks—Continued

Tu2C.5 • 15:15
Increasing Splitting Ratio of 10Gb/s-Class PONs by Using FW-DMF that Acts as Low Loss Splitter for Upstream and Conventional Splitter for Downstream, Masamichi Fujiwara[1], Ken-Ichi Suzuki[1], Naoto Yoshimoto[1], Manabu Oguma[2], Shunichi Soma[2]; *[1]NTT Access Network Service Systems Laboratories, NTT Corporation, Japan; [2]NTT Photonics Laboratories, NTT Corporation, Japan.* A simple optical splitter, a dual-mode fiber (DMF) is connected to a funnel-shaped waveguide (FW), is proposed and the feasibility of a 128-way 10G-EPON system using a 1 x 16 prototype is experimentally demonstrated.

Tu2C.6 • 15:30 *Top-Scored*
Measurement and Mitigation of Wavelength Drift due to Self-Heating of Tunable Burst-Mode DML for TWDM-PON **,** Yong Guo[1], Songlin Zhu[1], Guohua Kuang[1], Yongjia Yin[1], Yang Gao[1], Dezhi Zhang[1], Xin Liu[1]; *[1]Fixed network team, ZTE corporation, China.* The burst-mode 10G DML and EDC are first time demonstrated in symmetric 40Gbit/s TWDM-PON system over 40km passive reach at final NG-PON2 wavelength plan. Demonstration results verify that all ODN classes can be supported via industry achievable optical parameters.

Room 122

Tu2D • Amplifiers for SDM - II—Continued

Tu2D.4 • 15:15
S-band Thulium-doped Fiber Amplifier Enhancement using ASE Suppression, Sulaiman Wadi Harun[1], Siamak Dawazdah emami[1], Harith Ahmad[1], Hairul Azhar Abdul Rashid[2], Ahmad Razif Muhammad[1]; *[1]Universiti Malaya; [2]Multimedia Univ., Malaysia.* A new method for gain enhancement in S-band Thulium-doped fiber amplifier (TDFA) co-doped with Aluminum is demonstrated using a photonic crystal fiber and macro-bending approach to suppresses both amplified spontaneous emissions at 800 nm and 1800 nm

Tu2D.5 • 15:30
Excited State Absorption in Bismuth-doped Fibers with Various Glass Compositions, Evgeny M. Dianov[1], Konstantin E. Riumkin[1], Mikhail A. Melkumov[1], Igor A. Bufetov[1]; *[1]Fiber Optics Research Center of RAS, Russian Federation.* Excited state absorption (ESA) in various bismuth-doped fibers was investigated. No significant ESA in IR emission bands of Bi-doped germanosilicate and phosphosilicate fibers was found. Considerable ESA was observed in Bi-doped aluminosilicate fibers at 800-1700nm.

Room 123

Tu2E • Ring Resonators—Continued

Tu2E.6 • 15:15
High-speed on-chip photonic link based on ultralow-power microring modulator, Xi Xiao[1], Hao Xu[2], Xiaoyao Li[2], Zhiyong Li[2], Yude Yu[2], Jinzhong Yu[2]; *[1]State Key Laboratory of Optical Communication Technologies and Networks, Wuhan Research Inst. of Posts & Telecommunications, China; [2]Chinese Acad Sci Inst of Semiconductor, China.* We present an 15 GHz silicon-based on-chip photonic link composed of a 0.5 V-Vpp, 25 Gb/s tunable microring modulator and a ~40 GHz Ge-on-Si photodetector. Low-Vpp data transmissions of 12.5-20 Gb/s are experimentally demonstrated.

Tu2E.7 • 15:30 *Top-Scored*
Energy-Ffficient Active Photonics in a Zero-Change, State-Of-The-Art CMOS Process, Mark T. Wade[1], Jeffrey M. Shainline[1], Jason S. Orcutt[2], Chen Sun[2], Rajesh Kumar[1], Ben Moss[2], Michael Georgas[2], Rajeev J. Ram[2], Vladimir Stojanovic[3], Milos Popovic[1]; *[1]ECEE, Univ. of Colorado at Boulder, USA; [2]EECS, Massachusetts Inst. of Technology, USA; [3]EECS, Univ. of California Berkeley, USA.* Based on a novel, "spoked-ring" active microcavity, we demonstrate optical modulators in an unmodified 45nm SOI CMOS process at 5Gbps with <5fJ/bit energy consumption; and filters with record thermal tuning efficiency of 2μW/GHz.

Room 124

Tu2F • DSP-Based Optical Access—Continued

Tu2F.5 • 15:15
Real-Time Software-Defined Dynamic Resource Allocation using OpenFlow for Next-Generation OFDM-based Optical Access Networks, Stanley Johnson[1], Weiyang Mo[1], Milorad Cvijetic[1], Jun He[1], John Wissinger[1], Alan Willner[2]; *[1]College of Optical Sciences, The Univ. of Arizona, USA; [2]Univ. of Southern California, USA.* We demonstrate the first software-defined dynamic resource allocation of OFDM subcarriers and modulation formats using the OpenFlow protocol and real-time DSP. Dynamic resource allocation for HD video and text is achieved for 20km SSMF transmission.

Tu2F.6 • 15:30
Master-To-Slave Injection-Locked WRC-FPLD Pair With 16 DWDM-PON Channels For 16-QAM OFDM Transmission, Min-Chi Cheng[1], Cheng-Ting Tsai[1], Gong-Ru Lin[1]; *[1]National Taiwan Univ., Taiwan.* A partially coherent weak-resonant-cavity FPLD pair under master-to-slave injection-locking operation is demonstrated for optical 16-QAM OFDM transmission in DWDM-PON with 16 affordable channels achieving BER of below 6.1×10^{-5} at receiving power of -8 dBm.

Room 125

Tu2G • OFDM I—Continued

Tu2G.6 • 15:15
40Gbps 100-km SSMF VSB-IMDD OFDM Transmission Experiment Based on SSII Cancellation and FBG-Filtering, Cheng Ju[1], Xue Chen[1], Zhiguo Zhang[1]; [1]*Beijing Univ. of Posts and Telecommunications, China*. We propose and experimentally demonstrate a 40Gbps FBG-based VSB-IMDD OFDM scheme with SSII cancellation that extends the available bandwidth up to 10GHz over 100-km SSMF transmission.

Tu2G.7 • 15:30
Experimental Investigation of Discrete Multitone Transmission in the Presence of Optical Noise and Chromatic Dispersion, Annika Dochhan[1], Helmut Griesser[2], Laia Nadal Reixats[3], Michael H. Eiselt[1], Michela Svaluto Moreolo[3], Jorg P. Elbers[2]; [1]*ADVA Optical Networking SE, Germany;* [2]*ADVA Optical Networking SE, Germany;* [3]*CTTC, Spain*. Enabled by channel adaptive bit and power loading, we experimentally demonstrate discrete multitone transmission at 56Gb/s with simple intensity modulation and direct detection and achieve 50 km reach in the 1.55μm window.

Room 130

Tu2H • Tunable Lasers & Comb Sources—Continued

Tu2H.3 • 15:15
A Wide Bandwidth Coherent Optical Comb Source Based on a Monolithically Integrated Mode-Locked Ring Laser, Valentina Moskalenko[1], Sylwester Latkowski[1], Tjibbe de Vries[1], Luc M. Augustin[1], Xaveer Leijtens[1], Meint Smit[1], Erwin Bente[1]; [1]*Eindhoven Univ. of Technology, Netherlands*. A ring mode-locked laser fabricated as a monolithic photonic integrated circuit using a InP based integration technology is presented. It generates an optical coherent comb around 1546 nm with a record 11.5 nm 3 dB bandwidth.

Tu2H.4 • 15:30
An Integrated Heterodyne Optical Phase-locked Loop with Record Offset Locking Frequency, Mingzhi Lu[1], Hyun-chul Park[1], Eli Bloch[2], Leif Johansson[1], Mark Rodwell[1], Larry A. Coldren[1,3]; [1]*ECE, Univ. of California Santa Barbara, USA;* [2]*Electrical Engineering, Technion - Israel Inst. of Technology, Israel;* [3]*Materials, Univ. of California Santa Barbara, USA*. A highly-integrated optical phase-locked loop (OPLL) is realized by photonic and electronic integration. The experiment shows the full functionality of this heterodyne OPLL and 25 GHz offset locking frequency is achieved.

Room 131

Tu2I • Symposium on Enabling the Cloud: Datacenter as a Network I—Continued

Tu2I.4 • 15:30 Invited
Enabling Autonomic Provisioning in SDN Cloud Networks with NFV Service Chaining, Casimer DeCusatis, *IBM, USA* and Robert Cannistra, *Marist College, USA*. Experimental results are presented from an SDN/NFV testbed with automated, dynamically provisioned, 125 km optical WAN. Live VM migration for NFV video serving is demonstrated, along with Layer 0-3 orchestration using Open Daylight, OpenFlow, and DOVE.

Room 132

Tu2J • High Capacity Transmission Using SDM—Continued

Tu2J.4 • 15:30 *Top-Scored*
Space-Division Multiplexed Transmission Over 3 x 3 Coupled-Core Multicore Fiber, Roland Ryf[1], Nicolas K. Fontaine[1], Marc Montoliu[1,2], Sebastian Randel[1], Sun Hyok Chang[3], Haoshuo Chen[1,4], S. Chandrasekhar[1], Alan Gnauck[1], Rene-Jean Essiambre[1], Peter J. Winzer[1], Toshiki Taru[5], Tetsuya Hayashi[5], Takashi Sasaki[5]; [1]*Bell-Labs, Alcatel-Lucent, USA;* [2]*Universitat Politecnica de Catalunya, Spain;* [3]*Optical Transmission Technology Research Team, Electronics and Telecommunications Research Inst. (ETRI), Republic of Korea;* [4]*COBRA Inst., Eindhoven Univ. of Technol., Netherlands;* [5]*Optical Communications R\&D Laboratories, Sumitomo Electric Industries, Japan*. We experimentally demonstrate transmission over a novel multicore fiber with 9 cores arranged in 3 groups of 3 cores, where strong coupling occurs within the groups and weak couplings between groups. We transmitted over 2500km in a single group at a time and 715km when all 9 cores are used. Low-loss 3D waveguides are used as couplers.

Room 133

Tu2K • Nonlinear Effects in Optical Fibers—Continued

Tu2K.3 • 15:30
Highly Nonlinear Tellurite Glass Fiber for Broadband Applications, Mohamed A. Ettabib[1], Kamal Hammani[1], Xian Feng[1], Mohammad Belal[1], Jindan Shi[1], Adonis Bogris[2,3], Alexandros Kapsalis[2], Dimitris Syvridis[2], David J. Richardson[1], Periklis Petropoulos[1]; [1]*Optoelectronics Research Centre, Univ. of Southampton, UK;* [2]*National and Kapodistrian Univ. of Athens, Greece;* [3]*Department of Informatics, Technological Educational Inst. of Athens, Greece*. We report the characterization of loss and nonlinearity of a broadband tellurite glass fiber both at 1.55μm and 2μm wavelengths. The study is accompanied by a demonstration of wavelength conversion at both of these wavelengths.

Show Floor Programming

13:30–16:30
The Future of the Metro Core: A New and Innovative Approach to Delivering a Scalable, Yet Simplified, Metro Core Network, *Expo Theater II Programming*
For more details, see page 41

15:15–16:00
Snapshot on 400GE Standardization, *Expo Theater III Programming*
For more details, see page 43

Room 102	Room 120	Room 121	Room 122	Room 123	Room 124
Tu2A • RF Photonic Devices—Continued			**Tu2D • Amplifiers for SDM - II—Continued**	**Tu2E • Ring Resonators—Continued**	**Tu2F • DSP-Based Optical Access—Continued**

Tu2A.7 • 15:45
First Demonstration of a Tunable Single-Bandpass Photonic Radio-frequency Filter Based on Optical Frequency Comb from a Microring, Xiaoxiao Xue[1], Hyoung-Jun Kim[1], Yi Xuan[1,2], Jian Wang[1,2], Daniel E. Leaird[1], Minghao Qi[1,2], Andrew M. Weiner[1]; [1]*School of Electrical and Computer Engineering, Purdue Univ., USA;* [2]*Birck Nanotechnology Center, Purdue Univ., USA.* We demonstrate a photonic radiofrequency filter with greatly reduced complexity based on optical frequency comb from a SiN microring. A novel structure is proposed to suppress unwanted passbands and achieve a widely tunable single passband.

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Papers are available online for download. Visit www.ofcconference.org and click on the Download Digest Papers button.

Tu2F.7 • 15:45
N:1 Protection Design for Minimising OLTs in Resilient Dual-Homed Long-Reach Passive Optical Network, Avishek Nag[1], David B. Payne[1], Marco Ruffini[1]; [1]*Trinity College Dublin, Ireland.* An N:1 protection mechanism is proposed to reduce backup OLTs in a resilient dual-homed LR-PON deployment. We model the problem as an Integer Linear Program and solve it for an Irish network deployment.

16:00–16:30 Coffee Break, *South, Exhibit Halls A, B, C, North, Exhibit Hall D*

NOTES

Room 125

Tu2G • OFDM I—Continued

Tu2G.8 • 15:45
Experimental Demonstration of Elastic Optical Networking utilizing Time-Sliceable Bitrate Variable OFDM Transceiver, Josep M. Fabrega[1], Michela Svaluto Moreolo[1], F. Javier Vilchez[1], Bijan R. Rofoee[2], Yanni Ou[2], Norberto Amaya[2], Georgios S. Zervas[2], Dimitra E. Simeonidou[2], Yuki Yoshida[3], Ken-ichi Kitayama[3]; *[1]Ctr Tecnològic de Telecom de Catalunya, Spain; [2]High-Performance Networks Group, Univ. of Bristol, UK; [3]Osaka Univ., Japan*. A cost-effective time-sliceable IM/DD OFDM transceiver using low-complex DSP is experimentally investigated. Slicing capabilities are tested for concurrently serving 12.5GHz channels running at up to 10Gb/s variable bandwidth optical routes covering up to 185km.

Room 130

Tu2H • Tunable Lasers & Comb Sources—Continued

Tu2H.5 • 15:45
Single Quantum Dash Mode-Locked Laser as a Comb-Generator in Four-Channel 112 Gbit/s WDM Transmission, Mathilde Gay[1], Arthur O'Hare[1], Laurent Bramerie[1], Zhenyu Hao[1], Schadrac Fresnel[1], Christophe Peucheret[1], Pascal Besnard[1], Siddharth Joshi[2], Sophie Barbet[2], Francois Lelarge[2]; *[1]CNRS Foton, Université Européenne de Bretagne, Enssat, France; [2]III-V lab, France*. We demonstrate 100 km transmission at 28 Gbit/s/channel of 4 DWDM channels using a single quantum-dash mode-locked laser. The amplitude noise of each filtered laser line is improved using limiting amplification in an SOA.

Room 131

Tu2I • Symposium on Enabling the Cloud: Datacenter as a Network I—Continued

Room 132

Room 133

Tu2K • Nonlinear Effects in Optical Fibers—Continued

Tu2K.4 • 15:45
Conversion Efficiency and Crosstalk Optimization in Four-mode Phase-Sensitive Multicasting Mixer by Vectorial Phase Manipulation, Lan Liu[1], Zhi Tong[1], Andreas O. Wiberg[1], Yauheni Myslivets[1], Ping Piu Kuo[1], Nikola Alic[1], Stojan Radic[1]; *[1]Univ. of California San Diego, USA*. The input phases in a four-mode phase-sensitive multicasting, is manipulated yielding a 12-dB gain improvement compared with the phase-insensitive case. Additionally, up to 13-dB crosstalk reduction for arbitrary spectral region is achieved with phase management.

16:00–16:30 Coffee Break, *South, Exhibit Halls A, B, C, North, Exhibit Hall D*

NOTES

Show Floor Programming

13:30–16:30
The Future of the Metro Core: A New and Innovative Approach to Delivering a Scalable, Yet Simplified, Metro Core Network, *Expo Theater II Programming*
For more details, see page 41

15:15–16:00
Snapshot on 400GE Standardization, *Expo Theater III Programming*
For more details, see page 43

Room 102

16:30–18:30
Tu3A • Fiber Nonlinearity Mitigation
Presider: Gernot Goeger; Huawei, USA

Tu3A.1 • 16:30 *Top-Scored*
Coherent Reception and 126 GHz Bandwidth Digital Signal Processing of CO-OFDM Superchannel Generated By Fiber Frequency Conversion, Takahito Tanimura[1], Tomoyuki Kato[1], Ryo Okabe[1], Shoichiro Oda[1], Thomas Richter[2], Robert Elschner[2], Carsten Schmidt-Langhorst[2], Colja Schubert[2], Jens Rasmussen[1], Shigeki Watanabe[1]; *[1]Fujitsu Laboratories, Ltd., Japan; [2]Fraunhofer Inst. for Telecommunications, Heinrich-Hertz Inst., Germany.* We implement 126-GHz bandwidth coherent receiver and demonstrate multi-channel reception with nonlinear compensation (NLC) of a precisely frequency-allocated four-channel 28-GBd-QPSK OFDM superchannel sequentially aggregated using fiber-optic signal processing. Multi-channel back propagation-based NLC improved transmission performance.

Tu3A.2 • 16:45
Time-Division Hybrid Modulation Formats: Tx Operation Strategies and Countermeasures to Nonlinear Propagation, Vittorio Curri[1], Andrea Carena[1], Pierluigi Poggiolini[1], Roberto Cigliutti[1], Fabrizio Forghieri[2], Chris R. Fludger[3], Theo Kupfer[3]; *[1]DET, Politecnico di Torino, Italy; [2]Cisco Photonics Italy, Italy; [3]Cisco Optical GmbH, Germany.* We propose four strategies for TDHMF Tx operation. BER minimization permits PM-QPSK/PM-16QAM performance similar to PM-8QAM's. In TDHMF nonlinear propagation, predistortion and/or polarization interleaving enables the maximum reach predicted by GN-model.

Room 120

16:30–18:30
Tu3B • Panel: Energy-effiency in Telecommunication Operator Networks: a Reality Check

Organizer: Christoph Lange, *Deutsche Telekom Innovation Laboratories, Germany*

Energy efficiency of telecommunication networks has been investigated through the past years very intensively. Mainly cost but also sustainability reasons have been major drivers for identifying related improvement options on the different levels of systems, network architectures and operations. Related R&D efforts have led to a large variety of solutions for improving network energy efficiency. Now it is time to draw an interim balance: What is the status of adopting energy efficiency measures in operator networks – where are we now?The panel, with representatives from both operators and vendors, will consider the topic with aspects like adoption of energy efficiency techniques in large operator networks, eventual obstacles and challenges as well as remaining necessary R&D and operational efforts on the way towards energy efficient networks.

Speakers:

Flavio Cucchietti, *Telecom Italia Lab, Italy*

Jun-ichi Kani, *NTT Access Service System Laboratories, Japan*

Peter Vetter, *Alcatel-Lucent, USA*

Jun-ichi Kani, *NTT Access Service System Laboratories, Japan*

Room 121

16:30–18:30
Tu3C • Protection & Other Practical Considerations in PONs
Presider: Denis Khotimsky; Verizon Communications Inc, USA

Tu3C.1 • 16:30 Invited
PON Resilience, Frank Effenberger[1]; *[1]Access R&D, Futurewei Technologies, USA.* Passive Optical Networks are being applied to a wider set of applications, including those that are outage sensitive. Protection or resilience techniques address this need. This paper reviews these techniques, focusing on active research areas.

Room 122

16:30–18:00
Tu3D • Components for SDM
Presider: Shu Namiki; Natl Inst of Adv Industrial Sci & Tech, Japan

Tu3D.1 • 16:30 Invited
Fiber Based Multiplexing and Demultiplexing devices for Few Mode Fiber Space Division Multiplexed Communications, Ian Giles[1], Rongsheng Chen[1], Victor Garcia-Munoz[1]; *[1]Phoenix Photonics, UK.* All-fiber components offer an effective technology option for passive multiplexers and demultiplexers for few mode fiber transmission systems. New component options to meet the requirements are being explored for individual and mode group transmission.

Room 123

16:30–18:15
Tu3E • Novel Materials
Presider: Juerg Leuthold; ETH Zurich, Switzerland

Tu3E.1 • 16:30
Ultra-Small Coherent Mixer Consists of 5.5%-Δ ZrO_2-SiO_2-Based Low Loss PLC, Masanori Takahashi[1], Yasuyoshi Uchida[1], Shintaro Yamasaki[1], Junichi Hasegawa[1], Takeshi Yagi[1]; *[1]Furukawa Electric Co., Ltd., Japan.* Low propagation loss of 0.02 dB/cm was achieved in a 5.5%-Δ ZrO_2-SiO_2-based PLC. A coherent mixer employing the ZrO_2-SiO_2 PLC was successfully fabricated, and chip size was reduced to 2 mm x 4 mm.

Tu3E.2 • 16:45
Spot Size Converter with Cross-Vertical Taper for Low-Loss Coupling between ZrO_2-SiO_2 PLC and SMF, Shintaro Yamasaki[1], Yasuyoshi Uchida[1], Masanori Takahashi[1], Junichi Hasegawa[1], Takeshi Yagi[1]; *[1]Furukawa Electric Co., Ltd., Japan.* We developed a novel spot size converter with cross-vertical taper. Connection loss between ZrO_2-SiO_2 PLC with 5.5% Δ and SMF was reduced to 0.2 dB/facet at 1550 nm, and less than 0.4 dB/facet in C-band.

Room 124

16:30–18:30
Tu3F • Optical Access for Mobile Front/Back Haul
Presider: Peter Vetter; Alcatel-Lucent, USA

Tu3F.1 • 16:30 Tutorial
Optical Network Technologies and Architectures for Backhaul/Fronthaul of Future Radio Access supporting Big Mobile Data, Yukihiko Okumura[1], Jun Terada[1]; *[1]NTT DoCoMo, Japan.* As a new scheme of dense cells deployment in future cellular network, "Phantom cell concept" has been proposed that overlays multiple cell layers. In this tutorial, future radio access/mobile optical network (FRAMON) that realizes the concept and its requirements and challenging issues are explained.

Yukihiko Okumura joined NTT Radio Communications Systems Laboratories, Japan, in 1991, and since 1992, he has been engaged in the research, standardization and development of wideband/broadband mobile radio communication technologies, terminals and systems, at NTT Mobile Communications Network, Inc. (now NTT DOCOMO, INC.). He is a senior member of IEEE. Jun Terada joined the NTT LSI Laboratories in 1995, where he was engaged in research and development of low-voltage analog circuits. From 2006, he was engaged in high-speed front-end circuits for optical transceivers. Since 2012, he has been engaged in optical and wireless converged access networks at the NTT Access Network Service Systems Laboratories.

Room 125

16:30–18:30
Tu3G • OFDM II
Presider: Lianshan Yan; Southwest Jiaotong Univ., China

Tu3G.1 • 16:30 Invited
Digitally Sub-banded Coherent Optical OFDM Transmission, Moshe Nazarathy[1], Alex Tolmachev[1]; [1]*Technion Israel Inst. of Technology, Israel.* OFDM is much more efficiently processed digitally slicing received channel spectrum by under-decimated filter banks, decoding the spectral slices in an array of lower speed sub-band OFDM receivers. Low-complexity FPGA real-time implementation will be presented.

Room 130

16:30–18:30
Tu3H • InP-based Optoelectronic Devices
Presider: Lars Zimmermann; IHP, Germany

Tu3H.1 • 16:30 Invited
InP modulators with linear accelerator like segmented electrode structure, Tomoaki Kato[1]; [1]*Green Platform Research Laboratories, NEC Corporation, Japan.* Quasi-traveling-wave type InP modulators with accelerator like segmented electrode structure directly driven by CMOS IC were reviewed. Their potential for low-power, multi-level modulation and waveform equalizing performances were discussed.

Room 131

16:30–19:00
Tu3I • Symposium on Enabling the Cloud: Datacenter as a Network II

Tu3I.1 • 16:30 Invited
Extending SDN beyond the Data Center Walls, Stuart Elby, *Verizon, USA.* The service and economic benefits of extending virtualization and software defined networking across geographically dispersed data centers (aka The Cloud) will be discussed. A specific example pertaining to video distribution services will be explored, and gaps in what is currently available in the market place to achieve success will be highlighted.

Room 132

16:30–18:30
Tu3J • Spectral Shaping
Presider: Dirk van den Borne; Juniper Networks Inc., Germany

Tu3J.1 • 16:30 Tutorial
High capacity transport: 100G and beyond, Kim Roberts[1]; [1]*Ciena, Canada.* For excellent cost and performance, modern high capacity transport systems use digital coherent processing. Coherent methods will be explained, and measured performance will be shown for factory production coherent systems at 100 to 400 Gb/s.

Kim Roberts has innovated in the areas of optical transmission and high capacity packet connections since 1984. His creations are at the heart of much of Ciena's (Formerly Nortel's) optical transmission portfolio from the first OC-48 to the 40-400 Gb/s DSP-assisted coherent transceivers. He has been granted over 120 US patents while at labs in Edmonton, Harlow UK, and Ottawa. He was named a Nortel Fellow and received the Outstanding Engineer medal in 2008 from IEEE Canada.

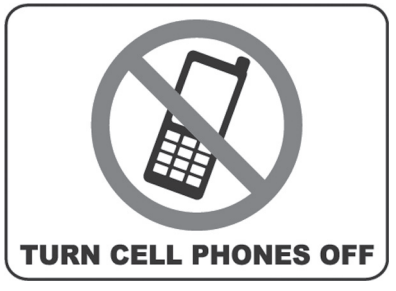
Room 133

16:30–18:30
Tu3K • Specialty Fiber and Fiber Optic Sensors
Presider: Misha Brodsky; AT&T Labs, USA

Tu3K.1 • 16:30 Invited
Specialty Fibers for Fiber-optic Sensors, Kay Schuster[1], Hartmut Lehmann[1], Tino Elsmann[1], Tobias Habisreuther[1], Sebastian Dochow[1]; [1]*Fiber optics, IPHT Jena, Germany.* The paper describes optical fibers due to evanescent field and interferometric sensing, advanced temperature measuring and Raman sensors. Fiber applications will be combined with a focus on technology efforts for the fiber and sensor fabrication.

Show Floor Programming

16:00–17:00
New Standards for Ethernet Access Networks, *Expo Theater III Programming*
For more details, see page 44



Room 102

Tu3A • Fiber Nonlinearity Mitigation—Continued

Tu3A.3 • 17:00 *Top-Scored*
Robust and Efficient Receiver-side Compensation Method for Intra-channel Nonlinear Effects, Tomofumi Oyama[1], Hisao Nakashima[2], Shoichiro Oda[1], Tomohiro Yamauchi[1], Zhenning Tao[3], Takeshi Hoshida[2], Jens Rasmussen[2]; [1]*Fujitsu Laboartories Ltd., Japan;* [2]*Fujitsu Limited, Japan;* [3]*Fujitsu R&D Center, Japan.* We propose a decision-aided intra-channel nonlinear equalizer based on a perturbation method, which offers one-stage compensation and symbol rate operation. It tolerates errors in decision-aided data and shows fine performance in 128Gbit/s DP-QPSK transmission experiment.

Tu3A.4 • 17:15
Dynamics of Intra Super-channel Fiber Nonlinearity Compensation in Flex-grid Optical Networks, Danish Rafique[1], Talha Rahman[1], Antonio Napoli[1], Bernhard Spinnler[1]; [1]*Research and Technology, Coriant GmbH, Germany.* The benefit of intra super-channel nonlinearity mitigation reduces with increasing sub-carrier count within the super-channel (higher net data-rate), with the maximum reach improvement, compared to linear compensation, of 150% for single-carrier 240Gb/s PM-16QAM.

Room 120

Tu3B • Panel: Energy-effiency in Telecommunication Operator Networks: a Reality Check—Continued

Room 121

Tu3C • Protection & Other Practical Considerations in PONs—Continued

Tu3C.2 • 17:00
Experimental Study of Type B Protection for TWDM-PON System, Takashi Nishitani[1], Jun Mizuguchi[1], Hiroaki Mukai[1]; [1]*Mitsubishi Electric Corporation, Japan.* Protection switching time is important factors in TWDM-PON system for business application because it defines the service outage time when failure occurs. An experiment using TWDM-PON assumed 40G-PON system shows that the protection switching time is 25.7 ms.

Tu3C.3 • 17:15 Invited
FTTdp: ONU Complexity Reduction, Michael P. McGarry[1], Elliott Gurrola[1]; [1]*Department of Electrical and Computer Engineering, Univ. of Texas at El Paso, USA.* We define and evaluate two strategies for reducing the complexity of an optical network unit deployed in a hybrid PON/DSL access network. This complexity reduction will result in reduced energy consumption and cost.

Room 122

Tu3D • Components for SDM—Continued

Tu3D.2 • 17:00 Invited
How To Connect Multicore and Multimode Fibers, Ryo Nagase[1]; [1]*Faculty of Engineering, Chiba Inst. of Technology, Japan.* Multicore and multimode fibers are proposed for use in space-division multiplexing for ultra-wide-band optical transmission systems. This paper introduces recent progress on multicore and multimode fiber connection technologies.

Room 123

Tu3E • Novel Materials—Continued

Tu3E.3 • 17:00 Invited
Graphene and Beyond for Ultrafast Optical Communications and Interconnects, Fengnian Xia[1]; [1]*Electrical Engineering, Yale Univ., USA.* We discuss the potential role of graphene in future optical communications. High speed graphene photodetectors, modulators and graphene plasmons are presented. Other two dimensional materials with a direct band gap for light emitting are covered.

Room 124

Tu3F • Optical Access for Mobile Front/Back Haul—Continued

Thank you for attending OFC. Look for your post-conference survey via email and let us know your thoughts on the program.

Room 125

Tu3G • OFDM II—Continued

Tu3G.2 • 17:00
Channel Equalization Based on Independent Component Analysis for Coherent Optical PDM-OFDM, XIANG LI[1], Wen-De Zhong[1], Alphones Arokiaswami[1], Changyuan Yu[2,3]; [1]*School of Electrical and Electronic Engineer, Nanyang Technological Univ., Singapore;* [2]*Department of Electrical and Computer Engineering, National Univ. of Singapore, Singapore;* [3]*A*STAR Inst. for Infocomm Research (I2R), Singapore.* We propose an independent component analysis based channel equalizer for coherent optical PDM-OFDM without using training symbols. The proposed scheme achieves transmission performance better than or as good as the conventional equalizer using training symbols.

Tu3G.3 • 17:15 *Top-Scored*
Nonlinear-Tolerant Adaptive Zero-Guard-Interval CO-OFDM for Highly Spectral Efficient Optical Transmission, Wei Wang[1], Qunbi Zhuge[1], Xian Xu[1], Mohamed Morsy-Osman[1], Mathieu Chagnon[1], Meng Qiu[1], David V. Plant[1]; [1]*Department of Electrical and Computer Engineering, Mcgill Univ., Canada.* An adaptive channel estimation method is proposed for zero-guard-interval CO-OFDM. The improvement in nonlinear tolerance, SOP tracking ability and residual CD tolerance compared to intra-frequency domain averaging is numerically and experimentally demonstrated.

Room 130

Tu3H • InP-based Optoelectronic Devices—Continued

Tu3H.2 • 17:00
AWG-DBR-based WDM Transmitter fabricated in an InP Generic Foundry Platform, Katarzyna Lawniczuk[1,2], Christophe Kazmierski[3], Mike Wale[1,4], Pawel Szczepanski[2,5], Ryszard Piramidowicz[2], Meint Smit[1], Xaveer Leijtens[1]; [1]*Technische Universiteit Eindhoven, Netherlands;* [2]*Warsaw Univ. of Technology, Poland;* [3]*III-V lab, Common laboratory of Alcatel-Lucent Bell Labs France,'Thales Research and Technology' and 'CEA Leti', France;* [4]*Oclaro Technology Ltd., UK;* [5]*National Inst. of Telecommunications, Poland.* We report a novel narrow-linewidth WDM transmitter operating at 10Gbps per transmission channel with 275kHz optical linewidth. The device was fabricated in generic InP-based foundry process and integrates AWG-laser with selective DBR-mirrors and Mach-Zehnder modulators.

Tu3H.3 • 17:15
An InP Monolithically Integrated Multi-Frequency Wavelength Converter, Francesca Bontempi[1], Nicola Andriolli[1], Stefano Faralli[1], Jonathan Klamkin[1,2], Emil Kleijn[3], Tjibbe de Vries[3], Giampiero Contestabile[1]; [1]*Scuola Superiore Sant Anna, Italy;* [2]*Boston Univ., USA;* [3]*Technische Universiteit Eindhoven, Netherlands.* We demonstrate a novel InP-PIC for all-optical wavelength conversion that monolithically integrates a digitally tunable 4-channel multi-wavelength laser and a SOA-MZI. Operations up to 5 Gb/s are shown by BER-measurement with moderate power penalty.

Room 131

Tu3I • Symposium on Enabling the Cloud: Datacenter as a Network II—Continued

Tu3I.2 • 17:00 Invited
Enabling High Performance Cloud Services through Optical Layer Programmability and Virtualisation, Dimitra Simeonidou; *University of Bristol, United Kingdom.* We report new research targeting optical layer programmability and virtualisation for advanced DC and Cloud infrastructures. We focus on novel coordinated software-hardware solutions to unlock flexibility, programmability and resource sharing in the optical layer.

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Room 132

Tu3J • Spectral Shaping—Continued

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Room 133

Tu3K • Specialty Fiber and Fiber Optic Sensors—Continued

Tu3K.2 • 17:00 Invited
Plastic Optical Fibers for Sensing Applications, Francis Berghmans[1], Hugo Thienpont[1]; [1]*Vrije Universiteit Brussel, Belgium.* We review recent developments in polymer optical fiber sensor technology and how such 'POF' sensors may extend the capabilities of the existing silica fiber sensors.

Show Floor Programming

16:00–17:00
New Standards for Ethernet Access Networks, *Expo Theater III Programming*
For more details, see page 44

Room 102

Tu3A • Fiber Nonlinearity Mitigation—Continued

Tu3A.5 • 17:30 *Top-Scored*
Multi-channel Nonlinearity Compensation of 128-Gb/s PDM-QPSK Signals in Dispersion-Managed Transmission Using Dispersion-Folded Digital Backward Propagation, Cen Xia[1,2], Xiang Liu[1], S. Chandrasekhar[1], Nicolas K. Fontaine[1], Likai Zhu[2], Guifang Li[2]; *[1]Bell Labs, Alcatel-Lucent, USA; [2]Univ. of Central Florida, CREOL, USA.* We demonstrate nonlinearity compensation of 37.5-GHz-spaced 128-Gb/s PDM-QPSK signals using dispersion-folded digital-backward-propagation and a spectrally-sliced receiver that simultaneously receives three WDM-signals, showing mitigation of intra-channel and inter-channel nonlinear effects in a 2560-km dispersion-managed TWRS-fiber link.

Tu3A.6 • 17:45 *Top-Scored*
Simplified Nonlinearity Pre-compensation Using a Modified Summation Criteria and Non-Uniform Power Profile, Ying Gao[1], Abdullah S. Karar[3], John C. Cartledge[1], Scott Yam[1], Maurice O'Sullivan[2], Charles Laperle[2], Andrzej Borowiec[2], Kim Roberts[2]; *[1]Electrical and Computer Engineering, Queen's Univ., Canada; [2]Ciena, Canada; [3]Mathematics and Statistics, Queen's Univ., Canada.* By modifying the summation selection criteria and using the non-uniform power distribution profile, a further reduction in the complexity of implementing the perturbation-based nonlinear pre-compensation algorithm for a 128 Gb/s DP 16-QAM signal is demonstrated.

Room 120

Tu3B • Panel: Energy-effiency in Telecommunication Operator Networks: a Reality Check—Continued

Room 121

Tu3C • Protection & Other Practical Considerations in PONs—Continued

Tu3C.4 • 17:45
Energy Management in NG-PON2, Rui Wang[1], Partha Bhaumik[1], Han Hyub Lee[2], Sang Soo Lee[2], Biswanath Mukherjee[1]; *[1]Univ. of California Davis, USA; [2]Electronics and Telecommunications Research Inst., Republic of Korea.* Real-time energy management in NG-PON2 is studied with impacts on quality of service and reconfiguration overhead quantified. The proposed methods are compatible with existing EPON/GPON protocols.

Room 122

Tu3D • Components for SDM—Continued

Tu3D.3 • 17:30
Mode Multiplexer/Demultiplexer Based on a Partially Elongated Multi-Core Fiber, Hitoshi Uemura[1], Yusuke Sasaki[1], Shoko Nishimoto[2], Takui Uematsu[2], Katsuhiro Takenaga[1], Koji Omichi[1], Ryuichiro Goto[1], Shoichiro Matsuo[1], Kunimasa Saitoh[2]; *[1]Optics and Electronics Laboratory, Fujikura Ltd., Japan; [2]Graduate School of Information Science and Technology, Hokkaido Univ., Japan.* A mode multiplexer/demultiplexer based on a partially elongated multi-core fiber is designed and fabricated. The mode conversion from the LP01 mode to the LP11 mode at two wavelengths is demonstrated by changing the elongating condition.

Tu3D.4 • 17:45
Spatial Mode Switchable, Wavelength Tunable Erbium Doped Fiber Laser Incorporating a Spatial Light Modulator, Yong-min Jung[1], Zhihong Li[1], Nicholas H. L. Wong[1], Jae Daniel[1], Jayanta K. Sahu[1], Shaiful Alam[1], David J. Richardson[1]; *[1]Optoelectronics Research Centre (ORC), UK.* We present a 2-mode group, switchable spatial-mode erbium-doped fiber laser incorporating a spatial light modulator. The laser wavelength can be tuned using an intra-cavity wavelength selective filter and provides >10dB extinction ratio between LP01/LP11 modes.

Room 123

Tu3E • Novel Materials—Continued

Tu3E.4 • 17:30
Small-sized Mach-Zehnder Interferometer Optical Switch Using Thin Film Ge2Sb2Te5 Phase-change Material, Takumi Moriyama[1], Hitoshi Kawashima[2], Masashi Kuwahara[2], Xiaomin Wang[2], Hideaki Asakura[1], Hiroyuki Tsuda[1]; *[1]Graduate School of Science and Technology, Keio Univ., Japan; [2]National Inst. of Advanced Industrial Science and Technology, Japan.* Small-sized Mach-Zehnder Interferometer optical switch using Ge2Sb2Te5 thin films was fabricated. Two thin films of 1-μm-square were sufficient for switching. The switching operation was successfully demonstrated by pulsed laser irradiation.

Tu3E.5 • 17:45
High-Efficiency Thermal-Tunable Microring Resonators Made of Cu-Dielectric-Si Hybrid Plasmonic Waveguides, Shiyang Zhu[1], Patrick Guo-Qiang Lo[1], Dim Lee Kwong[1]; *[1]Inst. of Microelectronics, Singapore.* Thermo-optic resonators based on Cu-dielectric-Si hybrid plasmonic waveguides are fabricated. By placing the TiN heater close to the Cu cap, they exhibit high tuning efficiency of 1.1 nm/mW and fast tuning speed of 17.2 μs.

Room 124

Tu3F • Optical Access for Mobile Front/Back Haul—Continued

Tu3F.2 • 17:30
Novel Synchronous Clock Distribution and Recovery for High-Speed UDWDM-OFDMA-based Mobile Backhaul, Ming Zhu[1,2], Neda Cvijetic[2], Ming-Fang Huang[2], Ting Wang[2], Gee-Kung Chang[1]; *[1]Georgia Inst. of Technology, USA; [2]NEC Laboratories America Inc., USA.* We propose and experimentally verify novel low-complexity clock distribution and recovery for high-speed UDWDM-OFDMA-based mobile backhaul using SSB modulation and envelope detection. 30Gb/s UDWDM-OFDMA transmission with synchronous 50MHz clock distribution over 40km SSMF is achieved.

Tu3F.3 • 17:45
A Novel DBA Scheme for TDM-PON based Mobile Fronthaul, Takayoshi Tashiro[1], Shigeru Kuwano[1], Jun Terada[1], Tomoaki Kawamura[2], Nobuyuki Tanaka[2], Satoshi Shigematsu[2], Naoto Yoshimoto[1]; *[1]NTT Access Network Service Systems Laboratories, NTT Corporation, Japan; [2]NTT Microsystem Integration Laboratories, NTT Corporation, Japan.* We propose a mobile-DBA with low-latency for a TDM-PON based mobile fronthaul. It utilizes mobile-scheduling information and reduces the latency to about 1/20 of conventional one. Measured latencies (< 50 μs) are enough for LTE.

Room 125

Tu3G • OFDM II—Continued

Tu3G.4 • 17:30 *Top-Scored*
Experimental Demonstration of Data-dependent Pilot-aided Phase Noise Estimation for CO-OFDM, Son T. Le[1], Thavamaran Kanesan[1], Mary McCarthy[1], Elias Giacoumids[1], Ian Phillips[1], Marc F. Stephens[1], Mingming Tan[1], Nick J. Doran[1], Andrew D. Ellis[1], Sergei K. Turitsyn[1]; [1]*Photonics research group, Aston Univ., UK.* We demonstrate a novel phase noise estimation scheme for CO-OFDM, in which pilot subcarriers are deliberately correlated to the data subcarriers. This technique reduces the overhead by a factor of 2

Tu3G.5 • 17:45
Direct-Detection Multi-Band OFDM Metro Networks Employing Virtual Carriers and Low Receiver Bandwidth, Tiago F. Alves[1], André Alberto[1], Adolfo Cartaxo[1]; [1]*IST/Instituto de Telecomunicações, Portugal.* A metro network using a novel multi-band (MB) OFDM signal is proposed to reduce the receiver bandwidth. A required OSNR for a BER=10-3 of 28 dB is demonstrated in a 240-km long 7-band MB-OFDM system.

Room 130

Tu3H • InP-based Optoelectronic Devices—Continued

Tu3H.4 • 17:30
Negative-Chirped EAM-SOA for Distance-Insensitive Optical OFDM Transmission in Long-Reach OFDMA PONs, Kuo-Chun Chang[1], Shin-Wei Shen[1], Mao-Chin Hsu[1], Yi-Jen Chiu[1], Chia Chien Wei[1], Chao-Kuei Lee[1]; [1]*National Sun Yat-sen Univ., Taiwan.* Enabled by negative-chirped EAM-SOA, we successfully demonstrate 23-Gbps OFDM transmission in the range of 60~100 km without adaptive bit- and/or power-loading. This distance-insensitive performance reveals the feasibility of simple and efficient OFDMA LR-PON.

Tu3H.5 • 17:45 *Top-Scored*
A Compact Low-Power 224-Gb/s DP-16QAM Modulator Module with InP-based Modulator and Linear Driver ICs, Taizo Tatsumi[1], Naoki Itabashi[1], Tomoko Ikagawa[1], Naoya Kono[1], Morihiro Seki[1], Keiji Tanaka[1], Kazuhiro Yamaji[1], Yasushi Fujimura[1], Katsumi Uesaka[1], Takashi Nakabayashi[1], Hajime Shoji[1], Shoichi Ogita[1]; [1]*Transmission Devices R & D Labs., Sumitomo Electric Industries, Ltd., Japan.* A compact 224-Gb/s DP-16QAM InP-based modulator module including linear driver ICs and polarization multiplexing micro-optics is demonstrated. A power dissipation is 3.2 W with compatible performance with LiNbO3-based modulator in back-to-back operation.

Room 131

Tu3I • Symposium on Enabling the Cloud: Datacenter as a Network II—Continued

Tu3I.3 • 17:30 Invited
Smart Cyber Infrastructure for Big Data processing, Paola Grosso; *University of Amsterdam, Netherlands.* The landscape of research cyber infrastructure is rapidly changing. There is a move towards virtualized and programmable infrastructure. The cloud paradigm enables the use of computing resources in different places and allows for optimizing workflows in either bringing computing to the data or the other way around. Programmable networks allow for utilizing networks in unprecedented ways to create application specific Internets. In this context, we present here the latest developments in our research group towards supporting Big Data sciences.

Room 132

Tu3J • Spectral Shaping—Continued

Tu3J.2 • 17:30
Subcarrier Multiplexing Using DACs for Fiber Nonlinearity Mitigation in Coherent Optical Communication Systems, Meng Qiu[1], Qunbi Zhuge[1], Xian Xu[1], Mathieu Chagnon[1], Mohamed Morsy-Osman[1], David V. Plant[1]; [1]*McGill Univ., Canada.* We experimentally generate subcarrier multiplexed signals using high-speed DACs and demonstrate the improved nonlinearity tolerance over single carrier signals in long-haul coherent optical transmission systems.

Tu3J.3 • 17:45
Nonlinearity Mitigation with Spectral Shaping for Channel Spacing Greater than Nyquist, Oleg Sinkin[1], Dmitri Foursa[1], Matt Mazurczyk[1], Hongbin Zhang[1], Jin-Xing Cai[1], Yu Sun[1], Alexei Pilipetskii[1]; [1]*TE SubCom, USA.* We experimentally and theoretically investigate digital spectral shaping for nonlinearity mitigation. We use transmitter digital-to-analog converter to shape channel spectrum to match the channel spacing and optimize linear and nonlinear performance. Theoretical calculations agree well with experiment.

Room 133

Tu3K • Specialty Fiber and Fiber Optic Sensors—Continued

Tu3K.3 • 17:30
Electrical Current-driven Dual-core Optical Fiber with Embedded Metal Electrodes, Zhenggang Lian[1], Martha Segura[1], Nina Podoliak[1], Xian Feng[1], Nicolas White[1], Peter Horak[1], Wei Loh[1]; [1]*Optoelectronics Research Centre, UK.* A dual suspended-core optical fiber with four embedded metal electrodes was fabricated by fiber drawing from a composite preform. Heating the fiber by running watt-level electrical power through the electrodes produced optical switching between cores.

Tu3K.4 • 17:45
Inverse-parabolic Graded-index Profile for Transmission of Cylindrical Vector Modes in Optical Fibers, Bora Ung[1], Lixian Wang[1], Charles Brunet[1], Pravin Vaity[1], Cang Jin[1], Leslie Rusch[1], Younes Messaddeq[1], Sophie LaRochelle[1]; [1]*Center for Optics, Photonics and Lasers, Universite Laval, Canada.* We propose and fabricate a novel few-mode optical fiber for transmission of cylindrical vector modes. Effective index separations larger than 2.1E-4, even with strong fiber bends, are achievable in the C-band.

Room 102	Room 120	Room 121	Room 122	Room 123	Room 124
Tu3A • Fiber Nonlinearity Mitigation—Continued	**Tu3B • Panel: Energy-effiency in Telecommunication Operator Networks: a Reality Check—Continued**	**Tu3C • Protection & Other Practical Considerations in PONs—Continued**		**Tu3E • Novel Materials—Continued**	**Tu3F • Optical Access for Mobile Front/Back Haul—Continued**

Tu3A.7 • 18:00
Mitigating Intra-channel Nonlinearity in Coherent Optical Communications Using ISI-free Polynomial Pulses, Abdullah S. Karar[3], Ying Gao[1], John C. Cartledge[1], Saeed Gazor[1,3], Maurice O'Sullivan[2], Charles Laperle[2], Andrzej Borowiec[2], Kim Roberts[2]; *[1]Electrical and Computer Engineering, Queen's Univ., Canada; [2]Ciena, Canada; [3]Mathematics and Statistics, Queen's Univ., Canada.* ISI-free polynomial pulses are considered for mitigating intra-channel nonlinearity for a 128 Gb/s DP 16-QAM system. A maximum transmission distance of 4500 km is achieved offering a 25% reach extension relative to root-raised-cosine pulses.

Tu3A.8 • 18:15
Efficient Fiber Nonlinearity Mitigation in 50-GHz-DWDM Transmission of 256-Gb/s PDM-16QAM Signals by Folded Digital-Back-Propagation and Channelized FBG-DCMs, Xiang Liu[1], S. Chandrasekhar[1], Peter J. Winzer[1], Benoit Maheux-L[2], Guillaume Brochu[2], Francois Trepanier[2]; *[1]Alcatel-Lucent Bell Labs, USA; [2]TeraXion, Canada.* We demonstrate DSP-efficient mitigation of intrachannel and interchannel nonlinear impairments in dispersion-managed DWDM transmission by using channelized-FBG-DCMs and dispersion-folded digital-back-propagation, showing similar nonlinearity tolerance as dispersion-unmanaged transmission for 256-Gb/s PDM-16QAM signals over 12×100-km SSMF spans.

Tu3C.5 • 18:00
Optical Network Unit (ONU) Power Saving in Time Division Multiplexed Passive Optical Networks (TDM-PONs), Yuanqiu Luo[1], Frank Effenberger[1]; *[1]Huawei Technologies Co Ltd, USA.* We review power saving in TDM-PONs and propose a mechanism to save the ONU power consumption with backward compatibility. Evaluation results show our proposal reduces ONU receiver power consumption as compared with G-PON and BiPON.

Tu3C.6 • 18:15
Correlation-based End-reflection-assisted Brillouin Analysis for Discriminating Small Branch Length Difference, Hiroshi Takahashi[1], Chihiro Kito[1], Fumihiko Ito[1], Kazuo Hotate[2]; *[1]NTT, Japan; [2]The Univ. of Tokyo, Japan.* A novel end-reflection-assisted Brillouin analysis is proposed and demonstrated for discriminating branches of PON with similar lengths, employing correlation domain Brillouin gain analysis and correlation based branch discrimination technique.

Tu3E.6 • 18:00
Silicon Waveguides and Filters in Hyperuniform Disordered Photonic Solids for the Near-infrared, Milan Milosevic[1], Marian Florescu[1], Weining Man[2], Paul Steinhardt[3], Salvatore Torquato[3], Paul Chaikin[4], Timothy Amoah[1], Geev Nahal[2], Ruth Ann Mullen[5]; *[1]Electronic Engineering, Univ. of Surrey, UK; [2]Physics and Astronomy, San Francisco State Univ., USA; [3]Physics, Princeton Univ., USA; [4]Physics, New York Univ., USA; [5]Etaphase, Incorporated, USA.* We report preliminary results for silicon waveguides and devices in hyperuniform disordered photonic solids. Temperature sensitivity of resonant defects is more than 500 times lower than that of the standard silicon microring resonators.

Tu3F.4 • 18:00
Dynamic Compression Method Using Wireless Resource Allocation for Digitized Radio over TDM-PON System, Naotaka Shibata[1], Shigeru Kuwano[1], Jun Terada[1], Naoto Yoshimoto[1]; *[1]NTT, Japan.* We developed a prototype of a network adapter that implements the dynamic compression method for digitized radio over TDM-PON systems. Experimental results show that the required PON bandwidth can be reduced to 1/8.

Tu3F.5 • 18:15
Joint Bandwidth Provisioning and Cache Management for Video Distribution in Software-Defined Passive Optical Networks, Xu Li[1], Konstantinos Kanonakis[1], Neda Cvijetic[1], Akihiro Tanaka[1], Chunming Qiao[2], Ting Wang[1]; *[1]NEC Lab America, USA; [2]The State Univ. of New York at Buffalo, USA.* We propose joint bandwidth provisioning and base station caching for video delivery in software-defined PON. Performance evaluation via custom simulation models reveals 30% increase in served video requests and 90% reduction in service response delays.

18:30–20:00 Conference Reception, *South, Rooms 103 & 104*

19:30–21:30 Rump Session — Will Traffic Growth Break the Internet — And Can Optical Communications Help?, *North, Room 130*

Room 125

Tu3G • OFDM II—Continued

Tu3G.6 • 18:00
Experimental Demonstration of Digital Coherent Superposition of Optical OFDM Subcarrier Pairs for Mitigation of Linear and Nonlinear Phase Noise, Xingwen Yi[1], Xuemei Chen[1], Chao Li[2], Ming Luo[2], Qi Yang[2], Zhaohui Li[3], Kun Qiu[1]; *[1]Key Laboratory of Optical Fiber Sensing and Communications, Ministry of Education, Uni of Elec Science & Tech of China, China; [2]State Key Lab of Optical Communication Technology and Networks, China; [3]Inst. of Photonics Technology, Jinan Univ., China.* We experimentally demonstrate digital coherent superposition of optical OFDM subcarrier pairs with Hermitian symmetry to mitigate phase noise, including laser phase noise and cross-phase modulation in a WDM transmission.

Tu3G.7 • 18:15
102.4-Gb/s Single-Polarization Direct-Detection Reception using Signal Carrier Interleaved Optical OFDM, Di Che[1,2], Xi Chen[2], Jiayuan He[2], An Li[2], William Shieh[2]; *[1]National ICT Australia-Victoria Research Laboratory, Australia; [2]The Univ. of Melbourne, Australia.* We experimentally demonstrate a 102.4-Gb/s single-polarization direct detection over 80-km SSMF using signal carrier interleaved OFDM. The scheme separates the carrier from the signal in time domain and achieves electrical spectral efficiency of 5.68 bits/s/Hz.

Room 130

Tu3H • InP-based Optoelectronic Devices—Continued

Tu3H.6 • 18:00 Invited
Optoelectronic Integrated Circuits (OEICs) for 100G Ethernet and Coherent Networks Based on Multi-Guide Vertical Integration Platform, Sasa Ristic[1,2], Miroslaw Florjanczyk[1], Michael Lebby[1,3]; *[1]OneChip Photonics, Canada; [2]McGill Univ., Canada; [3]Glyndwr Univ., UK.* We present monolithically integrated InP-based optoelectronic circuits, using our cost-efficient, multi-guide vertical integration platform, for the following applications: 100G Ethernet transmitters (100GBASE-PSM4 and 100GBASE-LR4), Ethernet receivers (100GBASE-PSM4, 100GBASE-LR4, and 40GBASE-LR4), and 112Gbps DP-QPSK coherent receivers.

Room 131

Tu3I • Symposium on Enabling the Cloud: Datacenter as a Network II—Continued

Tu3I.4 • 18:00
Infrastructure Architecture for Network Functions Virtualization with SLA Guarantee, Hideyuki Shimonishi; *NEC, Japan.* Infrastructure Architecture for Network Functions Virtualization with SLA Guarantee, This presentation covers a discussion on infrastructure architecture of a NFV system and how it differs from datacenter IaaS infrastructure in terms of traffic patterns, topology, SLAs, and controls on VM allocation and network routing.

Room 132

Tu3J • Spectral Shaping—Continued

Tu3J.4 • 18:00 Invited
Optical Spectral Shaping and High Spectral Efficiency in Long Haul Systems, Matt Mazurczyk[1]; *[1]TE SubCom, USA.* Spectral shaping implemented with digital-to-analog converters is a powerful technique for increasing spectral efficiency. We review both its background and experimental demonstrations including a record single core result of 44.1 Tb/s over 9,100 km.

Room 133

Tu3K • Specialty Fiber and Fiber Optic Sensors—Continued

Tu3K.5 • 18:00
Flat-top Beam from a 50μm-Core Yb-doped Leakage Channel Fiber, Fanting Kong[1,2], Guancheng Gu[1,2], Thomas W. Hawkins[1,2], Joshua Parsons[1,2], Maxwell Jones[1,2], Christopher Dunn[1,2], Monica T. Kalichevsky-Dong[1,2], Kanxian Wei[3], Bryce Samson[3], Liang Dong[1,2]; *[1]ECE, Clemson Univ., USA; [2]COMSET, Clemson Univ., USA; [3]Nufern, USA.* Flat-top beam is demonstrated in a 50μm-core leakage channel fiber using a central ytterbium-doped area with an index depression of ~2x10-4, resulting in an effective mode area of ~1880μm2, i.e. >50% increase from uniform core.

Tu3K.6 • 18:15
Rectangle Lattice Large Mode Area Photonic Crystal Fiber, Xin Wang[1], Shuqin Lou[1], Wenliang Lu[1]; *[1]School of Electronic and Information Engineering, Beijing Jiaotong Univ., China.* A rectangle-lattice photonic crystal fiber with a mode area of 2471 μm2 is successfully fabricated for the first time. Strong capacity of resisting bend distortion makes it good for compact high power fiber laser

18:30–20:00 Conference Reception, *South, Rooms 103 & 104*

19:30–21:30 Rump Session — Will Traffic Growth Break the Internet — And Can Optical Communications Help?, *North, Room 130*

Room 102

08:00–09:45
W1A • Advanced Transmission
Presider: Lara Garrett; TE SubCom, USA

W1A.1 • 08:00
5 x 50 Gb/s WDM Transmission of 32 Gbaud DP-3-PSK over 36,000 km Fiber with Spatially Coupled LDPC Coding, Fred Buchali[1], Laurent Schmalen[1], Axel Klekamp[1], Karsten Schuh[1], Andreas Leven[1]; *[1]Alcatel-Lucent Bell Labs, Germany.* : A novel 3-PSK modulation format with 2 dB SNR gain over BPSK is implemented for ultra long haul transmission. With spatially coupled LDPC coding, 50% reach extension is achieved leading to 36.000 km transmission distance.

W1A.2 • 08:15 ***Top-Scored***
6.3-Tb/s Unrepeatered Transmission over 402-km Fiber using High Power Yb-free Clad-pumped L-band EDFA, Benyuan Zhu[1], P. Borel[2], K. . Carlson[2], X. Jiang[3], D. Peckham[4], Robert Lingle[4], M. Law[5], J. Rooney[5], M. Yan[1]; *[1]OFS Laboratories, USA; [2]OFS, Denmark; [3]College of Staten Island,, CUNY, USA; [4]OFS, USA; [5]SPD, OFS, USA.* Unrepeatered transmission of 6.3-Tb/s (63x128-Gb/s) signals over 402-km of effective-area (Aeff) managed fiber link is achieved by employing high power Yb-free clad-pumped L-band EDFA and remote optically pumped amplifier, which is counter-propagating 2nd-order Raman pumped.

Room 120

08:00–10:00
W1B • Panel: Flexible Rate OTU for Beyond 100G

Organizer: Maarten Vissers, *Huawei, The Netherlands*

The Optical Transport Network (OTN) is becoming the main technology in provider transport networks worldwide to interconnect wireline and wireless service nodes in access, metro, core and backbone networks as well as small, medium and large enterprises and data centres regionally and globally. This panel addresses the evolution of the OTN over the past 15 years (OTN's 1st era) and the expected evolution for the next 15 years (OTN's 2nd era). Topics include flexible rate OTU network applications, beyond 100G OTU structure, service mappings and ODU grooming, forecast of the time line for beyond 100G OTU bit rates, standardization and market demand and necessary progress in electronic and photonic integration. Panel members represent network and data centre providers, IP and transport vendors and analysts.

Speakers:

The Need for FlexMAC and Flexible Framing in a Software Defined Coherent Modulation World, Tad Hofmeister, *Google, USA*

The Operator's view of Flexible/ Elastic Optical Networks, Takuya Ohara, *NTT Group, Japan*

Three Dimensions of Flexibility for Beyond 100G Transmission, Geoff Bennett, *Infinera, USA;* Andrew Schmit, *Infonetics, USA*

Room 121

08:00–10:00
W1C • Node Architecture and Qos
Presider: Georgios Zervas; Univ. of Bristol, UK

W1C.1 • 08:00
FPGA-based Optical Network Function Programmable Node, Yan Yan[1], Georgios S. Zervas[1], Bijan Rahimzadeh Rofoee[1], Dimitra E. Simeonidou[1]; *[1]Univ. of Bristol, UK.* The paper presents architecture, implementation and evaluation of optical network function programmable node with hitless inter-function and intra-function switch-over. It supports multiple network functions on opto-electronic programmable hardware providing function-based virtualization and high network performance.

W1C.2 • 08:15
Flexibility of Programmable Add/ Drop Architecture for ROADMs, Miquel Garrich Alabarce[1], Juliano Oliveira[1], Marcos Siqueira[1], Norberto Amaya[2], Georgios S. Zervas[2], Dimitra E. Simeonidou[2], Julio Oliveira[1]; *[1]CPqD, Brazil; [2]Electrical and Electronic Engineering, Univ. of Bristol, UK.* We introduce add/drop on demand (ADoD) architecture for ROADMs to provide higher flexibility and lower loss than current proposals. We quantitatively measure flexibility considering system's entropy and associate it with traffic uncertainty, upgradability, and resilience.

Room 122

08:00–10:00
W1D • TWDM PON
Presider: Shunji Kimura; NTT access network labs, Japan

W1D.1 • 08:00 **Invited**
PON Evolution for Residential and Business Applications, Vincent O'Bryne[1]; *[1]Verizon, USA.* This paper reviews Verizon's architecture and evolution plans for their PON network to support the increasing bandwidth demands of its residential and business customers on a flexible and robust platform for the coming decade.

Room 123

08:00–10:00
W1E • Optical Network Optimization II
Presider: Takehiro Tsuritani; KDDI R&D Laboratories, Japan

W1E.1 • 08:00
Flexible and automated operational control in SDN transport-base virtual router, Masahiro Hayashitani[1], Yohei Hasegawa[1], Kazuya Suzuki[1], Yasuhiro Mizukoshi[1]; *[1]NEC Corporation, Japan.* We propose and demonstrate a virtual router based on SDN transport which has automatic topology discovery function. We show that the virtual router contributes to flexible and automated operational control.

W1E.2 • 08:15
Field Demonstration of Datacenter Resource Migration via Multi-Domain Software Defined Transport Networks with Multi-Controller Collaboration, Yiming Yu[1], Yi Lin[2], Jie Zhang[1], Yongli Zhao[1], Jianrui Han[2], Haomian Zheng[2], Yadi Cui[1], Minglu Xiao[1], Hui Li[1], Yang Peng[1], Ji Yuefeng[1], Haifeng Yang[3]; *[1]Beijing Univ. of Posts and Telecommunications, China; [2]Huawei Technologies Co., Ltd., China; [3]21Vianet Group, Inc., China.* A multi-controller collaboration framework and three schemes for datacenter interconnection based on software defined transport networking are demonstrated via field networks. Multi-domain lightpaths are automatically provided with limited signaling latency.

Room 124

08:00–10:00
W1F • Use Cases and Transmission for DC Network
Presider: Naoya Wada; NICT, Japan

W1F.1 • 08:00
100 Gb/s PAM4-CAP2 Real-Time Modulation of a Single Optical Source for Next-Generation Datacommunication Links, Jonathan D. Ingham[1], Richard V. Penty[1], Ian White[1], David G. Cunningham[2]; *[1]Univ. of Cambridge, UK; [2]Avago Technologies, UK.* 100 Gb/s PAM4-CAP2 modulation is demonstrated for next-generation datacommunication links. Simulation studies indicate a power budget advantage of 2.5 dBo relative to PAM8 modulation. A real-time experimental demonstration is performed.

W1F.2 • 08:15
Novel High-Resolution OTDR Technology for Multi-Gbps Transceivers, Charlie Kuznia[1], Joe Ahadian[1], Dick Pommer[1], Rich Hagan[1], Paul Bachta[1], Man Wong[1], Kris Kusumoto[1], Sandra Skendzic[1], Chuck Tabbert[1], Mark Beranek[2]; *[1], USA; [2]Naval Air Systems Command, USA.* We present high-resolution optical time domain reflectometer (OTDR) integration into fiber optic transceivers. Transceivers with built-in-test (BIT) OTDR can characterize the fiber plant and isolate faults to reduce network installation and maintenance costs.

Room 125

08:00–10:00
W1G • Advanced Signal Generation & Monitoring
Presider: Changyuan Yu; National Univ. of Singapore, Singapore

W1G.1 • 08:00 Invited
Low Noise and Regenerative Phase Sensitive Amplifier based on PPLN Waveguides, Takeshi Umeki[1,2], Masaki Asobe[1], Hidehiko Takara[2], Osamu Tadanaga[1], Koji Enbutsu[1], Yutaka Miyamoto[2], Hirokazu Takenouchi[1,2]; [1]*NTT Photonics Labs, Japan;* [2]*NTT Network Innovation Labs, Japan.* We review the capabilities of phase sensitive amplifiers based on PPLN waveguides for optical communication. Specifically, we discuss their unique low noise amplification, phase and amplitude regeneration in multi-span transmissions, and multilevel phase coding signal amplification.

Room 130

08:00–10:00
W1H • Advanced Multiplexing

W1H.1 • 08:00
Experiment Turbulence Compensation of 50-Gbaud/s Orbital-Angular-Momentum QPSK Signals using Intensity-only based SPGD Algorithm, Guodong Xie[1], Yongxiong Ren[1], Hao Huang[1], Martin P. Lavery[2], Nisar Ahmed[1], Yan Yan[1], Changjing Bao[1], Long Li[1], Zhe Zhao[1], Yinwen Cao[1], Moshe Willner[1], Miles J. Padgett[2], Moshe Tur[3], Samuel Dolinar[4], Robert Boyd[5], Jeffrey Shapiro[6], Alan Willner[1]; [1]*U. of Southern California, USA;* [2]*School of Physics and Astronomy, Univ. of Glasgow, UK;* [3]*School of Electrical Engineering, Tel Aviv Univ., Israel;* [4]*Jet Propulsion Laboratory, California Inst. of Technology, USA;* [5]*Dept. of Physics and Astronomy, The Inst. of Optics, Univ. of Rochester, USA;* [6]*Research Laboratory of Electronics, Massachusetts Inst. of Technology, USA.* An intensity-only based algorithm is employed to compensate the turbulence effects on 50-Gbaud/s orbital angular momentum QPSK channels. By only measuring the intensity profile, the purity of the OAM beams is improved and crosstalk among channels is decreased.

W1H.2 • 08:15
Degenerate Mode-Group Division Multiplexing using Delayed Adaptive Frequency-Domain Equalization, Kai Shi[1], George Gordon[2], Benn C. Thomsen[1]; [1]*Electronic and Electrical Engineering, Univ. College London, UK;* [2]*Engineering, Univ. of Cambridge, UK.* A reduced complexity delayed adaptive frequency-domain equalizer is proposed for MIMO equalization in degenerate mode-group multiplexed systems. A factor of 2.8 reduction of the DSP complexity is obtained compared to the optimized delayed time-domain equalizer.

Room 131

08:00–10:00
W1I • Coherent Integrated Transceiver Technologies
Presider: Jonathan Klamkin; Boston Univ., USA

W1I.1 • 08:00 Invited
Coherent Transmitters and Receivers for Pluggable Modules, Young-Kai Chen[1]; [1]*Bell Labs, Alcatel-Lucent, USA.* We review recent advances in coherent transponders for pluggable modules. Critical technologies of photonic integration techniques, such as planar lightwave circuits, silicon photonics, compound semiconductor photonic integrated circuits, etc., and the associated electro-optical integration into compact modules will be discussed.

Room 132

08:00–10:00
W1J • Signal Generation
Presider: Jianping Yao; Univ. of Ottawa, Canada

W1J.1 • 08:00
Adaptive Photonic-Assisted M-ary ASK/M-QAM Millimeter-Wave Synthesis in Multi-Antenna Radio-over-Fiber System, Ming Zhu[1], Lin Cheng[1], Jing Wang[1], Cheng Liu[1], Gee-Kung Chang[1]; [1]*Georgia Inst. of Technology, USA.* We propose and experimentally verify novel photonic-assisted multi-antenna RoF system to achieve multiplexing gain by synthesizing two 1/0.5-Gb/s OOK/4-QAM mm-wave signals into a 2/1-Gb/s 4-ary ASK/16-QAM signal, or SNR gain by combining two identical channels.

W1J.2 • 08:15
Frequency-Hopping Microwave Waveform Generation Based on a Frequency-Tunable Optoelectronic Oscillator, Jianping Yao[1], Wangzhe Li[1], Weifeng Zhang[1]; [1]*Univ. of Ottawa, Canada.* High-speed and wideband frequency-hopping microwave waveform generation based on a frequency-tunable optoelectronic oscillator using a polarization modulator and a polarization-maintaining phase-shifted fiber Bragg grating is demonstrated.

Room 133

08:00–09:45
W1K • Network Control
Presider: Daniel Peterson; Verizon Communications Inc, USA

W1K.1 • 08:00
Analysis and Implementation of a 3-Way Handshake Signaling Protocol for Highly Dynamic Transport Networks, Ronald Skoog[1], Joel Gannett[1], Keith Kim[1], Haim Kobrinski[1], Michael Rauch[1], Ann C. Von Lehmen[1], Brian Wilson[1]; [1]*Optical Network Research, Applied Communication Sciences, USA.* A 3-Way handshake signaling protocol was previously developed that meets DARPA CORONET program requirements for highly dynamic transport networks. Presented here are extensions to OTN-based networks, and protocol validation in a 100-node emulation testbed.

W1K.2 • 08:15 Invited
The DE-CIX network, Arnold Nipper[1]; [1]*DE-CIX, Germany.* Abstract not available

Show Floor Programming

08:30–09:15
■ **Service Provider Summit**
Keynote: Packet Optical vs. OTN, *Expo Theater I Programming*
For more details, see page 39

09:15–10:45
■ **Service Provider Summit**
Panel I: Packet Optical Convergence, *Expo Theater I Programming*
For more details, see page 39

Room 102

W1A • Advanced Transmission—Continued

W1A.3 • 08:30
Transoceanic Transmission of Dual-Carrier 400G DP-8QAM at 121.2km Span Length with EDFA-Only, Shaoliang Zhang[1], Fatih Yaman[1], Ting Wang[1], Eduardo Mateo[2], Takanori Inoue[2], Yoshihisa Inada[2], Takaaki Ogata[2]; *[1]NEC Laboratories America Inc, USA; [2]Submarine Network Division, NEC Corporation, Japan.* 400-Gb/s dual-carrier DP-8QAM transmission over 6,787 km is reported at 121.2km span length, the longest to date with EDFA only. Spectral efficiency of 4.54 b/s/Hz is achieved thanks to Nyquist shaping and nonlinear compensation techniques.

W1A.4 • 08:45
1.92 Tbit/s, 64 QAM Coherent Nyquist Pulse Transmission over 150 km with a Spectral Efficiency of 7.5 bit/s/Hz, David O. Otuya[1], Keisuke Kasai[1], Toshihiko Hirooka[1], Masato Yoshida[1], Masataka Nakazawa[1]; *[1]Tohoku Univ., Japan.* We demonstrate, for the first time, a polarization-multiplexed 160 Gsymbol/s, 64 QAM coherent optical Nyquist pulse transmission. 1.92 Tbit/s data were successfully transmitted over 150 km with a spectral efficiency of 7.5 bit/s/Hz.

Room 120

W1B • Panel: Flexible Rate OTU for Byond 100G—Continued

Room 121

W1C • Node Architecture and Qos—Continued

W1C.3 • 08:30
Experimental Demonstration and Benefits of Self-Healing Hard-Wired and Synthetic ROADMs, Matija Dzanko[1], Marija Furdek[1,3], Norberto Amaya[2], Georgios S. Zervas[2], Branko Mikac[1], Dimitra E. Simeonidou[2]; *[1]Department of Telecommunications, Univ. of Zagreb, Faculty of Electrical Engineering and Computing, Croatia; [2]Department of Electrical and Electronic Engineering, Univ. of Bristol, Faculty of Engineering, UK; [3]Royal Inst. of Technology KTH, ICT School, Sweden.* Novel hard-wired and synthetic ROADM architectures with self-healing capabilities are experimentally demonstrated. Simulation results show significant improvements of availability and recovery time due to node-level restoration, with reduced mean down time and operator revenue losses.

W1C.4 • 08:45
Implications of Super-Channels on Colorless, Directionless and Contentionless (CDC) ROADM Architectures, Anuj Malik[1], Wayne Wauford[1], Steven Hand[1], Nitin Goel[1], Zhong Pan[1], Matthew Mitchell[1]; *[1]Infinera, USA.* This paper proposes CDC ROADM architecture compatible with emerging DWDM super-channel technology. A real world network model is used to quantify that this architecture requires fewer network components leading to less capital and operational costs.

Room 122

W1D • TWDM PON—Continued

W1D.2 • 08:30 Invited
Flexible TWDM PONs, Ning Cheng[1]; *[1]Huawei Technologies USA, USA.* A flexible TWDM PON is demonstrated with error-free performance using enhanced CFP transceiver for OLT and tunable SFP+ transceiver for ONUs. Such PON system allows pay-as-you-grow deployment, supports load balancing and achieves significant power saving.

Presentations selected for recording are designated with a ▶. Access these by visiting www.ofcconference.org and clicking on the View Presentations button.

Room 123

W1E • Optical Network Optimization II—Continued

W1E.3 • 08:30 Invited
SDN Concept: From Theory to Network Implementation, Ljubisa Tancevski[1]; *[1]Alcatel-Lucent, USA.* Virtualization and cloud transformation are already revolutionizing the data center environments and are promising to bring the same cloud economics to general networking. Software Defined Networking is a prime enabler for the transition to cloud networking.

Room 124

W1F • Use Cases and Transmission for DC Network—Continued

W1F.3 • 08:30
60-Gb/s CAP-64QAM Transmission Using DML with Direct Detection and Digital Equalization, Junwen Zhang[1,2], Xinying Li[2], Yan Xia[3], Yufei Chen[3], Xue Chen[4], Jianguo Yu[4], Jiangnan Xiao[2]; *[1]ZTE (TX) Inc, USA; [2]Fudan Univ., China; [3]ZTE Corp., China; [4]Bejing Univ. of Posts and Telecommunications, China.* Digital equalization based on modified DD-LMS algorithm is used to equalize the CAP-64QAM with reduced complexity and improved performances. A record 60-Gb/s CAP-64QAM over 20-km SSMF based on the DML and direct detection is demonstrated.

W1F.4 • 08:45
Digital QAM Modulation and Equalization for High Performance 400 GbE Data Center Modules, Ilya Lyubomirsky[1], William Ling[1,2]; *[1]Finisar Corp., USA; [2]Electrical Engineering, Stanford Univ., USA.* A digital QAM modem concept is proposed and investigated for 400-Gb/s data center modules based on 25G DFB transmitter technology. Monte-Carlo simulations, including DFB nonlinearities and RIN, show 2-dB advantage for QAM over optimized DMT.

W1G • Advanced Signal Generation & Monitoring—Continued

W1G.2 • 08:30
Experimental Demonstration of Optical Nyquist Generation of 32-Gbaud QPSK using a Comb-based Tunable Optical Tapped-Delay-Line FIR Filter, Morteza Ziyadi[1], Mohammad Reza Chitgarha[1], Amirhossein Mohajerin Ariaei[1], Salman Khaleghi[1], Ahmed Almaiman[1], Y. Akasaka[3], J.-Y. Yang[3], M. Sekiya[3], Moshe Willner[1], Joe Touch[2,1], Moshe Tur[3], Loukas Paraschis[4], Carsten Langrock[5], Martin Fejer[5], Alan Willner[1]; [1]*Ming Hsieh Department of Electrical Engineering, Univ. of Southern California, USA;* [2]*Information Science Inst., Univ. of Southern California, USA;* [3]*School of Electrical engineering, Tel Aviv Univ., Israel;* [4]*Cisco Systems, USA;* [5]*Edward L. Ginzton Laboratory, Stanford Univ., USA*. We experimentally demonstrate tunable optical Nyquist generation of 32Gbaud QPSK signals using optical tapped-delay line. Optical Nyquist spectra for different number of taps are shown, and 20% EVM and 2.8 dB OSNR penalty at BER of 1e-3 are measured.

W1G.3 • 08:45
Nonlinearity-Tolerant Frequency Domain Root M-shaped Pulse for Spectrally Efficient Coherent Transmissions, Xian Xu[1], Qunbi Zhuge[1], Benoît Châtelain[2], Meng Qiu[1], Mathieu Chagnon[1], Mohamed Morsy-Osman[1], Wei Wang[1], David V. Plant[1]; [1]*Electrical and Computer Engineering, McGill Univ., Canada;* [2]*Ciena Corporation, Canada*. A frequency domain M-shaped pulse with roll-off factors less than 1 is proposed and experimentally demonstrated to achieve a better nonlinearity tolerance than the RRC pulse for both PDM-QPSK and PDM-16QAM transmission systems.

W1H • Advanced Multiplexing—Continued

W1H.3 • 08:30
First Experimental Demonstration of a Time Domain Multiplexed SDM Receiver for MIMO Transmission Systems, Roy van Uden[1], Chigo Okonkwo[1], Haoshuo Chen[1], Frans Huijskens[1], Huug Waardt, de[1], A. Koonen[1]; [1]*COBRA Research Inst., Eindhoven Univ. of Technology, Netherlands*. Conventionally, an SDM system requires a 4-port oscilloscope for each dual polarization mode. Using a novel and cheaper 2×4-port oscilloscope SDM receiver, 3-mode 28GBaud DP-32QAM is experimentally verified after 41.7km few-mode fiber transmission.

W1H.4 • 08:45 *Top-Scored*
Ultra-High 230-bit/s/Hz Spectral Efficiency using OFDM/OQAM 64-QAM Signals over Pol-Muxed 22 Orbital Angular Momentum (OAM) Modes, Jian Wang[1], Shuhui Li[1], Chao Li[2], Long Zhu[1], Chengcheng Gui[1], Dequan Xie[2], Ying Qiu[2], Qi Yang[2], Shaohua Yu[2]; [1]*Wuhan National Laboratory for Optoelectronics, Huazhong Univ. of Science and Technology, China;* [2]*State Key Laboratory of Optical Comm. Technologies and Networks, China*. We demonstrate the multiplexing/demultiplexing of pol-muxed 22 orbital angular momentum (OAM) modes. Using 17.9-Gbit/s OFDM/OQAM 64-QAM signals over pol-muxed 22 OAM modes (44 channels in total), we achieve an ultra-high spectral efficiency of 230 bit/s/Hz.

W1I • Coherent Integrated Transceiver Technologies—Continued

W1I.2 • 08:30
128-Gb/s DP-QPSK using low-loss monolithic silicon IQ modulator integrated with partial-rib polarization rotator, Kazuhiro Goi[1], Hiroyuki Kusaka[1], Akira Oka[1], Kensuke Ogawa[1], Tsung-Yang Liow[2], Xiaoguang Tu[2], Patrick Guo-Qiang Lo[2], Dim Lee Kwong[2]; [1]*Fujikura Ltd., Japan;* [2]*Inst. of Microelectronics, Singapore*. 128-Gb/s DP-QPSK is realized using silicon IQ modulator monolithically integrated with partial-rib polarization rotator under +/-3.25-Vpp push-pull RF driving condition. Low passive insertion loss 12-13 dB is achieved over C band.

W1I.3 • 08:45
Simple Three-dimensional Simplex Modulator, Hiroshi Yamazaki[1], Yasuaki Hashizume[1], Takashi Saida[1]; [1]*NTT Photonics Laboratories, Japan*. We devised a simple 3D simplex modulator containing only two Mach-Zehnder sub-modulators. The modulator has smaller intrinsic modulation loss than that with the conventional configuration. It operated at 43 Gb/s.

W1J • Signal Generation—Continued

W1J.3 • 08:30 Invited
Tunable QAM Transmitter Based on Direct Modulation Laser, Joseph Kakande[1], Radan Slavik[2], Richard Phelan[3], Brian Kelly[3], David J. Richardson[2]; [1]*Bell Labs, Alcatel-Lucent, USA;* [2]*Optoelectronics Research Center, Univ. of Southampton, UK;* [3]*Eblana Photonics, Ireland*. We discuss a technique that allows for flexible synthesis of square QAM constellations via the direct modulation of tunable, injection locked, semiconductor lasers. The approach uses optical coherent multiplexing and we demonstrate full C-band tuning.

W1K • Network Control—Continued

W1K.3 • 08:45
E2E Traffic Engineering Routing for Transport SDN, fabio ubaldi[1], Paola Iovanna[1], Francesco Di Michele[2], Juan-Pedro Fernández-Palacios[3], Victor Lopez[3]; [1]*Ericsson, Italy;* [2]*CoRiTeL, Italy;* [3]*Telefonica R+D, Spain*. The article proposes a hierarchical routing approach, validated by simulation on real network operator, based on a novel adaptive virtualization scheme, suitable for transport SDN, allowing dynamic configuration of heterogeneous multi-domain packet-optical networks.

Show Floor Programming

08:30–09:15
■ **Service Provider Summit**
Keynote: Packet Optical vs. OTN, *Expo Theater I Programming*
For more details, see page 39

09:15–10:45
■ **Service Provider Summit**
Panel I: Packet Optical Convergence, *Expo Theater I Programming*
For more details, see page 39

Room 102

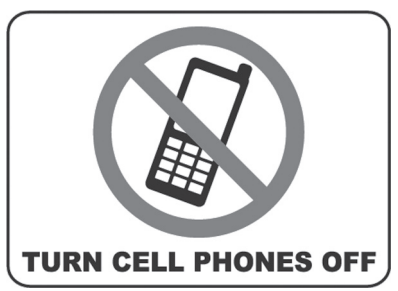
W1A • Advanced Transmission—Continued

W1A.5 • 09:00
Biorthogonal Modulation in 8 Dimensions Experimentally Implemented as 2PPM-PS-QPSK, Tobias A. Eriksson[1], Pontus Johannisson[1], Erik Agrell[2], Peter A. Andrekson[1], Magnus Karlsson[1]; [1]*Department of Microtechnology and Nanoscience, Chalmers Univ. of Technology, Sweden;* [2]*Department of Signals and Systems, Chalmers Univ. of Technology, Sweden.* We experimentally demonstrate biorthogonal modulation in 8 dimensions as binary pulse-position modulation polarization-switched QPSK. We compare this format with PM-QPSK at the same bit rate and show a 1.4 dB sensitivity gain and 84 % increased transmission distance.

W1A.6 • 09:15
2048 QAM (66 Gbit/s) Single-Carrier Coherent Optical Transmission over 150 km with a Potential SE of 15.3 bit/s/Hz, Shohei Beppu[1], Masato Yoshida[1], Keisuke Kasai[1], Masataka Nakazawa[1]; [1]*TohokuUniv., Japan.* We have successfully achieved a 2048 QAM transmission (66 Gbit/s) with a potential spectral efficiency of 15.3 bit/s/Hz in a single carrier coherent transmission over 150 km.

Room 120

W1B • Panel: Flexible Rate OTU for Byond 100G—Continued



Room 121

W1C • Node Architecture and Qos—Continued

W1C.5 • 09:00 Invited
QoS of Optical Metro Networks, Annie Gravey[1,3], Philippe Gravey[2], Michel Morvan[2], Bogdan Uscumlic[1,3], Lida Sadeghioon[1,3]; [1]*Computer Science Department, Telecom Bretagne, France;* [2]*Optics Department, Telecom Bretagne, France;* [3]*IRISA, France.* Metro networks support increasing traffic volumes and evolving traffic profiles. Revisiting metro networks architecture, this paper shows that both optical transparency and sub-wavelength granularity can be achieved, while still ensuring transport network QoS levels.

Room 122

W1D • TWDM PON—Continued

W1D.3 • 09:00
Delay Modulation for TWDM PONs, Ning Cheng[1], Min Zhou[2], Kerry Litvin[1], Frank Effenberger[1]; [1]*American Research Center, Huawei Technologies USA, USA;* [2]*Huawei Technologies, China.* Delay modulation using directly modulated laser at 10Gb/s is demonstrated for TWDM PONs with <1 dB dispersion penalty after 20km transmission. Compared to NRZ, delay modulation improves the carrier-to-Raman-crosstalk ratio of RF video by 10dB.

W1D.4 • 09:15
Automatic ONU Wavelength Control in TWDM PONs, Ning Cheng[1], Frank Effenberger[1]; [1]*American Research Center, Huawei Technologies USA, USA.* Low cost and effective approaches for automatic ONU wavelength control in TWDM PONs are proposed by using low-power and low-frequency/low-data-rate signal from the tunable ONU transmitter. Experimental results validate the proposed approaches.

Room 123

W1E • Optical Network Optimization II—Continued

W1E.4 • 09:00
Variation of OTN Switching Benefits in Real-World Networks Based on Network and Traffic Connectivity, Soumya Roy[1], Onur Turkcu[1], Steven Hand[1], Serge Melle[1]; [1]*Infinera, USA.* OTN switching enables high network efficiency and operational ease-of-use. This paper evaluates several real-world network and traffic models and concludes that OTN switching benefits are maximized more by traffic patterns rather than by physical topology.

W1E.5 • 09:15
Comparison of Converged Packet-Optical Core Network Architecture Options, Serge Melle[1], Satyajeet Ahuja[2], Steven Hand[1], Onur Turkcu[1]; [1]*Infinera Corporation, USA;* [2]*Facebook, USA.* Two architectural approaches for converged packet-optical core networks are compared in a North American network: IP over WDM and IP over OTN. Results show a converged OTN/WDM layer reduces IP/MPLS and total packet-optical network costs.

Room 124

W1F • Use Cases and Transmission for DC Network—Continued

W1F.5 • 09:00
50Gbit/s PAM-4 MMF Transmission Using 1060nm VCSELs with Reach beyond 200m, Sriharsha Kota Pavan[1], Justin Lavrencik[1], Roman Shubochkin[2], Yi Sun[2], Jinkee Kim[2], Durgesh S. Vaidya[2], Robert Lingle[2], Tomofumi Kise[3], Stephen Ralph[1]; [1]*Electrical and Computer Engineering, Georgia Inst. of Technology, USA;* [2]*Optical Fiber R&D, OFS Fitel, USA;* [3]*FITEL Products Division, Furukawa Electric Co., Ltd, Japan.* We experimentally demonstrate error-free transmission of 50Gbit/s PAM-4 signals over OM3 and prototype wideband fiber using 1060nm VCSELs. FEC-conformed performance is demonstrated over 200m. An analytic model allows identification of penalties and demonstrates negligible MPN.

W1F.6 • 09:15
Experimental measurements of the impact of multi-path interference on PAM signals, Chris R. Fludger[1], Marco Mazzini[2], Theo Kupfer[1], Matt Traverso[3]; [1]*Cisco Optical GmbH, Germany;* [2]*Cisco, Italy;* [3]*Cisco, USA.* We measure the impact of reflection induced multi-path interference on 32Gbaud PAM-2, 4 and 8. We show a good agreement with a Gaussian model and discuss system scenarios using standardised connectors.

Room 125

W1G • Advanced Signal Generation & Monitoring—Continued

W1G.4 • 09:00
A Highly-Integrated Optical Frequency Synthesizer Based on Phase-locked Loops, Mingzhi Lu[1], Hyun-chul Park[1], Eli Bloch[2], Leif Johansson[1], Mark Rodwell[1], Larry A. Coldren[1,3]; [1]*Electrical and Computer Engineering, Univ. of California Santa Barbara, USA;* [2]*Electrical Engineering, Technion - Israel Inst. of Technology, Israel;* [3]*Materials, Univ. of California Santa Barbara, USA.* The first highly-integrated optical synthesizer is realized by photonic integration and optical phase-locking technique. Preliminary results show >160 GHz output frequency range and a relative frequency accuracy as defined by the RF signal.

W1G.5 • 09:15
Cost-effective Optical Nyquist Pulse Generator with Ultra-flat Optical Spectrum Using Dual-parallel Mach-Zehnder Modulators, Qiang Wang[1], Li Huo[1], Yanfei Xing[1], Caiyun Lou[1], Bingkun Zhou[1]; [1]*Tsinghua Univ., China.* Rectangular-shaped optical frequency comb generation with Nyquist temporal waveforms using dual-parallel Mach-Zehnder modulators is proposed. Nyquist pulse with 3.66% duty cycle and 25-tone frequency combs with flatness within 0.5 dB is generated.

Room 130

W1H • Advanced Multiplexing—Continued

W1H.5 • 09:00 Tutorial
Superchannel for Next-Generation Optical Networks, Xiang Liu[1], S. Chandrasekhar[1]; [1]*Alcatel-Lucent Bell Labs, USA.* We review recent advances in the generation, detection, transmission, and networking of Tb/s-class optical superchannels. Enabling technologies such as advanced digital signal processing, bandwidth-flexible optical network elements, and large-scale photonic and electronic integration are discussed.

Xiang Liu is a Distinguished Member of Technical Staff at Bell Labs, Alcatel-Lucent. He received his Ph.D. degree in applied physics from Cornell University in 2000. Since joining Bell Labs, Xiang has been working on high-speed optical communication technologies including advanced modulation formats, digital coherent detection, fiber nonlinear impairment mitigation, and superchannel transmission. Dr. Liu has authored/coauthored over 250 journal and conference papers and holds 51 US patents. Dr. Liu is a Fellow of the OSA.

Room 131

W1I • Coherent Integrated Transceiver Technologies—Continued

W1I.4 • 09:00 Invited
Integrated photonic coherent receivers , Milan L. Mašanović[1]; [1]*Freedom Photonics, USA.* In this paper, provide an overview of the state-of-the-art for the photonic coherent receiver devices, and focus on some of the recent work done on full I-Q coherent receivers integrated with local oscillators.

Room 132

W1J • Signal Generation—Continued

W1J.4 • 09:00 Tutorial
Photonics-based Radio-Frequency Arbitrary Waveform Generation, Andrew M. Weiner[1]; [1]*Purdue Univ., USA.* Photonic generation of arbitrary radio-frequency arbitrary waveforms is reviewed, with an emphasis on ultrabroadband signal generation. Recent progress towards increased time aperture and time-bandwidth product and applications to wireless transmission are discussed.

Andrew M. Weiner is Scifres Family Distinguished Professor of Electrical and Computer Engineering at Purdue University. He is best known for his pioneering work on programmable femtosecond pulse shaping and its application to ultrafast signal processing. Prof. Weiner is author of the textbook Ultrafast Optics and has published over 270 journal articles. He is a Fellow of both OSA and IEEE, member of the U.S. National Academy of Engineering, and recipient of numerous awards, including most recently the IEEE Photonics Society Quantum Electronics Award. Prof. Weiner currently holds a National Security Science and Engineering Faculty Fellowship from the Department of Defense.

Room 133

W1K • Network Control—Continued

W1K.4 • 09:00
Impact of IP Layer Routing Policy on Multi-Layer Design, Eleni Palkopoulou[1], Ori Gerstel[2], Ioannis Stiakogiannakis[3], Thomas Telkamp[6], Victor Lopez[4], Ioannis Tomkos[5]; [1]*Cisco, Greece;* [2]*Cisco, Israel;* [3]*Foundation for Research and Technology, Greece;* [4]*Telefonica I+D, Spain;* [5]*Athens Information Technology Center, Greece;* [6]*Cisco, Netherlands.* We evaluate the impact of the IP layer routing policy (Hop-Based and Distance-Based) on the cost and latency of a multi-layer network design. We find that the optical network's regeneration requirements affect the optimal policy.

W1K.5 • 09:15 Invited
Impact of Internet Peering on Network Architectures and Economics, Brough Turner[1]; [1]*netBlazr Inc, USA.* The Internet backbone consists of ~6000 independent networks. The technology and economics of how these networks exchange data drives the location of data centers and the location and utilization of high capacity fiber links.

Show Floor Programming

08:30–09:15
■ **Service Provider Summit**
Keynote: Packet Optical vs. OTN, *Expo Theater I Programming*
For more details, see page 39

09:15–10:45
■ **Service Provider Summit**
Panel I: Packet Optical Convergence, *Expo Theater I Programming*
For more details, see page 39

Room 102

W1A • Advanced Transmission—Continued

W1A.7 • 09:30
On the Emulation of High Spectral Efficiency System in Laboratories Experiments, Gabriel Charlet[1], Patrice Tran[1], Patrick Brindel[1], Rafael Rios-Müller[1]; [1]*Alcatel-Lucent Bell Labs, France.* The impact of channel multiplexing on system performance is investigated in case of high spectral efficiency systems emulation. Implications of band edge filtering, guard bands and passive coupler loss are studied.

Room 120

W1B • Panel: Flexible Rate OTU for Byond 100G—Continued

Room 121

W1C • Node Architecture and Qos—Continued

W1C.6 • 09:30
Enhancement of Fiber Frequency Utilization by Employing Grouped Optical Path Routing, Yuki Terada[1], Yojiro Mori[1], Hiroshi Hasegawa[1], Ken-ichi Sato[1]; [1]*Department of Electrical Engineering and Computer Science, Nagoya Univ., Japan.* Optical path grouped routing not only simplifies the node's architecture, but also mitigates the signal degradation due to optical filtering at each node. It can improve frequency utilization of fibers or mitigate WSS requirements.

W1C.7 • 09:45
Hardware Scale and Performance Evaluation of Compact OXC Add/Drop Architecture, Hiroto Ishida[1], Hiroshi Hasegawa[1], Ken-ichi Sato[1]; [1]*Department of Electrical Engineering and Computer Science, Nagoya Univ., Japan.* We propose a novel add/drop architecture that suits large-scale optical cross-connect (OXC) nodes with subsystem modular architecture. Substantial hardware reduction is attained while the throughput offset is shown to be marginal.

Room 122

W1D • TWDM PON—Continued

W1D.5 • 09:30
Beneficial OLT Transmitter and Receiver Concepts for NG-PON2 Using Semiconductor Optical Amplifiers, Rene Bonk[1], Harald Schmuck[1], Wolfgang Poehlmann[1], Thomas Pfeiffer[1]; [1]*Bell Labs Germany, Alcatel-Lucent Germany, Germany.* OLT transmitter and receiver concepts using SOA for NG-PON2 are experimentally compared. A single SOA per wavelength channel at the Tx and a configuration comprising linear SOA followed by APDs at the Rx are beneficial.

W1D.6 • 09:45 *Top-Scored*
Measurement and Mitigation of Wavelength Drift due to Self-Heating of Tunable Burst-Mode DML for TWDM-PON, Dora van Veen[1], Wolfgang Poehlmann[2], Bob Farah[1], Thomas Pfeiffer[2], Peter Vetter[1]; [1]*Alcatel-Lucent, USA;* [2]*Alcatel-Lucent, Germany.* For TWDM-PON systems we report measurements of and mitigation methods for the unwanted wavelength drift of directly modulated burst-mode lasers due to self-heating of the laser junction.

Room 123

W1E • Optical Network Optimization II—Continued

W1E.6 • 09:30 Invited
Using SDN Technology to Enable Cost-effective Bandwidth-on-Demand for Cloud Services, Robert D. Doverspike[1], George Clapp[1], Pierre Douyon[2], Douglas Freimuth[5], Krishna Gullapalli[2], Jeffrey Hartley[2], Emmanuil Mavrogiorgis[1], James O'Connor[3], Jorge Pastor[1], K. Ramakrishnan[1], Michael Rauch[4], Mark Stadler[3], Ann C. Von Lehmen[4], Brian Wilson[4], Sheryl L. Woodward[1]; [1]*AT&T Labs, USA;* [2]*Brocade, USA;* [3]*Ciena, USA;* [4]*Applied Communication Sciences, USA;* [5]*IBM TJ Watson Research Center, USA.* We describe bandwidth-on-demand in an evolved multi-layer, SDN-based Cloud Services model. We also show an initial proof-of-concept demonstration of this capability.

Room 124

W1F • Use Cases and Transmission for DC Network—Continued

W1F.7 • 09:30 Invited
The Role of Optical Interconnections in Future Data Centers of Large Enterprises, Brad Spiers[1]; [1]*Bank of America, USA.* Abstract not available

10:00–12:00 W2A • Poster Session I, *North, Exhibit Hall C (coffee and snacks available)*

10:00–16:00 Exhibition and Show Floor, *South, Exhibit Halls A, B, C and North, Exhibit Hall D*

10:00–13:00 Unopposed Exhibit-Only Time, *South, Exhibit Halls A, B, C and North, Exhibit Hall D (concessions available)*

Room 125	Room 130	Room 131	Room 132	Room 133
W1G • Advanced Signal Generation & Monitoring—Continued	**W1H • Advanced Multiplexing—Continued**	**W1I • Coherent Integrated Transceiver Technologies—Continued**	**W1J • Signal Generation—Continued**	**W1K • Network Control—Continued**
W1G.6 • 09:30 **Accurate Bit Error Ratio Monitor by Spectral Filtering and Optical Power Measurements,** Shoichiro Oda[1], Tomohiro Yamauchi[1], Jeng-Yuan Yang[2], Youichi Akasaka[2], Olga Vassilieva[2], Yasuhiko Aoki[1], Motoyoshi Sekiya[2], Jens Rasmussen[1]; [1]*Fujitsu Laboratories Ltd., Japan;* [2]*Fujitsu Laboratories of America, Inc, USA.* We propose a novel bit error ratio monitoring method by optical bandpass filter and optical power measurements and experimentally demonstrate its sufficient accuracy with various fiber launched powers and wavelengths in WDM dispersion-uncompensated transmission link.		**W1I.5 • 09:30** **Monolithic Coherent Receiver Based on 120-Degree Optical Hybrids on Silicon,** Po Dong[1], Chongjin Xie[1], Lawrence L. Buhl[1]; [1]*Alcatel-Lucent Bell Labs, USA.* We present a monolithic dual-polarization coherent receiver by employing 120-degree optical hybrids on silicon. 112-Gb/s polarization-division-multiplexed quadrature phase-shift keyed signals are detected in the wavelength range of 1530-1580 nm with comparable performance to commercial receives.	Papers are available online for download. Visit www.ofcconference.org and click on the Download Digest Papers button.	
W1G.7 • 09:45 **Robust Autonomous Software-Defined Coherent Optical Receiver,** Pierre Isautier[1], Jie Pan[1], Stephen Ralph[1]; [1]*ECE, Georgia Inst. of Technology, USA.* A new robust Stokes space based modulation format recognition scheme using advanced statistical methods is demonstrated for autonomous software-defined coherent optical receiver applications. Experimental 1056km transmission signals are successfully identified among OOK/BPSK/QPSK/16-QAM and decoded with minimum BER at 16 or 32 Gbaud.		**W1I.6 • 09:45** **InP Coherent Receiver Chip with High Performance and Manufacturability for CFP2 Modules,** Selina Farwell[1], Pantelis Aivaliotis[1], Yahong Qian[1], Paul Bromley[1], Roger Griggs[2], Joseph Ng Yew Hoe[2], Colin Smith[2], Stephen Jones[1]; [1]*Oclaro Technology, UK;* [2]*Oclaro Technology, UK.* We report an InP coherent receiver chip with the highest reported responsivity (0.15A/W) together with excellent RF bandwidth (32GHz) and 4x4 MMI width fabrication control (< ±60nm 90% population) providing a highly manufacturable Rx for CFP2 modules		

10:00–12:00 W2A • Poster Session I, *North, Exhibit Hall C (coffee and snacks available)*

10:00–16:00 Exhibition and Show Floor, *South, Exhibit Halls A, B, C and North, Exhibit Hall D*

10:00–13:00 Unopposed Exhibit-Only Time, *South, Exhibit Halls A, B, C and North, Exhibit Hall D (concessions available)*

Show Floor Programming

08:30–09:15
■ **Service Provider Summit**
Keynote: Packet Optical vs. OTN, *Expo Theater I Programming*
For more details, see page 39

09:15–10:45
■ **Service Provider Summit**
Panel I: Packet Optical Convergence, *Expo Theater I Programming*
For more details, see page 39

10:00–12:00
W2A • Poster Session I

W2A.1
100 Gbit/s DP-QPSK Transmission over a 32 km Legacy Multi-Mode GI Fiber Using a Real-Time Digital Coherent Transceiver, Toshihiko Hirooka[1], Masataka Nakazawa[1], Tetsuro Komukai[2], Toshikazu Sakano[2]; *[1]Research Inst. of Electrical Communication, Tohoku Univ., Japan; [2]NTT Network Innovation Laboratories, Japan.* We demonstrate a 100 Gbit/s real-time digital coherent transmission over a 32-km GI-MMF with a 62.5 μm core diameter. The DSP enables the optical channel to be switched from SMF to GIF within 70 ms.

W2A.2
10-Gb/s, 20-km VCSEL Optical Access Link at 1.5 μm with 23-dB Power Budget, Jingjing Zhou[1], Changyuan Yu[1], Hoon Kim[1]; *[1]National Univ. of Singapore, Singapore.* We demonstrate 23-dB power budget of a 20-km unamplified optical access system using a 1.54-μm, 10-Gb/s VCSEL. It is enabled by using continuous-phase frequency-shift keying/amplitude-shift keying format, DC-balanced line coding, and avalanche photo-detector.

W2A.3
20 Gb/s Mode-Group-Division Multiplexing employing Hermite-Gaussian Launches over Worst-Case Multimode Fiber Links, Yunxi Li[1], Jonathan D. Ingham[1], Vojtech Olle[1], George Gordon[1], Richard V. Penty[1], Ian White[1]; *[1]Electrical Engineering, Univ. of Cambridge, UK.* For the first time, mode group division multiplexing is achieved in a multimode fiber link using a 2-D Hermite-Gaussian mode launch. 20 Gb/s error-free transmission is achieved over a 250 m worst-case OM1 multimode fiber link.

W2A.4
A 30 Gb/s full-duplex bi-directional transmission optical wireless-over fiber integration system at W-band, Chanjuan Tang[1], Fan Li[2], Junwen Zhang[1,2], Xinying Li[1], Jiangnan Xiao[1]; *[1]Fudan Univ., China; [2]ZTE Corporation, USA.* we propose and experimentally demonstrate a full-duplex bi-directional transmission optical wireless-over fiber integration system at W-band with the speed up to 15 Gb/s for both 95.4 GHz link and 88.6 GHz link for the first time.

W2A.5
A Data-Aided Amplitude and Phase Equalizer for Direct-Detection Optical OFDM, Chenxi Hao[1], Xuelin Yang[1], Weisheng Hu[1], Chenglin Bai[2]; *[1]State Key Lab of Advanced Optical Communication Systems and Networks, Shanghai Jiao Tong Univ., China; [2]Shandong Key Laboratory of Optical Communication Science and Technology, Liao Cheng Univ., China.* A data-aided equalizer is proposed and demonstrated to compensate the amplitude and phase fluctuations in direct-detection optical OFDM. Significant improvement in error vector magnitude is achieved, using time-domain averaging on amplitude and phase independently.

W2A.6
A Software-Defined Time Synchronization Solution in Transport Networks, Liuyan Han[1], Han Li[1], Lei Wang[1], Nan Hua[2]; *[1]China Mobile Research Inst., China; [2]Department of Electronic Engineering, Tsinghua Univ., China.* We propose the first software-defined time synchronization network solution by introducing programmable synchronization state transition matrix and output matrix. Experimental results show that it could effectively meet the multi-time-domain requirements and enhance flexibility.

W2A.7
All-Optical Tree-based Greedy Router, sahel sahhaf[1], Abhishek Dixit[1], Wouter Tavernier[1], Didier Colle[1], Mario Pickavet[1], Piet Demeester[1]; *[1]Department of Information Technology, Ghent Univ. - iMinds, Belgium.* Forwarding logic in greedy routing systems requires less memory and fewer components than longest-prefix match-based forwarding in IP routing. We demonstrate an all-optical design of a greedy router with desirable scalability and energy-efficiency characteristics enabling high data rate throughput.

W2A.8
Analysis of extended range variable gain hybrid Raman-EDFAs in systems using Nyquist-WDM 100/200G PM-QPSK/16QAM, Wladek Forysiak[1,3], Donald Govan[2], Ian McClean[2], Bimal Nayar[1], Olugbenga Olubodun[3], Nick J. Doran[3]; *[1]Oclaro Technology Ltd, UK; [2]Oclaro Technology Ltd, UK; [3]Aston Univ., UK.* We use the GN-model to assess Nyquist-WDM 100/200Gbit/s PM-QPSK/16QAM signal reach on low loss, large core area single-mode fibre using extended range, variable gain hybrid Raman-EDFAs. 5000/1500km transmission is possible over a wide range of amplifier spans.

W2A.9
Asynchronous MDM-OCDM-based 10G-PON over 40km-SMF and 2km-TMF Using Mode MUX/DeMUX at Remote Node and OLT, Takahiro Kodama[1], Tomoki Isoda[1], Koji Morita[1], Akihiro Maruta[1], Ryo Maruyama[2], Nobuo Kuwaki[2], Shoichiro Matsuo[2], Naoya Wada[3], Gabriella Cincotti[4], Ken-ichi Kitayama[1]; *[1]Department of Electrical, Electronics and Information Engineering, Osaka Univ., Japan; [2]Optics and Electronics Laboratory, Fujikura Ltd, Japan; [3]National Inst. of Information and Communications Technology (NICT), Japan; [4]Department of Applied Electronics, Univ. Roma Tre, Italy.* Asynchronous 2-mode x 4-code x 10Gbps, MDM-OCDM transmission over 42km of a set of SMF and TMF using mode MUX/DeMUX at remote node and OLT is experimentally demonstrated without dispersion compensation.

W2A.10
Broadband Predistortion Circuit Design for Electro-Absorption Modulator in Radio over Fiber System, Xiupu Zhang[1], Ran Zhu[1]; *[1]Electrical and Computer Engineering, Concordia Univ., Canada.* A broadband predistortion circuit is designed to remove 3rd order intermodulation distortion of electro-absorption modulator in radio-over-fiber system, resulting in spurious free dynamic range improvement of ~9 dB from 7 to 14 GHz.

W2A.11
Calculating Availability Bounds in Complex Systems and IP Network Topologies, Jonathan Weston-Dawkes[1]; *[1]The MITRE Corporation, USA.* A bounding algorithm, including resource consolidation, for high-precision estimation of connection availability is derived. Resource mincuts in a sample core IP network are generated to estimate the connection availability under different diversity assumptions.

W2A.12
CapEx Model and Analysis for Metro Networks: DWDM vs. Packet, Ming Xia[1], Stefan Dahlfort[1], Lynn Lu[2], Guangquan Wang[3], Shikui Shen[3]; *[1]Ericsson Research Silicon Valley, USA; [2]Ericsson Region North East Asia, China; [3]China Unicom Design Inst., China.* We propose a computational-efficient CapEx model capturing key cost factors to analyze packet- and DWDM- based metro networks. Study on a real network using market cost figures supports evolution towards DWDM under fast traffic growth.

W2A.13
Channelized Chromatic Dispersion Compensation for XPM Suppression and Simplified Digital SPM Compensation, Liang B. Du[1], Arthur J. Lowery[1]; *[1]Monash Univ., Australia.* Channelize dispersion compensation strongly suppresses inter-channel nonlinearities. We show that it also supports folded digital backpropagation, which can compensate for the intra-channel nonlinearity at a computational cost of only 1.8-times that of CD compensation alone.

W2A.14
Coherent Optical Transmission at 40 and 100 Gbps over 1000 km of DCF-free G.652 and G.655 Fibre Infrastructure, Erwan Pincemin[1], Omid Zia-Chahabi[1], Didier Grot[1], Thierry Guillossou[1]; *[1]France Telecom, France.* We experimentally compare the performances of 40 Gbps DP-BPSK, 40 Gbps DP-QPSK and 100 Gbps DP-QPSK modulation formats over 10x100 km of DCF-free transmission lines using either G.652 or G.655 fibres.

W2A.15
Constellation Expansion and Multi-Symbol Detection for Differentially Encoded 100G Systems, Paolo Leoni[1], Vincent A. Sleiffer[2], Stefano Calabro[3], Berthold Lankl[1]; *[1]Universitaet der Bundeswehr Muenchen, Germany; [2]COBRA Inst., Eindhoven Univ. of Technology, Netherlands; [3]Coriant R&D GmbH, Germany.* We propose an approach to differentially encoded 100G transmission that improves both spectral efficiency and OSNR performance over conventional DQPSK-based systems, demonstrating a practical performance beyond the theoretical limit of the conventional approach.

W2A.16
Cost Tradeoffs in Converged Metro Networks Designs, Enrique Hernandez-Valencia[1]; *[1]Alcatel-Lucent, USA.* The cost structure of converged packet-oriented metro aggregation networks is evaluated. Hierarchical Layer-2/Layer-3 architectures are shown to have better CAPEX structure than Flat networks models but topology and traffic volumes may justify other point solutions.

W2A.17
Cost-Efficient Design of Flexible Optical Networks Implemented by Architecture on Demand, Ajmal Muhammad[1], Georgios S. Zervas[2], Norberto Amaya[2], Dimitra E. Simeonidou[2], Robert Forchheimer[1]; *[1]Linkopings Universitet, Sweden; [2]High-Performance Networks Group, Bristol Univ., UK.* Architecture on demand (AoD) node offers considerable flexibility against traditional ROADMs. The paper presents a cost-efficient network planning strategy that exploits the flexibility inherent in AoD. Results show that AoD can save significantly in node modules through a proper network design.

W2A • Poster Session I—Continued

W2A.18
Delayed Self-homodyne Detection for OFDM-PON Downstream, Qi Yang[1], Rong Hu[1], Tao Gui[2], Zhaohui Li[2], Xi Chen[3], William Shieh[3], Haibo Li[1], Chao Li[1], Cai Li[1], Xiao Xiao[1], Shaohua Yu[1]; *[1]State Key Laboratory of Optical Comm., China; [2]Inst. of Photonics Technology, Jinan Univ., China; [3]Department of Electrical and Electronic Engineering, The Uni. of Melbourne, Australia.* We propose a novel OFDM-PON using the delayed self-homodyne detection technique. A cost/spectrum efficient 10.94-Gb/s downstream transmission is experimentally demonstrated over 20-km SSMF and 1:64 splitter without any optical amplifiers at ONUs.

W2A.19
Demonstration and Network Scalability Analysis of 8-Fiber-Delay-Line SOA-Based Optical Buffer Embedded Optical Packet Switching, Hideaki Furukawa[1], Satoshi Shinada[1], Takaya Miyazawa[1], Takahiro Hirayama[1], Naoya Wada[1], Hiroaki Harai[1]; *[1]National Inst. of Information and Communications Technology, Japan.* We demonstrated an 8-fiber-delay-line optical buffer with SOA switches for forwarding 100Gbit/s IP-packet-encapsulated optical packets. We derived the maximum number of node hops under error-free operation when buffer scale is increased up to 32 FDLs.

W2A.20
Demonstration of OpenFlow-Enabled Traffic and Network Adaptive Transport SDN, Philip N. Ji[1], Tiejun J. Xia[2], Junqiang Hu[1], Ming-Fang Huang[1], Yoshiaki Aono[3], Tsutomu Tajima[3], Glenn A. Wellbrock[2], Ting Wang[1]; *[1]NEC Laboratories America Inc, USA; [2]Verizon, USA; [3]Converged Network Division, NEC Corporation, Japan.* We experimentally demonstrate the first OpenFlow-enabled transport SDN that performs multi-flow switching by cross-layer optimization and configuring all major hardware elements, including adaptive EDFA-Raman amplifier, multi-degree superchannel transponder, and flexible grid switching node.

W2A.21
Demonstration of Real-time 1.2 Tb/s Transmission over 4 Types of Fiber with Nyquist WDM Prototype System, Chengliang Zhang[1], Yufei Chen[2], Runhan Wang[3], Xue Chen[4], Junjie Li[1], Yiran Ma[1], Qi Zhang[2], Hongyan Zhou[3], zheng yan[4], Bailin Shen[2], Qinmin Zhou[3], Dongdong Shang[2], Chao Ge[2]; *[1]Beijing Research Inst., China Telecom Corporation Limited, China; [2]ZTE Corporation, China; [3]State Key Laboratory of Optical Fibre and Cable Manufacture Technology, Yangtze Optical Fibre and Cable Company Ltd, China; [4]State Key Lab of Information Photonics and Optical Communications, Beijing Univ. of Posts and Telecommunications, China.* We demonstrate a 1.2 Tb/s real-time transmission over 4 types of optical fiber with 120G PDM-QPSK Nyquist WDM prototype systems. Performance of different fiber is compared and 3200km transmission is achieved without Raman amplification.

W2A.22
Development of LC Type Optical Visual Connection Identifier (V.C.I) For Multimode Fiber, Kanako Suzuki[1], Yoshihiro Nakatani[1], Seiji Kojima[1], Takahiro Sato[1], Tetsuya Sueoka[2], Takao Nishikawa[2]; *[1]Hitachi Metals,Ltd., Japan; [2]NTT communications Corp, Japan.* We developed the duplex LC type optical visual connection Identifier for multimode fibers to be able to confirm the on/off status of a certain line for decreasing the risk of disconnecting important live lines.

W2A.23
Digital Back-Propagation for High Spectral-Efficiency Terabit/s Superchannels, Gabriele Liga[1]; *[1]UCL, UK.* We assess the effectiveness of digital backpropagation algorithm for a 1.2 Tb/s high spectral efficiency superchannel when the input digital bandwidth is varied around the channel of interest. It is shown that the single channel case gives the best performance.

W2A.24
Digital Orthogonal Filtered Optical OFDM for Elastic PONs, Jianming TANG[1], Mario Bolea[1], Roger Giddings[1]; *[1]Bangor Univ., UK.* To perform software-controlled, bandwidth-variable and analogue-hardware-free channel add/drop networking functions, optical OFDM employing DSP-based orthogonal filters is proposed, optimized and evaluated, for the first time, which overcomes all fundamental limitations associated with conventional CAP modulation.

W2A.25
Dowstream and Upstream Nyquist Band Optimization for Heterodyne Coherent PON, Jacklyn D. Reis[1,2], Ali Shahpari[1], Ricardo M. Ferreira[1], Darlene M. Neves[1], Mário Lima[1], Antonio L. Teixeira[1,3]; *[1]Department of Electronics, Telecommunications and Informatics, Univ. of Aveiro, Instituto De Telecomunicações, Portugal; [2]CPqD Foundation, Brazil; [3]Coriant, Portugal.* This work presents a Multi-objective Genetic Algorithm for optimizing upstream and downstream Nyquist bands in coherent PON with self-heterodyne detection. Both power and frequency offset coefficients are found for symmetric Nyquist shaped 10 Gb/s per user.

W2A.26
Dual-wavelength Clock Recovery with Simultaneous Fourfold Demultiplexing Using an Optoelectronic Oscillator, Qiang Wang[1], Li Huo[1], Yanfei Xing[1], Dong Wang[1], Xin Chen[1], Caiyun Lou[1], Bingkun Zhou[1]; *[1]Tsinghua Univ., China.* Dual-wavelength Gaussian-like optical clock recovery with simultaneous error-free fourfold demultiplexing of a 100-Gb/s OTDM-DPSK signal are demonstrated with an improved optoelectronic oscillator. Frequency-doubled clock recovery is also achieved.

W2A.27
Energy and Spectrum Efficiency with Multi-Flow Transponders and Elastic Regenerators in Survivable Flexible Bandwidth Virtual Optical Networks, Bowen Chen[1,2], Weisheng Xie[2], Jie Zhang[1], Jason P. Jue[2], Yongli Zhao[1], Shanguo Huang[1], Wanyi Gu[1]; *[1]State Key Laboratory of Information Photonics and Optical Communications, Beijing Univ of Posts & Telecom, China; [2]Erik Jonsson School of Engineering and Computer Science, The Univ. of Texas at Dallas, USA.* Survivable energy-aware and spectrum-aware approaches (SEA/SSA) are developed to minimize energy and spectrum consumption in flexible bandwidth virtual optical networks. Simulation results show that SEA and SSA can efficiently reduce energy and spectrum consumption, respectively.

W2A.28
Experimental Demonstration of a Cognitive Optical Network for Reduction of Restoration Time, Christoforos Kachris[1], Dimitris Klonidis[1], Antonio Francescon[2], Domenico Siracusa[2], Elio Salvadori[2], Ramón J. Durán Barroso[3], Ignacio de Miguel[3], Robert Borkowski[4], Antonio Caballero[4], Idelfonso Tafur[4], Yabin Ye[6], Andrzej Tymecki[5], Ioannis Tomkos[1]; *[1]Athens Information Technology, Greece; [2]CREATE-NET, Italy; [3]Univ. of Valladolid, Spain; [4]Technical Univ. of Denmark, Denmark; [5]Orange Polska, Poland; [6]Huawei Technologies, Germany.* This paper presents the implementation and performance evaluation of a cognitive heterogeneous optical network testbed. The testbed integrates the CMP, the data plane and the cognitive system and reduces by 48% the link restoration time.

W2A.29
Experimental Demonstration of Reconfigurable Long-Reach UltraFlow Access: Software-Defined Dual-Mode Networks, Thomas Shun Rong Shen[1], Shuang Yin[1], Ahmad R. Dhaini[1], Leonid G. Kazovsky[1]; *[1]Stanford Univ., USA.* We propose and experimentally demonstrate a novel reconfigurable long-reach software-defined UltraFlow access network that provides flexible, robust and energy efficient optical Flow switched and legacy IP services to end-users located in wide areas.

W2A.30
Experimental Demonstration of Robustness and Accuracy of an MZI-based OSNR Monitor under Transmitter Drift and Reconfigurable Networking Conditions for Pol-Muxed 25-Gbaud QPSK and 16-QAM Channels, ahmed almaiman[1], Mohammad Reza Chitgarha[1], Wajih Daab[1], Morteza Ziyadi[1], Amirhossein Mohajerin Ariaei[1], Salman Khaleghi[1], Moshe Willner[1], Vijay Vusirikala[2], Wendy Zhao[2], Dan Kilper[3], Loukas Paraschis[4], Atiyah Ahsan[5], Michael Wang[5], Keren Bergman[5], Moshe Tur[6], Joe Touch[7], Alan Willner[1]; *[1]Ming Hsieh Department of Electrical Engineering, Univ. of Southern California, USA; [2]Google Inc., USA; [3]College of Optical Sciences, Univ. of Arizona, USA; [4]Cisco Systems, Inc., USA; [5]Department of Electrical Engineering, Columbia Univ., USA; [6]Tel Aviv Univ., Israel; [7]Information Sciences Inst., Univ. of Southern California, USA.* We experimentally demonstrate the robustness of an MZI-based OSNR monitor under reconfigurable network and transmitter drift. The monitor calibration factors for 25 Gbaud PM-QPSK signal are stored after assembly and applied to study the accuracy of the OSNR monitoring unit when different changing scenarios outside the monitor occurred

11:00–12:00
OIF Physical and Link Layer Session "56 Gbps Serial — Why, What, When?, *Expo Theater III Programming*
For more details, see page 44

11:00–12:30
■ **Service Provider Summit**
Panel II: Network Evolution, *Expo Theater I Programming*
For more details, see page 40

W2A • Poster Session I—Continued

W2A.31
Exploiting Degraded-Service Tolerance to Improve Performance of Telecom Networks, S. Sedef Savas[1], M. Farhan Habib[1], Massimo Tornatore[2,1], Biswanath Mukherjee[1]; *[1]Department of Computer Science, Univ. of California, Davis, USA; [2]Dipartimento di Elettronica Informazione e Bioingegneria, Politecnico di Milano, Italy.* Degraded-service-tolerant connections can operate with reduced bandwidth under failure conditions. We propose a provisioning scheme that accepts degraded services not only during failures but also during admission process to increase service acceptance and/or availability.

W2A.32
FEC Overhead and Fiber Nonlinearity Mitigation: Performance and Power Consumption Tradeoffs, Danish Rafique[1], Talha Rahman[1], Antonio Napoli[1], Bernhard Spinnler[1], Stefano Calabro[1]; *[1]Research and Technology, Coriant GmbH, Germany.* Increasing the FEC overhead necessitates substantial power-consumption requirements, alternatively, super-channel nonlinear mitigation ensures 30% reduced power-consumption, for a fixed distance at a lower overhead, and up to 35% improved reach, at a fixed FEC overhead.

W2A.33
Fiber-nonlinearity Limitation of Transmission Distances in Ultra-dense Gridless Photonic Networks, Yojiro Mori[1], Hiroshi Hasegawa[1], Ken-ichi Sato[1]; *[1]Department of Electrical Engineering and Computer Science, Nagoya Univ., Japan.* We investigate the maximum transmission distance of the multilevel-modulation formats for ultra-dense gridless photonic networks based on distance-adaptive modulation. Simulation results show the relationships among the transmission distance, the guard band, and the optical-filter design.

W2A.34
First demonstration of a wavelength swept discovery process for λ-tunable WDM/TDM-PON system, Masahiro Sarashina[1], Hideaki Tamai[1], Satoshi Furusawa[1], Akiya Suzuki[1], Masayuki Kashima[1], Toshiaki Mukojima[1], Shin Kaneko[2], Tomoaki Yoshida[2], Shunji Kimura[2], Naoto Yoshimoto[2]; *[1]Oki Electric Industry Co., Ltd., Japan; [2]NTT Access Network Service Systems Laboratories, NTT Corporation, Japan.* We proposed a wavelength swept discovery process for λ-tunable WDM/TDM-PON system. Our discovery process is successfully demonstrated on the λ-tunable WDM/TDM-PON prototype. We also confirmed that the ONU can receive the discovery message at any wavelength.

W2A.35
Global ROADM-Based Spectrum Equalizer in SDN Architecture for QoT Optimization at DWDM Networks, Eduardo C. Magalhães[1,2], Juliano Oliveira[1], Heitor Carvalho[1], Matheus Magalhães[1], Miquel Garrich Alabarce[1], Marcos Siqueira[1], Aldário Bordonalli[2], Julio Oliveira[1]; *[1]GSO - Optical Communication Division, CPqD, Brazil; [2]DMO - Department of Microwave and Optics, Unicamp, Brazil.* We introduce a global (end-to-end) ROADM-based spectrum equalizer algorithm running over DWDM networks on SDN architecture. Significant OSNR improvements are experimentally demonstrated for a DWDM coherent 80x112Gb/s system compared with local equalization schemes.

W2A.36
High degree optical cross-connect based on multicast switch, Thierry Zami[1]; *[1]Alcatel-Lucent, France.* 8x16 multicast switches enable contention-less WDM Optical Cross-Connect (OXC) as long as the node connectivity is smaller than 8. This study examines to what extent they can also suit 20-degree OXC featuring low intra-node contention.

W2A.37
High Linearity Downconverting Analog Photonic Link Based on Digital Signal Post-Compensation, NIU ZHENG[1], Hongchen Yu[1], Minghua Chen[1], Pengxiao Li[1], Hongwei Chen[1], Shizhong Xie[1]; *[1]TSINGHUA UNIV., China.* A downconverting analog photonic link based on DP-QPSK MZM is proposed. The nonlinear distortions components are significantly suppressed using DSP-based post-compensation method. Finally, an SFDR of 123.3 dB-Hz2/3 is achieved, which is improved by 21.5dB.

W2A.38
Improvement of Continuous-variable Quantum Key Distribution System by Using a Practical Noiseless Linear Amplifier, Yi-Chen Zhang[1], Song Yu[1], Wanyi Gu[1]; *[1]Beijing Univ. of Posts and Telecommunications, China.* We propose a practical modified continuous-variable quantum key distribution system to improve the secret key rate over long transmission distance by inserting a practical noiseless linear amplifier at the output of quantum channel.

W2A.39
Improving the Robustness to Timing Errors with Windowing Technique for 40GHz 64-QAM OFDM-RoF System, Fan Li[1,2], Junwen Zhang[1,4], Lin Chen[2], Xinying Li[4], Jiangnan Xiao[4], Gee-Kung Chang[3]; *[1]ZTE (TX) Inc, USA; [2]Hunan Univ., China; [3]Georgia Inst. of Technology, USA; [4]Fudan Univ., China.* this paper, 40GHz OFDM-RoF system with an I/Q modulator is demonstrated. The experimental results show that 18.8-Gb/s 64-QAM-OFDM signal carried by 38-GHz mm-wave after fiber-wireless link is immune to the timing errors with windowing technique.

W2A.40
Investigation on Burst-mode Interchannel Crosstalk in XG-PON and TWDM-PON, Han Hyub Lee[1], Hee Yeal Rhy[2], Gwang Yong Yi[2], Jong Hyun Lee[1], Sang Soo Lee[1]; *[1]Electronics and Telecommunications Research Inst., Republic of Korea; [2]Ericsson-LG, Republic of Korea.* Inter-channel crosstalk of burst-mode upstream in XG-PON and TWDM-PON are investigated. Differential optical path loss and ASE noise from 256 ONUs contribute to increasing power penalty. ASE noise filtering mitigates the impairment and ensures negligible penalty.

W2A.41
Jitter impact on mobile fronthaul links, Thierno Diallo[1,2], Anna Pizzinat[1], Philippe Chanclou[1], Fabienne Saliou[1], Fabrice Deletre[1], Christelle Aupetit-Berthelemot[2]; *[1]Orange Labs Networks, France; [2]Laboratoire XLIM, France.* An innovative setup for thorough jitter characterization in fronthaul links is introduced. Tests have been carried out on an operating LTE fronthaul link measuring jitter impact on BER, EVM and frequency deviation.

W2A.42
Long Reach UDWDM PON with SCM-QPSK Modulation and Direct Detection, Prince M. Anandarajah[1], Rui Zhou[1], Vidak Vujicic[1], Deseada Gutierrez Pascual[2,1], Eamonn Martin[1], Liam P. Barry[1]; *[1]Dublin City Univ., Ireland; [2]Pilot Photonics, Ireland.* We demonstrate a 100km un-repeated downstream transmission based on a 12.5GHz wavelength tunable comb source with 1.25GBd SSB-SCM-QPSK data. The pilot tone enables direct detection and phase noise independence with error free performance at -20dBm.

W2A.43
Optical CoMP Transmission in Millimeter-Wave Small Cells for Mobile Fronthaul, Lin Cheng[1], Cheng Liu[1], Ming Zhu[1], Jing Wang[1], Gee-Kung Chang[1]; *[1]Georgia Inst. of Technology, USA.* We propose and experimentally demonstrate a prototype of local centralized optical coordinated multipoint (CoMP) that targets beamforming applications in future-proof millimeter-wave small cells based on radio-over-fiber fronthauls.

W2A.44
Optical FlowBroker: Load-Balancing in Software-Defined Multi-Domain Optical Networks, Dan Marconett[1], Lei Liu[1], S.J.Ben Yoo[1]; *[1]UC Davis, USA.* We present a new OpenFlow control architecture, referred to as Optical FlowBroker, for multi-domain software-defined optical networks. The hierarchical brokers improve scalability and inter-domain global coordination, while allowing domain controllers to manage intra-domain forwarding decisions.

W2A.45
Optical Multiplexing of Asynchronous OOK and DQPSK Signals in PPLN Waveguide, Antonio Malacarne[1], Sergio Pinna[2], Antonella Bogoni[1]; *[1]National Laboratory of Photonic Networks, CNIT, Italy; [2]TeCIP, Scuola Superiore Sant'Anna, Italy.* A scheme for aggregating asynchronous OOK and DQPSK optical data flows by generating an 8-APSK signal at the original DQPSK signal wavelength, is demonstrated. The scheme is based on second-order nonlinear interaction in PPLN waveguide.

W2A.46
Optimization Design for Multi-Domain Optical Network Protection, Kaile Liang[1], Hao Bai[2], Mahshid Rahnamay-Naeini[3], Feng Xu[3], Marwan Batayneh[4], Majeed Hayat[1], Nasir Ghani[2]; *[1]ECE, UNM, USA; [2]Home, USA; [3]Cisco Systems, USA; [4]ViaSat, USA.* This paper develops a novel hierarchical optimization model for lightpath protection in multi-domain optical networks pursuant to several objectives. The proposed formulation is then solved and its results compared with some advanced distributed heuristic protection strategies.

W2A.47
Optimized Design of Fixed/Flex-Rate Line-Cards and Transceivers over Multiple Planning Cycles, António Eira[1,2], João Pedro[1,2], João Pires[2]; *[1]Coriant Portugal, Portugal; [2]Instituto de Telecomunicações, Portugal.* We present a comparison between line-card and transceiver designs based on single and multi-rate technology over multiple planning cycles. The analysis suggests multi-rate hardware is most suited to networks without significant regeneration requirements.

W2A.48
Performance Analysis of GA, ROA, and TSA for Solving the Max-RWA Problem in Optical Networks, Kharroubi Fouad[1], Jing He[1], Lin Chen[1]; *[1]School of Information Science and Engineering Hunan Univ., China.* In this paper the Max-RWA problem was mathematically formulated and solved approximately by three efficient random search algorithms namely Random Optimization Algorithm (ROA), Genetic Algorithm (GA) and Tabu Search Algorithm (TSA). The routing subproblem was insured exactly by the backtracking algorithm.

W2A • Poster Session I—Continued

W2A.49
Performance Dependence of Single-Carrier Digital Back-Propagation on Fiber Types and Data Rates, Antonio Napoli[1], Danish Rafique[1], Marc Bohn[1], Maxim Kuschnerov[1], Bernhard Spinnler[1], Markus Noelle[2]; *[1]R&D, Corianr GmbH, Germany; [2]Heinrich Hertz Inst., Fraunhofer Inst. for Telecommunications, Germany.* We extensively compare the performance of single channel digital back-propagation applied to different modulation formats and data-rates when different fiber types are considered.

W2A.50
Performance Evaluations of Large-Scale OXC that Achieves Modular and Hitless Expansion, Yasuhiro Tanaka[1], Hiroshi Hasegawa[1], Ken-ichi Sato[1]; *[1]Nagoya Univ., Japan.* We investigate the long-term, cost-effective and hitless expansion capabilities of a proposed OXC that can adapt to network traffic increases. The OXC offers substantial cost savings compared to the conventional OXC during scale expansion.

W2A.51
Photonic Architecture for Beam Forming of RF Phased Array Antenna, Shigeyuki Akiba[1], Masayuki Oishi[1], Jiro Hirokawa[2], Makoto Ando[2], Kyo Minoguchi[2], Yoshihiro Nishikawa[2]; *[1]KDDI R&D Laboratories Inc., Japan; [2]Electrical and Electronic Engineering, Tokyo Inst. of Technology, Japan.* System architecture utilizing photonic technology for beam forming of RF phased array antenna is studied. RSOA solution for uplink signal transmission and multi-core fiber approach for two dimensional phased array antenna are demonstrated.

W2A.52
Polarization-Insensitive Phase-trans-multiplexing of CSRZ-OOK and RZ-BPSK to RZ-QPSK via XPM in a PCF, Brice M. Cannon[1,2], Tanvir Mahmood[1,2], William Astar[1,2], Paul Boudra[1], Tinoosh Mohsenin[1], Gary M. Carter[1,2]; *[1]Univ. of Maryland Baltimore County, USA; [2]Laboratory for Physical Sciences, USA.* By utilizing cross-phase modulation, we demonstrated polarization-insensitive phase-transmultiplexing to RZ-QPSK in a photonic crystal fiber. The measured receiver sensitivity penalty at 10^{-9} BER was ≈1.8 dB for a randomly polarized CSRZ-OOK signal.

W2A.53
Power-Aware Multi-Layer Translucent Network Design: an Integrated OPEX/CAPEX Analysis, Silvia Saldaña Cercós[1], Leandro Resendo[2], Moisés R. Ribeiro[3], Anna Manolova Fagertun[1], Idelfonso Tafur[1]; *[1]Danmarks Tekniske Universitet, Denmark; [2]Department of System Information at the Federal Inst. of Technology of Espírito Santo, Brazil; [3]LABTEL-Electrical Engineering Department, Brazil.* We propose a three-phase network design model minimizing CAPEX and OPEX in IP-over-WDM architectures. By forbidding reconfiguration (accounting for 58\% of the OPEX) we achieve only 4.2\% increase in power consumption at no CAPEX expenses.

W2A.54
Proper selection for Modulation Randomness of Training Sequence for Efficient Optical DMT Transmission, Hao Chen[1], Lei Li[1], Weizhen Yan[1], Bo Liu[1], Zhenning Tao[1], Tomoo Takahara[2], Jens Rasmussen[2], Drenski Tomislav[3]; *[1]FRDC, China; [2]Fujitsu Laboratories Ltd., Japan; [3]Fujitsu Semiconductor Europe GmbH, Germany.* The randomness of bit sequence on probing and interfering sub-carrier shows different impact on performance. An efficient DMT probing method with very short training sequence and simple sequence synchronization is proposed for 107Gbps optical transmission.

W2A.55
Quantifying the Impact of Non-linear Impairments on Blocking Load in Elastic Optical Networks, David J. Ives[1], Andrew Lord[2], Paul Wright[2], Seb J. Savory[1]; *[1]Department of Electronic and Electrical Engineering, Univ. College London, UK; [2]British Telecom, UK.* We quantify the effect of transmitter power on the blocking load of an elastic optical network utilizing SNR adapted modulation formats. A fair channel assignment policy is shown to give the best blocking performance.

W2A.56
Reducing Nonlinear Distortion in Optical Phase Conjugation using a Midway Phase-Shifting Filter, Mohammad M. Morshed[1,2], Arthur J. Lowery[1,2], Liang B. Du[1,2]; *[1]Center for Ultrahigh bandwidth Devices for Optical Systems (CUDOS), Monash Univ., Australia; [2]Electrical and Computer Systems Engineering, Monash Univ., Australia.* The performance of optical phase conjugation (OPC) is improved by splitting the nonlinear element and inserting a phase-shifting filter. The maximum signal quality increases by 1.2 dB for 800-km 4-QAM 224-Gb/s CO-OFDM.

W2A.57
Smooth Quick-in and Fade-out Operations-enabled Emergency Optical Networks for Disaster Recovery, Sugang Xu[1], Masaki Shiraiwa[1], Noboru Yoshikane[2], Takehiro Tsuritani[2], Hiroaki Harai[1], Yoshinari Awaji[1], Naoya Wada[1]; *[1]Photonic Network Research Inst., National Inst. of Information and Communications Technology (NICT), Japan; [2]KDDI R&D Laboratories Inc., Japan.* We demonstrate a three-stage transition scenario of emergency optical networks in disaster recovery. The proposal enables cost-efficient quick-coupling of surviving resources from different networks to build emergency optical networks and smooth network-decoupling after recovery.

W2A.58
Spectrum Allocation for Time-varying Traffic in Elastic Optical Networks using Traffic Pattern, Sunny Shakya[1], Xiaojun Cao[1], Zilong Ye[2], Chunming Qiao[2]; *[1]Department of Computer Science, Georgia State Univ., USA; [2]Department of Computer Science and Engineering, SUNY-Buffalo, USA.* We propose sub-carrier allocation algorithms for time-varying traffic in Elastic Optical Networks using similar patterns of Internet traffic. These algorithms achieve lower blocking probability and minimize number of disruptions to the live connections.

W2A.59
Static Routing and Spectrum Assignment in Co-existing Fixed/Flex Grid Optical Networks, Xiaosong Yu[1,2], Yongli Zhao[1], Jie Zhang[1], Biswanath Mukherjee[2], Jiawei Zhang[1,2], Xinbo Wang[2]; *[1]Beijing Univ of Posts & Telecom, China; [2]Univ. of California, Davis, USA.* We consider the static routing and spectrum assignment (RSA) in co-existing fixed/flex grid optical networks. Integer Linear Programming (ILP) formulations are presented to minimize the utilized spectrum, and several heuristic algorithms are proposed and simulated.

W2A.60
A Novel Chip-multiprocessor Architecture with Optically Interconnected Shared L1 Optical Cache Memory, Pavlos Maniotis[1,2], Savvas Gitzenis[2,3], Leandros Tassiulas[2,3], Nikos Pleros[1,2]; *[1]Department of Informatics, Aristotle Univ. of Thessaloniki, Greece; [2]Information Technologies Inst., Center for Research and Technology Hellas, Greece; [3]Department of Electrical and Computer Engineering, Univ. of Thessaly, Greece.* We demonstrate a system-level CMP architecture where optical cache memories are shared among multiple processing cores through optical buses. System-level simulations show 25-45% execution time improvement and significant capacity requirements reduction through simpler memory hierarchy.

W2A.61
Symmetric 100-Gb/s TWDM-PON with DSB OFDM Modulation, Yuanbao Luo[1], Bangjiang Lin[1], Hui Yang[1], Juhao Li[1], Yongqi He[1], Zhangyuan Chen[1], Zhengbin Li[1]; *[1]Peking Univ., China.* We propose a 100-Gb/s TWDM-OFDM-PON architecture using four pairs of wavelengths. 4×25-Gb/s symmetric TWDM-OFDM-PON is experimentally demonstrated over 26.7 km fiber using 64-QAM mapping.

W2A.62
Time varying ISI model for nonlinear interference noise, Ronen Dar[1], Meir Feder[1], Antonio Mecozzi[2], Mark Shtaif[1]; *[1]Tel-Aviv Univ., Israel; [2]Univ. of L'Aquila, Italy.* We show that the effect of inter-channel nonlinear interference is equivalent to slowly varying inter-symbol-interference (ISI). We characterize the ISI coefficients for systems using distributed amplification and discuss the possibility for nonlinear noise cancelation.

W2A.63
Toward 20 Gbps upstream FDMA-PON real-time and low-speed DSP demonstrator, Stefano Straullu[1], Antonino Nespola[1], Paolo Savio[1], Silvio Abrate[1], Roberto Gaudino[2], Valter Ferrero[2], Joana Chang[2], Benoit Charbonnier[3]; *[1]ISMB, Italy; [2]Dipartimento di Elettronica e Telecomunicazioni, Politecnico di Torino, Italy; [3]Orange Labs, France Telecom, France.* We experimentally demonstrate a FDMA-PON system targeting 20 Gbps per wavelength in the upstream, using a real-time FPGA-based transmitter and low-speed baseband DSP, in the framework of the EU research project FABULOUS.

W2A.64
Ultra-compact Contentionless ROADM Architecture with High Resilience Based on Flexible Wavelength Router, Liangjia Zong[1], Gordon Ning Liu[1], Han Zhao[1], Teng Ma[1], Andrew Lord[2]; *[1]Huawei Technologies Co., Ltd, China; [2]BT Innovate and Design, UK.* We present a novel CDC-ROADM architecture based on flexible wavelength router which consists of two N×N WSSs. The proposed architecture is compact, low cost and provides a fully 1+1 redundant solution with high resilience.

W2A.65
Ultra-Fast All-Optical Self-Aware Protection Switching Based on a Bistable Laser Diode, Yi An[1], Dragana Vukovic[1], Abel Lorences Riesgo[1], Geert Morthier[2], Christophe Peucheret[1,3]; *[1]Department of Photonics Engineering, Technical Univ. of Denmark, Denmark; [2]Department of Information Technology, Ghent Univ., Belgium; [3]FOTON Laboratory - CNRS UMR 6082, France.* We propose a novel concept of all-optical protection switching with link failure automatic awareness based on AOWFF. The scheme is experimentally demonstrated using a single MG-Y laser diode with a record switching time ~200 ps.

Show Floor Programming

11:00–12:00
OIF Physical and Link Layer Session "56 Gbps Serial — Why, What, When?, *Expo Theater III Programming*
For more details, see page 44

11:00–12:30
■ **Service Provider Summit**
Panel II: Network Evolution, *Expo Theater I Programming*
For more details, see page 40

Room 102

13:00–15:00
W3A • Flex
Presider: Darli Mello; Universidade de Brasilia, Brazil

W3A.1 • 13:00 **Invited**
Complexity and Flexible Grid Networks, Massimo Tornatore[1], Cristina Rottondi[1], Annalisa Morea[2], Giuseppe Rizzelli[3]; *[1]Department of Electronics, Information and Bioengineering, Politecnico di Milano, Italy; [2]Alcatel-Lucent Bell Labs, France; [3]Network Rail Telecom, UK.* For the optimization of routing and spectrum allocation in a FlexiGrid Networks, we explore the tradeoff between network cost and problem complexity according to the following aspects: traffic grooming, regeneration, modulation/baud-rate assignment.

Room 120

13:00–15:00
W3B • Novel Network Elements
Presider: Chris Fludger; Cisco Optical GmbH, Germany

W3B.1 • 13:00
Crosstalk Analysis of FSK Light Label on 112 Gbps DP-QPSK Signal in CNCG ROADM Network, Goji Nakagawa[1], Shoichiro Oda[1], Kyosuke Sone[1], Yasuhiko Aoki[1], Kazuo Hironishi[1], Takahito Tanimura[1], Takeshi Hoshida[2], Jens Rasmussen[1]; *[1]Fujitsu Laboratories Limited, Japan; [2]Fujitsu Limited, Japan.* We investigated crosstalk of FSK supervisory channel superimposed on a 112 Gbps DP-QPSK caused by pass-band narrowing effect in CNCG ROADM network. We estimated maximum number of ROADM nodes and frequency misalignment tolerance between main signal and center frequency of WSS pass-band that the FSK light label technique could support.

W3B.2 • 13:15
Performance Comparison of Different 8QAM Constellations for the Use in Flexible Optical Networks, Markus Noelle[1], Felix Frey[1], Robert Elschner[1], Carsten Schmidt-Langhorst[1], Antonio Napoli[2], Colja Schubert[1]; *[1]Photonic Networks and Systems, FhG-HHI, Germany; [2]Coriant R&D GmbH, Germany.* We investigate the influence of DAC resolution and pulse shaping on the system performance of different 8QAM constellations. Furthermore, we experimentally show that a circular constellation outperforms the commonly used 8QAM constellation by 0.7 dB in terms of OSNR sensitivity at a BER of 3.8*10-3.

Room 121

13:00–15:00
W3C • Panel: How Can residential Broadband Networks Support the Small Cell Backhaul of the Future?

Organizer: Ed Harstead, *Alcatel Lucent, USA*

Small cells are the most likely backhaul application for residential broadband technologies. What are the backhaul requirements on the residential network, including bandwidth, latency, and cost? How likely, and what are the use cases if any, for residential broadband networks to need to support CPRI front haul for small cells?

Speakers:

Michael Peeters, *Alcatel-Lucent, Belgium*

Mike Bencheck, *Verizon, USA*

Demetrios Stamatelakis, *Telus, Canada*

Room 122

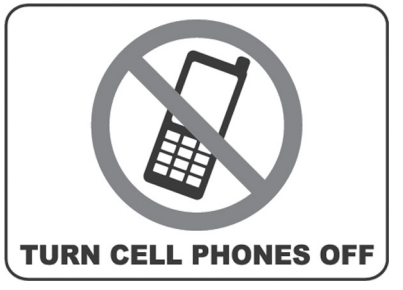
13:00–15:00
W3D • Fiber Measurements and Characterization
Presider: Alexey Turukhin; TE Subcom, USA

W3D.1 • 13:00 **Invited**
New OTDR Measurement and Monitoring Techniques, Andre CHAMPAVERE[1]; *[1]R&D, JDSU, France.* Since its first introduction three decades ago, optical-time-division reflectometry has become an indispensable tool to characterize fiber optic links in long-distance and local-area networks. We review the evolution of this technology and discuss emerging applications.

Room 123

13:00–14:30
W3E • Fiber Amplifiers: Design and Characterization
Presider: Lutz Rapp; Coriant, Germany

W3E.1 • 13:00 **Invited**
Modeling Raman amplification in multimode and multicore fibers, Cristian Antonelli[1], Antonio Mecozzi[1], Mark Shtaif[2]; *[1]Universita degli Studi dell'Aquila, Italy; [2]Tel Aviv Univ., Israel.* We present the theory of Raman amplification in multi-mode fiber structures in the framework of space-division multiplexed transmission. Random linear coupling between the various fiber modes plays a critical role in the process of amplification by equalizing the Raman gain within quasi-degenerate mode groups.



Room 124

13:00–15:00
W3F • Signal Processing I (Regeneration)
Presider: Marco Presi; Scuola Superiore di Studi Universitarie di Perfezionamento Sant' Anna di Pisa, Italy

W3F.1 • 13:00
Clock Recovery of Phase Modulated Optical OFDM Superchannel, Mark Power[1,2], Wei Jia[1,3], Roderick P. Webb[1,3], Robert J. Manning[1,3], Fatima C. Garcia Gunning[1,3]; *[1]Photonic Systems Group, Tyndall National Inst., UCC, Ireland; [2]Department of Electrical and Electronic Engineering, Univ. College Cork, Ireland; [3]Department of Physics, Univ. College Cork, Ireland.* We report a novel all-optical clock recovery technique for a BPSK OFDM superchannel. Four-wave mixing in SOAs strips the modulation from the superchannel sub-carriers, two of which beat in a photodiode to recover the clock.

W3F.2 • 13:15
Ultrafast All-Optical Clock Recovery Based on Phase-Only Linear Optical Filtering, Reza Maram[1], Deming Kong[2], Michael Galili[2], Leif Katsuo Oxenløwe[2], José Azaña[1]; *[1]INRS-Energie Materiaux et Telecom, Canada; [2]Department of Photonics Engineering, Technical Univ. of Denmark, Denmark.* We report on a novel technique for all-optical clock recovery from RZ OOK data based on phase-only filtering, significantly enhancing the recovered clock quality and energy-efficiency compared to the use of a Fabry-Perot filter.

Room 125

13:00–15:00
W3G • WDM Access
Presider: Chang-Hee Lee; Korea Advanced Inst of Science & Tech, Korea, Republic of

W3G.1 • 13:00
C and L band Self-seeded WDM-PON Links using Injection-locked Fabry-Pérot Lasers and Modulation Averaging, Tin Komljenovic[1], Dubravko Babic[1], Zvonimir Sipus[1]; [1]*Faculty of Electrical Engineering and Computing, Univ. of Zagreb, Croatia.* Self-seeded colorless WDM-PON optical links employing modulation averaging are demonstrated using commercially available matched Fabry-Pérot laser and receiver pairs in C and L bands over 60 km at 1.25 GBaud line rate.

W3G.2 • 13:15
First Demonstration of a Full C-Band Tunable WDM-PON System with Novel High-Temperature DS-DBR Lasers, Stephan Pachnicke[1], Jiannan Zhu[2], Mirko Lawin[1], Adrian Wonfor[2], Michael H. Eiselt[1], Richard V. Penty[2], Rosie Cush[3], Richard Turner[3], Paul Firth[3], Mike Wale[3], Ian White[2], Jorg P. Elbers[4]; [1]*ADVA Optical Networking AG, Germany;* [2]*Centre for Photonic Systems, Univ. of Cambridge, UK;* [3]*Oclaro Technology Ltd., UK;* [4]*ADVA Optical Networking SE, Germany.* We demonstrate automatic operation of a cooler-less tunable-laser based WDM-PON system. Using a pilot-tone based overhead channel and centralized wavelength locking scheme, 1 Gb/s and 10 Gb/s data transmission is demonstrated in a multi-user set-up.

Room 130

13:00–15:00
W3H • Network Virtualization
Presider: Martin Birk; AT&T Labs, USA

W3H.1 • 13:00
Advanced Modulation Formats in Cognitive Optical Networks: EU project CHRON Demonstration, Robert Borkowski[1], Antonio Caballero[1], Dimitris Klonidis[2], Christoforos Kachris[2], Antonio Francescon[3], Ignacio de Miguel[4], Ramón J. Durán Barroso[4], Darko Zibar[1], Ioannis Tomkos[2], Idelfonso Tafur[1]; [1]*Department of Photonics Engineering, Technical Univ. of Denmark, Denmark;* [2]*Athens Information Technology, Greece;* [3]*CREATE-NET, Italy;* [4]*Universidad de Valladolid, Spain.* We demonstrate real-time path establishment and switching of coherent modulation formats (QPSK, 16QAM) within an optical network driven by cognitive algorithms. Cognition aims at autonomous configuration optimization to satisfy quality of transmission requirements.

W3H.2 • 13:15 **Tutorial**
Network Function Virtualization - Beyond Carrier-grade Clouds, Diego Lopez[1]; [1]*Telefonica, Spain.* This tutorial will introduce the most salient features of the NFV concept, its current development, and the way in which its proponents believe network services are going to change because of NFV.

Dr Diego Lopez is responsible for Technology Exploration within the TPI/GCTO Unit in Telefonica I+D. Diego

Continued on page 107

Room 131

13:00–15:00
W3I • Symposium on Advanced Electro-optic Packaging and Assembly Technologies I and Panel Discussion
Presider: Nicholas Ilyadis; Broadcom, USA

W3I.1 • 13:00 **Invited**
500Gb/s and Beyond PIC-Module Transmitters and Receivers, Fred Kish[1]; [1]*Infinera Corporation, USA.* 500-Gb/s transmitter and receiver photonic integrated circuit (PIC) modules are reviewed as well as their scaling to Tb/s and higher data capacities.

Room 132

13:00–14:45
W3J • Coded Modulation II
Presider: Milorad Cvijetic; Univ. of Arizona, USA

W3J.1 • 13:00
Pilot-aided Log-likelihood Ratio for LDPC coded M-QAM CO-OFDM System, shengjiao cao[1], Pooi-Yuen Kam[1], Changyuan Yu[1,2]; [1]*Electrical and Computer Engineering, National Univ. of Singapore, Singapore;* [2]*A*STAR Inst. for Infocomm Research (I2R), Singapore.* Pilot-aided log-likelihood ratio as well as its approximation are derived for LDPC coded M-QAM CO-OFDM system with consideration of laser phase noise. Our metric performs better than the conventional metric in 16QAM and 64QAM simulation.

W3J.2 • 13:15
20x224Gbps (56Gbaud) PDM-QPSK Transmission in 50GHz grid over 3040km G.652 fiber and EDFA only link Using Soft Output Faster than Nyquist Technology, Liangchuan Li[1], Yanzhao Lu[1], Ling Liu[1], Deyuan Chang[1], Zhiyu Xiao[1], Yijia Wei[1]; [1]*Huawei Technologies Co., Ltd., China.* We report 20x224Gbps PDM-QPSK in 50GHz grid over G.652 fiber and EDFA-only link. Using Soft Output Faster than Nyquist and 7% SDFEC, 4bit/s/Hz net spectral efficiency transmission over 3040km with 21dB span loss is achieved.

Room 133

13:00–15:00
W3K • DSP Hardware
Presider: Chris Fludger; Cisco Optical GmbH, Germany

W3K.1 • 13:00 **Invited**
High-speed ASIC for Optical Communications, Jon Stanley[1]; [1]*Fujitsu Semiconductor Europe GmbH, UK.* Delivering continuous high performance at lower power presents a challenge to system and ASIC developers alike. Efficient DSP design is essential but the underlying technology has a significant role to play in an optimized solution.

Show Floor Programming

12:30–15:00
SDN 2.0 is Here - What Have We Learned?, *Expo Theater II Programming*
For more details, see page 42

13:00–15:00
■ **MarketWatch**
Panel III: Data Center Architecture and Content Delivery Strategies, *Expo Theater I Programming*
For more details, see page 38

14:00–15:00
OIF Networking & Operation Session, *Expo Theater III Programming*
For more details, see page 44

Room 102

W3A • Flex—Continued

W3A.2 • 13:30
Dynamic Differential Delay Aware RMSA for Elastic Multi-path Provisioning in GMPLS Flexi-grid DWDM Networks, Raul Muñoz[1], Ricard Vilalta[1], Michela Svaluto Moreolo[1], Josep M. Fabrega[1], Ramon Casellas[1], Francisco Javier Vílchez[1], Ricardo Martínez[1], Silvano Frigerio[2], Alberto Lometti[2]; *[1]Optical Networks and Systems, CTTC, Spain; [2]Alcatel Lucent Italia, Italy.* We experimentally evaluate multi-path RMSA algorithms that minimize the differential delay and the required buffer capacity. A proof-of-concept of multi-path routing, provisioning and transmission with a GMPLS-controlled Flexi-grid DWDM setup using S-BVTs is also presented.

W3A.3 • 13:45
Green Grooming in Elastic Optical Networks, Ying Wu[1,2], Weigang Hou[1], Lei Guo[1], Yejun Liu[1], Zhimin Sun[1]; *[1]Northeastern Univ. (China), China; [2]Liaoning Univ., China.* The elastic optical network has been a promising solution due to flexible spectrum provisioning. But the components consume more power compared with ordinary ones. Thus we study green grooming for improving spectrum and power efficiencies.

Room 120

W3B • Novel Network Elements—Continued

W3B.3 • 13:30
Over 10-Tbit/s/port Optical Packet Switching using Polarization-Multiplexed DWDM/16-QAM packets, Satoshi Shinada[1], Jose D. Mendinueta[1], Naoya Wada[1]; *[1]National Inst. of Information and Communications Technology, Japan.* We demonstrated a 10.24-Tbit/s/port (20 Gbaud 16-QAM × 64λ × 2-Polarizations) optical packet switching system using add and drop of multi-level modulated, wideband optical packets.

W3B.4 • 13:45 *Top-Scored*
Non-Data-Aided Feedforward Timing Recovery for Flexible Transceivers Employing PDM-MQAM Modulations, Mohamed Morsy-Osman[1], Mathieu Chagnon[1], Qunbi Zhuge[1], Xian Xu[1], David V. Plant[1]; *[1]McGill Univ., Canada.* A blind feedforward timing estimator using 2 samples/symbol that is modulation format transparent is modified for PDM signals. When used for interpolator control, sampling frequency offsets up to 5000 ppm are corrected experimentally for PDM-QPSK, -16QAM and -64QAM.

Room 121

W3C • Panel: How Can residential Broadband Networks Support the Small Cell Backhaul of the Future?—Continued

Room 122

W3D • Fiber Measurements and Characterization—Continued

W3D.2 • 13:30
10-Times Broadened Fast Optical Frequency Sweeping for High Spatial Resolution OFDR, Dan Xu[1], Jiangbing Du[1], Xinyu Fan[1], Qingwen Liu[1], Zuyuan He[1]; *[1]State Key Laboratory of Advanced Optical Communication Systems and Networks, Shanghai Jiao Tong Univ., China.* We demonstrate a method for high spatial resolution OFDR by utilizing the high order modulation sideband. 10-times broadened optical frequency sweeping is achieved. 1.5-cm spatial resolution is obtained with modulation frequency sweeping span of 800 MHz.

W3D.3 • 13:45
High-Dimensional Stokes-Space Analysis for Monitoring Fast Change of Mode Dispersion in Few-Mode Fibers, Qian Hu[1], Xi Chen[1], An Li[1], William Shieh[1]; *[1]Department of Electrical and Electronic Engineering, The Univ. of Melbourne, Australia.* We adopt high-dimensional Stokes-space analysis to measure the time evolution of the mode dispersion in few-mode fibers. One advantage of the method is that the laser phase noise is intrinsically cancelled.

Room 123

W3E • Fiber Amplifiers: Design and Characterization—Continued

W3E.2 • 13:30
Quasi Phase-Matched FOPA with 50 nm Gain Bandwidth Using Dispersion Stable Highly Nonlinear Fiber, Shigehiro Takasaka[1], Yuki Taniguchi[1], Masanori Takahashi[1], Jiro Hiroichi[1], Masateru Tadakuma[1], Hiroshi Matsuura[2], Kohei Doi[2], Ryuichi Sugizaki[1]; *[1]FITEL photonics Lab., Furukawa Electric Co., Ltd., Japan; [2]mechanical engineering, Tohoku Gakuin Univ., Japan.* Fabricated dispersion stable HNLFs enable a quasi phase-matched FOPA with only 2-stage configuration to have flat gain more than 22 dB with bandwidth of 50 nm. NF is less than 4.4 dB in C-band.

W3E.3 • 13:45 *Top-Scored*
Characterization of a Fiber-Optical Parametric Amplifier in a 5 x 28-GBd 16-QAM DWDM System, Isaac Sackey[1,2], Robert Elschner[2], Markus Nölle[2], Thomas Richter[2], Lutz Molle[2], Christian Meuer[1,2], Mahmoud Jazayerifar[1], Stefan Warm[1], Klaus Petermann[1], Colja Schubert[2]; *[1]Technische Universität Berlin, Germany; [2]Fraunhofer Inst. for Telecommunications, Heinrich Hertz Inst., Germany.* The performance of a FOPA as inline amplifier for 28-GBd 16-QAM signals at 20-dB gain in a 50-GHz 5-channel DWDM system is experimentally investigated. Less than 0.7-dB OSNR penalty at a BER of 1x10-3 was measured with 0-dBm per-channel output power.

Room 124

W3F • Signal Processing I (Regeneration)—Continued

W3F.3 • 13:30
Experimental Demonstration of All Optical Phase Noise Mitigation of 40-Gbits/s QPSK Signals by Mixing Differentially Delayed Nonlinear Products, A. Mohajerin-Ariaei[1], M. R. Chitgarha[1], M. Ziyadi[1], S. Khaleghi[1], A. Almaiman[1], M. J. Willner[1], J. Touch[2], J.-Y. Yang[3], Y. Akasaka[3], M. Sekiya[3], M. Tur[4], L. Paraschis[5], C. Langrock[6], M. M. Fejer[6], A. E. Willner[1], *[1]Department of Electrical Engineering, University of Southern California, USA; [2]Information Sciences Institute, University of Southern California, USA; [3]Fujitsu Laboratories of America, USA; [4]School of Electrical Engineering, Tel Aviv University, Israel; [5]Cisco Systems, USA; [6]Edward L. Ginzton Laboratory, USA.* We propose and demonstrate an all optical phase noise mitigation scheme by mixing differentially delayed nonlinear products. For 40-Gbits/s signals, phase squeezing results in phase noise range reduction of around 50% and 1.5 dB OSNR gain at BER 1e-5.

W3F.4 • 13:45
Counter-Dithering Pump Scheme for Cascaded Degenerate FWM Based Wavelength Converter, Hung Nguyen Tan[1], Takashi Inoue[1], Ken Tanizawa[1], Stephane Petit[2], Yoichi Oikawa[2], Shigehiro Takasaka[3], Takeshi Yagi[3], Shu Namiki[1]; *[1]National Inst. of Advanced Industrial Science and Technology (AIST), Japan; [2]Trimatiz Limited, Japan; [3]Fitel Photonics Laboratory, Furukawa Electric Co., Ltd., Japan.* We demonstrate counter-dithering of pumps between two cascaded FWM processes for highly-efficient format-independent wavelength conversion. Up-to -1.2dB FWM conversion efficiency is obtained over 32-nm. 86-Gbps DP-QPSK are converted with OSNR penalty below 0.3dB at 10^{-3} BER.

W3G • WDM Access—Continued

W3G.3 • 13:30 Invited

Nyquist Signaling for Spectrally-Efficient Optical Access Networks, Jacklyn D. Reis[1,2], Ali Shahpari[1], Ricardo M. Ferreira[1], Darlene M. Neves[1], Mário Lima[1], Antonio L. Teixeira[1,3]; *[1]Department of Electronics, Telecommunications and Informatics, Instituto de Telecomunicações, Univ. of Aveiro, Portugal; [2]CPqD Foundation, Brazil; [3]Coriant, Portugal.* In this work Nyquist technology application to future optical access networks is discussed. Implementation issues regarding low symbol rates are characterized. The potential benefits of Nyquist in symmetric/bi-directional PON are presented by means of parameter optimization.

W3H • Network Virtualization—Continued

is currently focused on identifying and evaluating new opportunities in technologies applicable to network infrastructures, and the coordination of national and international collaboration activities. His current interests are related to network infrastructural services (with special emphasis on security and AAA), new network architectures, and network programmability and virtualization. Diego is actively participating in the ETSI ISG on Network Function Virtualization (acting as Technical Manager of the group), the ONF, and the IETF WGs connected to these activities.

W3I • Symposium on Advanced Electro-optic Packaging and Assembly Technologies I and Panel Discussion—Continued

W3I.2 • 13:25 Invited

Packaging of Silicon Photonics Systems, Peter De Dobbelaere, Luxtera, USA. We will address the importance of packaging on performance, power dissipation and cost of photonic devices. In the case of silicon photonics we will provide some specific packaging examples. Finally we will propose a roadmap towards packaging of highly integrated and high I/O density silicon photonics based communications systems.

W3I.3 • 13:45 Invited

An edge-coupling chip-to-chip optical interconnects system, Jurgen Michel[1]; *[1]Massachusetts Inst. of Technology, USA.* We present an optical chip-to-chip coupling scheme with large misalignment tolerances. The coupling system is based on a multi-material platform with a polymer waveguide for the interconnection between chips. Simulation shows a position tolerance (3 dB coupling efficiency) of up to 1.0 μm when the polymer waveguide diameter equals 6.0 μm. The polymer waveguide can be easily fabricated by using a 3D laser lithography technique.

W3J • Coded Modulation II—Continued

W3J.3 • 13:30

Adaptive Joint Carrier Recovery and Turbo Decoding for Nyquist Terabit Optical Transmission in the Presence of Phase Noise, yu zhao[1], Nebojsa Stojanovic[1], Deyuan Chang[2], Changsong Xie[1], Bangning Mao[1], Le Binh[1], Zhiyu Xiao[2], Fan Yu[2]; *[1]Huawei Technologies Duesseldorf GmbH, Germany; [2]Huawei Technologies Co., Ltd, China.* An adaptive joint carrier recovery and soft LDPC turbo decoding scheme in the presence of nonlinear phase noise is proposed and experimentally verified with 1.9dB coding gain in Nyquist Terabit PDM-DQPSK systems.

W3J.4 • 13:45 Tutorial

Advanced coded-modulation for ultra-high-speed optical transmission, Ivan B. Djordjevic[1]; *[1]Department of Electrical and Computer Engineering, Univ. of Arizona, USA.* This tutorial represents an overview of advanced coded-modulation for optical communications. It describes the following ultra-high-speed optical transport enabling techniques: codes on graphs, adaptive coded-modulation, and turbo equalization.

W3K • DSP Hardware—Continued

W3K.2 • 13:30

Challenges with Pluggable Optical Modules for Coherent Optical Communication Systems, Thomas Duthel[1], Peter Hermann[1], Timo Winkler von Mohrenfels[1], James E. Whiteaway[1], Theo Kupfer[1]; *[1]Cisco Optical GmbH, Germany.* Coherent pluggable modules will separate the DSP chip from optics. Challenges of such architecture are exemplarily discussed for the transmitter side based on simulations. Measurements show state-of-the-art performance for a Nyquist 16QAM integrated InP transmitter.

W3K.3 • 13:45

Performance Analysis of Pre- and Post-compensation for Bandwidth-constrained Signal in High-Spectral-Efficiency Optical Coherent Systems, Zhensheng Jia[1], Hung-Chang Chien[1], Junwen Zhang[1], Ze Dong[1], Yi Cai[1]; *[1]Optics Lab, ZTE (TX), USA.* We present and analyze several pre- and post-compensation algorithms for bandwidth-limited optical signal on mitigation towards inter-symbol-interference (ISI) or joint ISI and inter-channel-interference (ICI) impairments. Experimental results and support to higher-order format are also demonstrated.

Continued on page 109

Show Floor Programming

12:30–15:00
SDN 2.0 is Here - What Have We Learned?, *Expo Theater II Programming*
For more details, see page 42

13:00–15:00
■ **MarketWatch Panel III: Data Center Architecture and Content Delivery Strategies,** *Expo Theater I Programming*
For more details, see page 38

14:00–15:00
OIF Networking & Operation Session, *Expo Theater III Programming*
For more details, see page 44

Room 102

W3A • Flex—Continued

W3A.4 • 14:00
Energy Efficiency of IP-over-Elastic Optical Networks with Sliceable Optical Transponder, Jiawei Zhang[1,2], Yonli Zhao[1], Jie Zhang[1], Biswanath Mukherjee[2]; [1]*Beijing Univ. of Posts and Telecommunications, China;* [2]*Univ. of California, Davis, USA.* We study power consumption of IP-over-Elastic optical networks with different elastic optical transponders. The results show that significant energy saving is achievable using sliceable transponder, and also show how transponder slicability can influence energy saving.

W3A.5 • 14:15
OpEx savings by reduction of stock of spare parts with Sliceable Bandwidth Variable Transponders, Beatriz de la Cruz Miranda[1], Oscar Gonzalez de dios[1], Victor Lopez[1], Juan-Pedro Fernández-Palacios[1]; [1]*Telefónica I+D, Spain.* This work analyses the OpEx savings related to stock of spare parts for Sliceable Bandwidth Variable Transponders versus traditional fixed rate transponders. Target cost of sliceable transponders based on these OpEx savings is obtained.

Room 120

W3B • Novel Network Elements—Continued

W3B.5 • 14:00
Optical Comb-enabled Cost-effective ROADM Scheme for Elastic Optical Networks, Paikun Zhu[1], Juhao Li[1], Luoping Niu[1], Yingying Xu[1], Yuanxiang Chen[1], Xiaopeng Xie[1], Xin Chen[1], Bingli Guo[1], Zhangyuan Chen[1], Yongqi He[1]; [1]*State Key Laboratory of Advanced Optical Communication Systems and Networks, Peking Univ., China.* We propose a ROADM Add/Drop scheme based on optical comb for elastic optical networks and experimentally demonstrates the feasibility. The scheme supports wide-range subband to superchannel Add/Drop functionality, while greatly saves network devices.

W3B.6 • 14:15
Optical Packet Switching Node Design for 400 G Software-defined Optical Networking with Coherent Detection, Ze Dong[1,2]; [1]*ZTE Tx, Inc, Optical Lab, USA;* [2]*Georgia Inst. of Technology, USA.* We demonstrate how to realize optical packet switching in the software-defined optical networking with 400-Gb/s line rate for the first time. The key functions of optical packet generation, label separation, and payload coherent detection are experimentally demonstrated.

Room 121

W3C • Panel: How Can residential Broadband Networks Support the Small Cell Backhaul of the Future?—Continued

Room 122

W3D • Fiber Measurements and Characterization—Continued

W3D.4 • 14:00
Measurement of Distributed Modal Birefringence in a Few-Mode Fiber Based on Brillouin Dynamic Grating, An Li[1], William Shieh[1]; [1]*The Univ. of Melbourne, Australia.* We report efficient generation and measurement of Brillouin dynamic grating in a few-mode fiber (FMF). By using a three-wave pump-probe setup combined with heterodyne coherent detection, distributed modal birefringence in a FMF has been characterized.

W3D.5 • 14:15
Modal Crosstalk Measurement Based on Intensity Tone for Few-Mode Fiber Transmission Systems, Takayuki Mizuno[1], Hidehiko Takara[1], Manabu Oguma[2], Takayuki Kobayashi[1], Yutaka Miyamoto[1]; [1]*NTT Network Innovation Laboratories, Nippon Telegraph & Telephone Corp, Japan;* [2]*NTT Photonics Laboratories, Nippon Telegraph & Telephone Corp, Japan.* We propose a novel method based on intensity tone for measuring modal crosstalk in few-mode fiber transmission systems. Our method can measure crosstalk for multiple modes simultaneously with wide dynamic range of 40 dB.

Room 123

W3E • Fiber Amplifiers: Design and Characterization—Continued

W3E.4 • 14:00
Wavelength Assignment Dependency of AGC EDFA Gain Offset under Dynamic Optical Circuit Switching, Kiyo Ishii[1], Junya Kurumida[1], Shu Namiki[1]; [1]*AIST, Japan.* Dynamic gain offsets in WDM AGC EDFAs caused by optical circuit switching are experimentally evaluated. A simple wavelength assignment policy can reduce the gain offsets by up to 0.7 dB after five cascaded EDFAs.

W3E.5 • 14:15
A Fully-integrated In-band OSNR Monitor using a Wavelength-tunable Silicon Microring Resonator and Photodiode, Qi Li[1], Kishore Padmaraju[1], Dylan F. Logan[2,3], Jason J. Ackert[2], Andrew P. Knights[2], Keren Bergman[1]; [1]*Electrical Engineering, Columbia Univ., USA;* [2]*Engineering Physics, McMaster Univ., Canada;* [3]*Ranovus Inc, Canada.* We demonstrate a novel in-band OSNR monitor with full optical components integration. The OSNR monitor is shown to have a working range of 17 dB for 40-Gb/s OOK and DPSK signals, and is insensitive to chromatic dispersion of 0-250 ps/nm.

Room 124

W3F • Signal Processing I (Regeneration)—Continued

W3F.5 • 14:00 ***Top-Scored***
Simultaneous Phase Regeneration of CoWDM BPSK Signals by Hybrid Optical Phase Squeezer, Takayuki Kurosu[1], Shu Namiki[1], Mingyi Gao[2]; [1]*Network Photonics Research Center, Natl Inst of Adv Industrial Sci & Tech, Japan;* [2]*School of Electronics and Information Engineering, Soochow Univ., China.* We propose a new concept of hybrid optical phase squeezer and demonstrate simultaneous phase regeneration of two CoWDM BPSK signals. A gain extinction ratio of 20dB is achieved with a pump power of only 3dBm.

W3F.6 • 14:15
1THz-Bandwidth Polarization-Diverse Optical Phase Conjugation of 10x114Gb/s DP-QPSK WDM Signals, Marc F. Stephens[1], Mingming Tan[1], Ian Phillips[1], Stylianos Sygletos[1], Paul Harper[1], Nick J. Doran[1]; [1]*Aston Inst. of Photonic Technologies, Aston Univ., UK.* Polarization diverse optical phase conjugation of a 1THz spectral-band 1.14Tb/s DP-QPSK WDM multiplex is demonstrated for the first time, showing a worst case Q2 penalty of 0.9dB over all conjugate wavelengths, polarizations and OSNR.

Room 125

W3G • WDM Access—Continued

W3G.4 • 14:00
Operation of a RSOA WDM PON Self-seeded Transmitter Over More than 50 km of SSMF up to 10 Gb/s, Paola Parolari[1], Lucia Marazzi[1], Marco Brunero[1], Mario Martinelli[1], Anaëlle Maho[2], Sophie Barbet[2], Francois Lelarge[2], Romain Brenot[2], Giancarlo Gavioli[3], Gael Simon[4], Fabienne Saliou[4], Qian Deniel[4], Philippe Chanclou[4]; *[1]DEIB, Politecnico di Milano, Italy; [2]III-V Lab, France; [3]Alcatel-Lucent Italia, Italy; [4]Orange Labs, France.* For the first time we present operation of a WDM PON self-seeded transmitter in the O-band achieving more than 50-km SSMF transmission up to 10 Gb/s over 8 channels.

W3G.5 • 14:15
70km external cavity DWDM sources based on O-band Self Seeded RSOAs for transmissions at 2.5Gbit/s, Gael Simon[1,2], Fabienne Saliou[1], Philippe Chanclou[1], Qian Deniel[1,2], Didier Erasme[2], Romain Brenot[3]; *[1]Orange Labs, France; [2]Télécom ParisTech, France; [3]III-V Labs, France.* A DWDM self-seeded source achieves transmission in the O-band up to 90km SSMF at 2.5Gbps. Moreover, a "face-to-face" self-seeded architecture permits to realize transmissions at 2.5Gbps with extra-long optical cavities reaching 70km of SSMF.

Room 130

W3H • Network Virtualization—Continued

W3H.3 • 14:15 *Top-Scored*
Flexible Virtual Network Provisioning over Distance-Adaptive Flex-Grid Optical Networks, Xi Wang[1], Qiong Zhang[1], Inwoong Kim[1], Paparao Palacharla[1], Motoyoshi Sekiya[1]; *[1]Fujitsu Laboratories of America, USA.* We present a flexible virtual optical network provisioning procedure for distance-adaptive flex-grid optical networks. Simulations show ~3 times increase in effective network capacity by leveraging the combined effect of flexible node mapping and distance-adaptive modulation.

Room 131

W3I • Symposium on Advanced Electro-optic Packaging and Assembly Technologies I and Panel Discussion—Continued

W3I.4 • 14:05 Invited
Integrating 3D-TSV and Photonics in System in Package Products: Challenges and Opportunities, Bill Bottoms[1]; *[1]ITRS, USA.*The new challenges which must be overcome to achieve this vision and the potential solutions will be discussed.

This Symposium will be followed by a panel discussion.

Room 132

W3J • Coded Modulation II—Continued

Dr. Djordjevic is an Associate Professor in Dept. of Electrical and Computer Eng. (College of Eng.) of University of Arizona (UA), with a joint appointment in College of Optical Sciences. Prior to joining UA, he was with University of Bristol and University of the West of England, Bristol, UK; Tyco Telecommunications, Eatontown, USA; National Technical University of Athens, Greece; and State Telecommunication Company, Nis, Serbia. During 2013 he was also with TU Darmstadt, Germany. Dr. Djordjevic is an author/co-author of four books, over 300 international journal/conference publications, and 17 US patents. Dr. Djordjevic serves as an associate editor for 3 journals.

Room 133

W3K • DSP Hardware—Continued

W3K.4 • 14:00
A Novel Adaptive Digital Pre-equalization Scheme for Bandwidth Limited Optical Coherent System with DAC for Signal Generation, Junwen Zhang[1,2], Hung-chang Chien[1]; *[1]ZTE (TX) Inc, USA; [2]Fudan Univ., China.* We propose and experimentally demonstrated a novel adaptive pre-equalization scheme for bandwidth limited optical coherent system using DAC for signal generation. System performance improvements are demonstrated by the results of 40-GBaud QPSK/8QAM/16QAM with adaptive pre-equalization.

W3K.5 • 14:15 Invited
Linear Optical Modulator, Akimasa Kaneko[1], Hiroshi Yamazaki[1], Yutaka Miyamoto[2]; *[1]NTT Photonics Laboratories, Japan; [2]NTT Network Innovation Laboratories, Japan.* The nonlinear (sinusoidal) response of a conventional Mach-Zehnder modulator is an obstacle to achieving low-loss and low-distortion electro-optic signal conversion in a DAC-based optical transmitter. Our linear optical modulator solves this problem.

Show Floor Programming

12:30–15:00
SDN 2.0 is Here - What Have We Learned?, *Expo Theater II Programming*
For more details, see page 42

13:00–15:00
■ **MarketWatch**
Panel III: Data Center Architecture and Content Delivery Strategies, *Expo Theater I Programming*
For more details, see page 38

14:00–15:00
OIF Networking & Operation Session, *Expo Theater III Programming*
For more details, see page 44

Room 102

W3A • Flex—Continued

W3A.6 • 14:30
Effect of Link Margins and Frequency Granularity on the Performance and Modulation Format Sweet Spot of Multiple Flexgrid Optical Networks, Abhijit Mitra[1,2], Andrew Lord[1], Subrat Kar[2], Paul Wright[1]; *[1]British Telecom Labratories, British Telecom, UK; [2]Department of Electrical Engineering, Indian Inst. of Technology, Delhi, India.* We consider range of modulation formats for small, medium and large networks as a function of line margin and frequency granularity. Capacity increases by 80%, 65% and 46.5% with 12.5GHz granularity at the OSNR limit.

W3A.7 • 14:45
Adaptive FEC Selection for Lightpaths in Elastic Optical Networks, Yongcheng Li[1], Hua Dai[1], Gangxiang Shen[1], Sanjay K. Bose[2]; *[1]Soochow Univ., China; [2]Indian Inst. of Technology, India.* We propose a new approach to adaptively select FEC types for lightpaths in elastic optical networks. An ILP model and a spectrum-window-based heuristic algorithm are developed to analyze its performance. The proposed FEC selection scheme can achieve good performance with low FEC overhead.

Room 120

W3B • Novel Network Elements—Continued

W3B.7 • 14:30 **Invited**
InP-based high-speed transponder, Robert A. Griffin[1]; *[1]Caswell, Oclaro plc, UK.* A new generation of line-side pluggable transponders and transceivers capable of flexible 100 and 200 Gb/s transmission will be underpinned by developments in InP PICs, which offer high performance, compact footprint and low power dissipation.

Room 121

W3C • Panel: How Can residential Broadband Networks Support the Small Cell Backhaul of the Future?—Continued

Presentations selected for recording are designated with a ▶. Access these by visiting www.ofcconference.org and clicking on the View Presentations button.

Room 122

W3D • Fiber Measurements and Characterization—Continued

W3D.6 • 14:30 *Top-Scored*
Measurement of Intramodal and Intermodal Brillouin Gain Spectra in a Few-mode Fiber, Kwang Yong Song[1], Yong Hyun Kim[1]; *[1]Physics, Chung-Ang Univ., Republic of Korea.* Brillouin gain spectra of intramodal and intermodal SBS for different pump-probe pairs of four LP modes (LP01, LP11, LP21, and LP02 modes) in a few-mode fiber are analyzed using mode-division multiplexer composed of mode-selective couplers.

W3D.7 • 14:45
Measurement of Mode Coupling Distribution Along a Few-Mode Fiber Using a Synchronous Multi-Channel OTDR, Masataka Nakazawa[1], Masato Yoshida[1], Toshihiko Hirooka[1]; *[1]Research Inst. of Electrical Communication, Tohoku Univ., Japan.* We demonstrate the nondestructive measurement of mode coupling along a few-mode fiber using a synchronous multi-channel OTDR. The mode coupling distribution between the LP_{01} and $LP_{11a,b}$ modes is successfully obtained with a 10-m spatial resolution.

Room 123

Room 124

W3F • Signal Processing I (Regeneration)—Continued

W3F.7 • 14:30
An Optical Phase Quantiser Exhibiting Suppressed Phase Dependent Gain Variation, Kyle R. Bottrill[1], Graham D. Hesketh[1], Francesca Parmigiani[1], Peter Horak[1], David J. Richardson[1], Periklis Petropoulos[1]; *[1]Optoelectronics Research Centre, Univ. of Southampton, UK.* We experimentally demonstrate an all-optical phase quantiser based on phase-sensitive amplification which alleviates phase noise to amplitude noise conversion. Phase transfer functions are measured for the very first time using a novel scheme.

W3F.8 • 14:45
Nearly-Ideal Optical Phase Conjugation based Nonlinear Compensation System, Karen Solis-Trapala[1], Takashi Inoue[1], Shu Namiki[1]; *[1]National Inst. of Advanced Industrial Science and Technology (AIST), Japan.* A nearly-ideal system design for fiber nonlinearity compensation is experimentally demonstrated showing an unprecedented 10dB nonlinear threshold improvement in 4×12Gbaud 16QAM WDM signals. The same results are predicted for a 4×67.25Gbaud 16QAM 2000km long transmission.

15:00–15:30 Coffee Break, *South, Exhibit Halls A, B, C, North, Exhibit Hall D*

Room 125

W3G • WDM Access—Continued

W3G.6 • 14:30
First System Demonstration of Hitless λ-Tuning Sequence for Dynamic Wavelength Allocation in WDM/TDM-PON, Shin Kaneko[1], Tomoaki Yoshida[1], Satoshi Furusawa[3], Masahiro Sarashina[2], Hideaki Tamai[2], Akiya Suzuki[3], Toshiaki Mukojima[3], Shunji Kimura[1], Naoto Yoshimoto[1]; [1]*NTT Access Network Service Systems Labs., Japan;* [2]*Oki Electric Industry Co. Ltd, Japan;* [3]*Oki Electric Industry Co. Ltd, Japan.* We propose hitless wavelength-tuning sequence for dynamic wavelength allocation in WDM/TDM-PONs and demonstrate highly frequent wavelength-tunings in 100-ms intervals without data-frame loss using MAC boards. Pay-as-you-grow operation based on the proposed sequence is also shown.

W3G.7 • 14:45
High Output Power and Burst Extinction Ratio ONU Using a Simple Configuration Booster SOA with Gain Peak Detuning for WDM/TDM-PON, Katsuhisa Taguchi[1], Kota Asaka[1], Shunji Kimura[1], Naoto Yoshimoto[1]; [1]*NTT, Japan.* We propose a high-output power λ-selective transmitter utilizing a simple configuration burst-mode booster SOA with gain peak detuning that achieve pattern effect mitigation. We successfully demonstrate over 40-dB loss budget and 40-km reach WDM/TDM-PON.

Room 130

W3H • Network Virtualization—Continued

W3H.4 • 14:30
Optical Grooming with Spectrum Engineering (OG-SE) in Flexi-Grid Networks, Xiaosong Yu[1], Yongli Zhao[1], Jie Zhang[1]; [1]*Beijing Univ of Posts & Telecom, China.* This paper introduces the concept of Spectrum Engineering in flexi-grid optical networks, and proposes an Optical Grooming algorithm with Spectrum Engineering (OG-SE). Simulation results show it performs well in blocking rate.

W3H.5 • 14:45
Experimental Evaluation of Virtual Topology Design and Reconfiguration in Optical Networks by means of Cognition, Domenico Siracusa[1], Antonio Francescon[1], Natalia Fernández[2], Ignacio de Miguel[2], Ramón J. Durán Barroso[2], Juan Carlos Aguado[2], Elio Salvadori[1]; [1]*CREATE-NET, Italy;* [2]*Universidad de Valladolid, Spain.* The effectiveness of a multi-objective virtual topology design algorithm and a reconfiguration policy supported by cognitive techniques is demonstrated in an emulated testbed deploying a centralized control and management architecture.

Room 131

W3I • Symposium on Advanced Electro-optic Packaging and Assembly Technologies I and Panel Discussion—Continued

Panel 1 - Chips and Modules
Presider: Lionel Kimerling, *MIT, USA*

14:30
Packaging Challenges for Next Generation HPCs, Frank Libsch, *IBM, USA*

14:35
3D integration: from tool box to photonic applications, Yann Lamy, *CEA-LETI*

14:40
Silicon Optical Interposer Performance, Takahiro Nakamura, *PETRA, Japan*

14:45
Open Discussion

Room 132

Room 133

W3K • DSP Hardware—Continued

W3K.6 • 14:45
DSP-Implementable Block Processing of Carrier-phase Recovery for M-QAM Signals, Takashi Inoue[1], Shu Namiki[1]; [1]*Natl Inst. of Adv. Industrial Sci. & Tech., Japan.* We propose a novel carrier-phase recovery scheme for M-QAM signals, which has DSP-implementable structure and is capable of carrier-frequency offset more than 10% of symbol rate. We demonstrate its operation for 16 and 64QAM signals.

15:00–15:30 Coffee Break, *South, Exhibit Halls A, B, C, North, Exhibit Hall D*

Show Floor Programming

12:30–15:00
SDN 2.0 is Here - What Have We Learned?, *Expo Theater II Programming*
For more details, see page 42

13:00–15:00
■ **MarketWatch**
Panel III: Data Center Architecture and Content Delivery Strategies, *Expo Theater I Programming*
For more details, see page 38

14:00–15:00
OIF Networking & Operation Session, *Expo Theater III Programming*
For more details, see page 44

Room 102

15:30–17:30
W4A • Defragmentation Control
Presider: Luis Velasco; Universitat Politècnica de Catalunya (UPC), Spain

W4A.1 • 15:30 Invited
Effective Utilization of Network by Spectrum Defragmentation, Kyosuke Sone[1], Xi Wang[2], Shinji Yamashita[1], Yasuhiko Aoki[1]; [1]*Fujitsu Laboratories Ltd., Japan;* [2]*Fujitsu Laboratories of America, Inc., USA.* We experimentally demonstrate hitless spectrum defragmentation and show the effectiveness of spectrum defragmentation through network simulations. In addition, we implement the OpenFlow extensions for spectrum defragmentation.

Room 120

15:30–17:00
W4B • Optical Network Optimization I
Presider: Sheryl Woodward, AT&T Labs, USA

W4B.1 • 15:30 Invited
CORONET: Testbeds, Cloud Computing, and Lessons Learned, Ann C. Von Lehmen[1], Robert D. Doverspike[2], George Clapp[2], Douglass M. Freimuth[4], Joel Gannett[3], Keith Kim[3], Haim Kobrinski[1], Emmanuil Mavrogiorgis[2], Jorge Pastor[2], Michael Rauch[2], K. Ramakrishnan[2], Ron Skoog[1], Brian Wilson[1], Sheryl L. Woodward[2]; [1]*Applied Communication Sciences, USA;* [2]*AT&T Labs - Research , USA;* [3]*Applied Communications Sciences;* [4]*IBM TJ Watson Research Center, USA.* We summarize the DARPA CORONET program approach to bandwidth-on-demand, and implementation and demonstration of Cloud Computing applications in network testbeds.

Room 121

15:30–17:30
W4C • Long Wavelength VCSELs and Quantum Dot Lasers
Presider: Daniel Kuchta; IBM TJ Watson Research Center, USA

W4C.1 • 15:30 Invited
Long wavelength vertical cavity surface emitting lasers for data communications, Eli Kapon[1]; [1]*Ecole Polytechnique Federale de Lausanne, Switzerland.* Low power consumption, integrability and recent progress in industrialization of long wavelength (>1.2μm) vertical cavity surface emitting lasers make them the light source of choice for data center communication links and integration with silicon photonics.

Room 122

15:30–17:15
W4D • Slow Light and Multicore Fiber
Presider: Testuya Nakanishi; Sumitomo Electric Industries Ltd, Japan

W4D.1 • 15:30 Invited
Dispersionless Low-loss Miniature Slow Light Delay Lines Based on Optical Fibers, Misha Sumetsky[1]; [1]*Aston Univ., UK.* A miniature slow light delay line with the record large delay time, small transmission loss, dispersion, and effective speed of light is proposed and demonstrated using the SNAP (Surface Nanoscale Axial Photonics) technology.

Room 123

15:30–17:00
W4E • Novel Optical Schemes
Presider: Camille Bres; EPFL, Switzerland

W4E.1 • 15:30 *Top-Scored*
1.9 μm Coherent Source Generation in Hydrogen-Filled Hollow Core Fiber by Stimulated Raman Scattering, Zefeng Wang[2,1], Fei Yu[1], William Wadsworth[1], Jonathan C. Knight[1]; [1]*Physics, Univ. of Bath, UK;* [2]*National Univ of Defense Technology, China.* A 1.9 μm fiber gas Raman converter is reported for the first time. A low loss hydrogen-filled hollow-core negative curvature fiber is pumped with a 1064 nm microchip laser, generating a 1907 nm output with quantum conversion efficiency >48%.

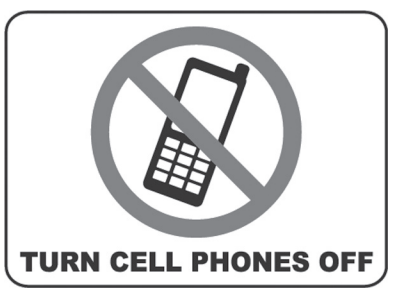
W4E.2 • 15:45
Broadly Time-Dispersion-Tuned Narrow Linewidth All-Fiber-Integrated Optical Parametric Oscillator, Lei Zhang[1], Sigang Yang[1], Hongwei Chen[1], Minghua Chen[1], Shizhong Xie[1]; [1]*Tsinghua Univ., China.* A highly efficient, narrow linewidth, time-dispersion-tuned all-fiber-integrated optical parametric oscillator is demonstrated. The output wavelength can be continuously tuned in the ranges from 960 to 1048 nm and from 1078 to 1180 nm.

Room 124

15:30–17:30
W4F • Signal Processing II
Presider: Kenneth Wong; University of Hong Kong, Hong Kong

W4F.1 • 15:30
Real-time All-optical OFDM Transmission System Based on Time-Domain Optical Fourier Transformation, Pengyu Guan[1], Deming Kong[2], Kasper Meldgaard Røge[1], Hans Christian Hansen Mulvad[1], Michael Galili[1], Leif Katsuo Oxenløwe[1]; [1]*DTU Fotonik, Technical Univ. of Denmark, Denmark;* [2]*State Key Laboratory of Information Photonics and Optical Communications, Beijing Univ. of Posts and Telecommunications, China.* We propose a novel simple all-optical OFDM transmission system based on time-domain OFT using time-lenses. A real-time 160 Gbit/s DPSK OFDM transmission with 16 decorrelated data subcarriers is successfully demonstrated over 100 km.

W4F.2 • 15:45
All-optical High-performance Demultiplexing Using Optical Nyquist Pulse Sampling, Daiki Seya[1], Koudai Harako[1], Toshihiko Hirooka[1], Masataka Nakazawa[1]; [1]*Research Inst. of Electrical Communication, Tohoku Univ., Japan.* We propose all-optical Nyquist demultiplexing using an optical Nyquist pulse as a sampling pulse. Crosstalk between data and sampling pulses is greatly reduced by the narrow spectral width, resulting in a 3-dB receiver sensitivity improvement.



Room 125

15:30–17:30
W4G • Coherent PON
Presider: Antonio Teixeira; Instituto de Telecomunicacoes, Portugal

W4G.1 • 15:30
Fully Coherent Self- Homodyne Bi-directional Enhanced Performance PON, Ali Shahpari1, Ruben S. Luis2, Jacklyn D. Reis1, Ricardo M. Ferreira1, Zoran Vujicic 1, Jose D. Mendinueta2, Mário Lima1, Naoya Wada2, Antonio L. Teixeira1, 1Department of Electronics, Telecommunications and Informatics, Instituto de Telecomunicações of Aveiro, Aveiro, Portugal, Photonic Network Research Institute Group , 2National Institute of Information and Communications Technology, Tokyo, Japan, We present a coherent-PON employing partial overlap of downstream/upstream Nyquist spectra, allowing bi-directional operation and enhanced spectral efficiency (2x120Gb/s@50GHz). Additionally, frequency shifting of Nyquist bands from the carrier allowed reduced RBS and dynamic SRS.

W4G.2 • 15:45
Simplified Polarization Diversity Heterodyne Receiver for 1.25Gb/s Cost-Effective udWDM-PON, Iván Cano[1], Adolfo Lerín[1], Victor Polo[1], Josep Prat[1]; *[1]Universitat Politecnica de Catalunya, Barcelona, CAT, Spain.* We propose a heterodyne receiver with a single-photodiode per polarization for ONU receiver in low-cost udWDM-PON. This grants polarization diversity operation showing a penalty of 6dB in sensitivity compared to a balanced detector.

Room 130

15:30–17:30
W4H • Network Design Challenges and Implementations
Presider: Tom Issenhuth; Microsoft, USA

W4H.1 • 15:30
Energy Saving Through Traffic Profiling and Prediction in Self-Optimizing Optical Networks, Domenico Siracusa[1], Federico Pederzolli[1,2], Renato Lo Cigno[2], Elio Salvadori[1]; *[1]CREATE-NET, Italy; [2]DISI, Univ. of Trento, Italy.* A method that automatically learns and predicts the traffic behavior to save energy by adjusting the number of active optical carriers is presented. Simulations prove it provides large savings and ensures low traffic loss probability.

W4H.2 • 15:45
Joint Optimization of Transmission Performance and Bandwidth Utilization Based on Software Defined Network, Wei Guo[1], Wang Bin[1], Yaohui Jin[1], Weisheng Hu[1], Ming Xia[2]; *[1]Shanghai Jiao Tong Univ., China; [2]Ericsson Research, USA.* We propose an extended Software Defined Networks (SDN) controller to improve bandwidth utilization with guaranteed transmission performance. An experimental implementation shows reduced bandwidth waste without impacting transmission delay and packet loss for designated applications.

Room 131

15:30–18:00
W4I • Symposium on Advanced Electro-optic Packaging and Assembly Technologies II
Presider: Nick Ilyadis, Broadcom, USA

W4I.1 • 15:35 Invited
Taking Optics to the Chip: From Board-mounted Optical Assemblies to Chip-level Optical Interconnects, Katharine E. Schmidtke[1], Frank Flens[1], Daniel Mahgarefteh[1]; *[1]Finisar Corporation, USA.* Board-mounted optical assemblies (BOAs) enable significant bandwidth density increase relative to pluggable optics at the card edge. We discuss the challenges for the next step in this evolution as optics moves towards the chip.

Room 132

15:30–17:15
W4J • Few-Mode Fiber Transmission
Presider: Ezra Ip; NEC Laboratories America Inc, USA

W4J.1 • 15:30
High-Dimensional Modulation for Mode-Division Multiplexing, Sercan O. Arik[1,2], David Millar[1], Toshiaki Koike-Akino[1], Keisuke Kojima[1], Kieran Parsons[1]; *[1]Mitsubishi Electric Research Labs, USA; [2]Department of Electrical Engineering, Stanford Univ., USA.* We explore high-dimensional modulation for mode-division multiplexed optical fiber communication systems, focusing on optimized 24-D modulation formats in six-mode fiber transmission. Compared with conventional formats, our simulations demonstrate up to 8.7 dB span loss budget improvement for 6 b/s/Hz intra-channel spectral efficiency.

W4J.2 • 15:45
Photonic-Lantern-Based Mode Multiplexers for Few-Mode-Fiber Transmission, Roland Ryf[1], Nicolas K. Fontaine[1], Marc Montoliu[1,2], Sebastian Randel[1], Burcu Ercan[1], Haoshuo Chen[1,3], S. Chandrasekhar[1], Alan Gnauck[1], Sergio G. Leon-Saval[4], Joss Bland-Hawthorn[4], Joel R. Salazar Gil[4], Yi Sun[5], Robert Lingle[5]; *[1]Bell-Labs, Alcatel-Lucent, USA; [2]Universitat Politecnica de Catalunya (ETSETB), Spain; [3]COBRA Inst., Eindhoven Univ. of Technol., Netherlands; [4]Inst. of Photonics and Optical Science (IPOS), The Univ. of Sydney, Australia; [5]OFS, USA.* We report transmission experiments in few-mode fibers supporting 6 spatial- and polarization modes, where low-loss photonic lanterns are used as mode multiplexers. We measured a transmission distance of 900~km for 32 WDM channels with a 100~GHz channel spacing and a distance of 1500~km for a single wavelength channel experiment.

Room 133

15:30–17:30
W4K • Carrier Recovery and Phase Noise
Presider: Leslie Rusch; Universite Laval, Canada

W4K.1 • 15:30 Tutorial
Carrier Recovery Algorithms and Real-time DSP Implementation for Coherent Receivers, Timo Pfau[1]; *[1]Bell Labs, Alcatel-Lucent, USA.* Different carrier recovery algorithms and strategies are presented and compared in terms of performance and hardware complexity, along with insights into the real-time implementation of such algorithms.

Timo Pfau received the Dr.-Ing. degree in electrical engineering from the University of Paderborn, Germany, in 2009. He is currently a Member of Technical Staff in the Enabling Physical Technologies domain at Bell Laboratories, Alcatel-Lucent in Murray Hill, NJ. His research interests include advanced modulation formats, digital signal processing, and real-time implementation of high-speed communication systems.

Show Floor Programming

15:30–16:30
The Buzz — A Real-Time Look at the News and Trends Happening at OFC, *Expo Theater II Programming*
For more details, see page 42

15:30–17:00
Workshop on Photonic Startups and Entrepreneurship, *Expo Theater III Programming*
For more details, see page 44

Room 102

W4A • Defragmentation Control—Continued

W4A.2 • 16:00
Demonstration of Online Spectrum Defragmentation Enabled by OpenFlow in Software-defined Elastic Optical Networks, Shoujiang Ma[1], Cen Chen[1], Shengru Li[1], Mingyang Zhang[1], Suoheng Li[1], Yan Shao[1], Zuqing Zhu[1], Lei Liu[2], S. J. Ben Yoo[2]; *[1]School of Information Science and Technology, Univ. of Science and Technology of China, China; [2]Department of Electrical and Computer Engineering, Univ. of California, Davis, USA.* We propose and experimentally demonstrate a control-plane framework to realize online spectrum defragmentation (DF) in software-defined elastic optical networks. Experimental results show that the spectrum DF enabled by OpenFlow reduces the blocking probability effectively.

W4A.3 • 16:15
Experimental Assessment of a High Performance Back-end PCE for Flexgrid Optical Network Re-optimization, Lluís Gifre Renom[1,2], Luis Velasco[1], Nacho Navarro[2,3], Gabriel Junyent[1]; *[1]Optical Communications Group (GCO), Universitat Politècnica de Catalunya (UPC), Spain; [2]Barcelona Supercomputing Center (BSC), Spain; [3]High Performance Computing Group, Universitat Politècnica de Catalunya (UPC), Spain.* A specialized high performance Graphics Processing Unit (GPU)-based back-end Path Computation Element (PCE) to compute re-optimization in Flexgrid networks is presented. Experimental results show 6x speedups compared to single centralized PCE.

Room 120

W4B • Optical Network Optimization I—Continued

W4B.2 • 16:00
Comparative cost analysis of optical networks with shared mesh protection in the beyond-100-Gb/s networks era, Noboru Yoshikane[1], Takehiro Tsuritani[1]; *[1]KDDI R&D Labs., Fujimino, Japan.* This paper shows a comparison of the number of network equipment, network cost and required fiber resource between the flexible-bitrate networks using 100/400-Gb/s signals with the conventional dedicated protection and the emerging shared mesh protection.

W4B.3 • 16:15
Withdrawn.

Room 121

W4C • Long Wavelength VCSELs and Quantum Dot Lasers—Continued

W4C.2 • 16:00 **Invited**
Long Wavelength High Speed VCSELs for Long Haul and Data Centers, Markus Ortsiefer[1], Benjamin Kögel[1], Jürgen Rosskopf[1], Christian Neumeyr[1]; *[1]Vertilas GmbH, Germany.* We present recent progress of long-wavelength VCSELs for optical communications with modulation rates between 10 and 25 Gbps and optical output powers well beyond 1 mW at 90°C which fulfill the requirements for high-performance, cost effective and green photonics.

Room 122

W4D • Slow Light and Multicore Fiber—Continued

W4D.2 • 16:00 *Top-Scored*
Tomographic Algorithm for Transverse Measurement of Multi-Core and Microstructured Optical Fibers, Andrew D. Yablon[1]; *[1]Interfiber Analysis, USA.* A new tomographic algorithm suitable for the transverse measurement of refractive index, residual stress, and spontaneous emission in multi-core and microstructured optical fibers is described and validated against several such fibers.

W4D.3 • 16:15 *Top-Scored*
Multicore-fiber Cable with Core Density of 6 cores/mm^2, Itaru Ishida[1], Yoshimichi Amma[1], Keisuke Hirakawa[1], Hitoshi Uemura[1], Yusuke Sasaki[1], Katsuhiro Takenaga[1], Naoto Ito[2], Ken Osato[2], Shoichiro Matsuo[1]; *[1]Optics and Electronics Laboratory, Fujikura limited, Japan; [2]Optical Fiber Cables R&D Dept., Fujikura limited, Japan.* An Ultra-high density cable with 12-core MCF was presented. A fabricated cable realized core density of 6 cores/mm^2. The change of crosstalk behavior before and after cabling was moderate thanks to adequate cable design.

Room 123

W4E • Novel Optical Schemes—Continued

W4E.3 • 16:00
Pump Attenuation Assisted One-third Harmonic Generation in Silica-germanate Fibers, Tianye Huang[1,2], Xuguang Shao[2], Zhifang Wu[1,2], Timothy Lee[3], Yunxu Sun[2], Huy Quoc Lam[4], Jing Zhang[5], Gilberto Brambilla[3], Ping Shum[1,2]; *[1]CINTRA CNRS/NTU/THALES, Nanyang Technological Univ., Singapore; [2]School of Electrical and Electronic Engineering, Nanyang Technological Univ., Singapore; [3]Optoelectronics Research Center, Univ. of Southampton, Southampton, UK; [4]Temasek Laboratories, Nanyang Technological Univ., Singapore; [5]National Metrology Centre, Agency for Science, Technology and Research (A*STAR), Singapore.* We theoretically study one-third harmonic generation (OTHG) in silica-germanate fibers wherein the efficiency, enhanced by pump attenuation, can reach up to 31% conversion in 34-meter-long fiber, which is 5 times that of the lossless OTHG.

W4E.4 • 16:15 **Invited**
Optical Frequency Combs for Telecom and Datacom Applications, Nikola Alic[1], Stojan Radic[1]; *[1]Qualcomm Inst. of Telecommunications, Univ. of California San Diego, USA.* We demonstrate compliance with and applicability of the new generation comb sources to telecom and datacom applications. The new sources are characterized by OSNRs surpassing 40 dB, encompassing C and L telecom bands.

Room 124

W4F • Signal Processing II—Continued

W4F.3 • 16:00 **Invited**
Applications of LCoS-Based Programmable Optical Processors, Michael A. Roelens[1], Jochen B. Schroeder[2], Patrick Blown[1], Cibby Pulikkaseril[1], Simon Poole[1], Steve Frisken[1]; *[1]Optical Instrumentation Group, Finisar, Australia; [2]CUDOS - School of Physics, The Univ. of Sydney, Australia.* We review the advances enabled by LCoS-based programmable optical processing technology, used in research, industrial and manufacturing applications.

W4G • Coherent PON—Continued

W4G.3 • 16:00
Experimental demonstration of a novel polarization-independent coherent receiver for PONs, Marco Presi[1], Raffaele Corsini[1], Ernesto Ciaramella[1]; *[1]TeCIP Institute, Scuola Superiore di Studi Universitarie di Perfezionamento Sant' Anna di Pisa, Pisa, PI, Italy.* We experimentally demonstrate a novel polarization-independent coherent receiver for low-cost PONs using intensity-modulation and low-cost components. The receiver is successfully tested in a 1.25 Gb/s long reach (66 km, 48 dB ODN loss) system.

W4G.4 • 16:15
Demonstration of 3-ONU Multiplexed Coherent IFDMA-PON Uplink System using Real-Time Prototypes, Kenji Ishii[1], Yuki Yoshida[2], Kiyoshi Onohara[1], Masaki Noda[1], Masamichi Nogami[1], Akihiro Maruta[2], Takashi Mizuochi[1], Ken-ichi Kitayama[2]; *[1]Optical Communication Technology Dept., Mitsubishi Electric Corporation Information Technology R&D center, Kamakura, Kanagawa, Japan; [2]Department of Electrical, Electronic and Information Eng., Osaka University, Suita, Osaka, Japan.* Coherent IFDMA-PON uplink system with 3 multiplexed ONUs is demonstrated experimentally. With a prototype of ONU transmitter and OLT receiver and two offline ONU transmitters, almost no penalty between all of subcarrier assignments was confirmed.

W4H • Network Design Challenges and Implementations—Continued

W4H.3 • 16:00 Invited
The Equinix Network, Lane Patterson[1]; *[1]Equinix, USA.* Abstract not available

Papers are available online for download. Visit www.ofcconference.org and click on the Download Digest Papers button.

W4I • Symposium on Advanced Electro-optic Packaging and Assembly Technologies II—Continued

W4I.2 • 15:55 Invited
Packaging Challenges in Next Generation Coherent Line Sides Components, Robert Blum[1]; *[1]Oclaro, USA.* Starting from lessons learned in the 10G and 40G space we'll present different packaging approaches for these new 100G coherent modules and sub-components and discuss packaging design trade-offs based on thermal and RF simulations.

W4I.3 • 16:15 Invited
Packaging Considerations for VCSEL-based High-density Photonic Interconnects, Mitch H. Fields[1]; *[1]Avago Technologies, USA.* Multilane optics for high-density interconnects are available today in a variety of pluggable-transceiver and board-mounted packaging options. In order to support demand for thousands to tens of thousands of these modules per week, highly efficient packaging and manufacturing technologies are required that do not compromise performance.. In the future, density and performance requirements as well as anticipated demand for such modules beyond hundreds of thousands of units per week will challenge existing capabilities. In this presentation, we explore historically successful packaging and assembly technologies and consider their applicability, as well as the applicability of new technologies, to next-generation high-density optical interconnects.

W4J • Few-Mode Fiber Transmission—Continued

W4J.3 • 16:00
8.96Tb/s (32×28GBaud×32QAM) Transmission over 0.95 km 19 cell Hollow-Core Photonic Bandgap Fiber, Roy van Uden[1], Chigo Okonkwo[1], Haoshuo Chen[1], Natalie V. Wheeler[2], Francesco Poletti[2], Marco Petrovich[2], David J. Richardson[2], Huug Waardt, de[1], A. Koonen[1]; *[1]COBRA Research Inst., Eindhoven Univ. of Technology, Netherlands; [2]Optoelectronics Research Centre, Univ. of Southampton, UK.* The longest coherent transmission distance of 0.95km, and highest distance×bandwidth product 19cell hollow-core photonic bandgap fiber (HC-PBGF) are demonstrated, indicating the potential for longer distance HC-PBGF high capacity coherent transmission applications.

W4J.4 • 16:15 Invited
6×28GBaud 128-SP-QAM Transmission over 41.7 km Few-Mode-Fiber with a 6×6 MIMO FDE, Roy van Uden[1], Chigo Okonkwo[1], Haoshuo Chen[1], Huug Waardt, de[1], A. Koonen[1]; *[1]COBRA Research Inst., Eindhoven Univ. of Technology, Netherlands.* By exploiting 4D constellations, 6×28Gbaud 128-SP-QAM transmission over 41.7km few mode fiber with 6×6 multiple-input multiple-output (MIMO) frequency domain equalization (FDE) is demonstrated to perform better than 8QAM, whilst carrying 0.5bit/symbol more information.

W4K • Carrier Recovery and Phase Noise—Continued

Show Floor Programming

15:30–16:30
The Buzz — A Real-Time Look at the News and Trends Happening at OFC, *Expo Theater II Programming*
For more details, see page 42

15:30–17:00
Workshop on Photonic Startups and Entrepreneurship, *Expo Theater III Programming*
For more details, see page 44

Room 102

W4A • Defragmentation Control—Continued

W4A.4 • 16:30 *Top-Scored*
SDN Control of All-Optical Frequency Conversion and Defragmentation for Super-channels, Francesco Paolucci[1], Nicola Sambo[1], Gianluca Meloni[2], Gianluca Berrettini[1], Francesco Fresi[1], Luca Poti[2], Piero Castoldi[1]; [1]*TeCIP, Scuola Superiore di Studi Universitari e di Perfezionamento Sant' Anna di Pisa, Italy;* [2]*CNIT, Italy.* Frequency conversion and a novel hitless defragmentation technique (based on PPLN waveguide) suitable for super-channels are demonstrated and automatically controlled. Extended OpenFlow sets power and frequency of the pumps responsible for conversion and defragmentation.

W4A.5 • 16:45 Invited
Adaptive Reconfiguration of Sub-lambda and Wavelength Paths for Unpredictable Traffic Demands, Akihiro Kadohata[1]; [1]*NTT Network Innovation Laboratories, Japan.* We have been investigated adaptive reconfiguration of sub-lambda and wavelength paths for unpredictable traffic demands. A numerical evaluation shows effective suppression of the number of fibers and total network equipment cost.

Room 120

W4B • Optical Network Optimization I—Continued

W4B.4 • 16:30
Impact of transponders and regenerators wake-up time on sleep-mode enabled translucent optical networks, Albert Pagès[1], Massimo Tornatore[2], Jordi Perelló[1], Salvatore Spadaro[1], Annalisa Morea[3]; [1]*Universitat Politècnica de Catalunya (UPC), Barcelona, CAT, Spain;* [2]*Politecnico di Milano, Milano, Italy;* [3]*Alcatel Lucent Bell Labs, Vilarceaux, France.* Sleep-mode enabled transponders and regenerators yield to substantial energy savings; however, their non-negligible wake-up time may degrade the network performance. We show that an appropriate dimensioning of the devices per node can compensate such effect

W4B.5 • 16:45
Contentionless and Near Contentionless Blocking Performance and Economics for All Coherent Metro/Regional Networks, Richard Younce[1], Steven Gringeri[2], Yajun Wang[1], Julia Larikova[1]; [1]*Tellabs, Naperville, IL, United States;* [2]*Verizon, Waltham, MA.* Architectural alternatives are considered for networks carrying all coherent transmission. Blocking and network economics are modeled for four high potential add/drop structures and the results provide clear direction for nodal architectural decisions.

Room 121

W4C • Long Wavelength VCSELs and Quantum Dot Lasers—Continued

W4C.3 • 16:30
Low Driving Voltage (< 400mVpp) Electro-absorption Modulator Laterally Integrated with VCSEL, Hamed Dalir[1], Yuta Takahashi[1], Fumio Koyama[1]; [1]*Electronics and Applied Physics, Tokyo Inst. of Technology, Japan.* A compact (8μm long) electro-absorption slow-light modulator is laterally integrated with a 980nm InGaAs VCSEL incorporating a bow-tie-shape oxide aperture. We demonstrate a low driving voltage below 400mVpp and large signal modulation up to 25Gbps.

W4C.4 • 16:45
Bifunctional 1550-nm Tunable Device and Its Transmission Characteristics, Weijian Yang[1], Yi Rao[2], Christopher Chase[2], Stephen Adair Gerke[1], Li Zhu[1], Michael Huang[2], Connie Chang-Hasnain[1]; [1]*Univ. of California Berkeley, USA;* [2]*Bandwidth 10 Inc, USA.* A continuously tunable, high-speed bifunctional device is demonstrated as tunable resonant cavity detector and VCSEL by simply changing bias polarity. Tunable receiver with 33.5-nm wavelength range is obtained. A VCSEL-VCSEL bidirectional communication link is demonstrated.

Room 122

W4D • Slow Light and Multicore Fiber—Continued

W4D.4 • 16:30
Dependence of Crosstalk Increase due to Tight Bend on Core Layout of Multi-Core Fiber, Tetsuya Hayashi[1], Testuya Nakanishi[1], Takashi Sasaki[1], Kunimasa Saitoh[2], Masanori Koshiba[3]; [1]*Optical Communications R&D Laboratories, Sumitomo Electric Industries Ltd, Japan;* [2]*Graduate School of Information Science and Technology, Hokkaido Univ., Japan;* [3]*Hokkaido Univ. Career Center, Japan.* Dependence of the tight-bend-induced crosstalk increase on the core layout is experimentally investigated. The crosstalk increase exponentially decreases with the core-to-core distance increase, and depends on the positions of excited and coupled cores.

W4D.5 • 16:45
Reconfigurable SDM Optical Vector Network Analyzer, Joel A. Carpenter[1], Benjamin J. Eggleton[1], Jochen Schröder[1]; [1]*Univ. of Sydney, Australia.* We present a spatially-diverse optical vector network analyzer which is capable of measuring some or all of the mode transfer matrix of a system in an arbitrary mode basis using single or multiple sweeps.

Room 123

W4E • Novel Optical Schemes—Continued

W4E.5 • 16:45
Erbium-Doped Laser with Multi-segmented Silicon Nitride Structure, Purnawirman Purnawirman[1], Ehsan S. Hosseini[1], Jie Sun[1], Thomas N. Adam[2], Gerry Leake[2], Douglas D. Coolbaugh[2], Michael R. Watts[1], Anna Baldycheva[1], Jonathan D. Bradley[1]; [1]*Massachusetts Inst. of Technology, USA;* [2]*CNSE, Univ. at Albany-SUNY, USA.* We report on DFB and DBR lasers formed from a wavelength insensitive multi-segmented silicon nitride waveguide. Using a five-segment waveguide, we obtain lasing in erbium-doped DBR (-3.6 dBm) and DFB (-7.3 dBm) cavities.

Room 124

W4F • Signal Processing II—Continued

W4F.4 • 16:30
Enhanced Tunable Parametric Delay Assisted by Gain-Transparent Stimulated Brillouin Scattering, liang wang[1,2], Chaoran Huang[2], Xiaofei Cheng[1], Chester Shu[2]; [1]*Inst. for Infocomm Research, A*STAR, Singapore;* [2]*Chinese Univ. of Hong Kong, Hong Kong.* We demonstrate extension of optical parametric delay by enlarging the wavelength conversion bandwidth through dynamic phase-matching control in fiber-based four-wave mixing. The delay range has been increased by 37% from 248 to 340 ps.

W4F.5 • 16:45
A Bandwidth-Tunable Narrowband Rectangular Optical Filter Based on Stimulated Brillouin Scattering, Wei Wei[1], Lilin Yi[1], Yan Zhang[1], Yves Jaouen[2], Yingxiong Song[3], Yi Dong[1], Weisheng Hu[1]; [1]*Shanghai Jiao Tong Univ., China;* [2]*Institut Telecom / Telecom ParisTech, France;* [3]*Shanghai Univ., China.* We present a narrowband rectangular optical filter based on stimulated Brillouin scattering in fiber utilizing digital feedback gain control. The reconfigurable filter with bandwidth from 50 MHz to 3 GHz is demonstrated with 10-MHz resolution.

Room 125

W4G • Coherent PON—Continued

W4G.5 • 16:30 **Tutorial**

Coherent Solution in Optical Access Networks, Dayou Qian[1], [1]*Juniper Networks, Sunnyvale, CA, United States.* Coherent technologies have been introduced to optical access networks because of its outstanding performance, spectrum efficiency, dispersion tolerance, burst-mode support, etc. This tutorial will review some coherent solutions for the next generation PON.

Dayou Qian received the B.S. degree in physics from Tsinghua University, China, the M.S. degree in electrical engineering from the University of California, Los Angeles, and the Ph.D. degree in electrical engineering from Florida International University, Miami, in 2000, 2002, and 2006, respectively. From May 2006 to August 2013, he was a Technical Staff Senior Member at NEC Laboratories America, Princeton, NJ. He is currently a Product Line Manager at Juniper Networks in Sunnyvale, CA. His research interests include optical line/client side interface design and transmission technologies. He has authored more than 100 papers for prestigious journals and conferences. He holds 6 U.S. patents with 38 others pending.

Room 130

W4H • Network Design Challenges and Implementations—Continued

W4H.4 • 16:30

Integrated Packet/Circuit Hybrid Network Field-Trial Demonstrating Sub-Wavelength Aggregation, Steinar Bjornstad[1,2], Raimena Veisllari[1], Jan P. Braute[2], Kurosh Bozorgebrahimi[3]; [1]*Telematics, Norwegian Univ. of Science and Technology, Norway;* [2]*TransPacket, Norway;* [3]*UNINETT, Norway.* We report aggregation of sub-wavelengths in an integrated packet/circuit hybrid optical network. Aggregation of packet streams with circuit quality of service combined with statistical multiplexing enables packet delay variation of only 15ns at 82.4% throughput.

W4H.5 • 16:45

Experimental Demonstration of Centralized Control Mechanism over All-optical Network Based on OpenFlow Protocol, wei yongjian[1], Guo Junhu[2], Ji Yuefeng[1], Li Hui[2]; [1]*State Key Laboratory of Information Photonics and Optical Communications, Beijing Univ. of Posts and Telecommunications, China;* [2]*Beijing Key Laboratory of Network System Architecture and Convergence, Beijing Univ. of Posts and Telecommunications, China.* We experimentally demonstrate a centralized control mechanism to control multiple optical network elements by a single OpenFlow controller. We also extend the OpenFlow protocol to support network functionality in optical transport network.

Room 131

W4I • Symposium on Advanced Electro-optic Packaging and Assembly Technologies II—Continued

W4I.4 • 16:35 **Invited**

Manufacturing Issues for Optical Electronic Data Communications Products, Richard F. Otte[1]; [1]*iNEMI, USA.* Optical electronic communications products require manufacturing assembly processes that combine both electronic and optical technologies. The talk explores several of the basic manufacturing processes that will be needed for emerging products, addresses the cost implications of these processes and describes some processes specific to optical electronic component manufacturing.

This Symposium will be followed by a panel discussion.

Room 132

W4J • Few-Mode Fiber Transmission—Continued

W4J.5 • 16:45 **Invited**

Using Orbital Angular Momentum Modes for Optical Transmission, Jian Wang[1], Alan Willner[2]; [1]*Wuhan National Laboratory for Optoelectronics, Huazhong Univ. of Science and Technology, China;* [2]*Department of Electrical Engineering, Univ. of Southern California, USA.* We reviewed recent works on optical transmission using OAM modes. Free-space OAM transmissions with 100.8Tbit/s capacity, 230.1bit/s/Hz spectral efficiency and 1.6-Tbit/s fiber OAM transmission were demonstrated. OAM networking functionalities and future challenges were discussed.

Room 133

W4K • Carrier Recovery and Phase Noise—Continued

W4K.2 • 16:30

Carrier Phase Estimation for DP-16QAM Using QPSK Partitioning and Quasi-Multiplier-Free Algorithms, Kang Ping Zhong[1], Jian Hong Ke[2], Ying Gao[2], John C. Cartledge[2], Alan Pak tao Lau[3], Chao Lu[1]; [1]*Photonics Research Center, Department of Electronic and Information Engineering, The Hong Kong Polytechnic Univ., Hong Kong;* [2]*Departmennt of Electrical and Computer Engineering, Queen's Univ., Canada;* [3]*Photonics Research Center, Department of Electrical Engineering, The Hong Kong Polytechnic Univ., Hong Kong.* A low complexity and linewidth tolerant two-stage carrier phase estimation (CPE) by using QPSK partitioning and quasi-multiplier free algorithm is proposed for DP-16QAM signal. The performance, linewidth tolerance the algorithm are numerically and experimentally demonstrated.

W4K.3 • 16:45

Homodyne OFDM using Simple Optical Carrier Recovery, Zhixin Liu[1], David S. Wu[1], David J. Richardson[1], Radan Slavik[1]; [1]*Univ. of Southampton, UK.* We use optical injection locking for carrier recovery in RF-pilot aided OFDM. Any need for optical prefiltering is eliminated and only narrow guard bands are required. Improved performance with respect to heterodyne detection is demonstrated.

Show Floor Programming

15:30–16:30
The Buzz — A Real-Time Look at the News and Trends Happening at OFC, *Expo Theater II Programming*
For more details, see page 42

15:30–17:00
Workshop on Photonic Startups and Entrepreneurship, *Expo Theater III Programming*
For more details, see page 44

Room 102

W4A • Defragmentation Control—Continued

W4A.6 • 17:15
Reduce Spectrum Defragmentation Latency in EONs with Effective Parallelization of Connection Reconfigurations, Changsheng You[1], Mingyang Zhang[1], Zuqing Zhu[1]; *[1]School of Information Science and Technology, Univ. of Science and Technology of China, China.* We investigate parallel defragmentation and propose a novel algorithm to achieve effective parallelization of the connection reconfigurations with a conflict graph. Simulation results show that the algorithm can effectively reduce the latency of traffic migrations.

Room 120

Room 121

W4C • Long Wavelength VCSELs and Quantum Dot Lasers—Continued

W4C.5 • 17:00 *Top-Scored*
High Performance 1.3μm InAs Quantum Dot Lasers Epitaxially Grown on Silicon, Alan Y. Liu[1], Chong Zhang[2], Andrew Snyder[3], Dimitri Lubychev[3], Joel M. Fastenau[3], Amy Liu[3], Arthur C. Gossard[1,2], John E. Bowers[1,2]; *[1]Materials, Univ. of California Santa Barbara, USA; [2]Electrical and Computer Engineering, Univ. of California Santa Barbara, USA; [3]IQE Inc., USA.* We demonstrate 1.3 μm InAs quantum dot lasers on silicon by molecular beam epitaxial growth with low thresholds (16 mA), high output power (>50 mW), high T0 (>200 K), and high temperature lasing (115 °C).

W4C.6 • 17:15
Modular Hybrid Dilated Mach-Zehnder Switch with Integrated SOAs for Large Port Count Switches, Qixiang Cheng[1], Adrian Wonfor[1], JinLong Wei[1], Richard V. Penty[1], Ian White[1]; *[1]Engineering Department, Univ. of Cambridge, UK.* A modular dilated MZI based optical switch with integrated SOAs is demonstrated with excellent -40dB crosstalk/extinction ratio, 3ns switching time and nearly penalty-free operation. Studies show an 8x8 switch with 14dB IPDR for 0.5dB penalty.

Room 122

W4D • Slow Light and Multicore Fiber—Continued

W4D.6 • 17:00
Development of Small MT Type 2-multicore Fiber Connector, Kengo Watanabe[1], Tsunetoshi Saito[1], Katsuki Suematsu[1], Ryo Nagase[2], Masato Shiino[1]; *[1]Furukawa Electric Co., Ltd., Japan; [2]Chiba Inst. of Technology, Japan.* We developed small MT type 2-MCF connector. PC condition for MT type MCF connector was studied theoretically and experimentally. Fabricated 2-MCF connector demonstrated return loss more than 46dB and connection loss less than Demonstration of 10G Burst-Mode DML and EDC in Symmetric 40Gbit/s TWDM-PON over 40km Passive Reach

Room 123

Room 124

W4F • Signal Processing II—Continued

W4F.6 • 17:00 **Invited**
All Optical Processing in QD-SOAs, Giampiero Contestabile[1]; *[1]Scuola Superiore Sant Anna di Pisa, Italy.* High-gain InAs QD-SOAs are promising active devices for efficient, broadband and high-speed signal processing. Recent results about wavelength conversion of intensity modulated and coherent signals are reviewed.

Room 125

W4G • Coherent PON—Continued

Room 130

W4H • Network Design Challenges and Implementations—Continued

W4H.6 • 17:00 Invited
Optical Networking Applications in the Mobile Backhaul and Fronthaul (geared toward Reliance Infotel), Anuj Jain[1]; [1]*Reliance Infotel, India.* Abstract Not Available

Room 131

W4I • Symposium on Advanced Electro-optic Packaging and Assembly Technologies II—Continued

Panel 2 - Board and Assembly
Introduction:
Lionel Kimerling, MIT, USA

16:50
Needed Advancements in Packaging and Assembly for Telecom Applications; Roman Egerov, *Verizon, US*

17:05
Packaging Optical Engines; Mehdi Asghari, *Mellanox, USA*

17:20
On the Way to the Photonic Router; Kobi Hasharoni, *Compass-EOS, Israel*

17:25
OPEN DISCUSSION

Room 132

W4J • Few-Mode Fiber Transmission—Continued

Room 133

W4K • Carrier Recovery and Phase Noise—Continued

W4K.4 • 17:00
A Study of Laser White and Brownian FM Noise in Coherent QPSK Signals, Keisuke Matsuda[1], Hiroshi Bessho[1], Kiyotomo Hasegawa[1], Tsuyoshi Yoshida[1], Kazuyuki Ishida[1]; [1]*Information Technology R&D Center, Mitsubishi Electric Corporation, Japan.* We studied laser noise numerically and experimentally in terms of frequency variance within frequency estimation response time, and showed that a normalized variance below 1×10^{-6} is required to limit the penalty to 0.5 dB.

W4K.5 • 17:15
Overcoming the Effect of Cycle Slips Caused by Low Frequency Noise from Monolithic Tunable Lasers, Tam N. Huynh[1], Liam P. Barry[1]; [1]*School of Electronic Engineering, Dublin City Univ., Ireland.* We investigate cycle slip effects of monolithic tunable lasers in a 10.7 Gbaud QPSK system employing feedback or feed-forward phase tracking algorithms. Experimental results demonstrate an increased probability of cycle slip due to low frequency noise in SGDBR lasers.

NOTES

Room 102

08:00–10:00
Th1A • Silicon Nitride and Liquid Crystal Devices
Presider: Takashi Saida; NTT Corporation, Japan

Th1A.1 • 08:00
Low Loss (<0.2dB per transition) CMOS Compatible Multi-Layer Si3N4-on-SOI Platform with Thermal-Optics Device Integration for Silicon Photonics, Ying Huang[1], Xianshu Luo[1], Junfeng Song[1], Tsung-Yang Liow[1], Patrick Guo-Qiang Lo[1]; [1]*Inst. of Microelectronics, A*STAR, Singapore.* A multi-layer Si3N4-on-SOI platform is demonstrated, achieving <0.2dB transition loss between layers over 70nm bandwidth. 0.8dB/cm propagation loss is measured for PECVD Si3N4 waveguide at λ=1580nm. Thermal-optic micro-ring filter is also integrated on the platform.

Th1A.2 • 08:15
Integrated Single and Multi-layer Si3N4 Platform for Ultra-low Loss Propagation and Small Bending Radii, Daryl T. Spencer[1], Martijn Heck[1], Renan Moreira[1], Jock T. Bovington[1], John E. Bowers[1], Arne Leinse[2], H.H. van den Vlekkert[2], Rene G. Heideman[2], Marcel Hoekman[2], Theo T. Veenstra[2]; [1]*Electrical and Computer Engineering, Univ. of California Santa Barbara, USA;* [2]*LioniX BV, Netherlands.* A combination of low loss and small bend radius Si3N4 waveguide regions are integrated with one etch step. Propagation losses of 1.5 dB/m and 7 dB/m are measured with a transition loss of ≤0.5 dB/taper.

Room 120

08:00–10:00
Th1B • Panel: 100G Deployment on Submarine Links

Organizers: Alexei Pilipetski, *TE Subcomm, USA;* and Michel Belanger, *Ciena, Canada*

Undersea systems have the longest reach among all optical transmission links. This represents a unique set of challenges in deploying spectrally efficient high bit rate transmission technologies. Nevertheless in response to the increasing capacity demand 100Gb/s coherent transmission technology made its way into the submarine space. The objective of this workshop is to review a number of topics including: how 100G technology helps in meeting capacity demand, the status of the 100G deployments, the benefits and upgrade potential of using 100G technology on the existing submarine links, impact of 100G coherent technology on the new system designs and their capabilities, and what can be expected beyond 100G. The workshop will cover the views of global system operators, transmission equipment manufactures and turn-key system suppliers.

Speakers:

Neal S. Bergano, *TE SubCom, USA*

José Chesnoy, *Alcatel-Lucent Submarine Networks, France*

Herve Fevrier, *Xtera Communications, Inc, USA*

Howard Kidorf, *Pioneer Consulting, USA*

Loren Berg, *Ciena Corporation, USA*

Glenn Wellbrock, *Director of Technology, Verizon Communications, USA*

Room 121

08:00–10:00
Th1C • Silicon Photonics I
Presider: Huapu Pan; FutureWei Technologies, Inc., USA

Th1C.1 • 08:00 **Invited**
A Path to 300 mm Hybrid Silicon Photonic Integrated Circuits, John E. Bowers[1], Jock T. Bovington[1], Alan Y. Liu[1], Arthur C. Gossard[1]; [1]*Univ. of California Santa Barbara, USA.* We describe recent advances in hybrid silicon components and photonic integrated circuits. We present a path towards scalable, ultralow cost photonic integrated circuits (PICs) on 300 mm silicon substrates.

Room 122

08:00–10:00
Th1D • Network Subsystem
Presider: Nicola Calabretta; Technische Universiteit Eindhoven, Netherlands

Th1D.1 • 08:00 **Invited**
Integrated Silicon Photonics Links for High Bandwidth Data Transportation, Hai-Feng Liu[1]; [1]*Intel Corporation, USA.* We review the technology development of integrated silicon photonics CWDM links, and demonstrate the transmission of 25Gb/s signals from integrated silicon photonics transceivers over a record 820m MMF optimized for high modal bandwidth at 1310 nm.

Room 123

Room 124

08:00–10:00
Th1E • Planning I
Presider: Akira Hirano; NTT, USA

Th1E.1 • 08:00 **Invited**
On the Role of Open-Source Optical Network Planning, Pablo Pavon-Marino[1], Jose-Luis Izquierdo-Zaragoza[1]; [1]*Technical Univ. of Cartagena, Spain.* We argue that open source network planning tools like Net2Plan, and related open repositories of planning resources, can help to bridge the gap between academia and industry speeding-up technology transfer of network planning investigations.

NOTES

Room 125

08:00–10:00
Th1F • Visible Light Communications

Presider: Neda Cvijetic; NEC Laboratories America Inc, USA

Th1F.1 • 08:00
3.25-Gbps Visible Light Communication System based on Single Carrier Frequency Domain Equalization Utilizing an RGB LED, Yuanquan Wang[1], Rongling Li[1], Yiguang Wang[1], Ziran Zhang[1]; [1]*Department of Communication Science and Engineering, Fudan Univ., China*. A 3.25-Gbps VLC-system applying 512QAM SC-FDE is experimentally demonstrated for the first time using an RGB-LED with 3-dB bandwidth of 10MHz. The BERs for all 3 wavelength channels are below the pre-FEC threshold of 3.8x10-3.

Th1F.2 • 08:15
Bi-directional 400 Mbit/s LED-based Optical Wireless communication for Non directed Line of Sight Transmission, Giulio Cossu[1], Raffaele Corsini[1], Amir M. Khalid[1], Ernesto Ciaramella[1]; [1]*Scuola Superiore Sant Anna di Pisa, Italy.* We experimentally demonstrate a 400 Mbit/s bi-directional optical wireless transmission operating in non-directed line-of-sight configuration, based on visible/infrared LEDs for downlink/uplink, exploiting adaptive Discrete Multi-Tone technique and optimized optical filters.

Room 130

08:00–10:00
Th1G • Applications & Deployments of FTTx

Presider: Rajesh Yadav; Verizon, USA

Th1G.1 • 08:00
FTTH Challenges in Latin America, Nelson H. Saito[1]; [1]*Furukawa Industrial SA Produtos Elétrico, Brazil*. FTTH is already a reality in the LATAM region. We investigated the causes of the difficulty of implementing a larger FTTH network in LATAM region, challenges & issues will be analyzed in this paper.

Th1G.2 • 08:15
Optical Fiber Runs through "In-Unit" with 0.9mm Drop, Clear Clips and Epoxy with Invisible Tracks, Christopher D. Levendos[1], Christina M. Colasanto[1], John L. Carey[1], Keith E. Kidd[1], Martin Durkin[1], Michael A. Chilicki[1], Patrick B. Anderson[1], Robert C. Ditmore[1], Sherry Hessenthaler[1], David Z. Chen[1]; [1]*Maint. Eng. Support, Verizon Communications Inc, USA*. Verizon has successfully initiated and deployed an innovative drop cable solution for the installation of FTTh services in existing, residential Multi-Dwelling-Unit applications. The new In-Unit cable consists of 0.9mm drop with G.657.B3 fiber and a field spliceable, mechanical connector.

Room 131

08:00–09:45
Th1H • Novel Amplification Technologies & Signal Processors

Presider: Ping Piu Kuo; Univ. of California San Diego, USA

Th1H.1 • 08:00 **Tutorial**
Amplification Technologies for Future Capacity and Reach Enhancements, Peter A. Andrekson[1]; [1]*Chalmers Tekniska Hogskola, Sweden*. A review of optical amplifier technologies will be given with the purpose to illustrate possible ways forward to delay the "capacity crunch". This includes Raman and parametric amplifiers as well as multi-core/few-mode amplifiers.

Andrekson is Professor of Photonics and previously spent several years in the US (Bell Labs, Cenix Inc., Lehigh University). His research interests include amplifiers, all-optical functionalities, and high spectral efficiency transmission. He co-founded Picosolve, now part of EXFO where he is a Director. Andrekson is a Fellow of the OSA and the IEEE and author of four-hundred scientific publications. He was member of the Board of Governors for the IEEE Photonics Society and has served as an expert for the evaluation of the Nobel Prize in Physics. Currently he holds an ERC Advanced Grant for work on phase-sensitive optical amplifiers.

Room 132

08:00–10:00
Th1I • Next Generation ROADM and Photonic Switch Architechures

Presider: Xi Wang; Fujitsu Laboratories of America, USA

Th1I.1 • 08:00
Gaussian Noise Model Aided In-band Crosstalk Analysis in ROADM-enabled DWDM Networks, Jie Pan[1], Pierre Isautier[1], Mark Filer[2], Sorin Tibuleac[2], Stephen Ralph[1]; [1]*Georgia Inst. of Technology, USA;* [2]*ADVA Optical Networking, USA*. We extend crosstalk weighting metric to the nonlinear region and combined with Gaussian noise model for system analysis and performance predictions. Nonlinear parametric interaction between crosstalk and signal is analyzed by simulation and experiment.

Th1I.2 • 08:15
N-degree ROADM Architecture Comparison: Broadcast-and-Select Versus Route-and-Select in 120 Gb/s DP-QPSK Transmission Systems, Mark M. Filer[1], Sorin Tibuleac[1]; [1]*R&D Optical Systems, ADVA Optical Networking SE, USA*. ROADM systems utilizing 4- and 9-degree broadcast-and-select or route-and-select architectures are studied experimentally with 120 Gb/s DP-QPSK transmission. Effects arising from passband narrowing and crosstalk accumulation due to non-ideal WSS filtering are considered concurrently.

Room 133

08:00–09:30
Th1J • SDM Theory & Characterization

Presider: Mark Shtaif; Tel-Aviv Univ., Israel

Th1J.1 • 08:00 **Tutorial**
Mode Division Multiplexed Transmission Systems, Peter J. Winzer[1], G. J. Foschini[1]; [1]*Alcatel-Lucent Bell Labs, USA*. We review multiple-input multiple-output space-division multiplexed (MIMO-SDM) system capacities and component characteristics, such as multiplexer crosstalk, modedependent loss/gain, distributed mode-dependent noise, and differential modal group delay.

Room 102

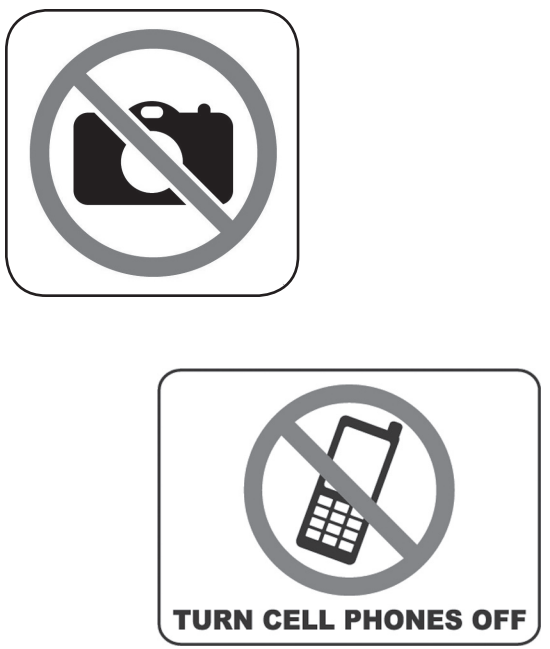
Th1A • Silicon Nitride and Liquid Crystal Devices—Continued

Th1A.3 • 08:30
Si3N4-on-SOI Polarization Rotator-Splitter Based on TM0-TE1 Mode Conversion, Wesley D. Sacher[1], Ying Huang[2], Ding Liang[2], Tymon Barwicz[3], Jared C. Mikkelsen[1], Benjamin J. Taylor[1], Patrick Guo-Qiang Lo[2], Joyce Poon[1]; *[1]Univ. of Toronto, Canada; [2]Inst. of Microelectronics, A*STAR, Singapore; [3]IBM Thomas J. Watson Research Center, USA.* A polarization rotator-splitter is demonstrated using a Si3N4 waveguide atop a silicon waveguide. The device exhibits polarization crosstalk < -19 dB, loss < 1.5 dB, and PDL < 1.0 dB over an 80 nm bandwidth.

Th1A.4 • 08:45
High Efficiency Silicon Nitride Grating Coupler with DBR, Huijuan Zhang[1], Chao Li[1], Xiaoguang Tu[1], Haifeng Zhou[1], Xianshu Luo[1], Mingbin Yu[1], Patrick Guo-Qiang Lo[1]; *[1]Inst. of Microelectronics, Singapore.* We have designed and demonstrated high efficiency Silicon nitride grating couplers with two periods of distributed Bragg reflectors at 1490 nm. The peak coupling efficiency is ~-2.6 dB and the 1-dB bandwidth is ~53 nm.

Room 120

Th1B • Panel: 100G Deployment on Submarine Links—Continued



Room 121

Th1C • Silicon Photonics I—Continued

Th1C.2 • 08:30 Invited
A CMOS Wafer-Scale, Monolithically Integrated WDM Platform for TB/s Optical Interconnects, Guoliang Li[1], Timothy Creazzo[1], Elton Marchena[1], Paul K. L. Yu[1], Stephen Krasulick[1]; *[1]Skorpios Technologies Inc., USA.* We present a unique Si photonics platform with butt-coupled III-V and SOI waveguides fabricated in a wafer-scale CMOS process. This enables high-efficiency lasers, modulators, photodetectors, and tuning-free Mux/Demux, which is ideal for TB/s optical interconnects.

Room 122

Th1D • Network Subsystem—Continued

Th1D.2 • 08:30
Demonstration of 1-to-13 PDM-8QAM SCFDM Superchannel Multicasting in HNLF, Paikun Zhu[1], Juhao Li[1], Yuanxiang Chen[1], Yingying Xu[1], Nan Zhang[1], Bingli Guo[1], Zhangyuan Chen[1], Yongqi He[1]; *[1]State Key Laboratory of Advanced Optical Communication Systems and Networks, Peking Univ., China.* All-optical superchannel multicasting is promising for flexible data grooming in future optical networks. In this work, we experimentally demonstrate 1-to-13 multicasting of 240 Gb/s PDM-8QAM SCFDM superchannel in HNLF.

Th1D.3 • 08:45 *Top-Scored*
Distributed Generation of a 400-Gb/s Nyquist 16QAM Dense Superchannel by Fiber-Frequency Conversion, Thomas Richter[1], Carsten Schmidt-Langhorst[1], Robert Elschner[1], Tomoyuki Kato[2], Shigeki Watanabe[2], Colja Schubert[1]; *[1]Photonic Networks and Systems, Fraunhofer Inst. for Telecommunications, Heinrich Hertz Inst., Germany; [2]Fujitsu Laboratories Ltd., Japan.* We generate an ultra-dense 400-Gb/s superchannel by combining four spatially distributed 28-GBd-Nyquist-16QAM-sub-carrier transmitters using optical processing in nonlinear fibers. The multiplexed sub-carriers are precisely frequency-allocated with guard bands down to 0% and achieve bit-error ratios below 3.8×10-3.

Room 123

Room 124

Th1E • Planning I—Continued

Th1E.2 • 08:30
Network-Efficient Superchannel Transmission by the Multichannel Compensation of Nonlinearities, Tiago Lima[1], Valery Rozental[1], André Barreto[1], Darli Mello[1]; *[1]Department of Electrical Engineering, Univ. of Brasilia, Brazil.* We investigate potential network-cost savings due to the multichannel compensation of nonlinearities generated by subcarriers within the same superchannel. Two case studies (European and German networks) demonstrated tangible cost reductions (6-11%) using 5 adjacent subcarriers.

Th1E.3 • 08:45
Finding an Objective Cost for Sliceable Flexgrid Transponders, Luis Velasco[1], Oscar Gonzalez de dios[2], Victor Lopez[2], Juan-Pedro Fernández-Palacios[2], Gabriel Junyent[1]; *[1]Optical Communications Group (GCO), Universitat Politecnica de Catalunya (UPC), Spain; [2]Telefónica, Investigación y Desarrollo, Spain.* We analyze the objective cost of SBVTs as a function of the traffic conveyed by IP/MPLS-over-flexgrid networks. Optimal results show that cost increment with respect to BVTs is related to the aggregation level.

Room 125

Th1F • Visible Light Communications—Continued

Th1F.3 • 08:30
LED-based Visible Light Communication in a Practical Indoor Interfered Environment Employing DMT and STBC, Chia Chien Wei[1], Fang-MIng Wu[2], Zhen-Yu Chen[1], Chun-Ting Lin[2], Yung-Jui Chen[1], Sien Chi[3]; *[1]Department of Photonics, National Sun Yat-sen Univ., Taiwan; [2]Inst. of Photonic System, National Chiao Tung Univ., Taiwan; [3]Department of Photonics, National Chiao Tung Univ., Taiwan.* We demonstrate practical indoor VLC of 3.2-m transmission, and investigate multipath interference between LEDs. Employing repetition coding, 161~266-Mbps DMT-signals are achieved depending on interference severity. Employing STBC, about fixed 220-Mbps data rate could be achieved.

Th1F.4 • 08:45
Next Generation Visible Light Communications: 10 Mb/s with Polymer Light-Emitting Diodes, Paul A. Haigh[1,2], Francesco Bausi[3,4], Zabih Ghassemlooy[1], Ioannis Papakonstantinou[2,4], Hoa Le Minh[1], Charlotte Flechon[3,4], Franco Cacialli[3,4]; *[1]Faculty of Engineering and Environment, Northumbria Univ., UK; [2]Department of Electronic and Electrical Engineering, Univ. College London, UK; [3]Department of Physics, Univ. College London, UK; [4]London Centre of Nanotechnology, Univ. College London, UK.* The first 10 Mb/s real-time organic visible light communications system based on polymer light-emitting diodes is demonstrated using a Virtex-6 FPGA-based LMS equalizer, with an improvement rate of 7 Mb/s compared to the current state-of-the-art.

Room 130

Th1G • Applications & Deployments of FTTx—Continued

Th1G.3 • 08:30
The Impact of Inter-platform Competition on the Economic Viability of Municipal Fiber Networks, Mathieu Tahon[1], Marlies Van der Wee[1], Sofie Verbrugge[1], Didier Colle[1], Mario Pickavet[1]; *[1]Ghent Univ. - iMinds, Belgium.* Local authorities investing in fiber broadband networks must meet the market investor principle. We apply a game theoretic approach to model the impact of inter-platform competition on the viability of the fiber business case.

Th1G.4 • 08:45 Invited
SDN and Potential Applicability to Access Networks, Nabil Bitar[1]; *[1]Verizon, USA.* This paper explores the applicability of the Software Defined Networking (SDN) paradigm to access networks. In particular, it describes Broadband and Enterprise use cases where SDN can play a role in enabling new network services.

Room 131

Th1H • Novel Amplification Technologies & Signal Processors—Continued

Room 132

Th1I • Next Generation ROADM and Photonic Switch Architechures—Continued

Th1I.3 • 08:30 Invited
Next Generation Photonic Node Architecture Using Software-defined Universal Transceivers, Yasuhiko Aoki[1], Xi Wang[2], Goji Nakagawa[1], Shoichiro Oda[1], Kyosuke Sone[1], Takahito Tanimura[1], Takeshi Hoshida[3], Paparao Palacharla[2], Motoyoshi Sekiya[2], Jens Rasmussen[1]; *[1]Fujitsu Laboratories Ltd., Japan; [2]Fujitsu Laboratories of America, Inc., USA; [3]Fujitsu Ltd., Japan.* Flexible and dynamic photonic node architecture for next generation software defined photonic network is described. The pooling architecture of universal transceivers provides the better utilization of network element.

Room 133

Th1J • SDM Theory & Characterization—Continued

Room 102

Th1A • Silicon Nitride and Liquid Crystal Devices—Continued

Th1A.5 • 09:00
Low-loss/Large-tolerance Mode Converter Between SiN Waveguide and Cleaved Single Mode Fiber, Lianxi Jia[1], Junfeng Song[1,2], Tsung-Yang Liow[1], Xianshu Luo[1], Xiaoguang Tu[1], Qing Fang[1], Edward Koh Sing Chen[1], Mingbin Yu[1], Patrick Guo-Qiang Lo[1]; *[1]Inst. of Microelectronics, Singapore; [2]State Key Laboratory on Integrated opto-electronics, China*. A mode converter is fabricated with SiON to reduce coupling loss between SiN waveguide and cleaved single-mode-fiber. The coupling loss is 1.2 and 1.4dB/facet for TE and TM mode with 3dB alignment tolerance of ±3.5μm.

Th1A.6 • 09:15
Transmission of a 1.44 Tbit/s Data Stream using a Feedback-Stabilized SiN Kerr Frequency Comb Source, Joerg Pfeifle[1], Yimin Yu[1], Philipp Schindler[1], Victor Brasch[2], Tobias Herr[2], Claudius Weimann[1], Klaus Hartinger[3], Ronald Holzwarth[3,4], Wolfgang Freude[1,5], Tobias J. Kippenberg[2], Christian Koos[1,5]; *[1]Inst. of Photonics and Quantum Electronics, Karlsruhe Inst. of Technology, Germany; [2]Ecole Polytechnique Federale de Lausanne, Switzerland; [3]Menlo Systems GmbH, Germany; [4]Max-Planck-Institut für Quantenoptik, Germany; [5]Inst. of Microstuctrue Technology, Karlsruhe Inst. of Technology, Germany.* Using a high-Q Kerr-nonlinear SiN microresonator as a frequency comb source we generate a 1.44 Tbit/s (20×18 GBd PDM-QPSK) data stream and transmit it over 300 km. The comb is stabilized by a feedback control.

Room 120

Th1B • Panel: 100G Deployment on Submarine Links—Continued

Room 121

Th1C • Silicon Photonics I—Continued

Th1C.3 • 09:00
An 8-Wavelength Laser Array with High Back Reflection Tolerance for High-Speed Silicon Photonic Transmitters, Laurent Schares[1], Yoon H. Lee[1,3], Daniel Kuchta[1], Uzi Koren[2], Len Ketelsen[2]; *[1]IBM TJ Watson Research Center, USA; [2]Avago Technologies, USA; [3]Cornell Univ., USA*. We have developed quarter-wave shifted laser arrays with embedded bare patch regions. As cw-light sources in 40-Gb/s links, these lasers show over 10 dB improvement in back reflection tolerance compared to a standard DFB reference design.

Th1C.4 • 09:15
Strain-induced Enhancement of Free-carrier Effects in SiGe for Optical Modulator and VOA Applications, Younghyun Kim[1], Mitsuru Takenaka[1], Takenori Osada[2], Masahiko Hata[2], Shinichi Takagi[1]; *[1]Univ. of Tokyo, Japan; [2]Sumitomo Chemical Co. Ltd, Japan.* Enhanced free-carrier effects in strained SiGe enable high-efficiency VOA, exhibiting 1/3 of power consumption of Si. The broadband operation from 1.34 to 1.64 μm and error-free operation for 18-dBm 12.5 Gb/s optical signal are obtained.

Room 122

Th1D • Network Subsystem—Continued

Th1D.4 • 09:00
640 Gbit/s Optical Packet Switching using a Novel In-Band Optical Notch-Filter Labeling Scheme, Ashenafi Kiros Medhin[1], Leif Katsuo Oxenløwe[1], Michael Galili[1]; *[1]Departement of Photonics Engineering, Technical Univ. of Denamrk, Denmark*. Optical packet switching of 640 Gbit/s data packets is reported using an in-band optical labeling technique based on notch-filtering of the data spectrum and extracting the label using a bandpass filter. BER 10^{-9} is achieved.

Th1D.5 • 09:15
Dynamic Routing of Millimeter-Wave Signal for In-Building Networks Using Integrated Resonant Switch Matrix, Jim (Shihuan) Zou[1], Prometheus DasMahapatra[1], Patty Stabile[1], Kevin Williams[1], E. Tangdiongga[1], A. Koonen[1]; *[1]COBRA, Eindhoven Univ. of Technology, Netherlands*. We demonstrate dynamic routing between millimeter-wave pico-cells for in-building networks by using an integrated resonant switch matrix. The 128-QAM mm-wave signal exhibits an EVM of only 2.3% in the dynamic operation.

Room 123

Room 124

Th1E • Planning I—Continued

Th1E.4 • 09:00
Impact of Reducing Channel Spacing from 50GHz to 37.5GHz in Fully Transparent Meshed Networks, Annalisa Morea[1], Jérémie Renaudier[1], Amirhossein Ghazisaeidi[1], Oriol Bertran Pardo[2], Thierry Zami[2]; *[1]Alcatel-Lucent, France; [2]Alcatel-Lucent France, France*. Accounting for tight filtering impairments, we show why the ideal extra capacity of 33% brought by 37.5GHz channel spacing (compared to 50GHz) may be significantly reduced under physical constraints of fully transparent meshed networks.

Th1E.5 • 09:15
Optimized Amplifier Placements for Improved Energy and Spectral Efficiency in Protected Mixed-Line-Rate Networks, Jorge Lopez Vizcaino[1,3], Yabin Ye[1], Felipe Jimenez[2], Andres Macho[2], Peter Krummrich[3]; *[1]Huawei Technologies Duesseldorf GmbH, Germany; [2]Telefónica I+D, Spain; [3]Technische Universitaet Dortmund, Germany.* We propose the selective placement of additional amplifiers to augment the energy and spectral efficiency of protected mixed-line-rate WDM scenarios. Significant energy efficiency per GHz improvements, network capacity enlargements and blocking reduction are achieved.

Th1F • Visible Light Communications—Continued

Th1F.5 • 09:00 **Tutorial**

High-speed Optical Wireless Communications Technologies, Volker Jungnickel[1]; [1]*Fraunhofer HHI, Germany.* This tutorial provides a review on high-speed optical wireless communications: Application scenarios, indoor propagation, adaptive transmission schemes using OFDM and single carrier, WDM, recent milestones reached and early ideas towards "cellular" optical wireless networks.

VOLKER JUNGNICKEL received a Dr. rer. nat. (Ph.D.) degree in physics from Humboldt University in Berlin in 1995. He worked on semiconductor quantum dots and laser medicine and joined Fraunhofer HHI in 1997. Since 2003, he is an adjunct lecturer at TU Berlin and project leader at HHI. He has contributed to high-speed indoor optical wireless links, first 1 Gb/s MIMO-OFDM mobile radio transmission experiments, a first real-time implementation and field trials for the LTE standard and using joint transmission coordinated multipoint (JT CoMP). He has authored and co-authored more than 160 conference and journal papers, book chapters and patents.

Th1G • Applications & Deployments of FTTx—Continued

Th1G.5 • 09:15 **Invited**

Mobile Backhaul Synchronization Requirements for Broadband Access Networks, Bill Powell[1]; [1]*Fixed Networks CTO Group, Alcatel-Lucent, USA.* There is a growing use of access networks to deliver not only wireless backhaul traffic, but also precise Time of Day (ToD) synchronization to wireless base stations. This is supported via enhancements to these technologies.

Th1H • Novel Amplification Technologies & Signal Processors—Continued

Th1H.2 • 09:00

Wavelength Conversion of QPSK Signals in Single-Pump FOPA with 20 dB Conversion Efficiency, Eduardo Temprana[1], Vahid Ataie[1], Ana Peric[1], Nikola Alic[1], Stojan Radic[1]; [1]*Electrical and Computer Engineering, UCSD, USA.* We demonstrate wavelength conversion of QPSK signals in a single-pump FOPA with 20 dB conversion efficiency. Phase distortions in the idler arising from pump-phase modulation were compensated after coherent detection using a novel time-domain approach.

Th1H.3 • 09:15 *Top-Scored*

Linear and Nonlinear Transmission of 16-QAM Over 105 km Phase-Sensitive Amplified Link, Samuel L. Olsson[1], Tobias A. Eriksson[1], Carl Lundström[1], Magnus Karlsson[1], Peter A. Andrekson[1]; [1]*Chalmers Univ. of Technology, Sweden.* We demonstrate 16-QAM transmission over a 105 km phase-sensitive amplified link showing significantly improved performance in both the linear and nonlinear propagation regime. Constellation and BER measurements are performed.

Th1I • Next Generation ROADM and Photonic Switch Architechures—Continued

Th1I.4 • 09:00

Crosstalk Optimization in Low Extinction-ratio Switch Fabrics, Yi Qian[1], Hamid Mehrvar[2], Huixiao Ma[1], Xiaoling Yang[1], Kun Zhu[1], H.Y. Fu[1], Dongyu Geng[1], Dominic Goodwill[2], Patrick Dumais[2], Eric Bernier[2]; [1]*Communication Technology Lab, Huawei Technologies Co., Ltd., China;* [2]*Huawei Technology Canada Co., LTD., Canada.* Intelligently setting nominally-idle cells in a PIC photonic switch reduces crosstalk. 100Gb/s DP-QPSK simulation shows 0.3dB OSNR improvement, for 13dB extinction ratio of a practical silicon photonic switch cell. The method operates correctly in a 10Gb/s NRZ test-bed.

Th1I.5 • 09:15

Silica-based PLC 1×N Switch for All Wavelength Bands, Toshio Watanabe[1], Takayuki Mizuno[1], Yasuaki Hashizume[1], Tetsuo Takahashi[1]; [1]*NTT Photonics Laboratories, NTT Corporation, Japan.* We describe a silica-based PLC switch that operates over a wavelength range of 1260-1610 nm. The fabricated 1×15 switch exhibits a WDL of <1.1 dB and an isolation of >40 dB with a low power consumption of 0.51 W.

Th1J • SDM Theory & Characterization—Continued

Th1J.2 • 09:00

Characterization of Mode-Dependent Loss in SDM Systems, Anton Andrusier[1], Mark Shtaif[1], Cristian Antonelli[2], Antonio Mecozzi[2]; [1]*Tel Aviv Univ., Israel;* [2]*Universita degli Studi dell'Aquila, Italy.* We show that mode dependent loss (MDL) in SDM systems can be effectively characterized by means of two scalar parameters. These parameters can be measured by means of a simple procedure and are uniquely related to the system capacity reduction caused by MDL.

Th1J.3 • 09:15

Experimental Time and Frequency Domain MIMO Channel Matrix Characterization versus Distance for 6×28Gbaud QPSK Transmission over 40×25km Few Mode Fiber, Neda Cvijetic[1], Ezra Ip[1], Narayan Prasad[1], Ming-Jun Li[2], Ting Wang[1]; [1]*NEC Laboratories America Inc, USA;* [2]*Corning Inc., USA.* We present the first experimental time- and frequency-domain MIMO channel matrix characterization versus distance for 6×28Gbaud recirculating loop transmission over 40×25km FMF. Beyond 10dB time- and frequency-domain singular-value spreads are observed, motivating nonlinear MIMO equalization.

Room 102

Th1A • Silicon Nitride and Liquid Crystal Devices—Continued

Th1A.7 • 09:30
Variable Optical Power Splitter with Field-Induced Waveguides in Liquid Crystals in Paranematic Phase, Florenta Costache[1], Haldor Hartwig[1], Kirstin Bornhorst[1], Martin Blasl[1]; *[1]Smart Micro-Optics SMO/AMS, Fraunhofer Inst. for Photonic Microsystems, Germany.* A novel 1×2 variable optical power splitter based on field-induced waveguides in paranematic phase liquid crystals is reported. Continuously, voltage adjustable splitting with sub-microsecond response time is demonstrated on a device fabricated on silicon backplane.

Th1A.8 • 09:45
Bistable Switching Operation in a Si Sampled Grating Waveguide with Ferroelectric Liquid Crystals Cladding, Katsumi Nakatsuhara[1], Akifumi Kato[2], Yoshiki Hayama[1]; *[1]Kanagawa Inst. of Technology, Japan; [2]The National Inst. of Advanced Industrial Science and Technology, Japan.* A Si sampled grating waveguide with a ferro-electric liquid crystal cladding was proposed and fabricated. The bistable switching operation of the fabricated device, which was latched without state-sustaining power, was demonstrated.

Room 120

Th1B • Panel: 100G Deployment on Submarine Links—Continued

Room 121

Th1C • Silicon Photonics I—Continued

Th1C.5 • 09:30
8x14Gb/s Si Ring WDM Modulator Array with Integrated Tungsten Heaters and Ge Monitor Photodetectors, Marianna Pantouvaki[1], Peter Verheyen[1], Guy Lepage[1], Jeroen De Coster[1], Hui Yu[2], Peter De Heyn[2], Adil Masood[2], Wim Bogaerts[2], Philippe Absil[1], Joris Van Campenhout[1]; *[1]imec, Belgium; [2]Information Technology, Ghent Univ., Belgium.* An 8x14Gb/s wavelength-division multiplexed Si ring modulator array is presented with uniform channel performance. Tungsten heaters and Ge monitor photodetectors at the ring modulator drop ports are co-integrated to track and control the modulation quality.

Th1C.6 • 09:45
Demonstration of over 1000-Channel Hybrid Integrated Light Source for Ultra-High Bandwidth Interchip Optical Interconnection, Takanori Shimizu[1,2], Makoto Okano[1,3], Hiroyuki Takahashi[1,2], Nobuaki Hatori[1,2], Masashige Ishizaka[1,2], Tsuyoshi Yamamoto[1,2], Masahiko Mori[1,3], Tsuyoshi Horikawa[1,3], Yutaka Urino[1,2], Takahiro Nakamura[1,2], Yasuhiko Arakawa[1,4]; *[1]PECST, Japan; [2]PETRA, Japan; [3]AIST, Japan; [4]The Univ. Tokyo, Japan.* An over 1000-channel hybrid integrated light source has been demonstrated by novel spot-size converters with a SiOx slab layer and by optimization considering thermal interference of multiple LD arrays for low power consumption.

Room 122

Th1D • Network Subsystem—Continued

Th1D.6 • 09:30 Invited
Photonic Interconnects for Data Centers, Tolga Tekin[1,2], Nikos Pleros[3], Dimitris Apostolopoulos[4]; *[1]System Integration and Interconnection Technologies, Fraunhofer IZM, Germany; [2]Research Center of Microperipheric Technologies, Technische Universität Berlin, Germany; [3]Centre for Research and Technology Hellas, Greece; [4]Inst. of Communications & Computer Systems / National Technical Univ. of Athens, Greece.* Power consumption and size appear as the main set of barriers in next-generation Data Center. PhoxTroT has been conceived to address optical interconnects at a holistic way among all hierarchy levels: chip-to-chip, board-to-board, rack-to-rack.

Room 123

Room 124

Th1E • Planning I—Continued

Th1E.6 • 09:30
Demonstration of All-optical Inverse Multiplexing in Elastic Optical Networks, Yingying Xu[1], Juhao Li[1], Paikun Zhu[1], Bingli Guo[1], Yuanxiang Chen[1], Yucheng Zhong[1], Yan Wang[1], Zhangyuan Chen[1]; Yongqi He[1]; *[1]Peking Univ., China.* We propose all-optical inverse multiplexing in elastic optical networks using superchannel multicasting to achieve efficient spectrum utilization. We show the benefit by simulation and demonstrate the feasibility by experiment on OFDM superchannel.

Th1E.7 • 09:45
On the Usage of Multiflow Transponders under Anycast and Unicast Traffic in Elastic Optical Networks, Krzysztof Walkowiak[1], Miroslaw Klinkowski[2]; *[1]Systems and Computer Networks, Wroclaw Univ. of Technology, Poland; [2]National Inst. of Telecommunications, Poland.* The impact of anycast and unicast traffic on transponder usage in both symmetric and asymmetric lightpath provisioning scenarios in Elastic Optical Networks is studied. Acceptable costs of multiflow transponders, with respect to 100G WDM transponders, are evaluated.

10:00–12:00 Th2A • Poster Session II, *North, Exhibit Hall C*

10:00–16:00 Exhibition and Show Floor, *Exhibit Halls A, B, C, North, Exhibit Hall D*

10:00–13:00 Unopposed Exhibit-Only Time, *Exhibit Halls A, B, C, North, Exhibit Hall D*

Room 125	Room 130	Room 131	Room 132	Room 133
Th1F • Visible Light Communications—Continued	**Th1G • Applications & Deployments of FTTx—Continued**	**Th1H • Novel Amplification Technologies & Signal Processors—Continued**	**Th1I • Next Generation ROADM and Photonic Switch Architechures—Continued**	
		Th1H.4 • 09:30 **Distributed Measurement of Signal Power Evolution in a Phase Sensitive Parametric Amplifier,** fatemeh alishahi[1], Armand Vedadi[1], Marcelo Soto[1], Andrey Denisov[1], Khashayar Mehrany[2], Luc Thevenaz[1], Camille-Sophie Bres[1]; [1]*Echole Polytechnique Federale de Lausanne (EPFL), Switzerland;* [2]*Sharif Univ. of Technology, Islamic Republic of Iran*. A method to measure the signal power evolution along phase-sensitive parametric amplifiers is proposed using Brillouin optical time-domain analysis. Different evolutions along the fiber are reported by varying input wave phases, including amplification and de-amplification.	Th1I.6 • 09:30 Invited **Flexibility in Submarine Fiber Optic Networks,** Bruce Nyman[1]; [1]*TE SubCom, USA*. Submarine networks are migrating from static to reconfigurable configurations, and are adopting OADM technology similar to that being deployed in terrestrial networks. We will examine the different technology and operating issues involved in implementing flexibility in terrestrial versus submarine networks.	
	Th1G.6 • 09:45 **A Practical Approach For Excess Bandwidth Distribution for EPONs,** Amr Elrasad[1], Basem Shihada[1]; [1]*CEMSE, KAUST, Saudi Arabia*. This paper introduces a novel approach called Delayed Excess Scheduling (DES), which practically reuse the excess bandwidth in EPONs system. DES is suitable for the industrial deployment as it requires no timing constraint and achieves better performance compared to the previously reported schemes.			

10:00–12:00 Th2A • Poster Session II, *North, Exhibit Hall C*

10:00–16:00 Exhibition and Show Floor, *Exhibit Halls A, B, C, North, Exhibit Hall D*

10:00–13:00 Unopposed Exhibit-Only Time, *Exhibit Halls A, B, C, North, Exhibit Hall D*

10:00–12:00
Th2A • Poster Session II

Th2A.1
1-THz Bandwidth of 70-krad/s Endless Optical Polarization Control, Benjamin Koch[1,2], Reinhold Noe[1,2], Vitali Mirvoda[1], David Sandel[1]; *[1]Univ. of Paderborn, Germany; [2]Novoptel GmbH, Germany.* We present the first endless polarization controller with a THz optical bandwidth, much wider than that of electronic polarization controllers. It is suitable for demultiplexing polarization-multiplexed signals at tracking speeds up to 70 krad/s.

Th2A.2
21.4 Gb/s Discrete Multitone Transmission over 50-m SI-POF Employing 6-channel WDM, Roman Kruglov[1], Juri Vinogradov[1], Sven Loquai[1], Olaf Ziemann[1], Christian-Alexander Bunge[2], Thomas Hager[3], Uwe Strauss[3]; *[1]POF-AC, Univ. of Applied Sciences, Germany; [2]Univ. for Telecommunication Leipzig, Germany; [3]OSRAM Opto Semiconductors GmbH, Germany.* We report the record capacity of 21.4 Gb/s over 50-m link based on SI-POF with 1-mm core diameter employing WDM technology with six laser-based channels.

Th2A.3
2D Asymmetric Silicon Waveguide Grating for Optical Transceiver, Chao Li[1], Haifeng Zhou[1], Mingbin Yu[1], Patrick Guo-Qiang Lo[1]; *[1]Inst. of Microelectronics, Singapore.* We designed and demonstrated a 2D asymmetric silicon waveguide grating for optical transceiver. The device exhibits triplexing behavior with minimum coupling loss of -5.7dB. It can be simply designed as a duplexer with polarization diversity.

Th2A.4
30-Gbps Silicon Microring Modulator for Short- and Medium-Reach Optical Interconnects, Antonio Malacarne[1], Fabrizio Gambini[1], Stefano Faralli[2], Jonathan Klamkin[3,2], Luca Poti[1]; *[1]National Laboratory of Photonic Networks, CNIT, Italy; [2]TeCIP, Scuola Superiore Sant'Anna of Pisa, Italy; [3]Boston Univ., USA.* The transmission performance of a silicon microring depletion-mode intensity modulator is demonstrated. BER measurements up to 10-12 for 25 Gbps and 30 Gbps over 10 km SMF validate performance for short- and medium-reach optical interconnects.

Th2A.5
50 Gb/s Silicon Traveling Wave Mach-Zehnder Modulator Near 1300 nm, Matthew Streshinsky[1,2], Ran Ding[3], Ari Novack[1,2], Yang Liu[3], Xiaoguang Tu[1], Andy Eu-Jin Lim[1], Edward Koh Sing Chen[1], Patrick Guo-Qiang Lo[1], Tom Baehr-Jones[3], Michael Hochberg[2,3]; *[1]Inst. of Microelectronics, A*STAR, Singapore; [2]Electrical & Computer Engineering, National Univ. of Singapore, USA; [3]Electrical & Computer Engineering, Univ. of Delaware, USA.* A silicon traveling-wave Mach-Zehnder modulator near 1300 nm is demonstrated to operate at 50 Gb/s with a differential 2 Vpp signal at 0 V reverse bias, achieving a 800 fJ/bit power consumption.

Th2A.6
A 16GHz Optical Cache Memory Architecture for Set-Associative Mapping in Chip Multiprocessors, Pavlos Maniotis[1,2], Dimitrios Fitsios[1,2], George T. Kanellos[2], Nikos Pleros[1,2]; *[1]Department of Informatics, Aristotle Univ. of Thessaloniki, Greece; [2]Information Technologies Inst., Center for Research and Technology Hellas, Greece.* We demonstrate a novel 16GHz physical layer optical cache memory architecture for the 2-way set associative cache mapping scheme. Both memory addresses and optical words are WDM-formatted while physical layer simulations demonstrate successful Read/Write operation.

Th2A.7
A Compact and Alignment-tolerant Si Polarization Rotator for Rib and Channel Waveguides, Haifeng Zhou[1], Huijuan Zhang[1], Lianxi Jia[1], Chao Li[1], Xianshu Luo[1], Patrick Guo-Qiang Lo[1]; *[1]IME of A*Star, Singapore, Singapore.* A compact (around 10μm long) and alignment-tolerant (no performance degradation under a misalignment of a waveguide width, typically > 300nm) polarization rotator with a single-sided slab is proposed by using two-step self-aligned photolithography.

Th2A.8
A High Performance Nonlinear Compensation Algorithm with Reduced Complexity Based on XPM Model, Yangyang Fan[1], Liang Dou[1], Zhenning Tao[1], Takeshi Hoshida[2], Jens Rasmussen[2]; *[1]Fujitsu R&D Center, China; [2]Fujitsu Limited, Japan.* A high performance nonlinear compensator is proposed based on XPM model. It achieves 1.7 dB Q improvement with 80% complexity reduction. It tolerates asynchronous process among multi-channels and the information interconnection speed far below baudrate.

Th2A.9
Suitability of 130 Gb/s and 260 Gb/s real time transponders for advanced A/D stages in wavelength cross-connects, Thierry Zami[1], Bruno Lavigne[1], Stefan Weisser[2], Markus Mayrock[2], Fabian Hauske[2], Diego Correa[3], Bradley McKay[3]; *[1]Alcatel-Lucent, France; [2]Alcatel-Lucent, Germany; [3]Alcatel-Lucent, USA.* Coherent detection and novel modulation schemes enable more compact channel insertion/extraction in wavelength cross-connects, but possibly with further optical noise. We experimentally assess the related penalties with real time 130 Gb/s and 260 Gb/s transponders.

Th2A.10
A Reconfigurable and Redundant Optically-connected Memory System Using a Silicon Photonic Switch, Takashi Shiraishi[1,3], Qi Li[1], Yang Liu[2], Xiaoliang Zhu[1], Kishore Padmaraju[1], Ran Ding[2], Michael Hochberg[2,4], Keren Bergman[1]; *[1]Electrical Engineering, Columbia Univ., USA; [2]Electrical and Computer Engineering, Univ. of Delaware, USA; [3]Photonics Laboratory, Fujitsu laboratories Ltd, Japan; [4]Inst. of Microelectronics, Singapore.* We demonstrate a novel optically-connected memory system based on a silicon photonic switch that enables reconfiguration and redundancy. The FPGA-emulated system achieved 10-Gb/s WDM communication between a CPU and two memory nodes.

Th2A.11
Accelerating HPC Workloads with Dynamic Adaptation of a Software-Defined Hybrid Electronic/Optical Interconnect, Kostas Christodoulopoulos[1], Kostas Katrinis[2], Marco Ruffini[1], Donal O'Mahony[1]; *[1]CTVR, Trinity College Dublin, Ireland; [2]IBM Research, Ireland.* We prototyped a dynamically adaptable hybrid electronic/optical interconnect using commodity switches and measured its reconfiguration delay. By reconfiguring the network at runtime to avoid congestion we accelerated the execution of parallel workloads.

Th2A.12
Adiabatically Widened Silicon Microring Resonators with Improved Tolerance to Wafer-scale Variations, Jared C. Mikkelsen[1]; *[1]Department of Electrical and Computer Engineering, Univ. of Toronto, Canada.* Silicon microrings with adiabatically widened bends are more tolerant to dimensional variations than standard designs. Improvements in the intra-die and wafer-scale variation of the resonance wavelength are demonstrated in the IMEC passives process.

Th2A.13
Advances in Characterization of the VCSEL Mode Partition Noise Penalty in Optical Fiber Channels, Jose M. Castro[1], Rick Pimpinella[1], Bulent Kose[1], Brett Lane[1]; *[1]CRD-Fiber Research, Panduit Corp, USA.* Theoretical and experimental study of MPN dynamics is presented. The MPN coefficient is characterized.

Th2A.14
All-Fiber Erbium Doped Fiber Laser Based on an Intracavity Polarizing Fiber Grating, Chengbo Mou[1], Zuxing Zhang[1], Zhijun Yan[1], Kaiming Zhou[1], Lin Zhang[1], Sergei K. Turitsyn[1]; *[1]Aston Inst. of Photonic Technologies, UK.* Using Aston-made special design polarizing grating, we have implemented a stretch-pulse mode locked erbium fiber laser. The laser has a simple and efficient all-fiber configuration with 90 fs output pulse duration and1.68 nJ pulse energy.

Th2A.15
An Ultra-Broadband Fiber Grating Coupler with Focusing Curved Subwavelength Structures, Qiuhang Zhong[1], Wei Shi[1,2], Yun Wang[3], Lukas Chrostowski[3], David V. Plant[1]; *[1]McGill Univ., Canada; [2]Université Laval, Canada; [3]Univ. of British Columbia, Canada.* We demonstrate the first fiber grating coupler with focusing curved subwavelength structures. An ultra-wide 1-dB bandwidth of over 100 nm with -6.7 dB coupling efficiency at 1550 nm has been experimentally achieved.

Th2A.16
An Ultracompact Silicon Polarization Beam Splitter Based on Mode Conversion in Multimode Waveguide, Wei Yang[1], Yanping Li[1], Xingjun Wang[1], Ziyu Wang[1]; *[1]Peking Univ., China.* A silicon ultracompact polarization beam splitter based on mode conversion is demonstrated for the first time. The measured extinction ratios are higher than 12dB within a wavelength range of 31nm.

Th2A.17
Bandwidth Performances Analysis for High-speed Silicon Depletion-mode Modulator, Hao Xu[1], Xiaoyao Li[1], Xi Xiao[2], Zhiyong Li[1], Yude Yu[1], Jinzhong Yu[1]; *[1]Chinese Acad Sci Inst of Semiconductor, China; [2]State Key Laboratory of Optical Communication Technologies and Networks, Wuhan Research Inst. of Posts & Telecommunications, China.* We present an analysis procedure for the high-speed silicon depletion-mode Mach-Zehnder modulator. The bandwidth performances, including electrical scatting parameters, electro-optic modulation responses and modulated optical signals at different frequencies, were characterized and verified by measurements.

Th2A.18
Bit-Error Rate Performance of Super-Nyquist WDM DP-QPSK Signals with Duobinary-Pulse Shaping, Koji Igarashi[1,2], Takehiro Tsuritani[1], Itsuro Morita[1]; *[1]KDDI R&D Laboratories, Japan; [2]Osaka Univ., Japan.* We experimentally investigate crosstalk characteristics of Super-Nyquist-WDM DP-QPSK signals with duobinary-pulse shaping. The bit-error rate performance of 100-Gbit/s-class duobinary-pulse shaped DP-QPSK WDM signals with frequency spacing of 25 GHz is evaluated experimentally.

Th2A.19
Chromatic Dispersion Estimation Method for Nyquist and Faster Than Nyquist Coherent Optical Systems, Nebojsa Stojanovic[1], Fotini Karinou[1], Bangning Mao[1]; *[1]Huawei, Germany.* We present an accurate blind method for chromatic dispersion estimation in coherent optical receivers. The method is independent of the modulation format and signal spectrum. The method performs well even in strongly bandlimited systems.

Th2A • Poster Session II—Continued

Th2A.20
Compact Bragg Grating Reflectors in Silicon Waveguides and Their Application to Resonator Filters, Thomas Chae[1,2], Efstratios Skafidas[1,2], Duk-Yong Choi[3]; *[1]National ICT Australia (NICTA), Australia; [2]Electrical and Electronic Engineering, Univ. of Melbourne, Australia; [3]Laser Physics Centre, Australian National Univ., Australia.* Compact reflectors which partially reflect and transmit over a wide wavelength range were realized in sub-wavelength silicon waveguides utilizing curved Bragg gratings and resonator filters based on those reflectors were demonstrated in a standard SOI platform.

Th2A.21
Compensation Method for Blind Segments of Distributed Optical-Fiber Vibration Sensor Based on Differential-Coherent OTDR, Chao Pan[1], Hongliang Ye[1], Mingming Li[1], Shuhui Zhao[1], Xiaohan Sun[1]; *[1]Southeast Univ., China*. Two blind segments in the spatial sensing range of distributed optical-fiber vibration sensor based on differential-coherent OTDR are discovered. Compensation method for blind segments is proposed and demonstrated experimentally.

Th2A.22
Complete Si-Photonics Device-library on 300mm wafers, Daivid Fowler[1], Charles Baudot[2,1], Jean_Marc Fedeli[1], Boris Caire[2,1], Leopold Virot[2,1], Alban Leliepvre[4], Gilles Grand[1], Andre Myko[1], Delphine Marris-Morini[3], Sonia Messaoudene[1], Aurelie Souhaité[2,1], Ségolène Olivier[1], Philippe Grosse[1], Guang-Hua Duan[4], Badhise Ben-Bakir[1], Frederic Boeuf[2], Laurent Vivien[3], Sylvie Menezo[1]; *[1]CEA-LETI, France; [2]ST Mircroelectronics, France; [3]Institut d'Electronique Fondamentale, France; [4]III-V Lab, France*. We report performances of active and passive devices in a Silicon-Photonic library on a 300mm-CMOS-platform, showing highly uniform behavior of passive WDM devices, Mach-Zehnder modulators and germanium photo-detectors with state of the art performances.

Th2A.23
Crosstalk Reduction in Holographic Wavelength Selective Switches Based on Phase-only LCOS Devices, Haining Yang[1], Brian Robertson[1], Daping Chu[1]; *[1]Univ. of Cambridge, UK*. A method to reduce crosstalk is proposed for holographic wavelength selective switches (WSSs) using a customized merit function. A reduction in crosstalk >8 dB is measured when multicasting with a phase-only LCOS device.

Th2A.24
Design of an Optical Fiber Supporting 16 OAM Modes, Charles Brunet[1], Bora Ung[1], Younes Messaddeq[1], Sophie LaRochelle[1], Eric Bernier[2], Leslie Rusch[1]; *[1]Center for Optics, Photonics and Lasers, Université Laval, Canada; [2]Huawei Technology Canada Co., LTD., Canada*. We present the design and fabrication of an optical fiber to support 16~OAM modes. The effective indices of each vector mode are designed for maximal separation facilitating the use of OAM modes for space-division multiplexing.

Th2A.25
Design of Dynamic Range Enhanced Colorless Reception Systems with Coherent Balanced Receiver, Xuan He[1,2], Bo Zhang[2], Rob Lofland[2], Yang Yue[2], Jason O. Neil[2], Ted Schmidt[2], Jon Anderson[2], Zhongqi Pan[1]; *[1]Electrical and Computer Engineering, Univ. of Louisiana at Lafayette, USA; [2]Juniper Networks, USA*. We experimentally demonstrate 77-channel 127-Gb/s PM-QPSK colorless system achieves, with <1 dB SNR penalty, -17 to -6 dBm/channel dynamic-range with relaxed 12 dBm LO power. Impacts from TIA saturation and polarization effects are also shown.

Th2A.26
Efficient Guard Interval Reduction for Coherent Optical OFDM, Hae Young Rha[2], Byoung Gu Jeon[1], Hae-Wook Choi[2]; *[1]Physics, KAIST, Republic of Korea; [2]Electrical Engineering, KAIST, Republic of Korea*. We propose an efficient dispersion compensation to reduce the guard interval in coherent optical-orthogonal frequency division multiplexing (CO-OFDM) systems. The proposed algorithm compensates dispersion using overlapped frequency domain equalizer (OFDE), timing offset at the transmitter. Simulations verify the validity of the proposed algorithm.

Th2A.27
Enhanced Nonlinear Thermo-optic Effect in Silicon Microring Resonators with p-i-p Microheaters for Non-reciprocal Transmission, Liangjun Lu[1], Linjie Zhou[1], Xinwan Li[1], Jianping Chen[1]; *[1]State Key Laboratory of Advanced Optical Communication Systems and Networks, Department of Electronic Engineering, Shanghai Jiao Tong Univ., China*. We report the enhancement of nonlinear thermo-optic effect in silicon microring resonators integrated with p-i-p microheaters. Non-reciprocal transmission is achieved at low input power of 32.4 μW with a non-reciprocal transmission ratio of ~19 dB.

Th2A.28
Erbium Doped Fiber Laser Mode Locked by Graphene in Carboxymethylcellulose Polymer Composite, Chengbo Mou[1], Raz Arif[1], Anatoly Lobach[2], Nataliya Spitsina[2], Valery Kazakov[3], Aleksey Rozhin[1], Sergei K. Turitsyn[1]; *[1]Aston Inst. of Photonic Technologies, UK; [2]Inst. of Problems of Chemical Physics RAS, Russian Federation; [3]Federal State Unitary Enterprise, Keldysh Research Center, Russian Federation*. We have presented and demonstrated efficient mode locking of erbium doped fiber laser using graphene carboxymethylcellulose (CMC) polymer composites. The laser gives out soliton pulse with duration of ~837 fs, and 0.19 nJ pulse energy.

Th2A.29
Estimation of OSNR for Nyquist-WDM Transmission Systems Using Statistical Moments of Equalized Signals in Digital Coherent Receivers, Md. Saifuddin Faruk[1], Yojiro Mori[2], Kazuro Kikuchi[3]; *[1]Electrical and Electronic Engineering, Dhaka Univ. of Engineering & Technology, Bangladesh; [2]Electrical Engineering and Computer Science, Nagoya Univ., Japan; [3]Electrical Engineering and Information Systems, The Univ. of Tokyo, Japan*. We propose a novel method of OSNR estimation in Nyquist-WDM transmission systems based on the measurement of statistical moments of equalized signals in the digital coherent receiver. Its effectiveness is verified with computer simulations.

Th2A.30
Experimental Evaluation of Residual Added Signal Crosstalk in a Silicon Photonics Integrated ROADM, Vito Sorianello[3], Francesco Testa[2], Philippe Velha[1], Sergio Doneda[1], Marco Romagnoli[3]; *[1]Scuola Sant'Anna, Italy; [2]Ericsson Telecomunicazioni, Italy; [3]CNIT, Italy.* The evaluation of the Residual Added Signal Crosstalk in a micro-ring based silicon photonic integrated ROADM is presented. The origin of the cross talk is mainly due to reflections at the Grating coupler interfaces.

Th2A.31
Fibers for Multi-channel Erbium Doped Amplifiers in Optical Space Communications, Mark Hill[1], Rebecca Gray[1], Judith Hankey[1], Andy Gillooly[1]; *[1]Fibercore Limited, UK*. A fiber developed for optical satellite communications and control, designed to take full advantage of the photo-annealing effect that results from pumping in the 980nm region and allows up to 100% recovery following radiation damage.

Th2A.32
Fractional Pulse Repetition-Rate Multiplication Based on Temporal Self-imaging, Reza Maram[1], José Azaña[1]; *[1]INRS-Energie Materiaux et Telecom, Canada*. We propose and experimentally demonstrate repetition-rate multiplication of picosecond optical pulse trains by a "fractional" factor based on temporal self-imaging, involving time phase modulation and first-order dispersion.

Th2A.33
Highly Uniform and Low-loss Passive Silicon Photonics Devices Using a 300mm CMOS Platform, Shankar Kumar Selvaraja[1], Peter De Heyn[2], Gustaf Winroth[1], Patrick Ong[1], Guy Lepage[1], Celine Cailler[3], Arnaud Rigny[3], Konstantin Bourdelle[3], Wim Bogaerts[2], Dries VanThourhout[2], Joris Van Campenhout[1], Philippe Absil[1]; *[1]imec, Belgium; [2]Ghent Univ.-imec, Belgium; [3]Soitec, France*. Using an advanced 300mm CMOS-platform, we report record-low and highly-uniform propagation loss: 0.45±0.12dB/cm for wires, and 2dB/cm for slot waveguides. For WDM devices, we demonstrate channel variation(3-σ) within-wafer and within-device of 6.1nm and 1.2nm respectively.

Th2A.34
High-performance Reflective Liquid Level Sensor Based on Titled Fiber Bragg Grating Inscribed in the Thin-core Fiber, Bobo Gu[1], Wenliang Qi[1,2], Yanyan Zhou[1,3], Jie Zheng[1,4], Ping Shum[1,2], Feng Luan[1,2]; *[1]School of Electrical and Electronics Engineering, Nanyang Technological Univ., Singapore; [2]CINTRA CNRS/NTU/THALES, Nanyang Technological Univ., Singapore; [3]Precision Measurements Group, Singapore Inst. of Manufacturing Technology, Singapore; [4]Inst. of Optoelectronic Technology, China Jiliang Univ., China*. A simple and compact reflective liquid level sensor based on a tilted fiber Bragg grating (TFBG) inscribed in a thin-core fiber is proposed and demonstrated. High sensitivity and temperature immunity are experimentally achieved.

Show Floor Programming

10:30–11:30
Splitter Placement in FTTB Installations, *Expo Theater II Programming*
For more details, see page 42

10:30–12:30
■ **MarketWatch Panel IV: 100/400G Pluggable Optics and its Enabling Technologies,** *Expo Theater I Programming*
For more details, see page 38

11:00–11:30
Harnessing Optical Layer Flexibility with SDN Intelligence, *Expo Theater III Programming*
For more details, see page 44

11:30–12:30
Enhanced Use Cases for a SDN-based Control Architecture for Optical Networks, *Expo Theater III Programming*
For more details, see page 45

11:30–12:30
Passive Optical LAN, *Expo Theater II Programming*
For more details, see page 42

12:30–13:00
Advances in Photonics for Optical Transmission Networks, *Expo Theater III Programming*
For more details, see page 45

Th2A • Poster Session II—Continued

Th2A.35
High-speed Silicon Modulators with Slow-wave Electrodes, Ran Ding[1], Yangjin Ma[1], Yang Liu[1], Yisu Yang[1], Andy E. Lim[2], Patrick Guo-Qiang Lo[2], Tom Baehr-Jones[1,3], Michael Hochberg[1,4]; [1]*Electrical and Computer Engineering, Univ. of Delaware, USA;* [2]*Inst. of Microelectronics, A*STAR (Agency for Science, Technology and Research), Singapore;* [3]*EastWest Photonics PTE LTD, Singapore;* [4]*Electrical and Computer Engineering, National Univ. of Singapore, Singapore*. We demonstrate a high-speed dual-drive silicon traveling-wave modulator with slow-wave, periodically phase-matched transmission-line electrodes and discuss the design aspects of such an approach. Our design also ensures true single-RF-mode operation independent of signaling schemes.

Th2A.36
IFFT Stage-dependent Minimum Bit Resolution Maps for Real-time Optical OFDM Transceivers, Jianming Tang[1], Junjie Zhang[1,2], Wenyan Yuan[1,2], Roger Giddings[1], Min Wang[2]; [1]*School of Electronic Engineering, Bangor Univ., UK;* [2]*Key Laboratory of Specialty Fiber Optics and Optical Access Networks, Shanghai Univ., China*. To significantly reduce the FPGA/ASIC resource usage in OOFDM transceivers, numerical identifications and experimental verifications are undertaken, for the first time, of an optimum map of minimum bit-resolutions of different IFFT stages against DAC resolutions.

Th2A.37
Impact of Fabrication Non-Uniformity on Chip-Scale Silicon Photonic Integrated Circuits, Lukas Chrostowski[1], Xu Wang[1], Jonas Flueckiger[1], Yichen Wu[1], Yun Wang[1], Sahba Talebi Fard[1]; [1]*Electrical and Computer Engineering, Univ. of British Columbia, Canada*. This study of 371 identical resonators on a 16x9 mm chip fabricated by a silicon photonics foundry reveals a strong linear correlation between the physical distance between devices and the variability in their wavelength mismatch.

Th2A.38
Improvement of Signal Quality after Long-Haul Transmission over Multi-Core Fiber with Adaptive MIMO-FDE Using Time-Domain Coefficient Selection, Manabu Arikawa[1], Emmanuel Le Taillandier de Gabory[1], Toshiharu Ito[1], Kiyoshi Fukuchi[1]; [1]*Green Platform Research Laboratories, NEC Corporation, Japan*. We show numerically signal degradation due to excess noise in adaptive MIMO-FDE used on transmission over MCF. We propose coefficient selection in time domain and obtain up to 2.9 dB of Q factor improvement.

Th2A.39
Inverse Dispersion Design in Silicon Waveguides, David Castello-Lurbe[1], Víctor Torres-Company[2], Enrique Silvestre[1]; [1]*Departament d'Òptica, Universitat de València, Spain;* [2]*Microtechnology and Nanoscience Department (MC2), Chalmers Univ. of Technology, Sweden*. We present a numerical tool to find the cross-section geometry of silicon-on-insulator waveguides that leads to a target dispersion profile. In <10 iterations, we achieve geometries providing ultraflattened dispersion over 350 nm bandwidth.

Th2A.40
Large Mode Area Hybrid Multi-trench Fiber for Anomalous Dispersion, Deepak Jain[1], Catherine Baskiotis[1], Jayanta K. Sahu[1]; [1]*Univ. of Southampton, UK*. We propose a novel fiber design that shows excellent filtering for higher-order-modes (>6dB/m) and low losses for fundamental mode (<0.05dB/m) at 1064nm, with an anomalous-dispersion>72ps/nm-Km and effective area >390μm2 with good bend robustness.

Th2A.41
Laser Integration with CMOS Assembly Process for Si Photonics, Ricky Tseng[1], James O'Callaghan[2], Feras Eid[1], Michael Gleeson[2], Brandon Rawlings[1], Mauro Kobrinsky[1], Ibrahim Ban[1], Roger Nagle[3], William McFarlane[1], Brian Corbett[2], Peter Chang[1]; [1]*Components Research, Technology Manufacturing Group, Intel Corporation, USA;* [2]*Tyndall National Inst., Ireland;* [3]*Ireland Research, Intel Ireland, Ireland*. High performance laser is integrated on Si substrates with evanescently coupled polymer waveguides. The design allows 2μm misalignment, consistent with CMOS assembly. 4μm gap and 8dB loss were demonstrated with improvement paths to <2dB loss.

Th2A.42
Low-Complexity Training-Aided 2x2 MIMO Frequency Domain Fractionally-Spaced Equalization, Fabio Pittalà[1,2], Amine Mezghani[2], Israa Slim[2], Josef A. Nossek[2]; [1]*European Research Center, Huawei Technologies Co Ltd, Germany;* [2]*Inst. for Circuit Theory and Signal Processing, Technische Universität München, Germany*. An efficient filter-tap calculation with minimized number of divisions is reported for training-aided 2x2 MIMO frequency domain fractionally-spaced equalizers. Performance evaluation is based on a 28-GBaud PDM-4QAM and PDM-16QAM optical transmission system.

Th2A.43
Magneto-optic Nonlinear Optical Loop Mirror for All-optical 3R Signal Regeneration, Feng Wen[1], Bao-Jian Wu[1], Xing-Yu Zhou[1], Hao Yuan[1], Kun Qiu[1]; [1]*Key Lab of Optical Fiber Sensing and Communications, Ministry of Education, Univ. of Electronic Science and Technology of China, China*. A magneto-optic nonlinear optical loop mirror using intrinsic Faraday Effect of fibers is proposed. Magnetically controllable regeneration experiment is carried out and the receiver sensitivity is further improved by 1.7dB under 200Gs magnetic field.

Th2A.44
Multi Functionality Demonstration for Multi Core Fiber Fan-in/Fan-out Devices using Free Space Optics, Yusaku Tottori[1], Hiroshi Tsuboya[1], Tetsuya Kobayashi[1]; [1]*OPTOQUEST CO.,LTD, Japan*. Multi functionality is demonstrated for multi core fiber fan-in/fan-out device using free space optics by an isolator at the beam intersection. Insertion loss and isolation are below 0.7 dB and over 50 dB, respectively.

Th2A.45
Negative Curvature Fibers with Reduced Leakage Loss, Walter Belardi[1], Jonathan C. Knight[1]; [1]*Physics, Univ. of Bath, UK*. We describe improved designs for "negative curvature" hollow core anti-resonant fibers. Numerical simulations show that introducing additional silica rings into the cladding results in a major reduction in the fiber leakage losses, for realizable fiber structures.

Th2A.46
Negative Group Velocity Propagation by Combination of an EDFA and a SBS Laser Ring cavity, Dinghuan Deng[1], Weiqing Gao[1], Zhongchao Duan[1], Tonglei Cheng[1], Takenobu Suzuki[1], Yasutake Ohishi[1]; [1]*Research Center for Advanced Photon Technology, Toyota Technological Inst., Japan*. Large negative group velocity propagation of optical pulse was demonstrated by the combined fast light effects of coherent population oscillations in an EDFA and a stimulated Brillouin scattering laser ring cavity.

Th2A.47
Novel Design of Large-Mode-Area Rod-Type Fibers with Negative Curvature Trenches at 1 μm, Junhua Ji[1], Jiang Sun[2,3], Johan Nilsson[2], Seongwoo Yoo[1,2]; [1]*EEE, Nanyang Technological Univ., Singapore;* [2]*ORC, Univ. of Southampton, UK;* [3]*Inst. of Lightwave Technology, Beijing Jiaotong Univ., China*. A novel large-mode-area fiber with negative curvature is proposed. A fundamental mode effective area can be over 5000 μm^2 with negligible losses at 1.06 μm. High-order-modes can be effectively suppressed by 100 times higher losses.

Th2A.48
On-Chip Demultiplexing of Polarization and Wavelength Multiplexed OFDM/OQAM 64/128-QAM Signals using Silicon 2D Grating Coupler and Microring Resonators, Jian Wang[1], Chengcheng Gui[1], Chao Li[2], Qi Yang[2], Junqiang Sun[1], Xinliang Zhang[1]; [1]*Wuhan National Laboratory for Optoelectronics, Huazhong Univ. of Science and Technology, China;* [2]*State Key Laboratory of Optical Comm. Technologies and Networks, China*. We design and fabricate an on-chip polarization and wavelength demultiplexer incorporating silicon 2D grating coupler and microring resonators. Moreover, we experimentally demonstrate the demultiplexing of polarization and wavelength multiplexed OFDM/OQAM 64/128-QAM signals.

Th2A.49
OSNR Monitoring by Using Single Sampling Channel Generated 2-D Phase Portrait, Yi Yu[1], Changyuan Yu[1,2]; [1]*National Univ. of Singapore, Singapore;* [2]*A*STAR Inst. for Infocomm Research (I2R),, Singapore*. We propose to monitor OSNR by using 2-dimension phase portrait that is depicted by single low-speed sampler with software synchronization technique. This method reduces monitoring setup cost, and increases tolerance to the aliased clock frequency estimation offset.

Th2A.50
Over 300 Channels Uncoupled Few-mode Multi-core Fiber for Space Division Multiplexing, Tatsuhiko Watanabe[1], Yasuo Kokubun[1]; [1]*Graduate school of engineering, Yokohama National Univ., Japan*. Ultra-large number of transmission channels FM-MCF for SDM was designed by optimizing the air hole assisted double cladding structure. 387 (129cores×3modes) channels can be theoretically accommodated in 200um diameter area of a fiber.

Th2A.51
Path to Silicon Photonics Commercialization: 25 Gb/s Platform Development in a CMOS Manufacturing Foundry Line, Andy E. Lim[1], Tsung-Yang Liow[1], Junfeng Song[1], Chao Li[1], Qing Fang[1], Xiaoguang Tu[1], Ning Duan[1], Kok Kiong Chen[1], Roger Poh Cher Tern[1], Chuan Peng[2], Bong woong Mun[2], Mohd Nurul Islam[2], Jae Soo Park[2], Chivukula Subbu[2], Patrick Guo-Qiang Lo[1]; [1]*Inst. of Microelectronics, Singapore;* [2]*GlobalFoundries, Singapore*. Silicon photonics platform in a commercial 0.18 μm CMOS foundry line is described. Low-loss Si passives and high speed germanium photodetectors (>20GHz) with low dark current (~11nA) and high responsivity (1.06A/W) at 1550nm are presented.

Th2A.52
PLC-type LP11 Mode Rotator with Single-trench Waveguide for Mode-division Multiplexing Transmission, Takui Uematsu[1], Nobutomo Hanzawa[2], Kunimasa Saitoh[1], Yuhei Ishizaka[1], Kouhei Masumoto[1], Taiji Sakamoto[2], Takashi Matsui[2], Kyozo Tsujikawa[2], Fumihiko Yamamoto[2]; [1]*Graduate School of Information Science and Technology, Hokkaido Univ., Japan;* [2]*NTT Access Network Service Systems Laboratories, NTT Corporation, Japan*. PLC-type LP11 mode rotator with a single-trench waveguide is designed and fabricated. Converting LP11a (LP11b) mode into LP11b (LP11a) mode is achieved with high conversion efficiency over a wide wavelength range.

Th2A.53
Pulse Design Trade-Offs for Spectrum-Efficient PDM-WDM Coherent Optical Transmission Systems, Amirhossein Ghazisaeidi[1], Jessica Fickers[2], Gabriel Charlet[1]; [1]*Bell Labs, France;* [2]*Université Libre de Bruxelles, Belgium*. We study the joint effect of pulse spectral rolloff and impulse-response truncation length on the performance of densely packed root-raised-cosine pulse-shaped 32.5 GBaud PDMQPSK and 16QAM, through extensive bit-error-rate and spectrum measurements.

Th2A • Poster Session II—Continued

Th2A.54
Record-high Sensitivity Receiver Using Phase Sensitive Fiber Optical Parametric Amplification, Rohit Malik[1], Samuel Olsson[1], Peter A. Andrekson[1], Carl Lundström[1], Magnus Karlsson[1]; [1]*Chalmers Univ. of Technology, Sweden*. We demonstrate record sensitivity (55 photons/bit) for on-off keying modulation at 10 Gb/s using a phase sensitive amplifier as preamplifier. Experimental results depicting the effects of pump phase modulation on the sensitivity are reported.

Th2A.55
Reduced Wafer-Scale Frequency Variation in Adiabatic Microring Resonators, Zhan Su[1], Ehsan S. Hosseini[1], Erman Timurdogan[1], Jie Sun[1], Gerald Leake[2], Douglas D. Coolbaugh[2], Michael R. Watts[1]; [1]*Research Laboratory of Electronics, Massachusetts Inst. of Technology, USA;* [2]*College of Nanoscale Science & Engineering, Univ. at Albany, USA*. We experimentally demonstrate that adiabatic microring resonators not only achieve high quality factors in the presence of electrical contacts but, importantly, exhibit reduced susceptibility to wafer-scale fabrication induced resonant frequency variations compared to standard microrings.

Th2A.56
Reducing Cabling Complexity in Large Flattened Butterfly Networks by an Order of Magnitude, Marton Csernai[1], Florin Ciucu[2], Ralf-Peter Braun[3], Andras Gulyas[1,4]; [1]*Budapest Univ. of Technology and Economics, Hungary;* [2]*Univ. of Warwick, UK;* [3]*Deutsche Telekom AG, Germany;* [4]*Hungarian Academy of Science, Information System Research Group, Hungary*. We show that cabling complexity in large flattened butterfly networks can be reduced by an order of magnitude, without increasing capital costs or control plane complexity, by employing DWDM transceivers and arrayed waveguide grating routers.

Th2A.57
Robust and Controllable Generation of Frequency Combs in Microresonators with Selected Sideband Feedback, Yufeng Jiang[1], Xin Zhao[1], Jian Wang[2], Ben Niu[2], Ya Liu[1], Guoqing Hu[1], Pei-Hsun Wang[2], Minghao Qi[2], Andrew M. Weiner[2], Zheng Zheng[1]; [1]*School of Electronic and Information Engineering, Beihang Univ., China;* [2]*School of Electrical and Computer Engineering & Birck Nanotechnology Center, Purdue, USA*. With feedback and amplification at selected sidebands of a SiN microring spectrum, we achieve controllable line spacing in the generated comb under relaxed pumping conditions. Such reduced pump power requirement is beneficial for many applications.

Th2A.58
Robust Design of 3-dB Directional Coupler with Weak Gap Sensitivity for Silicon Wire Waveguide, Guangwei Cong[1], Keijiro Suzuki[1], Sanghun Kim[1], Ken Tanizawa[1], Shu Namiki[1], Hitoshi Kawashima[1]; [1]*AIST, Japan*. We designed a robust 3-dB directional coupler which has a narrow silicon core and a wide gap. Performance insensitivity is improved by more than 10 times from the conventional coupler. Better stability was experimentally verified.

Th2A.59
Scalable and Distributed Optical Interconnect Architecture based on AWGR for HPC and Data Centers, Roberto Proietti[1], Zheng Cao[1], Yuliang Li[1], S.J.Ben Yoo[1]; [1]*Univ. of California Davis, USA*. We propose an AWGR-based scalable optical direct interconnect architecture exploiting a flat distributed Thin-CLOS topology at the core-layer. The architecture scales beyond 100,000 nodes with a diameter of 7, low latency, high degree and throughput.

Th2A.60
Scalable and Topology Adaptive Intra-data Center Networking Enabled by Wavelength Selective Switching, Zhonghua Zhu[1], Shan Zhong[1]; [1]*CoAdna Photonics Inc, USA*. We present an enhanced n-ary, 2 flat distributed optical switching architecture for intra-DC interconnection which using existing WSS components. The proposed architecture is highly scalable, topology adaptive and suitable for dynamic and diverse traffic pattern.

Th2A.61
Silicon Ridge Waveguide Directional Couplers with Improved Tolerance to Wafer-scale Variations, Jared C. Mikkelsen[1], Wesley Sacher[1], Joyce Poon[1]; [1]*Department of Electrical and Computer Engineering, Univ. of Toronto, Canada*. Silicon directional couplers are designed to be tolerant to width, height, coupling gap, and etch depth variations. Improvements in the wafer-scale variation of the splitting ratio are demonstrated in the IMEC Standard Passives process.

Th2A.62
Stability of Fiber Bragg Gratings Fabricated Using UV Ar+ and ArF Excimer in Bismuth-aluminum-doped Silica Fibers, Georgios Violakis[1], Hans G. Limberger[1], Valery M. Mashinsky[2], Evgeny M. Dianov[2]; [1]*Ecole Polytechnique Federale de Lausanne, Switzerland;* [2]*Fiber Optics Research Center RAS, Russian Federation*. Continuous annealing of fiber Bragg gratings fabricated using cw and pulsed laser irradiation in Bi-Al fibers of different concentrations show activation energy spectra linked to Bi-Al. Thermal stability maps were obtained by their analytical representation.

Th2A.63
Time-interleaved Carrier-suppressed Return-to-Zero QPSK for Filter-less Dual-carrier Transmission, Takahide Sakamoto[1], Guo-Wei Lu[1], Tetsuya Kawanishi[1]; [1]*NICT, Japan*. We demonstrate time-interleaved carrier-suppressed return-to-zero (TI-CSRZ) signaling, aiming for high-spectral-efficiency dual-carrier transmission. Optical filter-less modulation and demodulation schemes are proposed, achieving 40-Gb/s TI-CSRZ-QPSK.

Th2A.64
Transmission and Reception of Quad-Carrier QPSK-OFDM Signal with Blind Equalization, Fan Li[1,2], Junwen Zhang[1,4], Jiangnan Xiao[3], Xinying Li[3]; [1]*ZTE Corporation, USA;* [2]*Hunan Univ., China;* [3]*Fudan Univ., China;* [4]*Georgia Inst. of Technology, USA*. Quad-Carrier QPSK-OFDM signal transmission and reception is successfully demonstrated with blind equalization like a 25-QAM signal with CMMA equalization. The phase recovery can be realized with simple Viterbi algorithm and the FOE should be done after 4 subcarriers are separated with FFT.

Th2A.65
Tunable Third-harmonic Generation in a Novel Chalcogenide-tellurite Hybrid Optical Fiber, Tonglei Cheng[1], Dinghuan Deng[1], Weiqing Gao[1], Zhongchao Duan[1], Takenobu Suzuki[1], Yasutake Ohishi[1]; [1]*ofmlab, Japan*. A novel chalcogenide-tellurite hybrid optical fiber was fabricated. And Tunable third-harmonic generation from 568 nm to 869 nm is observed with the pump wavelength changing from 1700 to 2600 nm.

Th2A.66
Ultra-small, Low-crosstalk, Electrically-driven InGaAsP Photonic-wire Optical Switches on III-V CMOS Photonics Platform, Yuki Ikku[1], Masafumi Yokoyama[1], Osamu Ichikawa[2], Takenori Osada[2], Masahiko Hata[2], Mitsuru Takenaka[1], Shinichi Takagi[1]; [1]*Univ. of Tokyo, Japan;* [2]*Sumitomo Chemical Company Ltd., Japan*. Ultra-small, electrically-driven InGaAsP photonic-wire optical switches are demonstrated. Large carrier-induced index change in InGaAsP enables low crosstalk of -29 dB even with 50-μm-long phase shifters. 50-Gb/s WDM signals are successfully transmitted within 2-dB power penalty.

Show Floor Programming

10:30–11:30
Splitter Placement in FTTB Installations, *Expo Theater II Programming*
For more details, see page 42

10:30–12:30
■ **MarketWatch Panel IV: 100/400G Pluggable Optics and its Enabling Technologies,** *Expo Theater I Programming*
For more details, see page 38

11:00–11:30
Harnessing Optical Layer Flexibility with SDN Intelligence, *Expo Theater III Programming*
For more details, see page 44

11:30–12:30
Enhanced Use Cases for a SDN-based Control Architecture for Optical Networks, *Expo Theater III Programming*
For more details, see page 45

11:30–12:30
Passive Optical LAN, *Expo Theater II Programming*
For more details, see page 42

12:30–13:00
Advances in Photonics for Optical Transmission Networks, *Expo Theater III Programming*
For more details, see page 45

Room 102

13:00–15:00
Th3A • Semiconductor Lasers
Presider: Liming Zhang; Alcatel-Lucent Bell Labs, USA

Th3A.1 • 13:00 Invited
56-Gb/s Direct Modulation in InGaAlAs BH-DFB Lasers at 55°C, Kouji Nakahara[1], Yuki Wakayama[1], Takeshi Kitatani[1], Takafumi Taniguchi[1], Toshihiko Fukamachi[2], Yasushi Sakuma[2], Shigehisa Tanaka[1]; [1]*Hitachi,Ltd, Japan;* [2]*Oclaro Japan, Inc., Japan.* Direct modulation at 56 Gb/s of 1.3-μm InGaAlAs-MQW DFB laser, incorporating a ridge-shaped buried heterostructure (RS-BH), operating at 55°C, is experimentally demonstrated for the first time.

Room 120

13:00–15:00
Th3B • Resilient Networks
Presider: Ron Johnson; Cisco Systems, Inc., USA

Th3B.1 • 13:00 Invited
Multi-layer Restoration - The Impact on the Optical Layer, Matthias Gunkel[1]; [1]*Optical Packet Transport, Deutsche Telekom, Germany.* Multi-layer resilience including optical restoration against optical failures and backup interfaces provisioned against port failures is considered from an operator's perspective. This approach saves 25%-30% of the IP links in Deutsche Telekom's core network.

Room 121

13:00–15:00
Th3C • Low Power VCSEL Interconnect
Presider: Ali Ghiasi; Ghiasi Quantum LLC, USA

Th3C.1 • 13:00 Invited
The Evolution of 850nm VCSELs from 10Gb/s to 25 and 56Gb/s, Jim Tatum[1]; [1]*Finisar Corporation, USA.* VCSELs are now being commercially deployed in applications up to 28Gbps. This paper will present a review of current VCSEL and PD capability and explore the technology development required to extend operation to even higher data rates.

Room 122

13:00–14:45
TH3D • RF Photonic Processing
Presider: Periklis Petropoulos; Optoelectronics Research Centre, UK

TH3D.1 • 13:00
High-resolution, Photonically-sampled, Analog-to-Digital Conversion Employing Spatial Oversampling, Ori Golani[1], Luca Mauri[2], Fabiano Pasinato[2], Cristian Cattaneo[2], Guido Consonnni[2], Stefano Balsamo[2], Dan Marom[1]; [1]*Applied Physics, Hebrew Univ., Israel;* [2]*Oclaro Corporation, Italy.* Photonically-Sampled analog-to-digital conversion utilizing a spatial oversampling technique is described and experimentally demonstrated. Spatial oversampling's ability to boost the ADC's resolution is verified. Digitization of a 13GHz signal with 6.3 ENOB is demonstrated.

TH3D.2 • 13:15
Microwave Beamsteering with Tunable Spectral Filtering Using Cyclic Additional Optical True Time Delay, Zizheng Cao[1], Qing Wang[1], Rongguo Lu[1,3], Ad Reniers[2], Henrie Boom[1], E. Tangdiongga[1], A. Koonen[1]; [1]*COBRA Research Inst., Eindhoven Univ. of Technology, Netherlands;* [2]*Centre for Wireless Technology, Eindhoven Univ. of Technology, Netherlands;* [3]*State Key Laboratory of Electronic Thin Films and Integrated Devices, Univ. of Electronic Science and Technology of China, School of Optoelectronic Information, Univ. of Electronic Science and Technology of China, China.* A novel broadband microwave beamsteering scheme for high capacity wireless communication is proposed with tunable spectral filtering using cyclic additional optical true time delay. The experimental results match well with the theoretical analysis.

Room 123

13:00–15:00
Th3E • DSP Algorithms I
Presider: Noriaki Kaneda; Bell labs, USA

Th3E.1 • 13:00
Noise Power Directed Adaptive Frequency Domain Least Mean Square Algorithm with Fast Convergence for DMGD Compensation in Few-Mode Fiber Transmission Systems, Xuan He[1], Yi Weng[1], Junyi Wang[2], Zhongqi Pan[1]; [1]*Electrical and Computer Engineering, Univ. of Louisiana at Lafayette, USA;* [2]*LinkQuest Inc, USA.* We investigate a fast convergence adaptive FD-LMS algorithm for compensating DMGD in few-mode fiber systems. The new algorithm increases the convergence speed by 54% over conventional adaptive FD-LMS method with 8.1% hardware complexity increase.

Th3E.2 • 13:15
Frequency-Domain Clock Phase Detector for Nyquist WDM Systems, Kuang-Tsan Wu[1], Han Sun[1]; [1]*Infinera Corporation, Canada.* A novel frequency-domain clock phase detector is proposed for Nyquist WDM signals generated using very small raised-cosine roll-off factor. The jitter is shown to be lower than the time-domain approach and independent of the roll-off factor.

Room 124

13:00–15:00
Th3F • Demultiplexers and Switches
Presider: Joris Van Campenhout; InterUniv. Microelectronics Center, Belgium

Th3F.1 • 13:00 *Top-Scored*
Compact Wavelength Selective Switch Based on High-density Bragg Reflector Waveguide Array with 120 Output Ports, Xiaodong Gu[1], Fumio Koyama[1]; [1]*Photonics Integration System Research Center, P&I Lab., Tokyo Inst. of Technology, Japan.* A wavelength selective switch based on a Bragg reflector waveguide array is proposed with 120 output ports, exhibiting switching to arbitrary ports. The dense waveguide array with giant angular-dispersion enables large-scalability in small footprint.

Th3F.2 • 13:15 *Top-Scored*
16-Channel O-OFDM Demultiplexer in Silicon Photonics, Abdul Rahim[1,3], Stefan Schwarz[2], Jürgen Bruns[1], Lars Zimmermann[3], Sheikh Jalil Ahmed[1], Christian G. Schäffer[2], Klaus Petermann[1]; [1]*Fachgebiet Hochfrequenztechnik, Technische Universität Berlin, Germany;* [2]*Department of High-Frequency Engineering and Optoelectronics, Helmut-Schmidt-Universität, Germany;* [3]*IHP, Germany.* A 16 channel DFT filter based on 4×4 MMI couplers is designed and fabricated in SOI. The characterization of device has shown that it can demultiplex 16×36.5 Gbaud QPSK modulated sub-carriers of an O-OFDM super-channel.

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Room 125

13:00–15:00
Th3G • OFDM-based Optical Access
Presider: Jianming TANG; Bangor Univ., UK

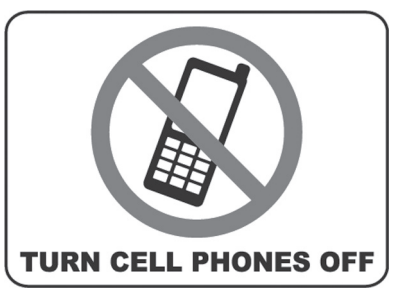
Th3G.1 • 13:00
32-dB Loss Budget High-Capacity OFDM Long-Reach PON over 60-km Transmission without Optical Amplifier, Chia-Chien Wei[1], Hsing Yu Chen[2,3], Hsuan-Hao Chu[2], Yu-Chao Chen[2], Cih-Yuan Song[2], I-Cheng Lu[2], Jyehong Chen[2]; *[1]National Sun Yat-sen Univ., Taiwan; [2]National Chiao Tung Univ., Taiwan; [3]Industrial Technology Research Inst., Taiwan*. For the first time, 33-Gbps 60-km OFDM transmission is demonstrated to show 32-dB loss budget without inline and pre-amplifier. Employing 10-GHz EAM and PIN, the long-reach PON can economically support 32 ONUs with >1-Gbps/ONU capacity.

Th3G.2 • 13:15
A Coherent-Based OLT Receiver with a Power-Controlled Optical Local Oscillator for Upstream OFDM/TDMA-PON, Sangyeup Kim[1], Jun-ichi Kani[1], Jun Terada[1], Naoto Yoshimoto[1]; *[1]NTT Corporation, Japan*. We propose a novel upstream OFDM/TDMA-PON using a coherent-based OLT receiver having a power-controlled local oscillator, achieving a power normalization range of 20dB and power budget of 29dB in 60-km transmission for 20-Gb/s 16QAM-OFDM system.

Room 130

13:00–14:30
Th3H • Access Networks
Presider: Ed Harstead; Alcatel-Lucent, USA

Th3H.1 • 13:00 Invited
Evolution of MSO Networks and Outside Plant Fiberization, Marek Hajduczenia[1]; *[1]ZTE Corporation, Portugal*. Abstract not available



Room 131

13:00–15:00
Th3I • SDN and PCE
Presider: Hans-Juergen Schmidtke; Juniper Networks Inc., USA

Th3I.1 • 13:00 Invited
Benefits of Active Stateful PCE for Flexgrid Networks, Filippo Cugini[1], Francesco Paolucci[2], Francesco Fresi[2], Gianluca Meloni[1], Gianluca Berrettini[2], Nicola Sambo[2], Alessio Giorgetti[1], Tommaso Foggi[1], Luca Poti[1], Piero Castoldi[2]; *[1]CNIT, Italy; [2]Scuola Superiore Sant'Anna, Italy*. Relevant benefits of the active stateful PCE architecture are experimentally demonstrated on a flexgrid network testbed. Two experiments are reported, including a first demo on PCE-controlled code-adaptation applied to a 1Tb/s super-channel.

Room 132

13:00–14:30
Th3J • Advanced Optical Transceivers
Presider: Thomas Wood; LGS Innovations, Bell Labs, USA

Th3J.1 • 13:00 Invited
Engineering Silicon Photonics Solutions for Metro WDM, Torben Nielsen[1]; *[1]Acacia Communications, Inc., USA*. We discuss opportunities that silicon photonics offers for metro and regional reach dense wavelength division multiplexing (DWDM) transceivers operating at 100G and beyond. In particular, we describe the unique advantages provided by silicon photonics for transceivers based on coherent detection.

Room 133

13:00–15:00
Th3K • Direct Detection
Presider: Etsushi Yamazaki; NTT Network Innovation Laboratories, Japan

Th3K.1 • 13:00
10 Gb/s CAP128 System Using Directly Modulated Laser for Short Reach Optical Communications, Li Tao[1,2], Yiguang Wang[1], Yuliang Gao[3], Alan Pak Tao Lau[3], Chao Lu[2]; *[1]Department of Communication Science and Engineering, Fudan Univ., China; [2]Photonics Research Center, Department of Electronic and Information Engineering, The Hong Kong Polytechnic Univ., Hong Kong; [3]Photonics Research Center, Department of Electrical Engineering, The Hong Kong Polytechnic Univ., Hong Kong*. We experimentally demonstrate a 10.5 Gb/s CAP128 system over 40 km SSMF using DML and direct-detection with a hybrid MMA/DD-LMS equalization scheme. The influences of RIN and laser linewidths of the DML are also investigated.

Th3K.2 • 13:15 *Top-Scored*
Generation and Transmission of 100-Gb/s PDM 4-PAM Using Directly Modulated VCSELs and Coherent Detection, Chongjin Xie[1], Silvia Spiga[2], Po Dong[1], Peter J. Winzer[1], Alan Gnauck[1], Christoph Gréus[3], Christian Neumeyr[3], Markus Ortsiefer[3], Michael Müller[2], Markus Amann[2]; *[1]Alcatel-Lucent Bell Labs, USA; [2]Walter Schottky Institut, TU München, Germany; [3]VERTILAS GmbH, Germany*. We generate a 100-Gb/s polarization-division-multiplexed 4-level pulse- amplitude-modulation signal with two directly modulated 1.5-μm single-mode VCSELs. Coherent detection and digital signal processing enable the transmission over 400-km standard single-mode-fiber (SSMF) within 20% overhead hard-decision forward-error-correction.

Show Floor Programming

13:00–15:00
■ **MarketWatch Panel V: PIC vs. Si Photonics: Hype or Reality?,** *Expo Theater I Programming*
For more details, see page 38

13:00–16:00
POF Symposium, *Expo Theater II Programming*
For more details, see page 42

Room 102

Th3A • Semiconductor Lasers—Continued

Th3A.2 • 13:30
Tunable 16 DFB Laser Array with Unequally Spaced Passive Waveguides for Backside Wavelength Monitor, Yoshifumi Sasahata[1], Keisuke Matsumoto[1], Takashi Nagira[1], Hitoshi Sakuma[1], Kazumasa Kishimoto[1], Masato Suzuki[1], Daisuke Suzuki[1], Yuichiro Horiguchi[2], Masakazu Takabayashi[2], Keita Mochizuki[3], Mitsunobu Gotoda[2], Hiroshi Aruga[3], Eitaro Ishimura[1]; *[1]High Frequency & Optical Device Works, Mitsubishi Electric Corporation, Japan; [2]Advanced Technology R & D Center, Mitsubishi Electric Corporation, Japan; [3]Information Technology R & D Center, Mitsubishi Electric Corporation, Japan.* We demonstrate tunable DFB laser array with 350 kHz linewidth and low power consumption of less than 0.58 W using backside wavelength monitor, which is suitable for future hybrid or monolithic integration with modulators.

Th3A.3 • 13:45
Monolithically Integrated 2-Section Lasers for Injection Locked Gain Switched Comb Generation, Rui Zhou[1], Prince M. Anandarajah[1], Deseada Gutierrez Pascual[1,2], John O'Carroll[3], Richard Phelan[3], Brian Kelly[3], Liam P. Barry[1]; *[1]DCU, Ireland; [2]Pilot Photonics, Ireland; [3]Eblana Photonics, Ireland.* We demonstrate compact multi-carrier transmitters based on 2 types of monolithically integrated lasers. A 2-section discrete mode laser and a passive feedback laser are gain switched resulting in 5-15GHz FSR tunable combs.

Room 120

Th3B • Resilient Networks—Continued

Th3B.2 • 13:30
Fast Restoration in SDN-based Flexible Optical Networks, Alessio Giorgetti[1], Francesco Paolucci[1], Filippo Cugini[2], Piero Castoldi[1]; *[1]TeCIP, Scuola Superiore di Studi Universitari e di Perfezionamento Sant' Anna di Pisa, Italy; [2]CNIT, Italy.* The benefits of the SDN control plane to drive fast restoration are demonstrated on Flexible Optical Networks. Required OpenFlow extensions are detailed. Simulations report improved recovery time with respect to GMPLS/PCE restoration.

Th3B.3 • 13:45
Enhancing Restoration Performance Using Service Relocation in PCE-based Resilient Optical Clouds, Jawwad Ahmed[1], Paolo Monti[1], Lena Wosinska[1], Salvatore Spadaro[2]; *[1]Communication Systems (CoS), KTH Royal Inst. of Technology, Sweden; [2]Universitat Politècnica de Catalunya (UPC), Spain.* This paper investigates the benefits of dynamic restoration with service relocation in resilient optical clouds. Results from the proposed optimization model show that service availability can be significantly improved by allowing a few service relocations.

Room 121

Th3C • Low Power VCSEL Interconnect—Continued

Th3C.2 • 13:30 *Top-Scored*
64Gb/s Transmission over 57m MMF using an NRZ Modulated 850nm VCSEL, Daniel Kuchta[1], Alexander V. Rylyakov[1], Clint L. Schow[1], Jonathan Proesel[1], Christian Baks[1], Petter Westbergh[2], Johan S. Gustavsson[2], Anders Larsson[2]; *[1]IBM TJ Watson Research Center, USA; [2]Dept. of Microelectronics and Nanoscience, Photonics Laboratory, Chalmers Univ. of Technology, Sweden.* We report a directly modulated 850nm VCSEL-based optical link operating error free (BER < 1E-12) at 64Gb/s over 57m of OM4 multimode fiber. At 60Gb/s, the error free distance increases to 107m.

Th3C.3 • 13:45
A 40-Gb/s VCSEL Transmitter for Optical Interconnect with Group-Delay Compensation Pre-Emphasis, Yukito Tsunoda[1], Mariko Sugawara[1], Hideki Oku[1], Satoshi Ide[1], Kazuhiro Tanaka[1]; *[1]Photonics laboratory, Fujitsu Laboratories Ltd., Japan.* We developed a 40-Gb/s VCSEL transmitter by over-driving a 25-Gb/s VCSEL using our pre-emphasis with group-delay compensation. This pre-emphasis improved the jitter property, and realized a 40-Gb/s operation with large optical modulation amplitude.

Room 122

TH3D • RF Photonic Processing—Continued

TH3D.3 • 13:30
Tunable Frequency-doubling Brillouin Optoelectronic Oscillator Using Single-sideband Suppressed-carrier Modulation, Jizhao Zang[1], Yan Li[1], Zhisheng Yang[1], Jian Wu[1], Wei Li[1], Rongqing Hui[1], Jintong Lin[1]; *[1]Beijing Univ. of Posts and Telecommunications, China.* A tunable frequency-doubling Brillouin optoelectronic oscillator pumped by a single-sideband suppressed-carrier modulated light is demonstrated. Microwave signal with a frequency range of 21.8-41.8GHz is generated using a RF source lower than 10GHz.

TH3D.4 • 13:45
A Fully Frequency Referenced Parametric Polychromatically Sampled Analog-to-Digital Conversion, Daniel J. Esman[1], Andreas O. Wiberg[1], Eduardo Temprana[1], Yauheni Myslivets[1], Ping Piu Kuo[1], Nikola Alic[1], Stojan Radic[1]; *[1]1Department of Electrical and Computer Engineering, Univ. of California San Diego, USA.* We present a novel scalable photonically-sampled analog-to-digital-converter based on parametric multicasting, polychromatic sampling and frequency referenced lasers. A sampling rate of 30-GS/s is achieved with three subrate-channels with a 6.2-ENOB performance of a 19-GHz signal.

Room 123

Th3E • DSP Algorithms I—Continued

Th3E.3 • 13:30
Feed-Forward and Feedback Timing Recovery for Nyquist and Faster than Nyquist Systems, Nebojsa Stojanovic[1], Yu Zhao[1], Changsong Xie[1]; *[1]Huawei, Germany.* We present a novel timing recovery architecture for Nyquist systems having their performance independent of the Nyquist filter and modulation formats. Excellent performance is demonstrated even in extremely bandlimited systems, called faster than Nyquist systems.

Th3E.4 • 13:45
Single-Carrier 448 Gb/s Dual-Polarization 16-QAM Transmission over 1200 km Using Fixed Look-Up Table Based MAP Detection, Ali Rezania[1], Jian Hong Ke[1], Ying Gao[1], John C. Cartledge[1]; *[1]Electrical and Computer Engineering, Queen's Univ., Canada.* Transmission of a single-carrier 448 Gb/s dual-polarization 16-QAM signal is demonstrated using fixed look-up table based maximum-a-posteriori detection at the receiver to mitigate pattern-dependent distortion in the transmitted signal arising from the high baud rate.

Room 124

Th3F • Demultiplexers and Switches—Continued

Th3F.3 • 13:30 Invited
Fine Resolution Arbitrary Optical Filtering with a Hybrid Guided-Wave/Free-Space Optics Platform, David Sinefeld[1], Roy Rudnick[1], Ori Golani[1], Noam Goldstein[1]; *[1]Hebrew Univ. of Jerusalem, Israel.* We apply a spatial light modulator to spectrally dispersed light at extremely fine resolution to realize an optical filter with the ability to set any spectral amplitude and phase modulation, subject to the optical resolution limit.

Room 125

Th3G • OFDM-based Optical Access—Continued

Th3G.3 • 13:30
50-Gbps 100-km EAM-based OFDM-IMDD Transmission Employing Novel SSII Cancellation, Hsing Yu Chen[1,2], Chia-Chien Wei[3], Yu-Chao Chen[2], Hsuan-Hao Chu[2], Cih-Yuan Song[2], I-Cheng Lu[2], Jyehong Chen[2]; *[1]Industrial Technology Research Inst., Taiwan; [2]National Chiao Tung Univ., Taiwan; [3]National Sun Yat-sen Univ., Taiwan.* We build a new SSII cancellation technique to compensate both modulator nonlinearity and dispersion-induced nonlinear distortion. Employing the SSII cancellation to optimize EAM operation, superior 50-Gbps EAM-based OFDM-IMDD transmission over 100-km SSMF is successfully demonstrated.

Th3G.4 • 13:45
Experimental Demonstration of Multi-band Upstream in Statistical OFDM-PONs and Comparison with Digital Subcarrier Assignment, Iván Cano[1], Xavier Escayola[1], Philipp Schindler[2], María C. Santos[1], Victor Polo[1], Juerg Leuthold[3,2], Josep Prat[1]; *[1]Universitat Politecnica de Catalunya, Spain; [2]Inst. of Photonics and Quantum Electronics, Karlsruhe Inst. of Technology, Germany; [3]Laboratory for Electromagnetic Fields and Microwave Electronics (IFH),Swiss Federal Inst. of Technology Zurich (ETHZ), Switzerland.* A multiband subcarrier allocation scheme is demonstrated for the uplink in a statistical OFDM-PON. Performance achieved is similar to digital subcarrier allocation, with the significant advantage of a lower transmitter complexity.

Room 130

Th3H • Access Networks—Continued

Th3H.2 • 13:30 **Tutorial**
Activities for Conformance and Interoperability Testing in EPON Standardization, Ken-Ichi Suzuki[1]; *[1]NTT Access Network Service Systems Laboratories, Japan.* This tutorial presentation introduces activities of conformance and interoperability testing for EPON systems, especially SIEPON compliant ones, in IEEE 1904.1 WG and related organizations. I also show activities for interoperability tests and events in Japan.

Ken-Ichi Suzuki, Ph.D. Senior Research Engineer, Supervisor, NTT Access Network Service Systems Laboratories, NTT Corporation. In 1990, he joined NTT laboratories, where he has been working on research and development of optical communication systems including PON based systems/technologies. Currently, he leads Full Service Access Group as a group leader for investigating optical access related services/technologies. He is an IEEE 802.3 WG voter and is a Vice Chair of IEEE P1904.1 SIEPON WG. He is a Director of Optical Access Ad-hoc WG in HATS conference in Japan for EPON interoperability. He is a member of IEEE, IEICE of Japan, and OSA.

Room 131

Th3I • SDN and PCE—Continued

Th3I.2 • 13:30 *Top-Scored*
SDN-based Provisioning Orchestration of OpenFlow/GMPLS Flexi-grid Networks with a Stateful Hierarchical PCE, Ramon Casellas[1], Raul Muñoz[1], Ricardo Martínez[1], Ricard Vilalta[1], Lei Liu[2], Takehiro Tsuritani[3], Itsuro Morita[3], Victor Lopez[4], Oscar Gonzalez de dios[4], Juan-Pedro Fernández-Palacios[4]; *[1]ONSD, CTTC, Spain; [2]Univ. of California, Davis, USA; [3]KDDI R&D Labs, Japan; [4]Telefónica I+D, Spain.* We report the experimental testbed evaluation of connectivity provisioning in which OpenFlow and GMPLS control planes interwork by means of an orchestrating stateful PCE. The hierarchical nature of the PCE allows seamless multi-domain operation.

Th3I.3 • 13:45
Flexible-Client: The Missing Piece Towards Transport Software-Defined Networks, Ankitkumar Patel[1], Konstantinos Kanonakis[1], Philip N. Ji[1], Junqiang Hu[1], Ting Wang[1]; *[1]NEC Laboratories America Inc, USA.* We introduce architectures to enable flexible-client functionality in software-defined transport networks for the first time, and propose an effective algorithm to provision time-varying traffic. Transponders with flexible-client interfaces improve spectral, energy, and management efficiencies.

Room 132

Th3J • Advanced Optical Transceivers—Continued

Th3J.2 • 13:30
Optical Transceiver for CWDM Networks with Multi sub-channel Interface, Hee Yeal Rhy[1], Gwang Yong Yi[1], Jongyoon Shin[2], Seungjoo Hong[2], Jong Yeong Lim[2], Yoon Koo Kwon[3], Kang Yong Jung[3], Ho Sung Cho[4], Sungmin Cho[2]; *[1]R&D, Ericssong-LG, Republic of Korea; [2]SK Telecom, Republic of Korea; [3]Lightron, Republic of Korea; [4]ELDIS, Republic of Korea.* This paper describes optical transceiver performance for CWDM network with multi sub-channel interface for optical mobile fronthaul applications with CPRI. It also describes standard optical link budget the said CWDM network with multi sub-channel interface.

Th3J.3 • 13:45
448 Gbit/s DP-16QAM Transmission Using Integrated Tunable CMOS Laser Sources, Elton Marchena[1], Marco Camera[2], Gianmarco Bruno[2], Hacene Chaouch[1], Sam Albanna[1], Hong Cai[1], Chris Blivin[1], Lina He[1], John Zyskind[1], Stephen Krasulick[1], Antonio Tartaglia[2], Amit Mizrahi[1], Rob Stone[2]; *[1]Skorpios Technologies, Inc., USA; [2]Ericsson Telecomunicazioni, Italy.* We demonstrate 448 Gbit/s transmission using CMOS silicon photonic, hybrid- integrated, full-band tunable lasers as transmit and local oscillator for 28 GBaud DP-16QAM. Marginal system performance differences were measured when compared with conventional commercially available lasers, proving suitability for coherent applications.

Room 133

Th3K • Direct Detection—Continued

Th3K.3 • 13:30 (Top Scored)
First Experimental Demonstration of Coherent CAP for 300-Gb/s Metropolitan Optical Networks, Jose Estaran[1], Miguel Iglesias[1], Darko Zibar[1], Xiaogeng Xu[2], Idelfonso Tafur[1]; *[1]Danmarks Tekniske Universitet, Denmark; [2]Huawei Technologies Co., Ltd., China.* We report on high-capacity coherent links employing dual polarization 2D-CAP modulation, allowing for signal design in 8-dimensional space. Successful demodulation of 221 Gb/s (7.5 b/s/Hz) and 336 Gb/s (7.8 b/s/Hz) after 225 km and 451 km of standard single-mode fiber (SSMF) is achieved.

Th3K.4 • 13:45
Nyquist-shaped Dispersion-precompensated Subcarrier Modulation with Direct Detection, Sezer Erkilinc[1], Sean Kilmurray[1], Stephan Pachnicke[2], Helmut Griesser[3], Benn Thomsen[1], Robert I. Killey[1]; *[1]Electronic and Electrical Engineering, Univ. College London, UK; [2]Optical Networking SE, ADVA, Germany; [3]Optical Networking SE, ADVA, Germany.* We report on the first experimental demonstration of 14 Gb/s direct-detection single-sideband subcarrier modulated quasi-Nyquist QPSK transmission. Using electronic pre-compensation, error-free transmission was achieved over 800 km of dispersion-uncompensated standard single-mode fiber.

Show Floor Programming

13:00–15:00
■ **MarketWatch Panel V: PIC vs. Si Photonics: Hype or Reality?,** *Expo Theater I Programming*
For more details, see page 38

13:00–16:00
POF Symposium, *Expo Theater II Programming*
For more details, see page 42

Room 102

Th3A • Semiconductor Lasers—Continued

Th3A.4 • 14:00
Suppression of Supermode Noise in a Harmonically Mode-locked Hybrid Silicon Laser Using an Intra-cavity Filter, Sudharsanan Srinivasan[1], Alois Arrighi[1], Martijn J. R. Heck[1], John Hutchinson[2], Erik Norberg[2], Gregory Fish[2], John E. Bowers[1]; *[1]Electrical and Computer Engineering, Univ. of California, Santa Barbara, USA; [2]Aurrion Inc, USA.* We present results from two hybrid silicon mode-locked lasers each with a 2GHz cavity and one with an intra-cavity filter; which allows for 20GHz operation and 55dB supermode noise suppression compared to harmonic mode-locking.

Th3A.5 • 14:15 *Top-Scored*
A Hybrid Silicon/InP Integrated All-Passive Feedback Stabilized Mode-Locked Laser, Michael L. Davenport[1], Sudharsanan Srinivasan[1], Martijn J. R. Heck[1], John E. Bowers[1]; *[1]Electrical and Computer Engineering Department, Univ. of California, USA.* An integrated delay line coupled cavity was used to stabilize a 10 GHz mode locked laser. Use of the cavity reduced the RF 3 dB linewidth for passive mode-locking from 1.06 MHz to 15 kHz.

Room 120

Th3B • Resilient Networks—Continued

Th3B.4 • 14:00 Invited
Benefits and challenges of TeliSonera's PanEuropean Network, Mattias Fridström[1]; *[1]TeliaSonera International Carrier, Sweden.* Abstract not available

Room 121

Th3C • Low Power VCSEL Interconnect—Continued

Th3C.4 • 14:00
High Speed Temperature Insensitive Optical Data Transmission with Compact 850nm TO-can Assemblies, Jaroslaw Turkiewicz[1], Jorg Kropp[2], Nikolay Ledentsov[2], Vitaly Shchukin[2], George Schaefer[2]; *[1]Inst. of Telecommunications, Warsaw Univ. of Technology, Poland; [2]VI-Systems, Germany.* Error-free operation at and above 28 Gbit/s is demonstrated for fully integrated TO-can based 850 nm transmitter and receiver subassemblies in a broad range of driving conditions and temperatures.

Th3C.5 • 14:15
40-Gb/s FPC-based Optical Transceiver with Integrated-lens on Small Active Area Diameter of Photodiode, Mariko Sugawara[1], Takashi Shiraishi[1], Takatoshi Yagisawa[1], Yukito Tsunoda[1], Hideki Oku[1], Satoshi Ide[1], Kazuhiro Tanaka[1]; *[1]Fujitsu Laboratories, Japan.* We demonstrated a high-speed FPC-based optical receiver above 40-Gb/s using novel lens-integrated technique on a small-active-area-diameter PD. The integrated-lens allows us to use high-bandwidth small-diameter photodiodes with low coupling loss.

Room 122

TH3D • RF Photonic Processing—Continued

TH3D.5 • 14:00 *Top-Scored*
The First Fully Photonics-based Radar Demonstrator: Concept and Field Trial, Paolo Ghelfi[1], Francesco Laghezza[1], Filippo Scotti[1], Giovanni Serafino[2], Amerigo Capria[3], Sergio Pinna[2], Antonella Bogoni[1]; *[1]National Laboratory of Photonic Networks, CNIT, Italy; [2]TECIP, Scuola Superiore Sant'Anna, Italy; [3]Laboratory of Radar & Surveillance Systems, CNIT, Italy.* We report the first fully photonics-based radar demonstrator. Photonics enables flexibility, wide bandwidth, precision, leading to a fully digital radar paradigm. Field trial results targeting commercial airplanes prove its effectiveness as a proof of concept.

TH3D.6 • 14:15 Invited
Analog and Digital Photonics for Future Military Systems, Paul J. Matthews[1]; *[1]Northrop Grumman Corp, USA.* Due to their unique capabilities, fiber-optics and photonics are key enabling technologies for many military sensors and systems. The influence of fiber-optics on current and future trends in military sensors will be presented.

Room 123

Th3E • DSP Algorithms I—Continued

Th3E.5 • 14:00
Blind and Universal DSP for Arbitrary Modulation Formats and Time Domain Hybrid QAM Transmissions, Yuliang Gao[1], Qunbi Zhuge[2], David V. Plant[2], Chao Lu[3], Alan Pak Tao Lau[1]; *[1]Electrical Engineering, The Hong Kong Polytechnic Univ., Hong Kong; [2]Electrical and Computer Engineering, McGill Univ., Canada; [3]Electronic and Information Engineering, The Hong Kong Polytechnic Univ., Hong Kong.* We propose a blind and universal DSP platform containing a new joint timing phase and frequency offset estimation technique. The quick convergence speed enables fast receiver initializations for flexible transmissions with arbitrary modulation formats.

Th3E.6 • 14:15
A Novel Update Algorithm in Stokes Space for Adaptive Equalization in Coherent Receivers, Gabriella Bosco[1], Monica Visintin[1], Pierluigi Poggiolini[1], Fabrizio Forghieri[2]; *[1]DET, Politecnico di Torino, Italy; [2]Cisco Photonics, Italy.* We propose a novel update algorithm based on error signals evaluated in Stokes space, independent of both phase-noise and frequency-offset. We compare its performance to standard CMA for PM-16QAM modulation, showing 0.5-dB gain at BER=10^{-2}.

Room 124

Th3F • Demultiplexers and Switches—Continued

Th3F.4 • 14:00
Optimized 90° Hybrids with Sidewall Grating in Silicon on Insulator, Thomas Föhn[1], Wolfgang Vogel[1], Martin Schmidt[1], Manfred Berroth[1], Jörg Butschke[2], Florian Letzkus[2]; *[1]Inst. of Electrical and Optical Communications Engineering, Univ. of Stuttgart, Germany; [2]Institut für Mikroelektronik Stuttgart, Germany.* MMI-based 90° hybrids are optimized with sidewall gratings acting as effective index medium, notably increasing the usable bandwidth. Optimum grating parameters are determined with eigenmode expansion and Floquet-Bloch theory.

Th3F.5 • 14:15
Delayed Interferometer Based Si-wire WDM Demultiplexers Fabricated by Phase Controllable and Productive 300-mm Wafer-scale ArF-Immersion Lithography Technology, Seok-Hwan Jeong[1], Daisuke Shimura[1], Takasi Simoyama[1], Tsuyoshi Horikawa[1,2], Yu Tanaka[1], Ken Morito[1]; *[1]Photonics Electronics Technology Research Association (PETRA), Japan; [2]National Inst. of Advanced Industrial Science and Technology (AIST), Japan.* We report good phase controllability and high production yield in Si-wire delayed interferometer-type demultiplexers fabricated by 300-mm wafer-scale ArF-immersion lithography technologies. The results are promising for utilization in high-density WDM interconnects.

Room 125

Th3G • OFDM-based Optical Access—Continued

Th3G.5 • 14:00
37.5-km Urban Field Trial of OFDMA-PON Using Colorless ONUs with Dynamic Bandwidth Allocation and TCM, Christian Ruprecht[1], Yingkan Chen[2], Daniel Fritzsche[3], Johannes von Hoyningen-Huene[1], Norbert Hanik[2], Erik Weis[4], Dirk Breuer[4], Werner Rosenkranz[1]; *[1]Chair for Communications, Univ. of Kiel, Germany; [2]Inst. of Communications Engineering, Technische Universität München, Germany; [3]EICT GmbH, Germany; [4]T-Labs, Deutsche Telekom AG, Germany.* An OFDMA-PON field trial using coherent detection in upstream and direct detection in downstream on 37.5 km feeder fiber is demonstrated. A power budget supporting 32 cost-effective colorless ONUs with dynamic bandwidth allocation is reported.

Th3G.6 • 14:15
17.125Gb/s over 25km Transmissions of Real-time Dual-band Optical OFDM Signals Modulated by 1GHz RSOAs, Jianming Tang[1], Qianwu Zhang[1,2], Emilio Hugues Salas[1], Yun Ling[1,3], Hongbo Zhang[1,3], Roger Giddings[1], Min Wang[2]; *[1]Bangor Univ., UK; [2]Key Laboratory of Specialty Fiber Optics and Optical Access Networks, Shanghai Univ., China; [3]Key Lab of Optical Fiber Sensing and Communication Networks, Univ. of Electronic Science and Technology of China, China.* Utilizing 1GHz RSOAs and 4GS/s DACs/ADCs, record-high 17.125Gb/s real-time dual-band OOFDM transmissions with 7dB receiver sensitivity improvements over IMDD-based 25km SSMFs are experimentally demonstrated, which show excellent robustness to 20dB variations in RSOA-injected optical powers.

Room 130

Th3H • Access Networks—Continued

Room 131

Th3I • SDN and PCE—Continued

Th3I.4 • 14:00
Filter Optimization in SDN-based Flexgrid Networks, Francesco Paolucci[2], Francesco Fresi[2], Alberto Castro[3], Luis Velasco[3], Filippo Cugini[1], Nicola Sambo[2], Alessio Giorgetti[2], Luca Poti[1], Piero Castoldi[2]; *[1]CNIT, Italy; [2]Scuola Superiore Sant'Anna, Italy; [3]Universitat Politècnica de Catalunya, Spain.* The novel superfilter technique for flexgrid optical networks is proposed to compact spectrum-contiguous lightpaths. The technique is applied in a specifically extended SDN architecture, showing significant gains in terms of spectral efficiency.

Th3I.5 • 14:15
ABNO: a Feasible SDN Approach for Multi-vendor IP and Optical Networks, Alejandro Aguado[1], Victor Lopez[1], Jaume Marhuenda[1], Oscar Gonzalez de dios[1], Juan-Pedro Fernández-Palacios[1]; *[1]Telefonica I+D, Spain.* ABNO architecture is proposed in IETF as a framework which enables network automation and programmability thanks to the utilization of standard protocols and components. This work not only justifies the architecture but also presents the first experimental demonstration.

Room 132

Th3J • Advanced Optical Transceivers—Continued

Th3J.4 • 14:00 Invited
100G/400G Project in Japan, Hiroshi Onaka[1]; *[1]Fujitsu Laboratories, Japan.*
Abstract not available

Room 133

Th3K • Direct Detection—Continued

Th3K.5 • 14:00
Blind Symbol Synchronisation in Direct-detection Optical OFDM Using Virtual Subcarriers, Rachid Bouziane[1], Peter A. Milder[2], Sean Kilmurray[1], Benn C. Thomsen[1], Stephan Pachnicke[3], Polina Bayvel[1], Robert I. Killey[1]; *[1]Department of Electronic and Electrical Engineering, Univ. College London, UK; [2]Department of Electrical and Computer Engineering, Stony Brook Univ., USA; [3]ADVA Optical Networking SE, Germany.* We investigate the performance of a novel blind symbol synchronisation technique using a 30.65Gb/s real-time 16-QAM OFDM transmitter with direct detection. The proposed scheme exhibits low complexity and does not have any bandwidth overhead.

Th3K.6 • 14:15
16-ary Stokes-vector Modulation Enabling DSP-based Direct Detection at 100 Gbit/s, Kazuro Kikuchi[1], Shojiro Kawakami[2]; *[1]The Univ. of Tokyo, Japan; [2]Photonic Lattice, Inc., Japan.* Multilevel optical signals designed in the three-dimensional Stokes space can be demodulated by a direct-detection receiver using low-complexity DSP. Simulation results demonstrate that the 16-ary signal can achieve the bit rate of 100 Gbit/s.

Show Floor Programming

13:00–15:00
■ **MarketWatch Panel V: PIC vs. Si Photonics: Hype or Reality?,** *Expo Theater I Programming*
For more details, see page 38

13:00–16:00
POF Symposium, *Expo Theater II Programming*
For more details, see page 42

Room 102

Th3A • Semiconductor Lasers—Continued

Th3A.6 • 14:30
Monolithic Buried Heterostructure DFB Laser Array for Integrated Optical Interconnects and WDM Systems, Jingsi Li[1], Song Tang[2], Jeffery Wang[3], Yue Liu[3], Haiming Xu[4], Qi Tang[4], Xiangfei Chen[2], Julian Cheng[1]; *[1]Univ. of Texas at Austin, USA; [2]Nanjing Univ., China; [3]ATG Technologies, Inc., USA; [4]Wuhan Huagong Genuine Optics Tech Co., Ltd., China.* We report a monolithic buried heterostructure DFB laser array by reconstruction equivalent chirp (REC) technique. Using interference lithography and photolithography, an integrated laser array with accurate wavelength control and good performance has been demonstrated.

Th3A.7 • 14:45
Uncooled Clear-Eye-Opening Operation (25 to 95°C) of 25.8/28-Gbps 1.3-μm InGaAlAs-MQW Directly Modulated DFB Lasers, Toshihiko Fukamachi[1], Atsushi Nakamura[1], Yasushi Sakuma[1], Shigenori Hayakawa[1], Ryu Washino[1], Masaru Mukaikubo[1], Kaoru Okamoto[1], Takayuki Nakajima[1], Katsuya Motoda[1], Kazuhiko Naoe[1], Kouji Nakahara[2], Yuki Wakayama[2], Kazuhisa Uomi[1]; *[1]Oclaro Japan, Inc., Japan; [2]Central Research Lab., Hitachi, Ltd, Japan.* Properties on an uncooled 1.3-μm DML applicable for 100GbE/OTU4 based SMF interfaces are described. We demonstrated 25.8-Gb/s mask margins of more than 20% up to 85°C. Moreover, clear 28.0-Gb/s eye diagram was obtained at 95°C.

Room 120

Th3B • Resilient Networks—Continued

Th3B.5 • 14:30
Network Cost Savings and Service Differentiation using Priority-driven sub-50ms Shared Mesh Protection, Soumya Roy[1], Sudhindra Kota[1], Onur Turkcu[1], Steven Hand[1], Krish Verma[1], Rajan Rao[1]; *[1]Infinera, USA.* This paper shows how shared mesh protection with prioritization of services and pre-emption of low-priority services, as defined in standards, G.808.3 and G.ODUSMP provide high network cost savings while enabling <50 ms recovery.

Th3B.6 • 14:45
Highly Survivable Software Defined Synergistic IP+Optical Transport Networks, Dongxu Zhang[1], Xuefei Song[2], Songtao Mai[1], Shuang Hao[1], Hongxiang Guo[1], Yinben Xia[2]; *[1]Beijing Univ. of Posts and Telecommunications, China; [2]Huawei Technologies, China.* A hierarchically controlled IP + Optical multilayer Transport SDN architecture is proposed, which highlights flexible resource provisioning and dynamic cross-layer restorations. The propositions are also demonstrated via an implemented testbed prototype.

Room 121

Th3C • Low Power VCSEL Interconnect—Continued

Th3C.6 • 14:30
Low Power CMOS-driven 1060 nm Multimode Optical Link, Jean Benoit Heroux[1], Tomofumi Kise[2], Masaki Funabashi[2], Toyohiro Aoki[1], Clint L. Schow[3], Alexander V. Rylyakov[3], Shigeru Nakagawa[1]; *[1]IBM Research - Tokyo, IBM Japan, Japan; [2]COE Team, FITEL Products division, Furukawa Electric Co., Ltd., Japan; [3]IBM Research - T.J. Watson Center, IBM, USA.* A high speed, low power 1060nm optical link with 90-nm CMOS chips is demonstrated using a VCSEL bias as low as 2 mA. A 4.9 pJ/bit efficiency is obtained at 20 Gbps.

Th3C.7 • 14:45
New MMF and VCSEL Metrics for System Reach Predictions, Denis Molin[1], Marianne Bigot-Astruc[1], Pierre Sillard[1]; *[1]Prysmian Group, France.* We propose new MMF and VCSEL metrics derived from standard measurements procedures and we demonstrate how to combine them to predict system performance.

Room 122

TH3D • RF Photonic Processing—Continued

Room 123

Th3E • DSP Algorithms I—Continued

Th3E.7 • 14:30 **Invited**
Energy Efficient Digital Signal Processing, Maxim Kuschnerov[1], Thomas Bex[1], Peter Kainzmaier[1]; *[1]Coriant R&D GmbH, Germany.* We discuss the major power reduction trends for DSP-ASICs used in coherent optical interfaces that target line card and pluggable applications. Optimization measures are shown for the digital and physical design of such integrated circuits.

Room 124

Th3F • Demultiplexers and Switches—Continued

Th3F.6 • 14:30
Low Crosstalk Wavelength Tunable Filter that Utilizes Symmetric and Asymmetric Mach-Zehnder Interferometers, Shoichi Takashina[1], Yojiro Mori[1], Hiroshi Hasegawa[1], Ken-ichi Sato[1], Toshio Watanabe[2]; *[1]Department of Electrical Engineering and Computer Science, Nagoya Univ., Japan; [2]NTT Photonics Laboratories, NTT Corporation, Japan.* We propose a novel AWG-based wavelength tunable filter architecture that utilizes symmetric and asymmetric Mach-Zehnder interferometers for switching and filtering functions. A prototype is fabricated as a PLC and its good performance is experimentally confirmed.

Th3F.7 • 14:45
One GHz Resolution Arrayed Waveguide Grating Filter with LCoS Phase Compensation, Roy Rudnick[1], David Sinefeld[1], Ori Golani[1], Dan Marom[1]; *[1]Applied Physics, Hebrew Univ., Israel.* We correct fabrication phase errors of 63-arm, 50GHz FSR AWG to achieve 1GHz resolution, by imaging the waveguides onto a phase spatial light modulator. Variable bandwidth and center frequency tuning is achieved by spatial filtering.

15:00–15:30 Coffee Break, *Exhibit Halls A, B, C, North, Exhibit Hall D*

Th3G • OFDM-based Optical Access—Continued

Th3G.7 • 14:30
P-OFDM: Spectrally Efficient Unipolar OFDM, Hany Elgala[1], Thomas D. C. Little[1]; [1]*Boston Univ., USA.* A novel OFDM signal format, polar-OFDM (P-OFDM), is proposed. P-OFDM offers twice as much spectral efficiency as state-of-the-art real-value unipolar OFDM formats. Inherently, the high PAPR is reduced and the numerical evaluation of the BER performance under dynamic-range constraint of optical sources demonstrates superior results.

Th3G.8 • 14:45
Up to 60 km Bidirectional Transmission of a 16 Channels × 10 Gb/s FDM-WDM PON Based on Self-Seeded Reflective Semiconductor Optical Amplifiers, Sy Dat Le[1], Aurelien Lebreton[1,2], Fabienne Saliou[1], Qian Deniel[1,3], Benoit Charbonnier[1], Philippe Chanclou[1]; [1]*Orange R&D, France;* [2]*Université de Bretagne Sud, France;* [3]*Telecom ParisTech, France.* We experimentally demonstrate for the first time a bidirectional transmission up to 60-km of a 16-channel-WDM-PON at 10-Gb/s. An optical-budget over 30-dB was obtained. This was based on self-seeded RSOAs and multi-level-modulation of RF signals.

Th3I • SDN and PCE—Continued

Th3I.6 • 14:30 Invited
Towards a Network Operating System, Victor Lopez[1], Oscar Gonzalez de Dios[1], Beatriz Fuentes[1], Marcelo Yannuzzi[2], Juan-Pedro Fernández-Palacios[1], Diego Lopez[1]; [1]*Telefonica I+D, Spain;* [2]*Technical Univ. of Catalonia, Spain.* A Network Operating System (NetOS) is a novel paradigm for developing a next-generation network management and operation platform. As we shall describe, NetOS not only goes far beyond the SDN concepts but also constitutes a fundamental enabler for NFV.

Th3K • Direct Detection—Continued

Th3K.7 • 14:30 Invited
Direct Detection Optical OFDM, Wei R. Peng[1]; [1]*Futurewei Technologies Inc., USA.* In this paper we review the prior works on DDO-OFDM systems, including the traditional DDO-OFDM that utilizes single band and single polarization, the multiband DDOOFDM superchannel, and the dual-polarization (PDM) DDO-OFDM.

15:00–15:30 Coffee Break, *Exhibit Halls A, B, C, North, Exhibit Hall D*

Show Floor Programming

13:00–15:00
■ **MarketWatch Panel V: PIC vs. Si Photonics: Hype or Reality?,** *Expo Theater I Programming*
For more details, see page 38

13:00–16:00
POF Symposium, *Expo Theater II Programming*
For more details, see page 42

Room 102

15:30–17:30
Th4A • Space Division Multiplexing
Presider: Roland Ryf; Alcatel-Lucent, USA

Th4A.1 • 15:30
Demonstration of Orbital Angular Momentum State Conversion Using Two Hybrid 3D Photonic Integrated Circuits, Chuan Qin[1], Binbin Guan[1], Ryan P. Scott[1], Roberto Proietti[1], Nicolas K. Fontaine[2], Tiehui Su[1], Carlo Ferrari[3], Mark Capuzzo[3], Fred Clemens[3], Bob Keller[3], Mark Earnshaw[3], S.J. Ben Yoo[1]; [1]*Univ. of California Davis, USA;* [2]*Bell Laboratories, Alcatel-Lucent, USA;* [3]*Bell Laboratories, Alcatel-Lucent, USA.* We demonstrate orbital angular momentum state conversion using two 3D photonic integrated circuits for free-space communication of 20-Gb/s QPSK signals. Different combinations of OAM states show error-free performance with 379,960 bits tested.

Th4A.2 • 15:45
1x11 Few-mode Fiber Wavelength Selective Switch Using Photonic Lanterns, Joel A. Carpenter[1], Sergio G. Leon-Saval[1], Joel R. Salazar Gil[1], Joss Bland-Hawthorn[1], Glenn Baxter[2], Luke Stewart[2], Steve Frisken[2], Michael A. Roelens[2], Benjamin J. Eggleton[1], Jochen Schröder[1]; [1]*Univ. of Sydney, Australia;* [2]*Finisar Australia, Australia.* We demonstrate an 11 port count wavelength selective switch supporting spatial superchannels of three spatial modes, based on the combination of photonic lanterns and a high-port count single-mode WSS.

Room 120

15:30–17:30
Th4B • Panel: SDN for Transport Networks

Organizers: Atsushi Iwata, *NEC, USA;* and Saurav Das, *Consultant, USA*

The adoption of Software Defined Networking (SDN) in transport networks is expected to enable programmability and optimization of multi-layer environments, rapid innovation with faster service insertion, and reduced carrier TCO. Five excellent speakers from different parts of the networking sector will discuss where SDN fits in transport, and how it can make a difference.

A sampling of topics the panelists will be asked to comment on: Since SDN can mean different things to different people, what is their definition of SDN? And why does it apply to transport networks? Has SDN always existed in transport? Is it just the latest buzzword? Can SDN be relevant for transport networks in isolation, or must we include interaction with higher layer networks? What will it take to deploy SDN in transport? Does SDN need to interoperate with existing operational transport control planes (if any)? Is SDN necessary? Is it inevitable Glenn Wellbrock, Director of Technology, Verizon Communications, USA

Speakers:

Andreas Gladisch, *Deutsche Telekom AG, Germany*

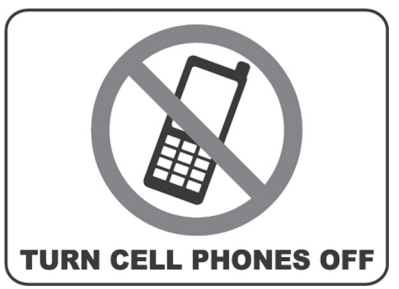
Frank Ruhl, *Independent Telecommunications Consultant (Previously Telstra), Australia*

Kohei Shiomoto, *NTT Network Service Systems Lab, Japan*

Room 121

15:30–17:15
Th4C • Silicon Photonics II
Presider: Po Dong; Alcatel-Lucent Bell Labs, USA

Th4C.1 • 15:30 **Invited**
Micron-scale Silicon Photonic Devices and Circuits, Dazeng Feng[1], Jonathan Luff[1], Shashank Jatar[1], Medhi Asghari[1]; [1]*Mellanox Technologies Inc., USA.* We will review the recent progress in the development of key micron-scale silicon photonics devices and circuits for high speed and low power WDM optical engine applications.



Room 122

Room 123

15:30–17:30
Th4D • DSP Algorithms II
Presider: Gabriella Bosco; Politecnico di Torino, Italy

Th4D.1 • 15:30 ***Top-Scored***
Experimental Demonstration of Pilot-Symbols-Aided Cycle Slip Mitigation for QPSK Modulation Format, Haiquan Cheng[1], Yan Li[1], Miao Yu[1], Jizhao Zang[1], Jian Wu[1], Jintong Lin[1]; [1]*Beijing Univ. of Posts and Telecommunications, China.* A pilot-symbols-aided phase unwrapping is proposed to do cycle-slip mitigations with fourth-power CPE. Experiments for 28 Gbaud SP-QPSK achieve 13 dB ROSNR at 1×10-3 with 1.56% overhead and 2 MHz combined linewidth without differential coding.

Th4D.2 • 15:45 ***Top-Scored***
Cycle-slip Correction in 100Gb/s PM-QPSK Systems, Ling Liu[1], Liangchuan Li[1]; [1]*Huawei Technologies Co., Ltd., China.* We proposed a cycle-slip correction method based on short-time Fourier transform, which corrects cycle-slips during a data frame. It improves pilot-assisted carrier phase recovery, and out-performs differential coding system by 0.6dB@1e-3 in hybrid transmission experiment.

Room 124

15:30–17:30
Th4E • Planning II
Presider: Annalisa Morea; Alcatel-Lucent, France

Th4E.1 • 15:30 ***Top-Scored***
Impact of Slice-ability on Dynamic Restoration in GMPLS-based Flexible Optical Networks, Matteo Dall'Aglio[2], Alessio Giorgetti[2], Nicola Sambo[2], Filippo Cugini[1], Piero Castoldi[2]; [1]*CNIT, Italy;* [2]*Scuola Superiore Sant'Anna, Italy.* This paper proposes a restoration scheme based on slice-ability in GMPLS-based flexible optical networks. Simulations show that the exploitation of slice-ability permits to significantly increase the amount of recovered traffic after link failure.

Th4E.2 • 15:45
Reliability-constrained Resource Allocation for Optically Interconnected Distributed Clouds, Yi Zhu[1], Yan Liang[1], Qiong Zhang[2], Qingya She[3], Xi Wang[2], Paparao Palacharla[2], Motoyoshi Sekiya[2]; [1]*Computer Science, Hawaii Pacific Univ., USA;* [2]*Fujitsu Laboratories of America, Inc., USA;* [3]*Fujitsu Network Communications, USA.* We propose heuristic algorithms to select data centers and allocate virtual machines based on various parameters in optically interconnected clouds for minimizing the maximum delay between selected data centers with reliability and computing resource constraints.

Room 125

15:30–17:15
Th4F • High-Speed Transmission
Presider: Michael Eiselt; ADVA Optical Networking SE, Germany

Th4F.1 • 15:30 Invited
Single-carrier and Dual-carrier 400-Gb/s and 1-Tb/s Transmission Systems, Gregory Raybon[1]; [1]*Alcatel-Lucent Bell Labs, USA*. Abstract not available

Thank you for attending OFC. Look for your post-conference survey via email and let us know your thoughts on the program.

Room 130

15:30–17:30
Th4G • Emerging Data Center Interconnect
Presider: Andrew Alduino; Intel Corporation, USA

Th4G.1 • 15:30 Invited
"CMOS Photonics" Main Innovations and Value in Data-centers, Kal Shastri[1]; [1]*Cisco, USA*. Abstract not available

Room 131

15:30–17:30
Th4H • Wideband Communications & Sensing
Presider: Guifang Li; Univ. of Central Florida, USA

Th4H.1 • 15:30 Tutorial
TeraHertz Photonics for Communications, Alwyn J. Seeds[1]; [1]*Electronic and Electrical Engineering, Univ. College London, UK*. Extending the high data-rate capacity of optical fibre transmission to wireless devices, requires greatly increased carrier frequencies. This tutorial will describe how photonic techniques can enable ultra-high capacity data transmission using signals at TeraHertz frequencies.

Alwyn Seeds received the Ph.D. and D.Sc. degrees from the University of London. After working as a Staff Member at MIT Lincoln Laboratory he moved to University College London, where he is Professor of Opto-electronics and Head of the Department of Electronic and Electrical Engineering. He has published over 400 papers and filed some 15 patents on microwave and opto-electronic devices and their systems applications. Professor Seeds has been elected a Fellow of the Royal Academy of Engineering (UK) and an IEEE Fellow (USA). He has served as Vice-President for Technical Affairs of the IEEE Photonics Society (USA).

Room 132

15:30–17:30
Th4I • Silicon Sources & New Wavelengths
Presider: Andrew Poon; Hong Kong Univ of Science & Technology, Hong Kong

Th4I.1 • 15:30 Invited
Light Emission from Photonic-Plasmonic Silicon Nanostructures, Luca Dal Negro[1]; [1]*Boston Univ., USA*. The development of efficient lasers and LEDs with sub-wavelength size is an ongoing grand challenge in nano-optics. In this talk we will discuss our progress towards plasmon-enhanced sources based on the widespread Si technology.

Room 133

15:30–17:00
Th4J • Architectures & Technologies for Computing Systems
Presider: George Papen; Univ. of California San Diego, USA

Th4J.1 • 15:30 Invited
Large Scale Data Warehouse Build Out Based on Commodity Ethernet Fabrics, Ariel Hendel[1]; [1]*Broadcom Corporation, USA*. Abstract not available

Show Floor Programming

13:00–16:00
POF Symposium, *Expo Theater II Programming*
For more details, see page 42

Th4A • Space Division Multiplexing—Continued

Th4A.3 • 16:00
First Demonstration of Polarization-multiplexing Combined with On-chip Mode-Division-Multiplexing, Christine P. Chen[1], Jeffrey B. Driscoll[1], Noam Ophir[1], Richard R. Grote[1], Richard M. Osgood, Jr.[1], Keren Bergman[1]; [1]*Electrical Engineering, Columbia Univ., USA.* Polarization-multiplexed data is transmitted jointly with on-chip 2-mode mode-division-multiplexed data. Error-free operation and 5 dB of power penalty at an aggregate 40-Gb/s data rate are demonstrated, showing potential for pol-mux and mode-division-multiplexing networks on chip.

Th4A.4 • 16:15
On-chip Multiplexing Conversion between PDM and MDM, Mengyuan Ye[1], Yu Yu[1], Weili Yang[1], Jinghui Zou[1], Yaguang Qin[1], Xinliang Zhang[1]; [1]*Wuhan National Lab for Optoelectronics, China.* A compact SOI device used for the conversions between PDM and MDM is proposed and demonstrated successfully. The proposed on-chip circuit can be used for accommodating the interface of systems utilizing different multiplexing techniques.

Th4B • Panel: SDN for Transport Networks—Continued

Th4C • Silicon Photonics II—Continued

Th4C.2 • 16:00
BOX-less Waveguide Ge PD for Bulk-Si Based Silicon Photonic Platform, Ho-Chul Ji[1], Kwan Sik Cho[1], Beom Seok Lee[1], Keun Yeong Cho[1], Sang Hoon Choi[1], Jeong Hye Kim[1], Yong Hwak Shin[1], Seong Gu Kim[1], Shin Young Lee[1], Hyun Il Byun[1], Sunil Parmar[1], Amir Nejadmal[1], Dong Hyun Kim[1], Jin Kwon Bok[1], Yong Sang Park[1], Dong Jae Shim[1], In Seong Joe[1], Bong Jin Kuh[1], Beom Seok Kim[1], Ki Chul Kim[1], Han Mei Choi[1], Kyoung Ho Ha[1]; [1]*Samsung Electronics Co., Ltd, Republic of Korea.* We present BOX-less waveguide Ge PD for bulk-Si optical interface platform. Despite of defective crystalline of Si-core layer, it shows low dark current (350 nA), high responsivity (1.05 A/W), and high speed operation (25 Gb/s).

Th4C.3 • 16:15
10 Gb/s Bit Error Free Performance of a Monolithic Silicon Avalanche Waveguide Integrated Photodetector, Jason J. Ackert[1], Abdullah S. Karar[2], John C. Cartledge[2], Paul E. Jessop[3], Andrew P. Knights[1]; [1]*Engineering Physics, McMaster Univ., Canada;* [2]*Electrical and Computer Engineering, Queen's Univ., Canada;* [3]*Physics and Computer Science, Wilfrid Laurier Univ., Canada.* Bit error free operation of a waveguide-integrated monolithic silicon avalanche photodiode is obtained for 10 Gb/s. The infrared photoresponse is enabled by the 1.8 μm absorption peak of the silicon divacancy defect, introduced via ion implantation.

Th4D • DSP Algorithms II—Continued

Th4D.3 • 16:00
Modulation Format Identification Based on Received Signal Power Distributions for Digital Coherent Receivers, Jie Liu[1], Zhenhua Dong[2], Kang Ping Zhong[1], Alan Pak Tao Lau[2], Chao Lu[1], Yanzhao Lu[3]; [1]*Department of Electronic and Information Engineering, The Hong Kong Polytechnic Univ., Hong Kong;* [2]*Department of Electrical Engineering, The Hong Kong Polytechnic Univ., Hong Kong;* [3]*Network Research Department, Huawei Technologies, China.* We propose a modulation format identification technique based on extracting and identifying specific features of received signal power distributions for digital coherent receivers. Simulation and experimental results demonstrate successful identification among six common modulation formats.

Th4D.4 • 16:15
1.15 Tb/s Nyquist PDM 16-QAM Transmission with Joint Matched Filtering and Frequency-Domain Equalization, Chen Zhu[1], Liang B. Du[2], Bill Corcoran[2], An V. Tran[3], Trevor Anderson[1], Arthur J. Lowery[2], Efstratios Skafidas[1]; [1]*Victoria Research Lab, NICTA, Electrical and Electronic Engineering, Univ. of Melbourne, Australia;* [2]*CUDOS, Electrical and Computer Systems Engineering,, Monash Univ., Australia;* [3]*Center for Technology Infusion, La Trobe Univ., Australia.* We experimentally demonstrate 18×64-Gb/s Nyquist PDM-16QAM signal transmission over 800-km single-mode fiber. The receiver matched filtering and channel's linear impairment compensation are jointly processed with a single linear filter, greatly reducing the computational complexity.

Th4E • Planning II—Continued

Th4E.3 • 16:00
After Failure Repair Optimization in Dynamic Flexgrid Optical Networks, Marc Ruiz[1], Mateusz Zotkiewicz[2], Alberto Castro[1], Miroslaw Klinkowski[3], Luis Velasco[1], Michal Pioro[2]; [1]*Optical Communications Group, Universitat Politecnica de Catalunya, Spain;* [2]*Inst. of Telecommunications, Warsaw Univ. of Technology, Poland;* [3]*Dept. Transmission and Optical Technologies, National Inst. of Telecommunications, Poland.* We introduce the problem of reoptimizing the network after a link failure has been repaired as an effective way for reducing capacity usage and improving network performance. Numerical results show gains higher than 42%.

Th4E.4 • 16:15 Invited
Energy Efficiency and Reliability Trade-off in Optical Core Networks, Pawel Wiatr[1], Jiajia Chen[1], Paolo Monti[1], Lena Wosinska[1]; [1]*School of ICT, Optical Networks Lab, KTH Royal Inst. of Technology, Sweden.* We assess the highest allowable reliability performance degradation of active components caused by applying energy-efficient mechanisms. EDFAs are identified as the most critical devices where energy saving might not cover the potential additional reparation cost.

Th4F • High-Speed Transmission—Continued

Th4F.2 • 16:00
1 Tb/s - 4x343 Gb/s Subcarriers on 50GHz Grid - Transmission over 480 km SMF with 22 GHz Bandwidth Semiconductor Modulator, Fred Buchali[1], Wildfried Idler[1], Karsten Schuh[1], Tino Brast[3], Steffan Schmid[3], Andreas Steffan[3], Nigel Cameron[2]; *[1]Alcatel-Lucent Bell Labs, Germany; [2]u2t photonics UK Ltd., UK; [3]u2t photonics AG., Germany.* A 1 Tb/s option is demonstrated with 4 subcarriers on the 50 GHz grid, modulated with 43GBd PM-16QAM using a 40 Gb/s GaAs I/Q modulator module. 6dB of OSNR margins are obtained with transmission over 480km SMF.

Th4F.3 • 16:15
Transmission of 400G Dual-Carrier DP-16QAM and Multi-Carrier DP-QPSK Signals over Regional and Long-Haul Distances with Span Lengths Greater than 200 km, Ming-Fang Huang[1], Shaoliang Zhang[1], Katsyuki Mino[2], Yoshiaki Aono[2]; *[1]NEC Laboratories America Inc, USA; [2]NEC Corporation, Japan.* We demonstrate transmission of 400-Gb/s Nyquist-rate dual-carrier DP-16QAM and multi-carrier DP-QPSK signals with 37.5-GHz carrier spacing. The transmission system with span length greater than 200-km SSMF with 44-dB loss and standard EDFA/RA amplification is employed.

Th4G • Emerging Data Center Interconnect—Continued

Th4G.2 • 16:00 *Top-Scored*
Reconfigurable 100 Gb/s Silicon Photonic Network-on-Chip, Po Dong[1], Young-Kai Chen[2], Tingyi Gu[1], Lawrence L. Buhl[1], David T. Neilson[1], Jeffrey H. Sinsky[1]; *[1]Alcatel-Lucent Bell Labs, USA; [2]Alcatel-Lucent Bell Labs, USA.* We report the first intra-chip 10×10 Gb/s wavelength-division multiplexing optical link based on a large-scale silicon photonic integrated circuit with 72 functional elements, which is also reconfigurable as a 10×10 non-blocking switch and a broadcasting network.

Th4G.3 • 16:15
Development of 1060nm 25-Gb/s VCSEL and Demonstration of 300m and 500m System Reach Using MMFs and Link Optimized for 1060nm, Tomofumi Kise[1], Toshihito Suzuki[1], Masaki Funabashi[1], Kazuya Nagashima[1], Robert Lingle[2], Durgesh S. Vaidya[2], Roman Shubochkin[2], John T. Kamino[2], Xin Chen[3], Scott Bickham[4], Jason E. Hurley[3], Ming-Jun Li[3], Alan F. Evans[3]; *[1]FITEL Products Division, Furukawa Electric Co., Ltd., Japan; [2]OFS FITEL, LLC., USA; [3]Science and Technology Division, Corning Incorporated, USA; [4]Corning Optical Fiber and Cable, Corning Incorporated, USA.* VCSELs operating at 25-Gb/s and 1060nm have been developed. System reaches of 300m and 500m have been demonstrated for multi-mode fiber and a multimode fiber link optimized at 1060nm respectively.

Th4H • Wideband Communications & Sensing—Continued

Th4I • Silicon Sources & New Wavelengths—Continued

Th4I.2 • 16:00 *Top-Scored*
Data Transmission at Terabit/s Data Rates Using Silicon-Organic Hybrid (SOH) Frequency Combs, Claudius Weimann[1], Philipp Schindler[1], Dagmawi Bekele[1], Robert Palmer[1], Dietmar Korn[1], Joerg Pfeifle[1], Sebastian Koeber[1], Rene Schmogrow[1], Luca Alloatti[1], Delwin L. Elder[2], Hui Yu[3], Wim Bogaerts[3], Larry R. Dalton[2], Wolfgang Freude[1], Juerg Leuthold[1,4], Christian Koos[1]; *[1]Inst. of Photonics and Quantumelectronics (IPQ), KIT, Germany; [2]Department of Chemistry, Univ. of Washington, USA; [3]Ghent Univ., IMEC, Belgium; [4]Electromagnetic Fields & Microwave Electronics Laboratory (IFH), ETH-Zurich, Switzerland.* We demonstrate frequency comb generation using silicon-organic hybrid (SOH) electro-optic modulators. The frequency combs are used for WDM data transmission at terabit/s data rates and distances of up to 300 km.

Th4I.3 • 16:15
High-contrast, All-silicon Waveguiding Platform for Multi-octave Integrated Photonics, Jeff Chiles[1], Saeed Khan[1,2], Jichi Ma[1], Sasan Fathpour[1,2]; *[1]CREOL, The College of Optics and Photonics, Univ. of Central Florida, USA; [2]Department of Electrical and Computer Engineering, Univ. of Central Florida, USA.* A novel all-silicon optical platform (ASOP) is demonstrated, enabling low-loss propagation in wavelengths of 1.2-8.5 μm. The robust platform offers enhanced CMOS compatibility for electronic-photonic integration in the broadest possible transparency range of silicon.

Th4J • Architectures & Technologies for Computing Systems—Continued

Th4J.2 • 16:00
2D Optoelectronic Engines with Wafer Scale Self-aligned Optical Cores, SAGI MATHAI[1], Paul Rosenberg[1], Wayne Sorin[1], Joseph Straznicky[1], Lennie Kiyama[1], Wayne Mack[1], Georgios Panotopoulos[1], Jason Culler[1], Kent Devenport[1], Michael Tan[1]; *[1]HEWLETT-PACKARD LABORATORIES, HEWLETT-PACKARD COMPANY, USA.* We developed a novel 24 channel (2x12) surface mount solder reflowable optoelectronic engine using MEMS manufacturing techniques, wafer scale packaging, and passive alignment. A fiber optic link operating at 16.5 Gbps/channel was demonstrated.

Th4J.3 • 16:15
A Low Latency Optical Top of Rack Switch for Data Centre Networks with Minimized Processor Energy Load, Shiyun Liu[1], Qixiang Cheng[2], Adrian Wonfor[2], Richard V. Penty[2], Ian White[2], Philip M. Watts[1]; *[1]Electronic and Electrical Engineering, Univ. College London, UK; [2]Centre for Advanced Photonics and Electronics, Univ. of Cambridge, UK.* We propose a low latency optical data center top of rack switch using recirculation buffering and a hybrid MZ/SOA switch architecture to reduce the network power dissipated on future optically connected server chips by 53%.

Room 102

Th4A • Space Division Multiplexing—Continued

Th4A.5 • 16:30
Experimental Demonstration of a Gain-flattening Filter for Few-mode Fiber Based on a Spatial Light Modulator, Ezra Ip[1], Yu Gu Ruo[1,2], Ming-Jun Li[3], Yue-Kai Huang[1], Joseph Kahn[2]; *[1]NEC Laboratories America Inc, USA; [2]Stanford Univerity, USA; [3]Corning Inc., USA*. We demonstrate a spatial light modulator-based few-mode fiber gain-flattening filter (FM-GFF). Arbitrary insertion loss is induced by a phase scattering function. We use the FM-GFF to flatten the output of a few-mode erbium-doped fiber amplifier.

Th4A.6 • 16:45
A Two-mode Division Multiplexing Filter Demonstrated Using a SOI Ring Resonator, Bryce Dorin[1], Winnie N. Ye[1]; *[1]Electronics, Carleton Univ., Canada*. We present experimentally a two-mode ring resonator add/drop filter which exhibits distinct resonances for each mode. This device demonstrates strong potential for channel selective filtering in mode-division multiplexing systems.

Room 120

Th4B • Panel: SDN for Transport Networks—Continued

Room 121

Th4C • Silicon Photonics II—Continued

Th4C.4 • 16:30
Monolithically Integrated 25Gbit/sec Receiver for 1.55µm in Photonic BiCMOS Technology, Dieter Knoll[1], Stefan Lischke[1], Lars Zimmermann[1], Bernd Heinemann[1], Daniel Micusik[1], Pylyp Ostrovskyy[1], Georg Winzer[1], Marcel Kroh[1], Rainer Barth[1], Thomas Grabolla[1], Katrin Schulz[1], Mirko Fraschke[1], Marco Lisker[1], Jürgen Drews[1], Andreas Trusch[1], Andreas Krüger[1], Steffen Marschmeyer[1], Harald Richter[1], Oksana Fursenko[1], Yuji Yamamoto[1], Benjamin Wohlfeil[2], Klaus Petermann[2], Andreas Beling[3], Bernd Tillack[1,2]; *[1]IHP, Germany; [2]TU Berlin, Germany; [3]Univ. of Virginia, USA*. A monolithically integrated 25Gbps receiver is shown as a demonstrator for a novel photonic BiCMOS process which allows for dense co-integration of 200GHz bipolar transistors and CMOS devices with waveguides, couplers, and Ge photodiodes.

Th4C.5 • 16:45
Polarization-insensitive 5x20Gb/s WDM Ge Receiver using Compact Si Ring Filters with Collective Thermal Tuning, Peter De Heyn[1], Jeroen De Coster[2], Peter Verheyen[2], Guy Lepage[2], Marianna Pantouvaki[2], Philippe Absil[2], Wim Bogaerts[1], Dries Van Thourhout[1], Joris Van Campenhout[2]; *[1]Information Technology, Universiteit Gent, Belgium; [2]InterUniv. Microelectronics Center (imec), Belgium*. A 5x20Gb/s WDM Ge receiver with 300GHz channel spacing is presented. Uniform flat-top channel responses result in a 0.1A/W fiber-referenced responsivity and crosstalk better than -15dB for all channels and polarization states.

Room 122

Room 123

Th4D • DSP Algorithms II—Continued

Th4D.5 • 16:30
Reducing the Power Consumption of the CMA Equalizer Update for a Digital Coherent Receiver, Daniel Cardenas[1], Domanic Lavery[1], Philip Watts[1], Seb J. Savory[1]; *[1]Electric and Electronic Engineering, Univ. College of London, UK*. A reduced complexity multiplier-free CMA equalizer update is proposed and synthesized for a 10 Gb/s receiver using a 45-nm CMOS process. The proposed algorithm allows up to 52% power consumption reduction without penalty in performance.

Th4D.6 • 16:45
Novel Equalizer Architecture for Hitless Rate Switching in Energy-Efficient Optical Systems, Valery Rozental[1], Gianmarco Bruno[2], Marco Camera[2], Darli Mello[1]; *[1]Universidade de Brasilia, Brazil; [2]Ericsson Telecomunicazioni, Italy*. We propose a novel equalizer architecture for hitless rate switching in energy-efficient optical systems. Power savings are achieved by rate reduction under low client traffic. The equalizer architecture is experimentally validated in a 100G system.

Room 124

Th4E • Planning II—Continued

Th4E.5 • 16:45
Physical Layer Characteristics and Design of Long Haul Fast Turn-on/off's and Flow Switched All-optical Networks, Vincent W. Chan[1]; *[1]Massachusetts Inst. of Technology, USA*. Adiabatic switching will quench EDFA transients at fast lightpath turn-on/off's. A new metric determines lightpath performance. The worst case occurs when there is only one channel present with non-decreasing performance as more wavelengths are added.

Room 125

Th4F • High-Speed Transmission—Continued

Th4F.4 • 16:30
Over 2000-km Transmission of 60-Gbaud PDM-QPSK Signal with Heterodyne Detection and SE of 4b/s/Hz, Xinying Li[1], Junwen Zhang[1,2], Fan Li[2], Jiangnan Xiao[1]; [1]*Fudan Univ., China;* [2]*ZTE (TX) Inc, USA.* We experimentally demonstrate 8×240-Gb/s WDM-PDM-QPSK signal transmission on 50-GHz grid over 5×420-km SMF-28 with 4-b/s/Hz net SE adopting simplified heterodyne detection and 9QAM-like procession. 9QAM-like procession is more efficient than digital-post-filtering for this heterodyne system.

Th4F.5 • 16:45
Transmission of 128-Gb/s PDM-4PAM Generated with Electroabsoption Modulators over 960-km Standard Single-Mode Fiber, Chongjin Xie[1]; [1]*Alcatel-Lucent Bell Labs, USA.* We generate a 128-Gb/s polarization-division-multiplexed 4-level amplitude-pulse modulation (PDM-4PAM) signal with electroabsorption modulators and transmit it over 960-km standard single-mode fiber (SSMF) using digital coherent detection with 20% overhead soft-decision forward-error-correction.

Room 130

Th4G • Emerging Data Center Interconnect—Continued

Th4G.4 • 16:30 Invited
Hybrid Silicon Photonics Integration, Ashok Krishnamoorthy[1]; [1]*Oracle, USA.* Abstract not available

Room 131

Th4H • Wideband Communications & Sensing—Continued

Th4H.2 • 16:30
Passive Approach for Phase Fluctuation Cancellation of Anonymous Microwave Signal Transmission, Zonglei Li[1], Lianshan Yan[1], YuLan Peng[1], Wei Pan[1], Bin Luo[1], LiYang Shao[1]; [1]*Southwest Jiaotong Univ., China.* A passive approach for phase fluctuation cancellation of anonymous microwave signal transmission is proposed and experimentally demonstrated. Phase drift of 54-ps for 2.45-GHz signals is reduced to 3.8-ps after 10-km SMF transmission.

Th4H.3 • 16:45 *Top-Scored*
Photonic Ultra-wideband Software-defined RF Receiver for Electronic Spectrum Measurements, Daniel Onori[1], Francesco Laghezza[2], Paolo Ghelfi[2], Sergio Pinna[1], Filippo Scotti[2], Giovanni Serafino[1], Antonella Bogoni[2]; [1]*TeCIP, Scuola Superiore Sant'Anna, Italy;* [2]*NLPN, CNIT, Italy.* The architecture of an innovative photonic assisted RF receiver for simultaneously filter, down-convert, and digitize received signals is presented. It allows the reception and analysis of RF signals up the mm-waves.

Room 132

Th4I • Silicon Sources & New Wavelengths—Continued

Th4I.4 • 16:30 Tutorial
Mid-IR Photonics, William Green[1]; [1]*IBM TJ Watson Research Center, USA.* Mid-infrared photonic integrated circuits can potentially reduce the cost, power consumption, and footprint of sensors for environmental monitoring, medical diagnostics, and threat detection. This tutorial explores platforms for the manipulation of mid-wave/short-wave infrared signals, with a focus upon silicon photonics.

Dr. William Green is a Research Staff Member and Manager of the Silicon Integrated Nanophotonics Group at the IBM Thomas J. Watson Research Center. His research activities encompass the design of devices and systems for terabit-per-second-class silicon optical interconnects. In addition, Dr. Green's work has extended the silicon photonic integrated circuit platform to the generation and processing of mid-infrared optical signals, for applications utilizing molecular spectroscopy. His work has been recognized through the 2012 IBM Corporate Award and the 2012 IEEE Photonics Society Young Investigator Award. Dr. Green is a Senior Member of the IEEE and the OSA.

Room 133

Th4J • Architectures & Technologies for Computing Systems—Continued

Th4J.4 • 16:30
Connector Performance Analysis for D-Shaped Multi-Core Multi Mode Fiber, Petar Pepeljugoski[1], Fuad E. Doany[1], Daniel Kuchta[1], Benjamin Lee[1], Clint L. Schow[1], Laurent Schares[1]; [1]*International Business Machines Corp, USA.* Investigation of connector performance for D-shaped multi-core MMF found that worst case equivalent connector offset >5.5m is possible with >2dB loss. Statistical simulations indicate that with proper launch conditions less than 0.75dB loss is possible.

Th4J.5 • 16:45
Highly Reliable Silicone Based Optical Waveguides Embedded in PCBs, Tobias Lamprecht[1], Markus Halter[1], Ranjith John[2], Chad Amb[2], Brandon Swatowski[2], Stefan Beyer[1], Daniel Meier[1], Ken Weidner[2], Felix Betschon[1]; [1]*vario-optics ag, Switzerland;* [2]*Dow Corning Corporation, USA.* Photopatterned silicone optical waveguides are overcoming major hurdles towards their integration in electro-optical printed circuit boards (EOCB) for optical interconnects. They show good optical performance after lamination and reflow soldering.

Room 102

Th4A • Space Division Multiplexing—Continued

Th4A.7 • 17:00
Few-mode Fiber Wavelength Selective Switch with Spatial-diversity and Reduced-steering Angle, Nicolas K. Fontaine[1], Roland Ryf[1], Chang Liu[1], Burcu Ercan[1], Joel R. Salazar Gil[2], Sergio G. Leon-Saval[2], Joss Bland-Hawthorn[2], David T. Neilson[1]; *[1]Alcatel-Lucent Bell Labs, USA; [2]School of Physics, Univ. of Sydney, Australia.* We demonstrated an LCoS based 1×2 wavelength selective switch with few-mode fiber inputs. A 3D waveguide that contains mode-demultiplexers with a reshuffling network enables mode-independent passbands and a reduced steering angle requirement.

Th4A.8 • 17:15
Dynamic Mode Group Equalization Filter and Variable Optical Attenuator for Few Mode Fibers, Israel Weiss[1], Jonathan Gerufi[1], David Sinefeld[1], Miri Blau[1], Moran Bin Nun[1], R. Benjamin Lingle[2], Lars E. Gruner-Nielsen[3], Dan Marom[1]; *[1]Applied Physics, Hebrew Univ. of Jerusalem, Israel; [2]OFS, USA; [3]OFS Fitel Denmark, Denmark.* Variable optical attenuation for few-mode fibers is presented, utilizing an amplitude spatial light modulator. -28dB uniform attenuation and 10dB differential mode equalization is demonstrated, potentially gain-balancing mode dependent amplification.

Room 120

Th4B • Panel: SDN for Transport Networks—Continued

Presentations selected for recording are designated with a ▶. Access these by visiting www.ofcconference.org and clicking on the View Presentations button.

Room 121

Th4C • Silicon Photonics II—Continued

Th4C.6 • 17:00
Monolithic Integration of Si-silica Waveguide Delay Line Interferometer and Germanium Photodetectors for 25-Gbit/s DPSK Demodulator, Tatsurou Hiraki[1,2], Hiroshi Fukuda[2], Tai Tsuchizawa[1,2], Rai Kou[1,2], Hidetaka Nishi[1,2], Kotaro Takeda[1,2], Tsuyoshi Yamamoto[2], Yasuhiko Ishikawa[3], Kazumi Wada[3], Koji Yamada[1,2]; *[1]NTT Nanophotonics Center, Japan; [2]NTT Microsystem Integration Laboratories, Japan; [3]Univ. of Tokyo, Japan.* A straight-shape Si-silica waveguide delay-line interferometer and Ge photodetectros(PD) are monolithically integrated for a DPSK demodulator. The device with a foot-print of 0.49 mm2 and a fiber-to-PD responsitivity of 0.29 A/W successfully demodulates 25-Gbit/s-DPSK signals.

Room 122

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Room 123

Th4D • DSP Algorithms II—Continued

Th4D.7 • 17:00
Aggressive Quantization on Perturbation Coefficients for Nonlinear Pre-Distortion, Qunbi Zhuge[1,2], Michael Reimer[2], Andrzej Borowiec[2], Maurice O'Sullivan[2], David V. Plant[1]; *[1]McGill Univ., Canada; [2]Ciena Corporation, Canada.* We experimentally demonstrate a 2.4 dB improvement in 200G DP-16QAM maximum system margin over 800 km of TrueWave Classic fiber using only 3 distinct perturbation coefficients in nonlinear pre-distortion with 50% chromatic dispersion pre-compensation.

Th4D.8 • 17:15
Reduced OSNR Penalty for Frequency Drift Tolerant Coherent Packet Switched Systems Using Doubly Differential Decoding, Anthony J. Walsh[1,2], James Mountjoy[3], Anthony Fagan[3], Colm Browning[1], Andrew D. Ellis[1,4], Liam P. Barry[1]; *[1]Rince Inst., Dublin City Univ., Ireland; [2]Tyndall National Inst., Ireland; [3]School of Electrical, Electronic and Communications Engineering, Univ. College Dublin, Ireland; [4]School of Engineering and Applied Science, Aston Univ., UK.* In this paper we will demonstrate the improved BER performance of doubly differential phase shift keying in a coherent optical packet switching scenario while still retaining the benefits of high frequency offset tolerance.

Room 124

Th4E • Planning II—Continued

Th4E.6 • 17:00
A Moving Source Routing Solution for High-speed Railway Communication in Optical Core Transport Networks, Nan Hua[1], Xiaoping Zheng[1]; *[1]Tsinghua Univ., China.* We consider the routing problem that one terminal of a connection moves along a determinate path. By avoiding frequent connection re-establishment, our proposed moving source routing solution can reduce handover latency with few communication interruptions.

Th4E.7 • 17:15
Maximum Entropy (MaxEnt) Routing and Spectrum Assignment for Flexgrid-based Elastic Optical Networking, Paul Wright[1], Michael C. Parker[2], Andrew Lord[1]; *[1]British Telecom, UK; [2]Lexden Technologies Ltd, UK.* A maximum entropy approach to routing and spectral allocation in elastic optical networks is implemented using a genetic algorithm and operated on a real network topology. This approach avoids fragmentation problems and increases network utilization.

Room 125

Th4F • High-Speed Transmission—Continued

Th4F.6 • 17:00
Transmission of 480-Gb/s Dual-carrier PM-8QAM over 2550km SMF-28 Using Adaptive Pre-equalization, Junwen Zhang[1,2], Hung-chang Chien[1], Ze Dong[1], Jiangnan Xiao[2]; [1]*ZTE (TX) Inc, USA;* [2]*Fudan Univ., China*. With a novel adaptive pre-equalization scheme based on DD-LMS, four 100-GHz channels, each carrying a 480-Gb/s dual-carrier PM-8QAM signal, are successfully transmitted over 2550-km SSMF with EDFA-only amplification.

Room 130

Th4G • Emerging Data Center Interconnect—Continued

Th4G.5 • 17:00
Nonlinear Compensation for 980 nm High Power, Single-Mode VCSELs for Energy Efficient OM 4 Fiber Transmission, I-Cheng Lu[1], Chia-Chien Wei[2], Hsing-Yu Chen[1,3], Pei-Yu Chung[1], Peng-Hao Huang[1], Jia-Wei Jiang[4], Kai-Lun Chi[4], Jin-Wei Shi[4], Jyehong Chen[1]; [1]*National Chiao Tung Univ., Taiwan;* [2]*National Sun Yat-sen Univ., Taiwan;* [3]*Industrial Technology Research Inst., Taiwan;* [4]*National Central Univ., Taiwan*. A nonlinear compensation method is demonstrated to boost the launch power for optical interconnects employing OFDM format. A 1.5 dB sensitivity improvement is obtained for a 2-km OM4 fiber transmission system at 15 Gbit/sec.

Th4G.6 • 17:15
Ultra-compact 320 Gb/s and 160 Gb/s WDM Transmitters Based on Silicon Microrings, Yang Liu[1], Ran Ding[1], Qi Li[2], Xuan Zhe[1], Yunchu Li[1], Yisu Yang[1], Andy E. Lim[3], Patrick Guo-Qiang Lo[3], Keren Bergman[2], Tom Baehr-Jones[1,5], Michael Hochberg[1,4]; [1]*Department of Electrical & Computer Engineering, Univ. of Delaware, USA;* [2]*Department of Electrical Engineering, Columbia Univ., USA;* [3]*Inst. of Microelectronics, A*STAR (Agency for Science, Technology and Research), Singapore;* [4]*Department of Electrical & Computer Engineering, National Univ. of Singapore, Singapore;* [5]*EastWest Photonics PTE LTD, Singapore*. We demonstrated 320Gb/s 8-channel and 160Gb/s 4-channel WDM transmitter using silicon microrings based on conventional common-bus architecture and a new "Mod-MUX" architecture respectively. We discuss and compare the two designs and highlight their complementary merits.

Room 131

Th4H • Wideband Communications & Sensing—Continued

Th4H.4 • 17:00 Invited
Optical Combs for Sensor Applications, Nathan R. Newbury[1]; [1]*National Inst. of Standards & Technology, USA.* Frequency combs provide a broadband, coherent, calibrated optical output in a single mode beam. We discuss three sensing applications that exploit this unique combination of properties: molecular spectroscopy, optical time-frequency transfer, and three-dimensional surface mapping.

Room 132

Th4I • Silicon Sources & New Wavelengths—Continued

Room 133

Th4J • Architectures & Technologies for Computing Systems—Continued

18:00–20:00 **Postdeadline Paper Sessions**