Network Application Interface

I-1

Collaboration of Dynamic Optical Path Network and SDN / NFV Technologies to Realize Flexible High-Capacity Network

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In order to achieve a flexible high-capacity network, collaboration of Dynamic Optical Path Network (D-Node) and SDN / NFV is important. We use "Lagopus", the SDN/OpenFlow software switch, as a terminal of D-Node for this purpose.

I-2

NSI-based Hierarchical Multi-granular Path Network Resource Management

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Group B

For the efficient deployment of various applications such as high-definition video streaming, we have developed a Network Services Interface (NSI) standard-based resource management system (RMS) for hierarchical multi-granular path networks.

I-3

Integration NFV into Dynamic Optical Path Network

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Group A

Network virtualization dramatically improves the flexibility of resource management in dynamic optical path network infrastructure. We are studying on 1) an operating system mechanism to improve the performance of NFV applications and 2) a virtualization mechanism to make NFV applications more scalable, robust and flexible.

Dynamic Node Technology

N-1

Energy efficient photonic network using dynamic CDCROADM with low loss silicon optical switches

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Group B

Dynamic CDC-ROADM systems using Si-TPA* are developed. Reduction of optical loss for energy efficient network and fast switching for improvement of reliability of dynamic optical path network is achieved.

* Silicon photonics based transponder aggregator

N-2

Standard Rack for Dynamic Node: A Conceptual Proposal

S. Namiki[1], J. Kurumida[1], K. Ishii[1], S. Suda[1], K. Komaki[2], T. Terahara[2], H. Onaka[2], S. Yanagimachi[3] , H. Takeshita[3], A. Tajima[3], K. Fukuchi[3]

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Group A

A concept of the standard rack for Dynamic Node is discussed. The concept would suit with open and disaggregated architecture to allow multi-vendor configurations of nodes, while hardware abstraction is the key in practice.

N-3

Energy Consumption of Data Communication Network in Japan Estimated with Unifying Top-down and Bottom-up Approach

Kiyo Ishii[1], Junya Kurumida[1], Ken-ichi Sato[2], Tomohiro Kudoh[1*], Shu Namiki[1]

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Group B

Concern about network energy consumption is growing as the continuous traffic increases. We estimate the energy consumption of the fixed broadband internet in Japan from 2000 to 2030. Effects of network optimization technologies on energy savings are discussed.

N-4	**Fast and Flexgrid Wavelength Switching of Narrow-Linewidth TDA-CSG-DR Lasers**	H. Matsuura[1], T. Kaneko[2], K. Tanizawa[1], E. Banno[2], K. Uesaka[2], H. Kuwatsuka[1], H. Iwai[3], S. Namiki[1], H. Shoji[2] [1] National Institute of Advanced Industrial Science and Technology (AIST), [2] Sumitomo Electric Industries, Ltd. , [3] Trimatiz Ltd.	Group A
	We have developed a fast and flexgrid wavelength switching light source with narrow-linewidth TDA-CSG-DR laser, wavelength locker using double etalons and FPGA control. Pre-emphasis for heater temperature control is effective to reduce switching time and its channel-by-channel variation.		

Optical Path Conditioning			
C-1	**Optical Multiplexing Technology Using Fiber-Optic Signal Processing**	Tomoyuki Kato, Takahito Tanimura, and Shigeki Watanabe Fujitsu Laboratories Ltd.	Group B
	Distributed ultra-dense optical multiplexing technology using fiber-frequency conversion is investigated. A precise subcarrier multiplexing into an optical frequency-division multiplexed signal from remote node is demonstrated based on free-running lasers without frequency locking.		
C-2	**Are Highly NonLinear Fibers Ready for Practical Applications?**	Shigehiro Takasaka, Takeshi Yagi Furukawa Electric Co., Ltd.	Group A
	We review developments of highly nonlinear fibers (HNLF) toward practical applications. Though compact packaging of HNLFs is available, compact packaging of HNLF applications is prevented by stimulated Brillouin scattering (SBS). SBS suppression techniques are discussed.		
C-3	**Basic study of a High-Speed Tunable Bandpass Filter**	K. Ota, S. Petit, K. Toyoda Trimatiz Ltd.,	Group B
	We are developing an optical tunable filter without moving part, based on an electro-optic effect to tune the central wavelength. It will be possible to increase the tuning speed while enabling an electronic control.		
C-4	**High-Index-Contrast Optical Waveguides for Polarization Diversity on Silicon Photonic Platform**	Akira Oka, Kazuhiro Goi, Yasuhiro Mashiko, Norihiro Ishikura, Kensuke Ogawa Advanced Technlogy Laboratory, Fujikura Ltd.	Group A
	Polarization diversity is crucial for photonic integrated circuits inserted in line of optical-fiber communication networks. A polarization demultiplexer/multiplexer, which consists of a polarization splitter/combiner and a polarization rotator, has been designed using high-index-contrast optical waveguides on silicon-photonic platform and characterized in terms of polarization-dependent loss in C and L bands.		
C-5	**Ultrafast constellation monitor**	Hiroshi Ohta, Futoshi Shirazawa, Takanori Goto Alnair Labs Corporation	Group B
	We introduce the constellation monitoring technology by using linear optical sampling method and SOP. This technique avoids the influence of optical phase noise from sampling pulse, and can observe constellation of DP-QPSK signal.		
C-6	**Field-Deployed Legacy Fiber System Enhanced by Mid-Span Spectral Inversion**	K. Solis-Trapala[1], M. Pelusi[2], H. Nguyen Tan[1], T. Inoue[1], S. Suda[1], S. Namiki[1] [1] Institute of Advanced Industrial Science and Technology (AIST) , [2] Centre for Ultrahigh bandwidth Devices for Optical Systems (CUDOS), University of Sydney	Group A
	We present the first field-deployed, standard legacy-fiber link empowered by mid-span spectral inversion (MSSI) enabling double the transmission reach of a 144 Gb/s DP-64QAM signal. Completely detrimental transmission was recovered for 693.2 km long reach.		

C-7	**Efficient Transceivers for Coherence-Related Networks**	Aaron Albores-Mejia, Takashi Inoue, Haruhiko Kuwatsuka National Institute of Advanced Industrial Science and Technology (AIST)	Group B
	Capacity demands in short-range networks (<80km) are driving the research into Terabit-class Transceiver concepts. Cost, energy consumption and hardware complexity are paramount metrics for such networks. Addressing these stringent considerations, this poster proposes, the coherence-related terabit transceiver concept.		
C-8	**Cascadability of an All-Optical Wavelength Converter for High-Order QAM Signals**	Hung Nguyen Tan, Takashi Inoue, and Shu Namiki National Institute of Advanced Industrial Science and Technology (AIST)	Group A
	We present 14, 10, 4 cascaded wavelength conversions of 48Gbit/s DPQPSK, 96Gbit/s DP-16QAM, 144Gbit/s DP-64QAM, respectively. The high cascadability results from high conversion efficiency achieved by a counter-dithering scheme with small impact of residual dithering.		
C-9	**Phase regeneration of BPSK signals and QPSK signals by Hybrid Optical Phase Squeezer**	Takayuki Kurosu, Hung Nguyen Tan, Karen Solis-Trapala, Shu Namiki National Institute of Advanced Industrial Science and Technology (AIST)	Group B
	We demonstrate low-power phase regeneration of QPSK signals and phase regenerative multicasting of BPSK signals using a newly proposed concept called hybrid optical phase squeezer (HOPS).		

Optical Path Processor			
P-1	**In-line optical amplification of silicon waveguides by hybrid-integrated InP-SOA for loss-less matrix switches**	Takeshi Matsumoto[1], Teruo Kurahashi[1], Ken Tanizawa[2], Keijiro Suzuki[2], Ayahito Uetake[1], Kazumasa Takabayashi[1], Kazuhiro Ikeda[2], Hitoshi Kawashima[2], Suguru Akiyama[1] [1] Fujitsu Laboratories Ltd. , [2] National Institute of Advanced Industrial Science and Technology (AIST)	Group A
	Large-scale and compact optical matrix switches made of silicon are key components for future energy-saving networks. These switches suffer from large cumulative losses due to the elements, such as phase shifters (PSs), couplers and intersections, which compose these switches. Therefore on-chip optical amplification is necessary to compensate for those losses. In this work, we investigated hybrid integration of indium-phosphide semiconductor optical amplifiers (InP-SOAs) on silicon photonics (SiPh) chips by using precise flip-chip bonding technologies. We demonstrated in-line optical amplification of SiPh chip, which compensated for on-chip optical losses of 1x8 splitters.		
P-2	**Optical Fiber Connecting Technique in High-Δ Optical Waveguide**	Junichi Hasegawa, Toshio Kimura, Toshikazu Mukaihara Furukawa Electric Co.,Ltd.	Group B
	We report low loss connecting technique between high-Δ ZrO2-SiO2 PLC and SMF. Coupling loss was reduced to less than 0.5dB/facet by developed two techniques, using high-Δ fiber and novel SSC.		
P-3	**Collimator fiber array with high density GRIN lens**	Keiichi Sasaki[1], Hisato Uetsuka[2] [1] KITANIHON ELECTRIC CABLE Co., LTD, [2] National Institute of Advanced Industrial Science and Technology (AIST)	Group A
	Fiber array with high density GRIN lens have been developed. One of the key factors for achieving wavelength cross connect switches with very high port count is the fill factor (α). To get small α , simulations are conducted. As a result, α of 1.40 is obtained, which is applicable for actual GRIN lens		
P-4	**Fast and accurate calibration method for large-port-count Si-wire PILOSS optical switch**	S. Suda, K. Tanizawa, K. Suzuki, H. Matsuura, K. Ikeda, S. Namiki, H. Kawashima National Institute of Advanced Industrial Science and Technology (AIST)	Group B
	We propose a calibration method for N × N Si-wire path-independent-insertion-loss (PILOSS) optical switches with thermo-optic Mach-Zehnder-interferometer (MZI) element switches. Calibration for a 32x32 switch is numerically demonstrated with an error less than 1% within an hour.		

P-5	**Development of Multi-Port Silicon Optical Switch**	Keijiro Suzuki, Ken Tanizawa, Guangwei Cong, Sang-Hun Kim, Kazuhiro Ikeda, Shu Namiki, Hitoshi Kawashima National Institute of Advanced Industrial Science and Technology (AIST)	Group A
	We report on our recent works for improvements in switching performance of silicon optical multi-port switches. For practical applications, its wavelength and polarization independence is discussed.		
P-6	**32 × 32 Si-wire thermo-optic PILOSS switch packaged with LGA interposer**	Ken Tanizawa[1], Keijiro Suzuki[1], Toshio Sugaya[2], Guangwei Cong[1], Satoshi Suda[1],Toshio Kimura[2], Kazuhiro Ikeda[1], Shu Namiki[1], Hitoshi Kawashima[1] [1] National Institute of Advanced Industrial Science and Technology (AIST), [2] FURUKAWA Electric Co.Ltd.	Group B
	We demonstrate a 32 × 32 Si-wire path-independent-insertion-loss switch packaged with 0.5-mm pitch LGA interposer. On-chip loss is measured to be 15.8 dB with trimming currents. Successful transmission of 43-Gb/s QPSK signal is achieved.		
P-7	**Pulse-width modulation driving of thermo-optic switches using monolithically integrated MOSFET on Si-photonic platform**	G.W. Cong[1], T. Matsukawa[2], T. Chiba[2], H. Tadokoro[2], M. Yanagihara[2], M. Ohno[1], H. Kuwatsuka[1], Y. Igarashi[2], M. Masahara[2], H. Ishikawa[1], S. Namiki[1], K. Yamada[1], H. Kawashima[1] National Institute of Advanced Industrial Science and Technology (AIST) [1] Electronics and Photonics Research Institute, [2] Nanoelectronics Research Institute	Group A
	Pulse-width modulation was demonstrated using monolithically integrated MOSFETs to drive thermo-optic(TO) Mach-Zehnder switches on Si-photonic platform. This work contributes to simple and power-efficient driving circuits for large-scale TO switches.		
P-8	**5x5 Wavelength Cross- Connect Module**	Hisato Uetsuka[1], Masao Tachikura[1], Hiroyuki Ohkubo[1], Keiichi Sasaki[2] [1] National Institute of Advanced Industrial Science and Technology (AIST), [2] Kitanihon Electric Cable Co., LTD	Group B
	The future WSS should handle many optical channels in addition to the CDC (Colorless, Directionless, Contentionless) and the flexible grid operations. Here, we have developed the 5x5 WXCs with different switching engines as MEMS mirror and LCoS.		

Guest	＊ Guest posters are invited to present the research results and/or activities that are outside the VICTORIES project.		
G-1	**Polarization diversity circuit for a silicon optical switch using photonic crystal thin film waveplates**	Koki Sugiyama[1], Takafumi Chiba[2], Takayuki Kawashima[2], Shojiro Kawakami[2], Hiroshi Takahashi[3], Hiroyuki Tsuda[1] [1] Graduate School of Science and Technology, Keio University, [2] Photonic Lattice, Inc., [3] Department of Information and Communication Sciences, Sophia University	Group A
	We proposed a compact 4x8 polarization diversity circuit using silica waveguides and photonic crystal waveplates. This enables to suppress the polarization dependence of the silicon 4x4 optical switches.		
G-2	**Design of a Current-Driven 2x2 Optical Switch Using Phase-Change Material**	Kentaro Kato[1], Hitoshi Kawashima[2], Masashi Kuwahara[2], Hiroyuki Tsuda[1] [1] Graduate School of Science and Technology, Keio University, 2 National Institute of Advanced Industrial Science and Technology (AIST)	Group B
	We proposed and designed a current-driven 2x2 optical switch using Si waveguides and phase-change material. The structure of the phase shifter was optimized to reduce the required switching energy and insertion loss.		

G-3	**Fiber-to-chip coupling structure for Si wire waveguide**	Yuriko Maegami, Ryohei Takei, Emiko Omoda, Takeru Amano, Makoto Okano, Masahiko Mori, Toshihiro Kamei, Youichi Sakakibara National Institute of Advanced Industrial Science and Technology (AIST)	Group A
	Spot-size converters (SSCs) comprised of a three dimensionally tapered Si wire waveguide, a SiON secondary waveguide, and a SiO2 spacer inserted between them, which exhibited fiber-to-chip coupling loss of 1.5 dB/facet for both the quasi-TE and TM modes and a small wavelength dependence in the C and L-band regions.		
G-4	**Silicon Mach-Zehnder Optical Path Switch based on In-plane Switching Mode Liquid Crystal**	Y. Atsumi[1], T. Miyazaki[1,2], M. Okano[1], R. Takei[1], N. Miura[2], M. Mori[1], Y. Sakakibara[1,2] [1] National Institute of Advanced Industrial Science and Technology (AIST), [2] Meiji University	Group B
	Silicon Mach-Zehnder optical switch with liquid crystal cladding was fabricated. The $V_{\pi}L$ of 0.4 V・mm, minimum path crosstalk of −17 dB, and small insertion loss was obtained for the device with 100-μm-long phase-shifter.		
G-5	**Vertically-Curved Waveguide Fabrication Using Ion Implantation Method for Vertical Coupling**	T. Yoshida[1], R. Takei[1], S. Tajima[2], E. Omoda[1], N. Miura[2], M. Mori[1], Y. Sakakibara[1,2] [1] National Institute of Advanced Industrial Science and Technology (AIST), [2] Meiji Univ.	Group A
	A novel vertical coupler for wide bandwidth vertical coupling on silicon photonics circuit devices is developed. A distinct feature of the vertical coupler is its three-dimensionally curved silicon waveguide shape formed by ion implantation method.		
G-6	**Limitation and Improvement in the Sensitivity of Optical Frequency Noise Measurement**	Hidemi Tsuchida National Institute of Advanced Industrial Science and Technology (AIST), Electronics and Photonics Research Institute	Group B
	The sensitivity of 0.1 Hz2/Hz at 10-MHz Fourier frequency was achieved in optical frequency noise measurement by quantitative clarification of various limiting factors and subtraction of the resulting noise floor.		
G-7	**PHOENICS (PHOtonics ENgineering Innovation ConSortium)**	Haruhiko Kuwatsuka[1], Shu Namiki[1], Isao Matsushima[1], Senichi Suzuki[2] [1] National Institute of Advanced Industrial Science and Technology (AIST), [2] NTT Device Innovation Center	Group A
	PHOENICS has been established as an AIST consortium for the industry of optical devices in communication systems from 2015. An eco-system of optical devices industry, called as virtual fab system, is discussed in the consortium.		
G-8	**Flow-centric Computing – A data center architecture in the post-Moore era–**	Ryousei Takano[1], Tomohiro Kudoh[2] [1] National Institute of Advanced Industrial Science and Technology (AIST), [2] The University of Tokyo	Group B
	To satisfy real-time big data processing with low-energy consumption in the post-Moore era, we propose flow-centric computing, a software-defined data center architecture. Resources in data center are disaggregated and are connected through huge bandwidth optical path network. The data center OS reassembles heterogeneous resources to process a data flow in a pipeline manner.		
G-9	**Exabit Optical Network for High-Performance Datacenters**	T. Inoue, T. Kurosu, K. Ishii, H. Kuwatsuka, and S. Namiki National Institute of Advanced Industrial Science and Technology (AIST)	Group A
	A design concept of optical network enabling Exabit/s interconnect between 100,000 nodes for future high-performance datacenters is discussed, where a large-scale optical switch fabric and a high-capacity and energy-efficient WDM transmission scheme play key roloes.		