Vertically Integrated Center for Technologies of Optical Routing toward Ideal Energy Savings

第9回「光ネットワーク超低エネルギー化技術拠点」シンポジウム

Network Application Interface

I-1	**High Performance SDN Virtual Switch for NFV Infrastructures**	Hirokazu Takahashi, Norio Sakaida, and Katsushiro Shimano NTT Network innovation Laboratories	Group A	SDN/NFV provides agility and flexibility for network services. However, virtual switches for NFV infrastructures can be bottlenecks. In order to realize high performance SDN virtual switch, we developed a network driver for connecting virtual machines and applied it into our Lagopus.
I-2	**A performance analysis mechanism for software-based packet processing**	Takahiro Hirofuchi[1], Ryousei Takano[1]and Tomohiro Kudoh[2] [1]National Institute of Advanced Industrial Science and Technology (AIST), [2]The University of Tokyo	Group B	We are developing a mechanism to analyze complex internal behavior of packet processing software. It probes ring buffer activities by means of light-weight sampling techniques, records cache miss events with causative memory objects, and visualizes performance bottlenecks. This mechanism enables developers to maximize the efficiency of pipeline parallelism in their multi-staged packet processing programs.

Dynamic Node Technology

N-1	**8×32 TransPonder Aggregator Blade for Disaggregated Optical Transmission System**	Shigeyuki Yanagimachi, Hitoshi Takeshita, Shigeru Nakamura, and Akio Tajima IoT Devices Research Laboratories, NEC Corporation	Group A	8 × 32 TransPonder Aggregator blade for dynamic disaggregated optical node using silicon photonics switches is developed. The blade matches the concept of open and disaggregated optical node system proposed by VICTORIES.
N-2	**Open & Disaggregated Optical Transport System : 1FINITY**	O. Takeuchi, D. Suzuki, K. Komaki, T. Terahara Network Products Business Unit, Fujitsu Ltd.	Group B	Open and disaggregated optical transport platform : 1FINITY and 400Gbps muxponder : T200 was developed. That enable users to flexibly and agilely build high-capacity optical network.
N-3	**Open and Disaggregated Rack and Standard Blade for DOPN**	S. Suda[1], K. Ishii1, H. Matsuura[1], T. Terahara[2], K. Komaki[2], D. Suzuki[2], S. Yanagimachi[3], H. Takeshita[3] and S. Namiki[1] [1]National Institute of Advanced Industrial Science and Technology (AIST), [2]Network Products Business Unit, Fujitsu Ltd., [3]IoT Devices Labs., NEC Corporation	Group A	VICTORIES proposes a concept of open and disaggregated rack and standard blade that mount optical functional modules such as silicon-based optical switch, CDC-ROADM, and ODU cross-connect for building dynamic optical path networks. It opens up a new way to pay-as-you-grow multiple-vendor platform.
N-4	**Functional Capability Description of Optical Nodes for Dynamic and Disaggregated Networks**	Kiyo Ishii[1], Atsuko Takefusa[2], Ryousei Takano[1], Shu Namiki[1], Tomohiro Kudoh[3] [1]National Institute of Advanced Industrial Science and Technology (AIST), [2]National Institute of Informatics (NII), [3]The University of Tokyo	Group B	Generic description of a network system is important to realize programmable, agile, and open transport networks. Representing functional capabilities of various network devices in a common format will enhance network flexibility and availability.
N-5	**DOPN Tokyo Test Bed and its Applications**	VICTORIES Outreach Group National Institute of Advanced Industrial Science and Technology (AIST)	Group A	A test bed field trial of the Dynamic Optical Path Network (DOPN) is now under construction in Tokyo Metropolitan area. DOPN is an optical-switch based low-layer network, whose unique features are ultra-high guaranteed bandwidth, ultra-low latency, and ultra-low energy operation. One of the typical applications is the remote immersive musical session. Using our test bed, clinical applications based onuncompressed 8K real time transmission, low-cost tele-presence conferencing based on 4K Tele-Session Systems will be demonstrated. The test bed will be open for collaborations.

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	**Development of High-Speed Tunable Bandpass Filter**	K. Ota,N. Nishikawa TrimatizLtd.,	Group A	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-3	**Monolithic integration of polarization-division multiplexing waveguides and IQ modulators for high-speed optical signal generation**	N. Ishikura[1], K. Goi[1], H. Zhu1, M. Illarinov[1], H. Ishihara[1], A. Oka[1], K. Mashiko[1], T. Ori[1], K. Ogawa[1], Y. Yoshida[2], K. Kitayama[3], T.-Y. Liow[4], X. Tu[4], G.-Q. Lo[4], D.-L. Kwong[4] [1]Fujikura Ltd., [2]National Institute of Information and Communications (NICT), [3]School for the Creation of New Photonics Industries, [4]Institute of microelectronics, Singapore	Group B	Monolithic photonic integrated circuit consisiting of polarization-division multiplexing waveguides and IQ Mach-Zehnder modulators are designed and fabricated on the basis of silicon photonics platform. Beyond-100G modulation in various modulation formats with drive voltage amplitude of 2VPPD or lower is demonstrated.
C-4	**Possible phase noise reduction of TDA-CSG-DR tunable lasers by external optical feedback**	Toshimitsu Kaneko, Masaaki Okamoto and Katsumi Uesaka Sumitomo Electric Industries, Ltd., Japan	Group A	An effect of external optical feedback to laser diodes was investigated toward higher-level modulation in digital coherent system. A 320MHz-1 delayed feedback to TDA-CSG-DR tunable laser significantly reduced phase noise at ~100MHz in Fourier frequency. A further investigation indicated that faster feedback is necessary to obtain effective transmission quality.
C-5	**Development of High-speed Monitoring Technology**	Hiroshi Ohta, Futoshi Shirazawa, Takanori Goto Alnair Labs Corporation	Group B	We introduce the monitoring technology, constellation measurement of 100-Gbit/s DP-QPSK signal and signal wavelength measurement with high-speed measurement time. The constellation was observed utilizing SOP, and the signal wavelength was measured based on polychromator.
C-6	**Squeezing of optical phase noise without phase-to-amplitude noise conversion**	Takayuki Kurosu and Shu Namiki National Institute of Advanced Industrial Science and Technology (AIST)	Group A	We present a method to reduce phase noise of optical signals without increasing amplitude noise. The proposed concept was implemented by a novel technique called hybrid phase squeezer (HOPS) and successfully applied to reduce the phase noise of BPSK signals.
C-7	**All-Optical Wavelength Converter for WDM signals**	Takashi Inoue[1], Kazuya Ota[2], Shigehiro Takasaka[3], and Shu Namiki[1] [1]National Institute of Advanced Industrial Science and Technology (AIST), [2]Trimatiz Ltd., [3]Furukawa Electric Co., Ltd.	Group B	We develop a format-agnostic and guard-band-less all-optical wavelength converter which is capable of multi-channel optical signals. The proposed structure and preliminary experimental result on multi-channel wavelength conversions are discussed.

Poster Presentations

Group A　Group A　13:15–14:00　　Group B　Group B　15:30–16:30

Optical Path Processor			
P-1	**1x8 Compact Silicon Splitter and Switch with on-Chip Optical Amplification by Flip-Chip Bonded InP-SOA**	Takeshi Matsumoto[1], Teruo Kurahashi[1], Ken Tanizawa[2], Keijiro Suzuki[2], Ayahito Uetake[1], Kazumasa Takabayashi[1], Kazuhiro Ikeda[2], Hitoshi Kawashima[2], and Suguru Akiyama[1] [1]Fujitsu Laboratories Ltd., [2]National Institute of Advanced Industrial Science and Technology (AIST) Group A	We investigated hybrid-integration of an InP semiconductor optical amplifier (SOA) on a silicon photonics chip using flip-chip bonding for on-chip loss compensation. Operation of 1x8 silicon switch is successfully demonstrated with on-chip optical amplification by flip-chip bonded SOA.
P-2	**Optical Fiber Connecting Technique Using High-Δ Silica-based PLC**	Junichi Hasegawa[1], Toshikazu Mukaihara[1], Kazuhiro Ikeda[2], Ken Tanizawa[2], Keijiro Suzuki[2], Hitoshi Kawashima[2] [1]Furukawa Electric Co.,Ltd. [2]National Institute of Advanced Industrial Science and Technology (AIST) Group B	We report on optical fiber connecting techniques between Si waveguides and single-mode fibers. Coupling loss was reduced to 2.1 dB/facet by using high-Δ Silicabased PLC. We aim to further reduce the coupling loss.
P-3	**High Port-Count Wavelength Cross-Connect Switch(WXC)**	Hisato Uetsuka[1], Masao Tachikura[1], Masahiro Okawa[1], Yao Bin[1], Keiichi Sasaki[2] [1]National Institute of Advanced Industrial Science and Technology (AIST), [2]Kitanihon Electric Cable Co., Ltd. Group A	We propose a wavelength cross-connect switch using our newly invented wide-angle steering devices. By using the devices, the port count of WXC can be much increased. Our development target at present is 32x32 WXC, so high-precision 32 port fiber arrays are also developed.
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, and 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	**Driving Circuit for 32X32 Optical Matrix Switch using High-resolution Pulse-width Modulation**	H. Matsuura, S. Suda, K. Tanizawa, K. Suzuki, K. Ikeda, H. Kawashima, and S. Namiki National Institute of Advanced Industrial Science and Technology (AIST) Group A	Applied power of 2048 heaters on 32X32 matrix switch are controlled by pulse-width modulation. Using two frequency counters with Vernier-effect, we verified the timing-resolution of 6480 steps with 1 μs repetition rate. Five FPGAs (Field Programmable Gate Arrays) and other circuits are assembled on a printed circuit board, and it is installed to 1RU-height “Standard Blade”.
P-6	**Full Path Characterization of 32 × 32 Si-Wire Strictly-Non-Blocking Optical Path Switch**	Ken Tanizawa, Keijiro Suzuki, Satoshi Suda, Hiroyuki Matsuura, Kazuhiro Ikeda, Shu Namiki, and Hitoshi Kawashima National Institute of Advanced Industrial Science and Technology (AIST) Group B	We demonstrate all 1024 path connections of a compact 32 × 32 strictly-non-blocking thermooptic Si-wire switch. Advanced 300-mm wafer fabrication, dense electronic flip-chip packaging, and pulse-width-modulation heater control are successfully integrated.
P-7	**8 × 8 Si PILOSS Switch Based on Double Mach-Zehnder Elements for Broadband Operation**	K. Suzuki, K. Tanizawa, S. Suda, H. Matsuura, K. Ikeda, S. Namiki, and H. Kawashima National Institute of Advanced Industrial Science and Technology (AIST) Group A	We review recent achievements in multi-port optical switches based on silicon photonics, in which broadband operation is focused. For wavelength independence, a double Mach - Zehnder switch is adopted, and we demonstrate -20 dB crosstalk in >30-nm bandwidth.
Guest	＊ Guest posters are invited to present the research results and/or activities that are outside the VICTORIES project.		
G-1	**Large-Scale Intra-Datacenter Switch Using Silicon-Photonic Multicast Switches and Tunable Filters**	Yojiro MORI[1], Koh Ueda[1], Keijiro Suzuki[2], Hiroyuki Matsuura[2], Ken Tanizawa[2], Satoshi Suda[2], Kazuhiro Ikeda[2], Shu Namiki[2], Hitoshi Kawashima[2], Shigeru Nakamura[3], Shigeyuki Yanagimachi[3], Akio Tajima[3], and Ken-ichi Sato[1,2] [1]Nagoya University, [2]National Institute of Advanced Industrial Science and Technology (AIST), [3]NEC Corporation Group B	We propose novel optical circuit switch architecture for intra-datacenter networking. The key components, optical multicast switches and tunable filters, are fabricated using silicon photonics. Proof-of-concept transmission experiments are performed using newly developed silicon-photonic devices.
G-2	**Wavelength Selective External Cavity Laser Using an InAs Quantum Dot Gain Chip and an Arrayed-Waveguide Grating for T-band Optical Communication**	Yudai Okuno[1], Yoshinori Sawado[2], Katsumi Yoshizawa[2], Yasunori Tomomatsu[3], Hiroyuki Tsuda[1] [1]Keio University, [2]Pioneer Micro Technology Corporation, [3]Koshinkogaku Corporation Group A	The wavelength selective external cavity laser using an InAs quantum dot gain chip and an arrayed-waveguide grating for T-band optical communication is proposed. The output wavelength can be tuned from 1041.8 nm to 1090.5 nm.
G-3	**1 × 2 Wavefront Control Type Compact Silicon Wavelength Selective Switch**	Fumi Nakamura, Kyosuke Muramatsu, Hiroyuki Tsuda Department of Electronics and Electrical Engineering, Faculty of science and technology, Keio University Group B	A 16-channel 1 × 2 wavefront control type wavelength selective switch with 200-GHz channel spacing on a silicon substrate is designed. A two-step etched rib structure is adopted in order to reduce loss in the boundary between the slab and the arrayed-waveguide.
G-4	**Development of standard high speed silicon optical modulator on 300mm CMOS line and high-efficiency modulator design**	Guangwei Cong, Yuriko Maegami, Morifumi Ohno, Makoto Okano, Koji Yamada National Institute of Advanced Industrial Science and Technology (AIST) Group A	The well-established PDK will be the key for an advanced Si photonics foundry to achieve efficient design and mass production, which is believed as the core competence for industry service. For such a purpose, we are developing the standard high-speed silicon modulator for AIST SCR 300mm line and continuing to invent the design for better performance.
G-5	**Highly Efficient Fiber Coupling Structure for Si Wire Waveguide Using Standard CMOS Compatible SiN Waveguides**	Yuriko Maegami, Makoto Okano, Guangwei Cong, Morifumi Ohno and Koji Yamada National Institute of Advanced Industrial Science and Technology (AIST) Group B	We propose and design a highly efficient fiber coupling structure for Si wire waveguides consisting of a Si inverted taper and a CMOS-compatible SiN waveguide. A small SiN waveguide with a 310 nm-square core can provide low-loss and low-polarization-dependent fiber-SiN coupling and SiN-Si mode conversion.
G-6	**Waveform Measurement Technique for Optical Phase/Frequency-Modulated Signals**	Hidemi Tsuchida National Institute of Advanced Industrial Science and Technology (AIST) Group A	A novel technique is proposed and demonstrated for measuring the temporal waveforms of optical phase/frequency-modulated signals based on the delayed self-heterodyne method with a delay time much shorter than the modulation period.
G-7	**Ecosystem of photonic component manufacturing aimed by PHOENICS**	Haruhiko Kuwatsuka, Koji Yamada, Hitoshi Kawashima, Isao Matsushima, Shu Namiki National Institute of Advanced Industrial Science and Technology (AIST) Group B	An AIST consortium, PHOtonics ENgineering Inovation ConSortium (PHOENICS), is discussing the construction of an ecosystem for the manufacturing of photonics components using so-called “ virtual fab system ”, covering domestic Si-photonics foundry service of 300mm Si wafer product line in AIST Super Clean Room (SCR).