43rd European Conference on Optical Communication

ecoc2017

GOTHENBURG • SWEDEN

17-21 September 2017

Final Programme

Hosted by

CHALMERS UNIVERSITY OF TECHNOLOGY

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ECOC 2017 Programme overview

TIME	ROOM F1	ROOM F2	ROOM F3	ROOM F4	ROOM F5	ROOM F6	ROOM G4
SUNDAY 17 SEPTEMBER							
09:00-13:00 *(Coffee 10:00-11:30)*	**WS 1:** Road to 5G and photonics for 5G mobile networks	**WS 7:** Optical wireless communication	**WS 3:** Data Center Networks: Meeting the Emerging Requirements for Capacity, Cost, Energy Consumption and Reach	**WS 6:** Which is the right path for PON beyond 10G single wavelength?	**WS 4:** Constellation shaping – a simple add-on or a tool to combat the nonlinear fiber limit?	**WS 2:** Silicon Photonics	
13:00-14:00	LUNCH BREAK						
14:00-18:00 *(Coffee 15:00-16:00)*	**WS 1** continued...		**WS 3** continued...	**WS 8:** Opportunities for machine learning in optical communication: from components characterisation, systems design and network optimisation	**WS 5:** What is the Best Fibre for the Deployment of Space-Division Multiplexing Systems?	**WS 2** continued...	
18:00-19:30	GET TOGETHER, HALL F						
19:30-22:30	Lab Automation Hackathon (pre-registration mandatory) Room G1						
MONDAY 18 SEPTEMBER							
09:00-10:00	COFFEE - CONGRESS FOYER						
10:00-12:30	Opening Ceremony and Plenary Session - Congress Hall						
12:30-14:00	LUNCH BREAK						
14:00-15:30	**M.1.A:** Technologies for Integration and Optical Switches (SC5)	**M.1.B:** Advances in Optical Fronthaul (SC8)	**M.1.C:** Novel III.V Transmitters and Receivers (SC2)	**M.1.D:** Coded Modulation (SC3)	**M.1.E:** SDM Transmission 1 (SC6)	**M.1.F:** High-Capacity Subsystems (SC4)	
15:30-16:00	COFFEE - EXHIBITION HALL						
16:00-17:30	**M.2.A:** 5G Transport (SC7)	**M.2.B:** Long-Wave-Length Fibre Lasers and Amplifiers (SC1)	**M.2.C:** III-V/Si Hybrid Integration (SC2)	**M.2.D:** Capacity (SC3)	**M.2.E:** SDM Transmission 2 (SC6)	**M.2.F:** Transceivers and Monitoring (SC4)	
18:30-20:30	WELCOME RECEPTION, UNIVERSEUM						
TUESDAY 19 SEPTEMBER							
08:30-10:00	**Tu.1.A:** Fibre Characterisation and Sensing (SC1)	**Tu.1.B:** Radio-Over-Fiber Advances in Optical Fronthaul (SC8)	**Tu.1.C:** High-Density Integration and Packaging (SC2)	**Tu.1.D:** Geometric Shaping (SC3)	**Tu.1.E:** Submarine Transmission (SC6)	**Tu.1.F:** Space-Division Multiplexing Subsystems (SC4)	**Tu.1.G:** Control and Orchestration (SC7)
10:00-10:30	COFFEE - EXHIBITION HALL						
10:00-12:00	Exhibition Only Time						
12:00-13:30	LUNCH BREAK						12:00-13:30 Women's Leadership in Science & Technology (Pre-registration mandatory)
13:30-15:00	**Tu.2.A:** Transceivers for Datacom (SC5)	**Tu.2.B:** Optical Wireless (SC8)	**Tu.2.C:** PICs for Signal Processing (SC2)	**Tu.2.D:** Probabilistic Shaping (SC3)	**Tu.2.E:** Direct-Detection and Freespace Transmission (SC6)	**Tu.2.F:** Node & Network Architectures (SC7)	
15:00-15:30	COFFEE - EXHIBITION HALL						
15:30-17:00	Poster Session 1 & Refreshments - Hall F						
17:45-19:00	CONCERT, GOTHENBURG CONCERT HALL						
WEDNESDAY 20 SEPTEMBER							
08:30-10:00	**W.1.A:** Advanced Modulation for Data Centre Interconnects (SC5)	**W.1.B:** Space-Division Multiplexing Fibres (SC1)	**W.1.C:** Integrated Si Photonics I (SC2)	**W.1.D:** Nonlinear Compensation (SC3)	**W.1.E:** Advances in Multi-Wavelength PON (SC8)	**W.1.F:** High-Performance ICs for Photonics (SC4)	
10:00-10:30	COFFEE - EXHIBITION HALL						
10:30-12:00	**W.2.A:** Cloud and Data Centre Networking (SC7)	**W.2.B:** Access Technologies for 25 G and Beyond (SC8)	**W.2.C:** Integrated Si Photonics II (SC2)	**W.2.D:** DSP for Short-Reach Transmission (SC3)	**W.2.E:** Nonlinear Transmission and Compensation (SC6)	**W.2.F:** Few-Mode Fibres and Amplifiers (SC1)	
12:00-13:30	LUNCH BREAK						
13:30-15:00	**W.3.A:** Machine Learning and Artificial Intelligence (SC7)	**W.3.B:** Single-Core and Multi-Core Fibre Transmission (SC1)	**W.3.C:** Eigenvalue Communication Systems (SC3)	**W.3.D:** Emerging Trends for Future Access Networks (SC8)	**W.3.E:** Propagation and Characterisation (SC6)	**W.3.F:** Mode-Division Multiplexing (SC4)	
15:00-15:30	COFFEE - EXHIBITION HALL						
15:30-17:00	Poster Session 2 & Refreshments - Hall F						
19:00-00:00	CONFERENCE DINNER, KAJSKJUL 8						
THURSDAY 21 SEPTEMBER							
08:30-10:00	**Th.1.A:** Elastic Networks (SC7)	**Th.1.B:** Coherent Technologies in Access Networks (SC8)	**Th.1.C:** Low-Power Transmitters (SC2)	**Th.1.D:** Digital Signal Processing (SC3)		**Th.1.E:** High Spectral Efficiency Modulation Techniques (SC6)	**Th.1.F:** Optical Signal Processing (SC4)
10:00-10:30	COFFEE - HALL F						
10:30-12:00	**Th.2.A:** Fibre Connectivity for Data Centres (SC5)	**Th.2.B:** Local Area Networks (SC8)	**Th.2.C:** Software Defined Networks (SDN) (SC7)	**Th.2.D:** Optical Amplifiers for SDM (SC1)		**Th.2.E:** Nonlinear Characterisation and Compensation (SC6)	**Th.2.F:** DSP Subsystems (SC4)
12:00-13:30	LUNCH BREAK						
13:30-15:00	Post Deadline Paper Sessions						
15:00-15:30	COFFEE - HALL F						
15:30-16:00	Awards and Closing Ceremony, Room F4-F5						

ECOC 2017 Topics

1. Fibres, Fibre Devices and Fibre Amplifiers

- Optical fiber design, fabrication and characterisation
- Physics of light propagation in optical fibers
- Fiber amplifiers and fibre lasers
- Fiber based devices for telecommunication, sensing and other applications
- Highly nonlinear fibers and their applications for nonlinear optical signal processing
- Specialty optical fibers for improved linear and/or nonlinear transmission performance
- Low–latency fibers and fibers for new wavelength ranges

2. Integrated Optoelectronic Devices and Optical Processors

- Design, fabrication and characterisation of devices and components
- Novel integrated devices and functionalities
- Integrated light sources, directly modulated lasers and VCSELs in bulk, quantum well, quantum dot or other materials
- Integrated III–V, including InP and GaAs, data modulators, detectors, amplifiers and switches
- Silicon and hybrid III–V/silicon photonics for data modulation, detection, amplification, switching and interconnecting
- Packaging of advanced novel devices, testing of performance and reliability
- Novel material platforms and structured materials such as photonic crystals, plasmonics, graphene a.o.
- Integrated nonlinear waveguides on various material platforms for optical signal processing

3. Digital Techniques for Optical Communication Systems

- Modelling, design, and implementation of digital signal processing for long–haul, to medium– and short–range optical communication systems
- Novel digital signal processing algorithms for optical transmitters and receivers, and DSP algorithms with reduced complexity
- Novel error correction coding, advanced data encoding and signal shaping for optical communication links
- Schemes for impairment mitigation, increased spectral efficiency and mutual information, including nonlinear Fourier transformation and digital back–propagation

4. Transmission Subsystems and Optical Network Elements

- Modelling, design, implementation and test of optical, optoelectronic, or electrical (incl. DAC/ADC) subsystems
- Line terminals, optical transmitter and receiver subsystems for advanced modulation formats and increased speed and/or capacity
- Multiplexing and demultiplexing subsystems for advanced and/or spectrally efficient data formats including DMT, OFDM, OCDMA and Nyquist–WDM
- Optical performance monitoring techniques and subsystems
- Subsystems for network functionalities, including e.g. wavelength –selective switching, add–drop multiplexing, optical switching, optical packet routing, system–on–a–chip (SoC) and on–chip networks
- Analog signal processing subsystems and novel schemes of nonlinear optical signal processing for subsystem–functionalities

5. Datacom and Computercom Hardware

- Deployable technology, like real–time online processing systems and low–cost solutions, including novel packaging of integrated optics and parallel transceivers, and Si photonic low–cost solutions
- Demonstrations, network deployments and field trials using novel architectures and/or novel switching schemes and technologies, including SDN over WDM, TDM, SDM optical switching and/or hybrid electronic/optical or all–electronic switching
- Data center and HPCS (High Performance Computing System) specific hardware, including VCSEL based parallel links with advanced modulation, hybrid integrated electronic/optical engines for broadband interconnecting and WDM/CWDM interconnects
- Demonstrations using novel network devices, including nanophotonic high–density components for on–chip networks, as well as integrated spatial multiplexers for high–density parallelism, novel interconnects and transceivers

6. Point-to-Point Transmission Links

- Transmission system modelling
- Lab and field implementation of optical fiber transmission links
- Lab and field implementation of free–space optical and THz wireless transmission links.
- Satellite communication links
- Transmission system level implications of physical impairments and impairment mitigation techniques
- Capacity, reach, flexibility of optical transmission systems and solutions to overcome the current limitations
- Demonstrations of combined novel fibers, devices, subsystems and multiplexing techniques in transmission experiments
- Quantum communication systems

7. Core, Metro, and Data Center Networks

- Networking aspects of architecture, planning and scaling of broad–band optical transport for optical circuit– and packet–switched core, metro and data center networks, including cost and energy conside–rations
- Control, orchestration, and management functions, as well as integration with higher layer network services
- Network deployments and field trials
- Architecture, planning and scaling of optical transport for inter– and intra–data center and HPCS networks
- Network management, control plane design and orchestration of data centers and HPCS for photonic and hybrid photonic/electronic interconnects
- Energy, scalability, latency considerations for data center and HPCS networks

8. Access, Local Area and Indoor Networks

- Photonics for 5G technologies
- Photonics for Cloud services
- Fiber–to–the–premises (FTTx)
- Passive optical access networks
- In–building optical networks
- Radio–over–fiber systems
- Optical free–space communication systems
- Hybrid wireless/optical free–space network solutions

Content

43RD EUROPEAN CONFERENCE ON OPTICAL COMMUNICATION

Welcome to Gothenburg

Dear Friends and Optical Colleagues from all over the world, The joint Chairs wish you warmly welcome to the 43rd ECOC held in the city of Gothenburg, Sweden.

We believe you will find ECOC 2017 an exhilarating and concentrated mixture of technological and social connectivity. The conference, the exhibition, the venue, and the city itself are all practically on top of each other, giving you the best possible opportunity to connect with science, colleagues, customers, companies, and products from the entire globe.

The city of Gothenburg is the second largest city in Sweden, an old 17th century seaport with a fortified and moated old town. Dutch and British merchants were prominent in its early days, and the city was originally laid out with canals instead of streets to assist the transport mode of those days - ships - long before optical fibre. Today, the old fortifications and canals are mixed with a modern and charming maritime city with everything within walking distance from the conference venue. The Gothenburgers are known for their friendly and open attitude, and English is spoken everywhere.

ECOC 2017 is a Nordic conference; Sweden, Denmark, Norway, and Finland all co-operate for the event. The Nordic countries are well known for their leading industries and communication technologies and we hope you will take the opportunity to extend and improve your business in all of Scandinavia. We will be happy to assist you with business contacts for all countries.

This year, we are aiming at the first Environmental Certification of an ECOC Conference. Both the city and the venue are top-ranked in sustainability, and we have been working through all conference processes against the standard “Svensk Miljöbas”. The biggest challenge, however, is not the eco-cookies for the coffee, but the approximately 1 500 tonnes of carbon that a typical ECOC emits in terms of air-travel. Despite all our efforts on Optical Communication... We have therefore introduced the “Green Platinum Sponsor” level that specifically supports the CO2-compensation for the air travel. We hope this, quite necessary, arrangement will continue and become the premier sponsoring item.

The Social Programme is as full as usual, the get-together after the workshops, an evening at the science center across the street from the conference, a concert, and a conference dinner down in the old harbour sheds. Also, the town is only a few minutes by foot or tram away, so do take a break and enjoy the old town.

On the technical side, the developments in coherent systems and advanced modulation are fascinating. ”Light” today is just another carrier, and we treat it like radio technology, but at 193 THz. Amazing. With systems pretty much up at the Shannon limit and good old Ethernet at 400 Gb/s, it seems that Fibre-To-The-Home has, shall we say, sufficient capacity for the moment? Probably, quite a few of us have 10Gb/s Ethernet at home, but with low utilization… Instead, Datacenters have emerged as the bandwidth-guzzler, but with different topology, distances and challenges than access networks. But the power, size and cost-focus is even stronger. This new direction is evident in the creation of a new Subcommittee at ECOC this year - ”Datacom and Computercom Hardware”. And Sunday’s are not free anymore, as you may have noticed. The ECOC workshop series is transforming into a full-day, six-parallell-session event and a dynamic discussion platform for the very latest issues - don’t miss it.

In all, ECOC is at the leading tech - and social - edge as usual, and we hope you take the opportunity to enjoy both the technical and social scene here in Gothenburg.

Once again, warmly welcome,

PER O. ANDERSSON,
GENERAL CHAIR

PETER ANDREKSON,
TPC CHAIR

LEIF KATSUO OXENLØWE
TPC CHAIR

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Per O. Andersson
RISE Acreo AB, Sweden

Technical Programme Committee Chair

Peter Andrekson
Chalmers University
of Technology, Sweden

Technical Programme Committee Chair

Leif Katsuo Oxenløwe
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Stefan Dahlfort
Ericsson, Sweden

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Sweden Meetx, Sweden

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Ronald Freund, Fraunhofer Heinrich Hertz Institute, Germany
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Juergen Leuthold, ETH Zurich, Switzerland
Ton Koonen, COBRA TU Eindhoven, The Netherlands
David Richardson, ORC – University of Southampton, UK
Giancarlo Prati, Scuola Superiore S. Anna, Pisa, Italy
Will Stewart, University of Southampton, UK
Peter Van Daele, IMEC iMinds– Ghent University, Belgium
Jörg-Peter Elbers, ADVA AG Optical Networking, Germany
Christian Lerminiaux, University of Technology of Troyes, France

International Advisory Committee (IAC) members

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Simon Fleming, University of Sydney, Australia
Toshio Morioka, Technical University of Denmark
Jintong Lin, Beijing University of Posts and Telecommunications, China
Robert Tkach, Nokia Bell Labs, USA

SC 1 – Fibres, Fibre Devices and Fibre Amplifiers

Chair: Hans Limberger, EPFL Switzerland, Switzerland

Patrice Mégret, University of Mons, Belgium
Lianshan Yan, Southwest Jiaotong University, China
Peter Ingo Borel, OFS Fitel Denmark, Denmark
Pierre Sillard, Prysmian Group, France
Bernhard Schmauß, Universität Erlangen–Nürnberg, Germany
Marco Santagiustina , Università di Padova, Italy
Kunimasa Saitoh, Hokkaido University,Japan
Ivana Gasulla, Universitat Politècnica de Valencia, Spain
Luc Thévenaz, EPFL Switzerland, Switzerland
Francesco Poletti, ORC, UK
Kasyapa Balemarthy, OFS, USA
Michael Sumetsky, Aston Institute of Photonic Technologies (AIPT), UK

SC 2 – Integrated Optoelectronic Devices and Optical Processors

Chair: Leo Spiekman, Aeon Corporation, USA

Dries Van Thourhout, imec – Ghent University, Belgium
Yikai Su, Shanghai Jiao Tong, China
Mircea Guina, Tampere University of Technology, Finland
Sylvie Menezo, CEA–LETI, France
Andreas Umbach, Finisar Corporation, Germany
John Donegan, Trinity College, Dublin Ireland
Antonio Fincato, STMicroelectronics, Italy
Takuo Tanemura, University of Tokyo, Japan
Hiroyuki Uenohara, Tokyo Institute of Technology, Japan
Myung-Ki Kim, KAIST, Korea
Aiqun Liu, Nanyang Technological University, Singapore
Pascual Muñoz, VLC Photonics, Spain
Marc Sorel,Glasgow University, UK
Joe Campbell, Virginia University, USA
Fan Wei Jun, Nanyang Technological University, Singapore

SC 3 – Digital Techniques for Optical Communication Systems

Chair: Benn Thomsen, Microsoft, UK

Xiaoke Yi, University of Sydney, Australia
Darko Zibar, Tecnical University of Denmark, Denmark
Yves Jaouen, IMT – Telecom Paritech, France
Helmut Grießer, ADVA Optical Networking, Germany
Antonella Bogoni, CNIT, Italy
Giancarlo Gavioli, Nokia, Italy
Kiyoshi Fukuchi, NEC, Japan
Ezra Ip, NEC Labs, USA
Massimiliano Salsi, Juniper, USA
Chigo Okonkwo, COBRA – TU Eindhoven, Netherlands
Andreas Leven, Nokia Bell–Labs, Germany
Dan Sadot, Ben Gurion University, Israel

SC 4 – Transmission Subsystems and Optical Network Elements

Chair: Michael Galili, Technical University of Denmark, Denmark

David Plant, McGill University, Canada
Laurent Bramerie, ENSSAT / Université de Rennes 1, France
Hercules Avramopoulos, National TU Athens, Greece
Moshe Tur, Tel Aviv University, Israel
Pierpaolo Boffi, Politecnico di Milano, Italy
Takashi Inoue, National Institute of Advanced Industrial Science and Technology (AIST), Japan
Toshihiko Hirooka, Tohoku University, Japan
Jochen Schröder, Chalmers University of Technology (CTH), Sweden
Niels Quack, EPFL Switzerland, Switzerland
Andrew Ellis, Aston University, UK
Adonis Bogris, Technological Educational Institute of Athens, Greece
Norbert Hanik, TU München, Germany

SC 5 – Datacom and Computercom Hardware

Chair: Romain Brenot, Huawei in Munich, Germany

Folkert Horst, IBM, Switzerland
Gordon Ning Liu, Huawei Technologies Co. Ltd, China
Xin Yin, Ghent University, Belgium
Fabienne Saliou, Orange Labs, France
Roberto Sabella, Ericsson Telecommunicazioni, Italy
Takahiro Nakamura, Photonics Electronics Technology Research Association (PETRA), Japan
Oded Raz, COBRA – TU Eindhoven, Netherlands
Luca Alloatti, ETH Zurich, Switzerland
Richard Pitwon Xyratex ,UK
Clint Schow, Univ. Of California, Santa Barbara, USA
Mads Lønstrup Nielsen, Mellanox, Denmark
Jose Capmany, Universitat Politecnica de Valencia, Spain
Christoph Schulien, Ranovus GmbH, Germany
Carlo Mariotti, Cisco Photonics, Italy

SC 6 – Point-to-Point Transmission Links

Chair: Magnus Karlsson, Chalmers University of Technology (CTH), Sweden

Gabriel Charlet, Nokia Bell–Labs, France
Yann Frignac, Insitut Mines–Télécom / Télécom SudParis, France
Peter Krummrich, Technische Universität Dortmund, Germany
Chao Lu, Hong Kong Polytechnic University, Hong–Kong
Mark Shtaif, Tel Aviv University, Israel
Antonio Mecozzi, University of l'Aquila, Italy
Takeshi Hoshida, Fujitsu, Japan
Yutaka Miyamoto, NTT, Japan
Beatriz Ortega, Universitat Politecnica de Valencia, Spain
Sergei Popov, Royal University of Technology (KTH), Sweden
Alexii Pilipetskii, Subcom, USA
René-Jean Essiambre, Nokia Bell–Labs, USA
Rob Smets, SURFnet, Netherlands
Robert Killey, UCL, UK

SC 7 – Core, Metro, and Data Centre Networks

Chair: Sebastien Bigo, Nokia Bell-Labs, France

Dimitrios Apostolopoulos, National Technical University of Athens, Greece
Achim Autenrieth, ADVA Optical Networking, Germany
Colle Didier, iMinds – Ghent University, Belgium
Carlo Cavazzoni, Telecom Italia, Italy
Hiroaki Harai, National Institute of Information and Communications Technology (NICT), Japan
Itsuro Morita, KDDI Research Inc. Japan
Nobuhiko Kikukchi, Hitachi ,Japan
Steinar Bjørnstad, Norwegian University of Science and Technology, Transpacket, Norway
Raul Muñoz, Centre technologic de telecommuni–cacions de catalunya, Spain
Lena Wosinska, KTH Royal Institute of Tecknology, Sweden
Dimitra Simeonidou, University of Bristol, UK
Tom Issenhuth, Huawei Technologies Co., LTD, USA
Palacios Fernandez Juan Pedro, Telefonica, Spain

SC 8 – Access, Local Area and Indoor Networks

Chair: Stefan Dahlfort, Ericsson, Sweden

Eduward Tangdiongga, COBRA – TU Eindhoven, Netherlands
Elaine Wong, University of Melbourne, Australia
Jan Watté, Commscope, Belgium
Yuefeng Ji, Beijing Univ of Posts and Telecommunica–tions, China
Philippe Chanclou, Orange Labs, France
Dirk Breuer, Deutsche Telekom, Germany
Roberto Gaudino, Politecnico di Torino, Italy
Kota Asaka, NTT, Japan
Junichi Nakagawa, Mitsubishi Electric, Japan
Kwangjoon Kim, ETRI, Korea
Yan Shi, Genexis, Netherlands
Guillermo Carpintero, Universidad Carlos III de Madrid, Spain
Chia-Chien Wei, National Sun Yat–Sen University, Taiwan
Dora Van Veen, Nokia Bell–Labs, USA
Derek Nesset, Huawei, UK

Road to 5G and Photonics for 5G Mobile Networks

Organisers:
Yan Shi, Former Genexis, The Netherlands
Kota Asaka, NTT, Japan
Gemma Vall-Llosera, Ericsson, Sweden
Patryk Urban, Ericsson, Sweden

Location:
Room F1

Common abstract:
The 5G network evolution drives distinct technologies and applications forward, not only the mobile broadband services, but also vertical industries across boundaries. Massive capacity, massive connectivity and diverse deployment scenarios bring the big challenges to 5G. This workshop is set to give specific insight on the key requirements and applications of 5G in the telecom and datacom networks. Specifically, we will consider: a) Global 5G vision and road map, 5G key applications and technology evolutions; b) the technology integration from the radio access and optical access networks, to the last meter connection where we will discuss recent 5G field trial achievements; c) the transformation of the radio access networks (RAN) and, consequently, the underlying transport network; d) future technologies that can enable the post 5G era

Workshop structure

1st session
(9:00-10:45): The global 5G vision

Moderator: Gemma Vall-Llosera, Ericsson, Sweden

The 5G network evolution drives distinct technologies and applications forward, not only the mobile broadband services, but also vertical industries across boundaries. Massive capacity, massive connectivity and diverse deployment scenarios bring the big challenges to 5G. The 5G infrastructure providers are required to identify and address the requirements by providing the short term and long term solutions. The first session will focus on the "Global 5G vision" and give an overview on the key requirements and applications of 5G, the necessary breakthroughs, and the possible road map for 5G technology evolution.

Confirmed speakers:
Sándor Albrecht, "5G as a technology and business innovation platform for industries", Ericsson, Sweden
Martin Kristensson, "Nokia 5G end-to-end network vision for massive connectivity", Bell Labs Nokia, Sweden
Albert Rafel, "Service applications over 5G; requirements and their impact on the Metro-Haul Network; an operator's perspective", British Telecom, United Kingdom

Coffee break 10:45-11:15

2nd session
(11:15-13:00): 5G field trial and optical access

Moderator: Kota Asaka, NTT Japan

There are leading-edge breakthroughs of technologies which have been demonstrated by 5G prototypes and field trial recently. From the technical perspectives, much work has been progressed on the 5G vision, although we are not there yet to candidate the technologies which can fully flesh out for the standard and clarify consensus. One of the main points is the technology integration from the radio access and optical access networks to the last meter connection. In this session we present the recent 5G field trial achievements, and address a holistic approach on the 5G theme from optical access point of view.

Confirmed speakers:
Jason Feng, "High speed and short reach optical interconnects application in the scenarios of 5G", Huawei, China
Satoshi Suyama, "NTT DOCOMO's Activities on 5G Trials", NTT DOCOMO, Japan
Tatsuya Shimada, "Optical access technologies for 5G mobile system", NTT, Japan
Tae Joong Kim, "Disconnecting Optical Fiber Cables in 5G and Its Beyond – Moving Network", ETRI, Korea
Piet Demeester, "Flexible wireless test facilities in Europe", Ghent University, Belgium

Lunch break (13:00-14:00)
-lunch sponsored by IEEE Photonics Chapter Sweden
IEEE Photonics Chapter Sweden is pleased to invite all the participants registered to this workshop for a networking lunch. Soft drinks, coffee and tea are included. Lunch vouchers will be distributed to the workshop participants on site.

3rd session
(14:00-15:30) 5G transport systems.

Moderator: Patryk Urban, Ericsson, Sweden

With the advent of 5G new capacity trends are imposed on both the telecommunication and data communication networks. Many of the services that the 5G network delivers to user premises have stringent requirements: non-limiting access to data (5nine availability), Nx10Gbit/s (N = 1 – 500) data rates, latencies of < 1ms for tactile Internet and a factor of 10 increase in battery life time for small devices. These requirements impose a transformation of the radio access networks (RAN) and, consequently, imposes a rethinking of the underlying transport network. Optical technologies with their conventional benefits of high bandwidth, protocol transparency, scalability, low latency, high resiliency and network re-configurability, are today perceived as a promising key piece of the radio access network puzzle, in both front haul and back haul transport areas. But previous and current generation of optical networking technologies (e.g. SDH/SONET, WDM, OTN, as well as analog Radio over Fiber (a-RoF). etc.) need to be reconsidered to match the needs of the emerging RAN transport segments. Re- configurability features, provided by WDM technologies, can further increase fronthaul transport efficiency.

Confirmed speakers:
Fabio Cavaliere, "5G RAN architecture and use cases", Ericsson, Sweden
Michael Eiselt, "EU Project 5G XHAUL: Optical technologies supporting 5G", ADVA, Germany
Alain Mourad, "EU project 5G CrossHaul: 5G transport systems", InterDigital Europe Ltd, UK
Roberto Llorente, Maria Morant, Andres Macho "Multiservice SDM-based 5G C-RAN: Architecture and performance analysis", UPV, Spain

4th session
(16:00-17:30) Future enabling technologies for 5G

Moderator: Patryk Urban, Ericsson, Sweden

Optical technologies are also redefining the design of the radio heads, with photonic enabled beamforming for example. They are a main player in quantum communication and computing, they started to show exceptional performance when embedded with graphene and they are emerging as key enablers for visible light communication, free space optics (FSO), space division multiplexing application amongst others.

Confirmed speakers:
Frank Koppens, "Graphene photonics for 5G", ICFO, Barcelona, Catalonia
Antonella Bogoni, "Optical beamforming", SSSA, Italy
Ton Koonen, "Dynamic picocell configuration and radio beam steering", TU/e, The Netherlands
Lech Wosinski," Silicon nanophotonics and plasmonics for 5G applications", KTH, Stockholm, Sweden

Silicon Photonics

Organisers:
Hercules Avramopoulos, National TU Athens, Greece
Clint Schow, Univ. Of California, Santa Barbara, USA
Luca Alloatti, ETH Zurich, Switzerland
Roel Baets, Ghent University – IMEC, Belgium

Location:
Room F6

Abstract:
Silicon photonics hold promise for commoditizing PICs, following the example of silicon microelectronics. The excitement of early demonstrations was followed by a period of consolidation where major technological hurdles were overcome, raising expectations for an

imminent era of productivity and market ramp-up.

This workshop aims to highlight the latest achievements in silicon photonics, and elucidate on the requirements posed by prominent application fields. Experts on the various integration platforms as well as users of the technology are brought together, and attempt to answer burning questions, such as:

What needs to be done for silicon photonics to dominate short- and medium-reach communications?

How can silicon photonics match the economics of VCSEL links?

What level of electronic/photonic integration is needed to support the demands of next-generation datacenters?

What is the best flavor of III-V and silicon integration for very large-scale PICs with multiple functionalities and many ports?

What is the path for cost-effective best power efficiency, on-chip lasers, or off-chip optical power supplies?

Are III-V-on-silicon lasers ready for prime time?

Is it possible to meet the I/O requirements of multi-terabit switches in datacenters?

Can photonics be brought all the way to the chip to revolutionize the way microprocessors and computing subsystems are conceived and designed in the next decade?

Is there a path for realising chip-to-chip photonic interfaces in 2025?

What are the main challenges and opportunities of the adoption of optical links?

How does the cost of silicon photonics chips scale with volume?

What is the path to low-cost packaging of silicon photonics chips?

Is silicon photonics only affordable for high-volume products?

Are packaging costs strangling the uptake of silicon photonics?

As optics moves into chip-packages, how must the global supply chain evolve?

Workshop structure

Session 1

Lionel C. Kimerling, MIT, USA
"Merging Photonics with nano-electronics"
Jörg-Peter Elbers, ADVA, Germany
"Silicon Photonics for Exascale Data Networks"
Greg Fish, Juniper Networks, USA
"Heterogeneous Integration of III-V/Si Photonics for high optical speed transceivers"
Paraskevas Bakopoulos, NTUA, Greece
"VCSEL-enabled silicon photonics for short-reach optical interconnects"
Elad Mentovich, Mellanox Technologies, Israel
"Silicon photonics for 400 Gb/s short-reach optical interconnects"
Mehrad Ziari, Infinera, USA
"Multi-channel Tb/s-scale PICs for High-Capacity Interconnects"

Session 2

Michael Hochberg, Elenion, USA
"Complexity and volume scaling in silicon photonics: How do we make optics look more like electronics?"
John Bowers, UC Santa Barbara, USA
"III-V on Si Lasers: Ready for Primetime"
Kevin Williams, TU/e, The Netherlands
"Integrating Silicon and monolithic InP photonics"
Peter De Dobbelaere, Luxtera, USA
"Real world trade-offs for high volume silicon photonics transceiver manufacturing"
Kazuhiko Kurata, PETRA, Japan
"Hybrid integration of LD chips on silicon photonics integrated circuits"
Richard Pitwon, Seagate Systems, UK
"Accelerating the commercial viability of silicon photonics in exascale data centere environments"

Session 3

Sebastien Rumley, Columbia University, USA
"Can integrated optics meet the challenge of Multi-Terabyte/s off-chip bandwidths?"
Nikos Pleros, AUTH, Greece
"Chip-scale disaggregated computing via Silicon Photonics: can be more than replacing a link!"
Mitsuru Takenaka, University of Tokyo, Japan
"Electronic-photonic integrated circuits based on heterogeneous integration of Ge/III-V on Si"

José Luis Gonzalez, CEA, France
"Electronics and silicon photonics for optical networks on-chip and many cores modules"
Rajeev Ram, MIT, USA
"Toward high performance computing with electronic-photonic integration"
Igor Krestnikov, Innolume, Germany
"GaAs-based comb-laser for interconnect applications"

Session 4

Chris Doerr, Acacia Communications, USA
"Short- to long-reach optical communications: where does silicon photonics fit in and does it make economic sense?"
Philippe Absil, IMEC, Belgium
"Is there still a need for R&D silicon photonics "foundries" in the eco-system?"
Norbert Keil, HHI, Germany
"Is Hybrid the new Monolithic? Why the photonic integration technologies should work together"
Peter O'Brien, Tyndall, Ireland
"What does it take to drive down the cost of silicon PIC packaging?"
Jessie Rosenberg, IBM USA
"High-throughput and scalable packaging: an enabler for silicon photonics?"
Abdul Rahim, Ghent University and ePIXfab, Belgium
"Standardisation and Diversification in Silicon Photonics Platforms: What do they bring?"

Data Center Networks: Meeting the emerging requirements for capacity, cost, energy consumption and reach

Organisers:
David Plant, McGill University, Canada
Yikai Su, Shanghai Jiao Tong University, China
Sylvie Menezo, CEA-LETI, France
Dimitris Apostolopoulos, National Technical University of Athens, Greece

Location:
Room F3

Abstract:
Data centre traffic is surging with sustained annual growth rates as high as 25% expected by 2020. Deployment of photonic technologies for rack-to-rack communication is leading to faster and greener system implementations. From the network perspective, new, flatter network architectures, along with optical switching, are being advocated in order to boost efficiency.

Moreover, as silicon photonics has made its way into data centers with the PSM4 parallel 4 X 25Gbps as a cost effective solution below 500m, WDM is considered as a possible solution to meet near future datacenter requirements in terms of performance, cost and power consumption. TEC-free transceiver solutions are key for these applications that require 70°C and even higher operating temperatures but further developments on Silicon Photonics or III-V technology are required.

Furthermore, to date switching has been performed by electronic switches but with the ever increasing data capacity, the back planes of the electronic switches seem to impose limitations on data transfer speed, interconnect density and power requirement. Combined with electronic switches, optical switching may be able to handle large traffic of coarse granularity with high

speed, large capacity, low latency and low power consumption.

Finally, to effectively apply these technologies and network concepts, an SDN control and orchestration framework is necessary inside and across data centres. From a system perspective, optical interconnects are bound by stringent cost ($/Gb/s) and energy targets (mW/Gb/s) that add up to -and dominate- technological feasibility aspects. Scaling systems with conventional NRZ modulation cannot meet the overall requirement matrix, spurring research into new topics such as high-order modulation formats, channel equalization, forward-error correction and multiplexing.

This workshop will highlight the latest achievements in datacenter network architectures, switching technologies for datacenters, optical interconnection systems, and modules for intra and inter datacenter connectivity. The workshop is divided into four complementary sessions:

Workshop structure

Session 1. Network and system challenges in the exascale cloud datacenter era

Moderator: Dimitris Apostolopoulos, NTUA, Greece

Chongjin Xie, Senior Director, Chief Optical Network Architect, Alibaba, USA
“Scalability of Optical Technologies for Growing Exascale Datacenters”
Katharine Schmidtke, Sourcing Manager, Optical Technology Strategy, Facebook, USA
“Increasing datacenter bandwidth: A network or a technology issue?”
Loukas Paraschis, Senior Director, Sales, Cloud and Content, Infinera, USA
“Transport Innovations in Next-Generation DCI Networks”
Richard Pitwon, Photonics group leader, Seagate, UK
“Proliferation of system embedded photonic interconnect in exascale data centres”

Panel discussion (30 min approx.)
Session 2. Silicon based WDM transceivers for transmissions between and across data centers?

Moderator: Sylvie Menezo, CEA-LETI, France

Dr. Karen Liu, Sr. Director of Product Marketing, KAIAM Corp. USA
“Optimizing wavelength parallelism in advanced data center transceiver”
Radha Nagarajan, CTO optical group, INPHI, USA
“Switch Pluggable Silicon Photonics PAM 4, DWDM Modules for 4Tbit/s, >80km Inter-Datacenter Links”
Dr. Yu Tanaka, Senior Researcher, PETRA, Japan
“Silicon-photonics-based WDM technologies for short reach interconnection”
Geza Kurczveil, senior member of Large-Scale Integrated Photonics (LSIP) Group at Hewlett Packard Labs
“High-temperature operation and control of multi-channel heterogeneous light sources on silicon”

Panel discussion (30 min approx.)

Session 3. Optical switching devices and technologies for datacenters

Moderator: Yikai Su, Shanghai Jiao Tong University, China

Topics to cover: Optical switching devices, fast switching devices, enabling technologies (Si photonics, MEMS, III-V, LCOS, PLC) and optical switching architectures
Po Dong, Nokia Bell Labs, USA
“Silicon photonic devices for datacenters”
Ken-ichi Sato, Nagoya University, Japan
“Large scale switching devices and systems for datacenters”
Siyuan Yu, University of Bristol, UK
“III-V devices for optical switching”
Xiaolu Song, Huawei, China
“Optical interconnection devices”

Panel discussion (30 min approx.)

Session 4. Intra- and inter- data center transmission systems: Choices and challenges

Moderator: David Plant

Qunbi Zhuge, Ciena, Canada
“Software defined coherent technologies for inter-datacenter networks”
Stephane Lessard, Ericsson, Canada
“Datacenter Networking for 5G applications”
Elad Mentovic, Mellanox, Israel
“Intra- Datacenter Challenges; System Perspective”
Neal Bergano, TE Connectivity, USA
“Undersea cable networks: moving massive amounts of data around the world”

Panel discussion (30 min approx.)

Which is the right path for PON beyond 10G single wavelength?

Organisers:
Derek Nesset, Huawei, UK
Jun Shan Wey, ZTE, USA

Location:
Room F4

Abstract:
Network operators are facing an expanding list of difficult choices in upgrading their Gigabit-era PONs. The first choice is whether to bypass the 10 Gbit/s PONs and go directly to something more future proof, but relatively immature, such as NG-PON2. Even considering the 10 Gbit/s PON flavours, there are different opinions concerning symmetric or asymmetric line rates. The target applications will determine the technical direction, along with the appropriate costs. Intense debates about the potential technology choices have been taking place in the IEEE802.3ca and ITU-T Q2/SG15 standards groups.

In the past, IEEE and ITU-T have moved in step and broadly matched each other in system release dates and physical layer specifications. This enabled shared volumes of common components. However, the two bodies are defining two very different systems with 100G-EPON and NG-PON2. IEEE aims for 100 Gbit/s PON capacity by 2025 and ITU T already has an 80 Gbit/s capacity option in NG-PON2. ITU-T opted for the flexibility and operational simplicity of wavelength tunable ONUs at 10Gbit/s, while IEEE is moving towards 25, 50, and 100 Gbit/s line rates with fixed wavelengths and bonded channels.

With IEEE and ITU-T adopting different approaches to PON evolution beyond 10G-EPON and XG(S)-PON respectively, this workshop will debate the various pros and cons from a service provider, system integrator and component vendor perspective. The workshop seeks to understand why the different approaches have been followed and what the respective trade-offs are.

What are the advantages of tunability with higher aggregate capacity?

Why did IEEE think that bonded 25Gbit/s channels were more attractive?

Is having these two different systems good for the entire industry given previous IEEE/ITU-T alignment at the physical layer?

What are the applications? Residential FTTH/B, Business Services, 5G?

Is there a prospect for convergence in PON standards?

What is the long term technology direction that PON should follow?

Are there any potential roadblocks and what are the necessary breakthroughs?

This workshop includes expert speakers from network operators deploying PON technology, system vendors with experience of IEEE and/or ITU-T PON, component vendors and academic researchers providing a longer term technology perspective. A lively and thought provoking workshop is anticipated and audience participation will be strongly encouraged.

Workshop structure

Workshop Session 1 (09:00)

Vincent O’Byrne (Verizon, USA) : Making the case for NG-PON2: Verizon’s Perspective
Fabienne Saliou (Orange, France) : What are the realistic applications for PON capacity above 10G?
Ed Harstead (Nokia, USA) : Higher line rate PONs: an alternative take enabled by advances in datacenter technologies
Yong Guo (ZTE, China) : Is the industry ready for another high capacity PON?
Lilin Yi (Shanghai Jiao Tung Univ., China) : 25Gbps PON and beyond
Kai Habel (Fraunhofer Heinrich-Hertz-Institute, Germany): Why we should use OFDM for future PON systems

Speaker Panel – Q&A

Coffee Break (10:50-11:10)

Workshop Session 2 (11:10)

Kenichi Suzuki (NTT, Japan): What is the next step for PON deployment in Japan?
John Johnson (Broadcom, USA) : Why 100G-EPON is the logical next step in PON evolution: An optical components perspective
Junichi Nakagawa (Mitsubishi Electric, Japan) : Upcoming challenges for PON transceiver vendors
Peter Ossieur (Tyndall National Institute, Ireland) : Innovations in burst-mode optical receiver ICs at 25G and beyond
Weiping Huang (Hisense, China) : Challenges in meeting diverse future PON transceiver requirements
Frank Effenberger (Huawei, USA) : The future of PON is converged

Speaker Panel – Q&A

End (13:00)

Constellation shaping – a simple add-on or a tool to combat the nonlinear fiber limit?

Organisers:
Metodi P. Yankov, Technical University of Denmark, Denmark
Erik Agrell, Chalmers University of Technology, Sweden

Location:
Room F5

Abstract:
Constellation shaping has in recent years gathered popularity as a tool for extending the reach of coherent optical communication systems. Particularly, probabilistic shaping has been shown to be beneficial for systems, operating at high-order QAM (beyond 16QAM). Current practical constellation shaping methods allow for 10-20% data rate/reach increase mostly due to their tolerance to the white Gaussian noise originating from amplification. However, such constellations are generally intolerant to nonlinear noise and are thus limited to operating in the weakly nonlinear region.

Constellation constructions which are tolerant to nonlinearities, and at the same time provide high spectral efficiency and can be implemented with reasonable complexity in order to support very high-speed optical communications are as of yet unavailable.

This workshop aims at providing a forum for discussion between leading scientists in the field, with a focus on constellation shaping for the nonlinear region of transmission. We will review currently popular constellation shaping methods and discuss different aspects of their implementation, scalability, integrability with existing systems, and potential gains that they provide. Important aspect of the discussion will be whether these schemes and their gains can be extended into the nonlinear region, or completely new solutions are required in order to drastically improve the system performance.

The workshop will include, but is not limited to the following discussion topics:

Practical implementation in current state-of-the-art transceivers and systems—what are the requirements for the transceiver architecture and protocols?

How does shaping fit with other popular nonlinearity mitigation/compensation techniques, such as digital back-propagation, optical phase-conjugation, and sub-carrier multiplexing? Are they complementary or competitive?

What is a "nonlinearity tolerant constellation"?

Geometric vs. probabilistic shaping—is joint optimisation beneficial/feasible, or is either sufficient independently? What are the tradeoffs?

Are we limited to the weakly nonlinear regime, or are there benefits from operating in the nonlinear regime?

Shaping for SDM systems—are there gains, and are they worth the effort?

Shaping for short-reach noncoherent communication—is that feasible?

Workshop structure

Session 1: Theoretical aspects of shaping: Nonlinearity mitigation and power efficiency

9:00 – Session I opening
9:05 – Georg Böcherer, Technical University of Munich, Germany, "Probabilistic, geometric, X-dimensional, X-ary: The probabilistic amplitude shaping Swiss army knife", by Georg Böcherer, Patrick Schulte and Fabian Steiner.
9:15 – Marco Secondini, School of Advanced Studies, Sant'Anna, Pisa, Italy, "Possible approaches to design a nonlinearity-tolerant constellation", by Marco Secondini.
9:25 – Tobias Fehenberger, Technical University of Munich, Germany, "On the limits of per-symbol probabilistic shaping in optical fiber communications", by Tobias Fehenberger.
9:35 – Ivan Djordjevic, University of Arizona, Tucson, Arizona, U.S.A., "Exploring the non-uniform shaped modulation formats", by Zhen Qu and Ivan B. Djordjevic.
9:45 – Hartmut Hafermann, Huawei Technologies, France, "Nonlinearity-tolerant high-dimensional modulation formats", by Hartmut Hafermann.
9:55 – Mariia Sorokina, Aston University, Birmingham, U.K., "Ripple distribution for nonlinear fiber-optic channels", by Mariia Sorokina, Stylianos Sygletos, and Sergei Turitsyn.

Open mic & panel discussion (10:05-10:50)

Coffee break (10:50-11:10)

Session 2: Practical aspects and applications of constellation shaping

11.10 - Session II opening
11:15 – Toshiaki Koike-Akino, Mitsubishi Electric Research Laboratories, Cambridge, Massachusetts, U.S.A., "Constellation shaping: hypes versus reality", by Toshiaki Koike-Akino, David S. Millar, Keisuke Kojima, and Kieran Parsons.
11:25 – Olga Vassilieva, Fujitsu Laboratories of America, Inc., "Is it an ultimate technology and what is the application area", by Olga Vassilieva, Inwoong Kim and Tadashi Ikeuchi.
11:35 – Alexandre Graell i Amat, Chalmers University of Technology, Gothenburg, Sweden, "Probabilistic shaping and hard-decision decoding: can we close the gap with soft-decision decoding?", by Alexandre Graell i Amat
11:45 – Fred Buchali, Nokia Bell Labs, Stuttgart, Germany, "Experimental proof of probabilistic shaping", by Fred Buchali.
11:55 – Xiang Zhou, Google Inc., U.S.A. "Constellation shaping: can it be useful for short reach communication?", by Xiang Zhou and Hong Liu.
12:05 – Stephen Grubb, Facebook, Menlo Park, California, U.S.A., "The applications of PCS in submarine and long haul optical networks", by Stephen Grubb

Open mic & panel discussion (12:15-13:00)

What is the Best Fibre for the Deployment of Space-Division Multiplexing Systems?

Organisers:
René-Jean Essiambre, Bell Labs, Nokia, Holmdel, NJ, USA
Takashi Sasaki, Innovation Core SEI, Inc., San Jose, CA, USA
Chigo Okonkwo, Eindhoven University of Technology, Dept. of Electrical Engineering, Eindhoven, The Netherlands

Location:
Room F5

Abstract:
The fate of the commercial deployment of space-division multiplexing (SDM) fibers depends primarily on the cost per transported bit of information for the anticipated data traffic demand in future optical networks and the transmission performance of SDM fibers relative to single-mode fibers. The most important elements impacting the introduction of SDM fibrs in optical networks are: 1) the ratio of the average traffic demand to the nonlinear Shannon limit of single-mode fibers, 2) the cost of SDM transponders, amplifiers and optical add-drop multiplexers and 3) the transmission performance of commercially-deployable SDM fibers.

Many different flavours of SDM fibers are considered for future backbone optical networks. One can classify SDM fibers in three broad types: 1) multimode-based fibers, including few-mode fibers, 2) multicore fibers that suppress linear crosstalk between cores, and 3) coupled-core multicore fibers designed with strong linear coupling to reduce linear and nonlinear impairments. An important practical difference between SDM fibers of types 2 and 3 is that type 2 fibers only require real-time multiple-input multiple-output (MIMO) processing on each individual core while type 3 requires processing of all cores/modes simultaneously. Currently, type 1 SDM fibers require at a minimum processing of all modes belonging to the same mode groups, for each mode group.

A very important characteristic of SDM fibers that may determine which SDM fiber may emerge in commercial systems to replace single-mode fibers are the nonlinear transmission performance of these SDM fibers in the high-capacity regime relative to arrays of single-mode fibers. The nonlinear performance of these fibers remains a very active area of research and the workshop is intended to share the latest results, predictions, intuitions and convictions on "What is the best SDM fiber?"

What is the Best Fiber for the Deployment of Space-Division Multiplexing Systems?

Workshop structure

Part 1: Historical Perspective and Space-Division Multiplexing (SDM) Fibers

Andrew Chraplyvy and Bob Tkach, Bell Labs – Nokia, USA
"Topic: Historical perspective on introducing new optical fibers in optical networks"
Neal Bergano, TE Subcom, USA
"Topic: Introducing new optical fibers in submarine networks"

Part 2: SDM Fibers

Tetsuya Hayashi, Sumitomo Electric Industries, Ltd., Japan
"Topic: Coupled-core multicore transmission fibers"
Pierre Sillard, Prysmian, France
"Topic: Multimode fibers"
Taiji Sakamoto, NTT, Japan
"Topic: Multicore and multimode fibers"
Ming-Jun Li, Corning, USA
"Topic: Fabrication of SDM fibers"
Lars Grüner-Nielsen, Danish Optical Fiber Innovation, Denmark
"Topic: Few-mode transmission fibers"

Part 3: SDM Systems

Yutaka Miyamoto, NTT, Japan
"Topic: Wish list for SDM systems"
Roland Ryf, Bell Labs – Nokia, USA
"Topic: SDM transmission in coupled-core multicore and multimode fibers"
Ben Puttnam, NICT, Japan
"Topic: SDM transmission in multicore fibers"
Koji Igarashi, Osaka University, Japan
"Topic: SDM transmission experiments"

Part 4: SDM Subsystems

Nick Fontaine Bell Labs – Nokia, USA
"Topic: SDM switches and ROADM"
Ryo Nagase, Chiba Institute of Technology, Japan
"Topic: Multicore fibre connectors"
Ezra Ip, NEC Labs, USA
"Topic: SDM amplifiers technologies and SDM transmission"
Rodrigo Amezcua Correa, Univ. Central Florida, USA
"Topic: SDM fibers and amplifiers"
Yongmin Jung, University of Southampton, U.K.
"Topic: SDM optical amplifiers"
Haoshuo Chen, Bell Labs – Nokia, USA
"Topic: SDM optical amplifiers"

Optical Wireless Communication

Organisers:
Murat Uysal, Ozyegin University, Turkey
Zabih Ghassemlooy, Northumbria University, UK

Location:
Room F2

Abstract:
The increasing number of mobile devices and advanced multimedia applications combined with the worldwide adoption of social media has led to an exponential growth in mobile data traffic at a global level. 5G and B5G wireless networks are envisaged to meet this extraordinary data demand, where emerging applications and services such as Smart City, Smart Buildings, Factories of Future, Intelligent Transportation Systems, Smart Grid and the Internet of Things will play a significant role beyond voice and data services for users.

To address these challenges there are a number of options including (i) the spatial reuse of the frequency spectrum in dense networks by adopting higher spectral efficiency modulation and coding techniques; (ii) spectrum sharing, hoping and borrow; (iii) moving to higher RF bands (i.e., beyond 300 GHz); and (iv) shifting to entirely to the optical spectrum bands. The Optical Wireless Communications (OWC) technology (including Free Space Optical communications or Visible Light Communications (VLC)) offers opportunities in three distinctive optical band of infrared, visible, and ultraviolet that could be deployed in indoor and outdoor environment as well as underwater.

High speed signal transmission, operation in unregulated spectrum, robustness to electromagnetic interference, spatial frequency reuse and inherent security, high energy efficiency (i.e., a green technology) and reduced interference are some of the main advantages of OWC, which is positioned as a powerful alternative and complementary technology to RF solutions both at

backhaul and access network levels.

The recent surge in research and development activities in OWC has led to the development of new solutions capable of delivering ubiquitous, high date rate, and low-cost wireless access networks in a variety of scenarios, as will be described throughout this Workshop. The workshop is composed of two sessions as outlined below:

Workshop structure

Session 1:

Moderator: Murat Uysal, Ozyegin University, Turkey

(20') Zhengyuan (Daniel) Xu,
"Optical Wireless Communication over Broad Spectra"

(20') Majid Safari,
"MIMO Free-space optical communication: Sparse or Monolithic apertures"

(20') Murat Uysal,
"A Custom-Design Atmospheric Channel Emulator for the Performance Evaluation of Free Space Optical Communication Systems"

(20') Rafael Perez Jimenez,
"Visible Light Communciations and IoT applications"

Coffee Break

Session 2:

Moderator: Hany Elgala, State University of New York at Albany, USA

(20') Petr Chvojka,
"Overview of Visible Light Communications"

(20') Ampalavanapillai Nirmalathas,
"Multigigabit Wireless Access for Indoor Applications Using Optical Wireless Transmission"

(20') Hany Elgala,
"Visible Light Based Backscatter Communication"

(20') Behrooz Makki,
"On the performance of RF-FSO systems"

Panel discussion

Opportunities for machine learning in optical communication: from components characterisation, systems design and network optimisation

Organisers:

Darko Zibar, DTU Fotonik, Technical University of Denmark
Henk Wymeersch, Chalmers University of Technology, Sweden
Ilya Lyubomirsky, Inphi, USA

Location:
Room F4

Abstract:
In broad terms, machine learning is a multidisciplinary research area where some of the main tasks are to infer plausible models to describe the observed data and use the inferred models to make predictions. The core of the machine learning approaches is generalization: first the model is learned from the measured data acquired under one set of system configurations, and then the inferred model is applied to perform predictions for a new set of system configurations. Machine learning is especially useful for optimization and performance prediction for systems that exhibit complex behaviors and where analytical model are hard to derive and numerical procedures time consuming. Recently, machine learning methods have started to enter the field of photonics, ranging from quantum mechanics, nanophotonics, optical communication and optical networks. Moreover, a few optical implementations of some machine learning algorithms have also been proposed recently.

The field of machine learning offers many powerful techniques, however, linking it to optical communication and photonics in general may not be trivial. In particular, choosing the right machine learning algorithm strongly depends on the problem that needs to be solved. In this workshop, we will address how techniques from machine learning can be applied in the field of optical communication and photonics, and which benefits machine learning methods can bring to optical communication. We will explore how machine learning can be used to design better lasers, predict the performance of optical communication systems, perform nonlinearity mitigation, optimize data centers and enable intelligent test & measurement equipment for next generation of optical networks. Moreover, we will look into how all-optical signal processing and integrated photonics can benefit the field of machine learning and which novel research opportunities could arise for all-optical solutions.

Workshop structure

Session 1

14.00-14:05; Darko Zibar, DTU Fotonik, Denmark "Introduction to part I: ML for physical layer"
14:05-14:25; Thomas Schon, Uppsala University, Sweden, "Machine learning: trends and perspectives"
14:25-14:35; Hansjoerg Haisch, Keysight Technologies, Germany "Data analytics for measurement equipment"
14:35-14:45; Takahito Tanimura, Fujitsu Labs, Japan "Deep learning in optical performance monitoring"
14:45-14:55; Alan P. T. Lau, Hong Kong Polytechnic University, China "Application of machine learning to optical performance monitoring"
14:55- 15:05; Jakob Thrane, MLytico, Denmark "Machine learning methods for system performance prediction"
15:05-15:15; Christian Schaeffer, Helmut Schmidt University, Hamburg, Germany "Application of ML in coherent quantum receivers"
15:15-15:25; Seb Savory, Cambridge University, UK "Machine learning: transceivers to networks"
15:25-15:45; Panel discussion: what have we learned from part I and what are the future prospects

Coffee Break **15:45-15:55**

Session 2

15:55-16:00; Henk Wymeersch, Chalmers University of Technology, Sweden "Introduction to part II: ML for networking layer"
16:00-16:10; Danish Rafique, ADVA, Germany "Data Analytics based Network Operation and Management infrastructure"
16:10-16:20; Cristina Rottondi, Dalle Molle Institute for Artificial Intelligence, Switzerland "Machine learning-assisted routing and spectrum assignment in flexible optical networks"
16:20-16:30; Luis Velasco, Universitat Politècnica de Catalunya, Spain "A distributed data analytics architecture for cognitive transport networks"
16:30-16:40; Naga V. Irukulapati, Ericsson, Sweden "The need for machine learning and data analytic for future communication infrastructure"
16:40-16:45; Ilya Lyubomirsky, Inphi, USA "Introduction to part III: non-telecom applications of ML in optics"
16:45-16:55; Peter Bienstman, Ghent University, Belgium "Integrated-photonics implementation of reservoir computing neural networks"
16:55-17:05; Satyajeet Sing Ahula, Facebook, USA "Applications of machine learning in Facebook's production network"
17:05-17:15; Radha Nagarajan, Inphi, Sweden "LIDAR DSP and sensor fusion based on deep neural networks"
17:15-17:25; Nasser Mohammadiha, Zenuty, Sweden "Machine Learning for autonomous driving"

Panel discussion: what have we learned from part II-III and what are the future prospects 17.25-18.00

Plenary speakers

Dr. Vijay Vusirikala

10:30 – 11:00 Congress Hall

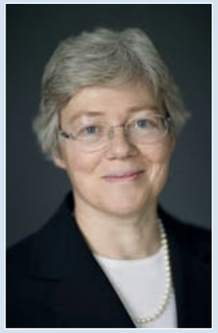
A Decade of Software Defined Networking at Google

Abstract: Google's global cloud infrastructure is built on three pillars: ubiquity, disaggregation and high availability. To support these three pillars, we have been building a network unparalleled in reach, scale and capability over the last decade. Early on, we realized that the network we needed to support our services did not exist and could not be bought. Hence, over the past 10+ years, we set out to fill in the required pieces in–house. Our fundamental design philosophy is that the network should be treated as a large–scale distributed system and leverage the same control infrastructure we developed for Google's compute and storage systems. In the process, we made every network layer intelligent, fault–tolerant, highly reliable and programmatically manageable to allow for rapid evolution and innovation. Software defined networking is the only way we build network infrastructure at Google today.

Vijay Vusirikala is Head of Optical Network Architecture and Engineering at Google, responsible for technology development, design, scaling and optimization of Google's optical network covering client optics, campus, metro, long haul and submarine links. His team spurred a number of network innovations and catalyzed early adoption of new optical technologies such as open line systems, Data Center Interconnect (DCI), Subsea Open Cables, C+L band line systems, and programmable transport layer, in a large scale production environment.

Prior to Google, Vijay was Director of Marketing at Infinera where he worked with major global network operators to design and deploy PIC based digital optical networks. Prior to joining Infinera, he was at Motorola Access Networks as Director of Market Development for PON, DSL, and IPTV products. Earlier, he was with Sycamore Networks in senior system architecture and product management roles, where he defined architecture for reconfigurable optical networks, and integrated switching and transport systems.

Vijay has published extensively and holds 15+ patents in optical components, system design and network architecture. He is a frequent speaker at industry conferences and executive forums. He received an MS in Physics and a Ph.D in EE with a focus on optoelectronic integration from the University of Maryland, College Park and a BSEE from IIT, Madras in India



Professor Anne L'Huillier

11:00 – 11:30 Congress Hall

50 years of Nobel Prizes in Photonics: From 1964 to 2014

Abstract: This presentation will describe some of the Nobel prizes in Physics in the area of Photonics. Starting from the 1964 Nobel prize to Townes, Basov and Prokhorov "for fundamental work in the field of quantum electronics, which has led to the construction of oscillators and amplifiers based on the maser–laser principle" to the 2014 Nobel prize to Akasaki, Amano and Nakamura "for the invention of efficient blue light–emitting diodes which has enabled bright and energy–saving white light sources".

Anne L'Huillier is professor in Atomic Physics at Lund University since 1997. Her research is centered around high–order harmonic generation in strong laser fields and its applications, in particular, to attosecond science. She was elected to the Royal Swedish Academy of Sciences in 2004 and has been member of the Nobel committee for Physics from 2007 to 2015.

Professor Philip Diamond

11:30 – 12:00 Congress Hall

Square Kilometre Array and how it will be Heavily Reliant on Optical Fibre Systems

Abstract: The Square Kilometre Array, a next–generation radio telescope, will change the way humanity views the Universe. Building on 70 years of radio astronomy developments, astronomers and engineers are designing what will be the largest scientific instrument on the planet. The SKA, currently in the detailed design phase, will be built in Australia and South Africa by an international consortium, currently of 10 nations. The science to be done by SKA encompasses almost the entire history of the Universe, from exploring the so–called Cosmic Dawn, when the first stars and galaxies were formed, to understanding how planets are formed in the present day. Along the way SKA will enable precise studies of the secrets of gravity, dark energy, dark matter and the molecular building blocks of life.

I will discuss the current status of SKA, as the project prepares for the transition to construction. I will describe in detail the critical role that optical fibre systems play in enabling the SKA, with its requirement to transmit data at Tbit/sec rates over hundreds and thousands of kilometres, to become a reality.

Professor Philip Diamond is the Director–General of the SKA (Square Kilometre Array). He was appointed to this position in October 2012, and is responsible for the team designing and ultimately constructing the SKA, which, when completed, will be the largest scientific project on Earth.

From 2010 – 2012 he was the Chief of CSIRO Astronomy and Space Science (CASS), which operates the major radio astronomy facilities in Australia, namely Parkes, the Compact Array and Mopra. CASS also operates the NASA Deep Space Network tracking station at Tidbinbilla, near Canberra, and has built ASKAP, the Australian SKA Pathfinder, in the Murchison in Western Australia.

Prof Diamond moved to Australia in June 2010, leaving his previous role as Director of the Jodrell Bank Centre for Astrophysics, part of the School of Physics and Astronomy at the University of Manchester in the UK. The University owns and operates the giant Lovell Telescope and, on behalf of the UK's Science and Technology Facilities Council, the e–MERLIN/VLBI National Facility. Prof. Diamond was responsible for the operation of both facilities.

Professor Diamond completed his PhD at the University of Manchester in 1982. He worked at the Onsala Space Observatory in Sweden and the Max–Planck Institute for Radioastronomy in Bonn, Germany before moving to the National Radio Astronomy Observatory (NRAO) in the USA for 12 years. He held the position of Deputy Director of the NRAO's VLA and VLBA before moving back to the UK in 1999 upon being appointed as the Director of MERLIN.

Professor Diamond's research interests include studies of star birth and death; exploring both through the use of radio interferometers such as MERLIN. He is also interested in high resolution studies of supernovae, both in our own Galaxy and in others. Finally, he also dabbles in studies of discs of molecular gas rotating around super–massive black–holes at the centres of other galaxies. He has published ~300 research papers in astronomy.

Phil is married to Jill; they have a son who recently graduated with a degree in Biochemistry and Genetics from the University of Leeds and a daughter who works as a project manager for a company installing remote scanning devices in libraries, warehouses and factories. He enjoys reading, supporting Manchester United and the England Rugby and Cricket teams, watching his son play rugby and playing the (very) occasional game of squash.

Plenary speakers

Kazuo Hagimoto

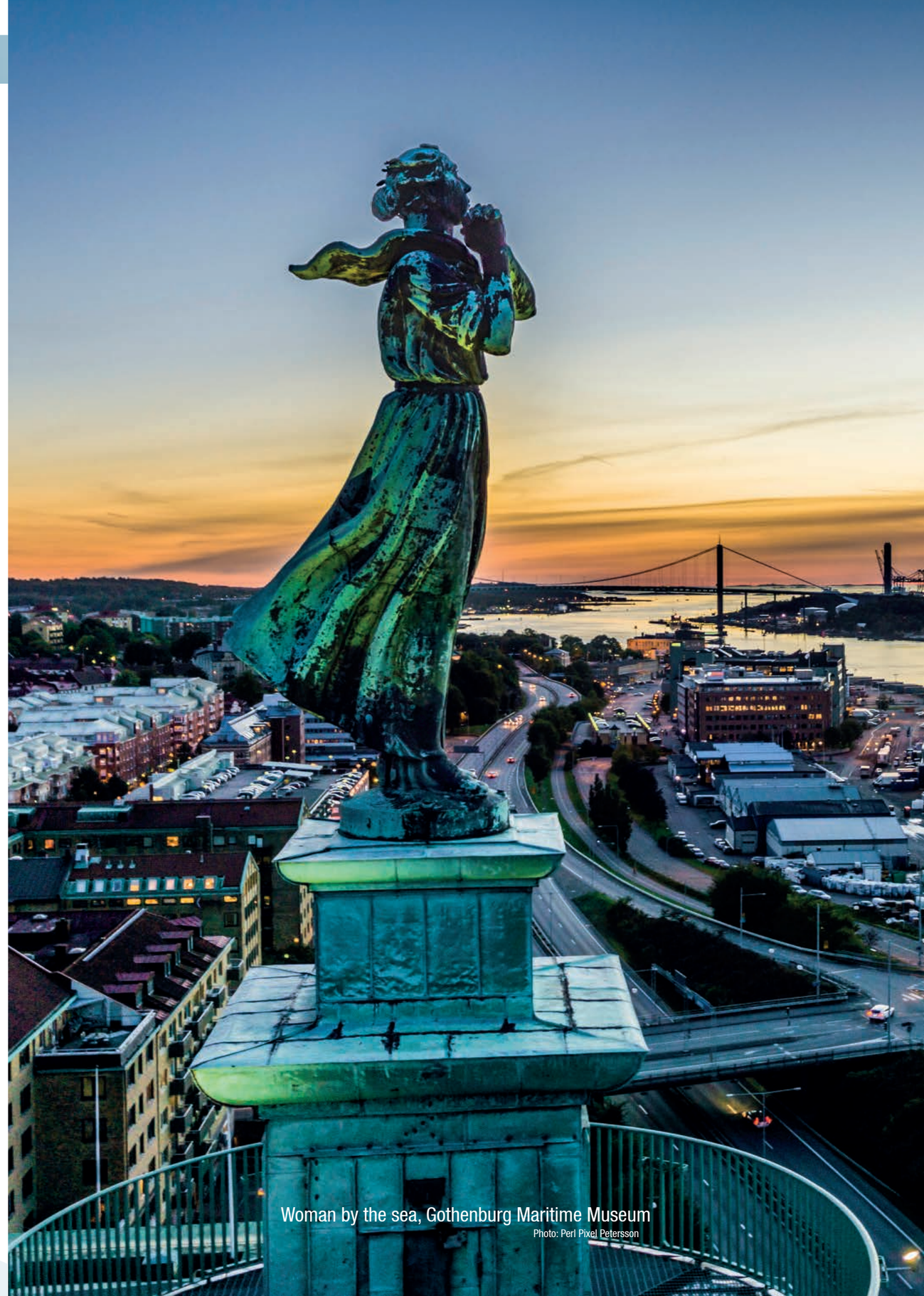
12:00 – 12:30 Congress Hall

Optical Communications: Past, Present, and Future

Abstract: Looking back the milestones of Fiber–Optic Systems, the future of related technologies will be discussed referring to the evolution of wireless systems. Because optical communications are based on the laser frequencies of the 200 THz.

Mr. Hagimoto joined the NTT Electrical Communications Laboratories, Yokosuka, Japan in 1980, where he has led R&D projects on high-speed optical communications systems including 10G and higher EDFA repeatered systems. After a executive director of Science and Core Technology Laboratory Group, which is responsible for leading edge technologies of NTT R&D activities, he has been the President and CEO of NTT Electronics Corporation since 2013. His current research interests include very large capacity optical network systems and media networking technologies utilizing these systems.

Mr. Hagimoto is a fellow of IEEE and the IEICE of Japan, and a member of OSA. He has served as a program co–chair of OAA'93 in Yokohama, Japan, a general co–chair of OAA'94 in Colorado, and the TPC chair of ICC2011 in Kyoto. He is currently a member of IEEE Photonics Society BoG (2015–17). He received the Sakurai Memorial Prize from the Optoelectronic Industry and Technology Development Association in 1989, the Oliver Lodge premium from the IEE in 1991, the Kenjiro Takayanagi memorial award in 1994, the achievement awards from the Institute of Electronics, Information and Communication of Engineers of Japan (IEICE) in 1994 and 2006, Maejima Award from TEISHIN association Japan in 2007, the 7th Industry–Academia–Government Collaboration Honor Program Prime Minister Award in 2009, and the Medal with Purple Ribbon from Japan in 2016.



Woman by the sea, Gothenburg Maritime Museum
Photo: Perl Pixel Petersson

Thursday 21 September 2017, 10:30-11:30 Room F4-F5
SC 1 – Fibers, Fiber Devices and Fiber Amplifiers

Th.2.D.1
David Richardson, Optoelectronics Research Centre – University of Southampton, UK
"Optical Amplifiers for Space-Division-Multiplexed Systems"

David Richardson obtained his B.Sc. and PhD in fundamental physics from Sussex University U.K. in 1985 and 1989 respectively. He joined the Optoelectronics Research Centre (ORC) at the University of Southampton in 1989 and was awarded a Royal Society University Fellowship in 1991 in recognition of his pioneering work on short pulse fibre lasers. Professor Richardson has been Deputy Director of the ORC with responsibility for optical fibre and laser related research since 2000. He has published more than 1000 research papers and produced more than 30 patents during his time at Southampton. He was one of the co–founders of SPI Lasers Ltd an ORC spin–off venture acquired by the Trumpf Group in 2008. Professor Richardson is a Fellow of the IEEE, OSA and IET and was elected a Fellow of the Royal Academy of Engineering in 2009. He received a Royal Society Wolfson Research Merit Award in 2013 for his optical communications research and was a recipient of the H2020 "Breaking the Optical Transmission Barriers" Horizon Prize following his involvement in the PHOTONMAP consortium.

Wednesday 20 September 2017, 08:30-09:30 Room F3
SC 2 – Integrated Optoelectronic Devices and Optical Processors

W.1.C.1
Christopher R. Doerr, Acacia, USA
"Integrated Silicon Photonics"

Christopher R. Doerr earned a B.S. in aeronautical engineering and a B.S., M.S., and Ph.D. in electrical engineering from the Massachusetts Institute of Technology. He was a pilot in the U.S. Air Force. Since joining Bell Labs in 1995, Doerr's research has focused on integrated devices for optical communication. He received the OSA Engineering Excellence Award in 2002. He is a Fellow of IEEE, OSA, and Bell Labs. He was Editor–in–Chief of IEEE Photonics Technology Letters from 2006–2008. He was awarded the IEEE William Streifer Scientific Achievement Award in 2009. He was a Technical and General Chair of OFC. He joined Acacia Communications in 2011, where he is AVP of Integrated Photonics.

Monday 18 September 2017, 16:00-17:00 Room F4
SC 3 – Digital Techniques for Optical Communication Systems

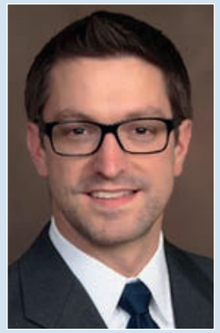
M.2.D.1
Erik Agrell, Chalmers, Sweden
"Capacity Bounds in Optical Communications"

Erik Agrell is a Professor in Communication Systems at Chalmers University of Technology since 2009. In 2010, he cofounded the Fiber–Optic Communications Research Center (FORCE) at Chalmers, where he leads the signals and systems research area. He is a Visiting Professor at University College London in 2014–2017. His research interests belong to the fields of information theory, coding theory, and digital communications, and his favorite applications are found in optical communications. He received the 1990 John Ericsson Medal, the 2009 ITW Best Poster Award, the 2011 GlobeCom Best Paper Award, the 2013 CTW Best Poster Award, and the 2013 Chalmers Supervisor of the Year Award.

Wednesday 20 September 2017, 13:30-14:30 Room F6
SC 4 – Transmission Subsystems and Optical Network Elements

W.3.F.1
Nicolas K. Fontaine, Nokia Bell Labs, USA
"Components For Space-Division Multiplexing"

Nicolas K. Fontaine is currently a Distinguished Member of the Technical Staff at Nokia Bell Labs working in the advanced photonics division at the Crawford Hill lab. He obtained his Ph. D. in 2010 from the University of California, Davis. At Bell Labs, he develops devices for space–division multiplexing in multi–core and few mode fibers, builds switching devices, and investigates spectral slice coherent receivers for THz bandwidth waveform measurement.



Monday 18 September 2017, 14:00-15:00 Room F1
SC 5 – Datacom and Computercom Hardware

M.1.A.1
Benjamin Lee, IBM, USA
"Silicon Photonic Switching: Technology and Architecture"

Benjamin G. Lee received the B.S. degree from Oklahoma State University, Stillwater, OK, USA, in 2004, and the M.S. and Ph.D. degrees from Columbia University, New York, NY, USA, in 2006 and 2009, respectively, all in electrical engineering. In 2009, he became a Postdoctoral Researcher at IBM Thomas J. Watson Research Center, Yorktown Heights, NY, USA, where he is currently a Research Staff Member. His research interests include silicon photonic devices, integrated optical switches and networks for high–performance computing systems and datacenters, and highly parallel multimode transceivers. He is a Member of the Optical Society and the IEEE Photonics Society. He currently serves on the Board of Governors for the Photonics Society.

Wednesday 20 September 2017, 10:30-11:30 Room F5
SC 6 – Point-to-Point Transmission Links

W.2.E.1
Sergei K. Turitsyn, Aston University, UK
"Nonlinear Fourier Transform Based Transmission"

Professor Sergei K. Turitsyn graduated from the Department of Physics of the Novosibirsk University, in 1982 and received his Ph.D. degree in Theoretical and Mathematical Physics from the Budker Institute of Nuclear Physics, Novosibirsk, Russia in 1986. In 1992 he moved to Germany, first, as a Humboldt Fellow and then working in the collaborative projects with Deutsche Telekom. Currently, he is a director of the Aston Institute of Photonic Technologies. He was a Principal Investigator in 55 national and international, research and industrial projects. Turitsyn was the recipient of a Royal Society Wolfson Research Merit Award in 2005. In 2011 he was awarded the European Research Council Advanced Grant. In 2014 he received Lebedev medal by the Rozhdestvensky Optical Society and in 2016 Aston 50th Anniversary Chair medal. He is a Fellow of the Optical Society of America and the Institute of Physics.

Tuesday 19 September 2017, 08:30-09:30 Room G4
SC 7 – Core, Metro, and Data Centre Networks

Tu.1.G.1
Ramon Casellas, CTTC, Spain
"Control, Management and Orchestration of Optical Networks: An Introduction, Challenges and Current Trends"

Ramon Casellas (IEEE Senior Member) is with CTTC, Spain, since 2006 where he holds a Senior Researcher position. Before, he worked as an associate professor at the networks and computer science department at the ENST France, having obtained his Ph.D. in 2002. Since joining CTTC, he has been involved in multiple European, national and industry grant research projects, on topics related to traffic engineering, network optimization and network control and management, with emphasis on optical and multi–layer transport networks. His research interests include the GMPLS/PCE architectures and protocols, Software Defined Networks (SDN) and Network Function Virtualization (NFV). He has coauthored over 150 papers, 4 book chapters and 4 IETF RFCs.

Tuesday 19 September 2017, 13:30-14:30 Room F2
SC 8 – Access, Local Area and Indoor Networks

Tu.2.B.1
Ton Koonen, Eindhoven University of Technology, The Netherlands
"Optical Wireless Systems: Technology, Trends and Applications"

Ton Koonen is Full Professor in Eindhoven University of Technology since 2001. He is Chairman of the group Electro–Optical Communication Systems since 2004, Vice–Dean of the Dept. Electrical Engineering since 2012, and Scientific Director of the Institute for Photonic Integration at TU/e since Jan. 2016. Before 2001, he worked more than 20 years in applied research in industry, amongst others in Philips Telecommunication Industry and Bell Labs – Lucent Technologies. He is a Bell Labs Fellow (1998), IEEE Fellow (2007), OSA Fellow (2013), and Distinguished Guest Professor of Hunan University, Changsha, China (2014). In 2011, he received an Advanced Investigator Grant of the European Research Council. He (co–)authored more than 650 papers on optical fiber communication. His current research interests include spatial division multiplexed systems, access and in–building fiber networks, including high–capacity POF networks, radio–over–fiber techniques, and optical wireless communication techniques.

SC 1 – Fibers, Fiber Devices and Fiber Amplifiers

Wednesday 20 September 2017, 13:30-14:00 Room F2
Stojan Radic, University of California San Diego, USA
"Frequency Stabilisation and its Implication in Optical Networks"

Tuesday 19 September 2017, 08:30-09:00 Room F1
Radan Slavik, University of Southampton, UK
"Ultralow Thermal Sensitivity of Phase and Propagation Delay in Hollow-Core Fibres"

Wednesday 20 September 2017, 08:30-09:00 Room F2
Cristian Antonelli, University of L'Aquila, Italy
"Propagation Effects in SDM Fibers"

Wednesday 20 September 2017, 10:30-11:00 Room F6
Guifang Li, University of Central Florida, USA
"Weakly-coupled Few-Mode Fibers and their Applications"

Monday 18 September 2017, 16:00-16:30 Room F2
Camille-Sophie Brès, Ecole Polytechnique Fédérale de Lausanne, Switzerland
"Low Power Amplified Mid IR Parametric Conversion in Tapered Chalcogenide Photonic Crystal Fibres"

SC 2 – Integrated Optoelectronic Devices and Optical Processors

Tuesday 19 September 2017, 14:00-14:30 Room F3
Daniel Blumenthal, UCSB Santa Barbara, USA
"Ultra-Low Loss Si3N4 Planar Waveguide Platform and Applications"

Monday 18 September 2017, 15:00-15:30 Room F3
Takuro Fujii, NTT Corporation, Japan
"High Performance Epitaxially Grown III-V Membrane Lasers on Si"

Monday 18 September 2017, 16:00-16:30 Room F3
Timo Aalto, VTT, Finland
"Transceivers for 400G Based on Hybrid Integrated Thick SOI and III/V Chips"

Wednesday 20 September 2017, 11:30-12:00 Room F3
Frédéric Boeuf, STMicroelectronics, France
"Challenges in Silicon Photonics Process Technology"

Tuesday 19 September 2017, 08:30-09:00 Room F3
Wolfram Pernice, University of Münster, Germany
"Integrated Quantum Photonic Circuits with Electrically Driven Light Sources"

SC 3 – Digital Techniques for Optical Communication Systems

Tuesday 19 September 2017, 14:00-14:30 Room F4
Georg Böcherer, Technical University of Munich, Germany
"Fast Probabilistic Shaping Implementation for Long-Haul Fiber-Optic Communication Systems"

Wednesday 20 September 2017, 09:30-10:00 Room F4
Marco Secondini, TeCIP Institute, Scuola Superiore Sant'Anna, Italy
"Fiber Nonlinearity Mitigation in WDM Systems: Strategies and Achievable Rates"

Thursday 21 September 2017, 08:30-09:00 Room F4-F5
Vahid Aref, Nokia Bell Labs, Germany
"Does the Cross-Talk Between Nonlinear Modes Limit the Performance of NFDM Systems?"

Wednesday 20 September 2017, 10:30-11:00 Room F4
Jens Rasmussen, Fujitsu, Japan
"DSP for Short Reach Optical Links"

Monday 18 September 2017, 14:30-15:00 Room F4
Toshiaki Koike-Akino, MERL, USA
"Irregular Polar Coding for Multi-Level Modulation in Complexity-Constrained Lightwave Systems"

SC 4 – Transmission Subsystems and Optical Network Elements

Wednesday 20 September 2017, 14:30-15:00 Room F6
Joel Carpenter, The University of Queensland, Australia
"Principal Modes in Multimode Fiber"

Thursday 21 September 2017, 08:30-09:00 Room G4
Hiroshi Yamazaki, NTT Corporation, Japan
"Ultra-Wideband Digital-to-Analog Conversion Technologies for Tbit/s Channel Transmission"

Monday 18 September 2017, 16:30-17:00 Room F6
Michael Eiselt, ADVA Optical Networking SE, Germany
"Optical Transceivers for Mobile Front-Haul and PON Applications"

Tuesday 19 September 2017, 08:30-09:00 Room F6
Masatoshi Suzuki, KDDI Research, Inc, Japan
"Peta Bit Per Second Optical Transmission with Spatial Division Multiplexing"

Wednesday 20 September 2017, 08:30-09:00 Room F6
Jean-Yves Dupuy, III-V Lab, France
"High Performance Electronics for High-speed Optical Transceivers in Datacom and Telecom Applications"

Wednesday 20 September 2017, 09:30-10:00 Room F6
Yannick De Koninck, Luxtera Inc, USA
"Advanced Silicon Photonics Transceivers"

SC 5 – Datacom and Computercom Hardware

Thursday 21 September 2017, 10:30-11:00 Room F1
Hans-Juergen Schmidtke, Facebook, USA
"Application-driven Requirements for Next-Generation Data Center Interconnects"

Tuesday 19 September 2017, 13:30-14:00 Room F1
Dazeng Feng, Mellanox Technologies Inc, USA
"Silicon Photonics Integration Platform for High Performance Interconnects"

Tuesday 19 September 2017, 14:00-14:30 Room F1
Jessie Rosenberg, IBM Watson Research Center, USA
"Monolithic Silicon Photonic WDM Transceivers"

Wednesday 20 September 2017, 09:30-10:00 Room F1
Frank Chang, Inphi Corp, USA
"New Paradigm Shift to PAM4 Signaling at 100/400G for Cloud Data Centers: A Performance Review"

SC 6 – Point-to-Point Transmission Links

Monday 18 September 2017, 14:00-14:30 Room F5
Yuta Wakayama, KDDI Research, Inc, Japan
"Ultra-High Spectral Efficiency Few-Mode Multicore Fibre Transmission"

Tuesday 19 September 2017, 08:30-09:00 Room F5
Alexei Pilipetski, TE SubCom, USA
"The Role of SDM in Future Transoceanic Transmission Systems"

Thursday 21 September 2017, 09:30-10:00 Room F6
Masanori Nakamura, NTT Network Innovation Laboratories, Japan
"Long Haul Transmission at High Baud Rates toward over 100-GBaud with Coded Modulation"

Wednesday 20 September 2017, 11:30-12:00 Room F5
Arthur Lowery, Monash University, Australia
"Distributed Nonlinear Compensation using Optoelectronic Circuits"

Monday 18 September 2017, 16:00-16:30 Room F5
Roland Ryf, Nokia Bell Labs, USA
"Long-Haul Transmission Over Multi Core Fiber with Coupled Cores"

Thursday 21 September 2017, 08:30-09:00 Room F6
Junho Cho, Nokia Bell Labs, USA
"High Spectral Efficiency Transmission with Probabilistic Shaping"

SC 7 – Core, Metro, and Data Centre Networks

Thursday 21 September 2017, 09:30-10:00 Room F1
Nicola Sambo, Scuola Superiore Sant'Anna, Italy
"Control and Management of Sliceable Transponders"

Thursday 21 September 2017, 10:30-11:00 Room F3
Marc De Leenheer, ON.Lab, USA
"SDN Control of Optical Networks"

Wednesday 20 September 2017, 10:30-11:00 Room F1
Kevin Sparks, Nokia Bell Labs, USA
"Could the Transformation to Cloud-Optimized Networking be Opening a New Era for Dynamic Optical Networking?"

Tuesday 19 September 2017, 13:30-14:00 Room F6
Ken-Ichi Sato, Nagoya University, Japan
"Realization and Application of Large-scale Fast Optical Circuit Switch for Data Center Networking"

Monday 18 September 2017, 16:00-16:30 Room F1
Anna Tzanakaki, University of Athens, Greece, and University of Bristol, UK
"Optical Networking: An Important Enabler for 5G"

SC 8 – Access, Local Area and Indoor Networks

Wednesday 20 September 2017, 13:30-14:00 Room F4
Jun-Ichi Kani, NTT Access Network Service Systems Laboratories, Japan
"Flexible Access System Architecture to Support Diverse Requirements and Agile Service Creation"

Monday 18 September 2017, 14:00-14:30 Room F2
Xiang Liu, Huawei, USA
"Recent Progresses on Efficient Mobile Front-haul for 5G Wireless Networks"

Thursday 21 September 2017, 11:00-11:30 Room F2
Piet Demeester, Ghent University, Belgium
"ATTO: Wireless Networking at Fiber Speed"

Thursday 21 September 2017, 08:30-09:00 Room F2
Naoki Suzuki, Mitsubishi Electric Corporation, Japan
"100G to 1T Based Coherent PON Technology"

Lab Automation Hackathon

Sunday, 17th September, 19:30 – 22:00

Place: Svenska Mässan, Gothenburg, Sweden

Room: G1

Organisers:
Jochen Schröder, Chalmers University of Technology
Nicolas Fontaine, Nokia Bell Labs
BinBin Guan, Acacia Communications

Lab work is most efficient when data can be acquired in an automated way. Especially when taking measurements over long durations automated acquisition avoids introducing human error and allows researchers to concentrate on the fun part of experimental work. Open source software in easy to learn languages such as Python provides just as much, or more features/interoperability for lab automation than alternative commercial software. In this hackathon several researchers with 10+ years experience of lab automation will show you the power of using Python to quickly get a lab experiment running and display the measurements in a browser. We will learn from companies that work in photonics how they take advantage of Python to create easy interfaces to their software and hardware.

Bring a laptop to participate in the exercise. There will also be plenty of time for mingling and discussion. Light food and drinks will be served.

Women's Leadership in Science and Technology

Tuesday, 19th September, 12:00-13:30

Place: Svenska Mässan, Gothenburg, Sweden

Room: G4

A light lunch will be served at the session.
Pre- registration mandatory.

Organisers:
Qin Wang, RISE Acreo
Lauren Mecum, IEEE Photonics Society
Patryk Urban, IEEE Photonics Sweden

To promote personal and professional growth for women in Science, Technology, Engineering and Mathematics (STEM) this special networking event will be arranged as part of the ECOC 2017 conference.

Two top female leaders are invited and will give talks to share their personal successful experience with the participants, which can hopefully inspire/encourage young female professionals and PhD students to be as future leaders in STEM areas.

The event chair is Dr. Lauren Mecum, IEEE IPS

12:00 Welcome and opening introduction, Dr. Qin Wang, RISE Acreo AB12:05 Brief of IEEE WIP, Dr. Lauren Mecum

12:10 Announcement of European Women in Space Technology Initiative, Dr. Linda Mondin, European Space Agency (ESA).

12:15 Invited talk, Pia Sandvik, RISE

12:35 Invited talk, Anna Rathsman, Swedish Space Corporation (SSC)

12:55 Panel discussions, Pia Sandvik, Anna Rathsman and Linda Mondin will be in the panel to have interactions with audiences and answer questions.

13:30 End

Pia Sandvik
Pia Sandvik, CEO, RISE Research Institutes of Sweden. Pia has switched between research and the business sectors, and that's something she enjoys. Her aim for RISE is to focus on both coordination synergies and develop new services that benefit customers and society.

Anna Rathsman
Anna Rathsman, Vice President & CTO, Technology & Innovation, Swedish Space Corporation (SSC). Her role as Chief Technical Officer is to provide the technical vision, support the business development, sets the tone and guides direction for the company's development and deployment of core technologies.

M.1.A: Technologies for Integration and Optical Switches
Room F1 (SC5)
Chair: Alloatti Luca, ETH Zurich, Switzerland

14:00 M.1.A.1 Tutorial
Silicon Photonic Switching: Technology and Architecture
Benjamin Lee, IBM, Yorktown Heights, USA
Densely integrated efficient photonic switching technologies show potential for transforming optical networks across diverse markets from longhaul to shortreach distance scales. This work reviews current technologies and architectures, while expounding on a few key enabling innovations

15:00 M.1.A.2
Smart Routing Tables for Integrated Photonic Switch Fabrics
Qixiang Cheng; Meisam Bahadori; Yishen Huang; Sebastien Rumley; Keren Bergman, Columbia University, NewYork, USA
Smart routing tables aware of physical-layer parameters are first realized for 4x4-port silicon photonic switch device, improving the worst-case power-penalty by 8.8dB and reducing dynamic-range requirement on receivers by 7.8dB. An 8x8-port switch is further simulated achieving 16.1dB power-penalty improvement.

15:15 M.1.A.3
Automated Calibration and Characterization for Scalable Integrated Optical Switch Fabrics without Built-in Power Monitors
Yishen Huang; Qixiang Cheng; Nathan Abrams; Ji Zhou; Sebastien Rumley; Keren Bergman, Columbia University, New York, USA
Highly accurate calibration and characterization process for optical switch fabrics without built-in power monitors is first proposed, substantially reducing cost and complexity for device integration and packaging. The multi-input scheme ensures method's scalability, which we demonstrate experimentally with automated implementat

M.1.B: Advances in Optical Fronthaul
Room F2 (SC8)
Chair: Gaudino Roberto, Politecnico di Torino, Italy

14:00 M.1.B.1 Invited
Recent Progresses on Efficient Mobile Front-haul for 5G Wireless Networks
Xiang Liu; Frank Effenberger; Huaiyu Zeng; Sharief Megeed, Huawei USA, Bridgewater, USA
We review recent progresses made in the field of mobile front-haul to support massive MIMO, cloud radio access networking, and small cell deployment. The evolution of mobile front-haul towards 5G wireless and its impact on time-sensitive optical networking are discussed

14:30 M.1.B.2
Practical Mobile-DBA Scheme Considering Data Arrival Period for 5G Mobile Fronthaul with TDM-PON
Hiroyuki Uzawa; Hiroko Nomura; Tatsuya Shimada; Daisuke Hisano; Kenji Miyamoto; Yu Nakayama; Keita Takahashi; Jun Terada; Akihiro Otaka, NTT, Yokosuka-shi, Japan
For mobile fronthaul with TDM-PON, we propose a practical DBA scheme that allocates proper time slots by estimating the data-arrival period from mobile scheduling information. Experiments show that the scheme actually satisfies the fronthaul latency requirement for the first time.

14:45 M.1.B.3
High Tolerance against Chirp Induced PAM4 Eye Skewing in DML-based Digital Mobile Fronthaul with 11dB EVM Reduction
Haiyun Xin; Kuo Zhang; Mingxia Zhang; Hao He; Weisheng Hu Shanghai Jiao Tong University, Shanghai, China
We demonstrate 40Gbps digitized LTE-like signal delivery in low-cost DML-based system. By interleaving sample bits, eye skewing induced issue is addressed. EVM of wireless signal after 20km transmission can be reduced by up to 11dB, keeping comparable with BtB case.

15:00 M.1.B.4
Low Latency Symbol Level Transmission Scheme for Mobile Fronthaul with Intra PHY Split RAN Architecture
Kenji Miyamoto; Tatsuya Shimizu; Jun Terada; Akihiro Otaka, NTT Corporation, Yokosuka, Japan
We propose a low latency transmission scheme for mobile fronthaul with intra PHY split RAN architecture. It forwards short segments of encoded bit data corresponding to modulation symbols of wireless signals. Evaluation results confirm the latency reduction of 140 us.

15:15 M.1.B.5
Optical Video Transmission System of Terrestrial Broadcasting by Digitized-RoF Technology with Rate Reduction Method
Ryota Shiina; Toshihito Fujiwara; Tomoki Sugawa, NTT Access Network Service Systems Laboratories, Yokosuka, Kanagawa, Japan
We propose a simple and cost effective DRoF-based optical video transmission system. Experiments on actual multiple terrestrial broadcasting signals verify the feasibility of the system and its new rate reduction method

M.1.C: Novel III-V Transmitters and Receivers
Room F3 (SC2)
Chair: Fincato Antonio, ST Microelectronics, Italy

14:00 M.1.C.1
A Novel Ultralow Power Consumption Transmitter Having a Laser Injection-Locked by a Silicon Microring Modulator
Tomoyuki Akiyama; Shinsuke Tanaka; Shigeaki Sekiguchi, PETRA, Fujitsu Ltd., Fujitsu Ltd., Atsugi, Japan
We propose a novel transmitter with a microring modulator providing seed light to injection-lock a laser at ring resonance. As resonance tuning becomes negligible, power consumption of 0.93 mW/Gbps including laser, lowest among all Si PIC transmitters, has been achieved.

14:15 M.1.C.2
Wideband material for Low linewidth Widely Tunable Laser and Reach Extender for Optical Access Networks
Agnès Verdier, III-V Lab, Palaiseau, France
We demonstrate ultra-wideband operation of a low linewidth tunable laser and a polarization independent reach extender, based on the same broadband material

14:30 M.1.C.3
Quantum-Well Laser Emitting at 1.2 µm-1.3 µm Window Monolithically Integrated on Ge Substrate
Mircea Guina1; Riku Isoaho2; Jukka Viherälä2; Arto Aho2; Antti Aho2; Antti Tukiainen2
1Tampere University of Technology, Optoelectronics Research Centre, Optoelectronics Research Centre, Tampere, Finland; 2Tampere University of Technology, Tampere, Finland
We report a quantum-well laser diode monolithically integrated on Ge substrate. The gain is provided by two GaInNAsSb/GaAs quantum-wells with emission at 1200 nm-1300 nm. The diode exhibits continuous-wave operation with mW-level output power at room temperature.

14:45 M.1.C.4
Fully Integrated Stokes Vector Receiver with MQW-based Photodetectors on InP
Takahiro Suganuma; Samir Ghosh; Mohiyuddin Kazi; Ryoma Kobayashi; Yoshiaki Nakano; Takuo Tanemura, The University of Tokyo, Tokyo, Japan
We fabricate and experimentally demonstrate a compact direct-detection-based Stokes vector (SV) receiver with on-chip photodetector (PD). Compressively strained multiple-quantum-well PD array is monolithically integrated on InP-based passive polarization-converting circuit to retrieve SV of input light from the photocurrent signals.

15:00 M.1.C.5 Invited
High Performance Epitaxially Grown III-V Membrane Lasers on Si
Takuro Fujii; Koji Takeda; Hidetaka Nishi; Shinji Matsuo, NTT Corporation, Atsugi, Kanagawa, Japan
The integration of III-V lasers on Si is the key to realizing large-scale photonic integrated circuits. A new epitaxial growth technique for use with a directly bonded InP-based membrane on SiO2/Si enables us to fabricate high performance buried heterostructure lasers.

M.1.D: Coded Modulation
Room F4 (SC3)
Chair: Jaouen Yves, IMT – Telecom Paritech, France

14:00 M.1.D.1
24-Dimensional Modulation Formats for 100 Gbit/s IM-DD Transmission Systems Using 850 nm Single-Mode VCSEL
Xiaofeng Lu; Vladimir S. Lyubopytov; Idelfonso Tafur Monroy, Technical University of Denmark, Kgs. Lyngby, Denmark
Twenty-four dimensional modulation format with 2 bit/symbol spectrum efficiency is proposed and investigated in an up to 100 Gbit/s VCSEL-based IM-DD transmission system with respect to the channel bandwidth and the power budget.

14:15 M.1.D.2
Experimental Demonstration of Space-Time Coding for MDL Mitigation in Few-Mode Fiber Transmission Systems
El Mehdi Amhoud[1]; Ghaya Rekaya-Ben Othman[2]; Laurent Bigot[3]; Mengdi Song[3]; Esben Ravn Andresen[4]; Guillaume Labroille[4]; Marianne Bigot-Astruc[4]; Yves Jaouen[2]
[1]Télécom ParisTech, PARIS, France; [2]Télécom ParisTech, Paris, France; [3]University of Lille, Lille, France; [4]University of Lille, Paris, France; [5]CAILabs SAS, Rennes, France; [6]Prysmian Group, Haisnes, France
We demonstrate through experimental measurements the potential of Space-Time coding in mitigating mode-dependent loss (MDL) in few-mode fiber transmission systems. The Q-factor is improved by 3.4 dB for an MDL of 10 dB.

14:30 M.1.D.3 Invited
Irregular Polar Coding for Multi-Level Modulation in Complexity-Constrained Lightwave Systems
Toshiaki Koike-Akino[1]; Congzhe Cao[2]; Ye Wang[1]; Stark Draper[3]; David Millar[1]; Kieran Parsons[1]; Keisuke Kojima[1]; Milutin Pajovic[1]; Lidia Galdino[4]; Daniel J Elson[4]; Domaniç Lavery[4]; Polina Bayvel[4]
[1]MERL, Cambridge, USA; [2]University of Alberta, Edmonton, Canada; [3]University of Toronto, Toronto, Canada; [4]University College London, London, UK
We experimentally demonstrate that the irregular polar codes outperform state-of- the-art LDPC codes, while the computational complexity in encoding and decoding can be significantly reduced by at least 30% over the regular polar codes with a marginal performance improvement.

15:00 M.1.D.4
On Achievable Information Rates for Coherent Fiber-Optic Systems with Hard Decision Decoding
Alireza Sheikh[1]; Alexandre Graell I Amat[1]; Gianluigi Liva[2]
[1]Chalmers University of Technology, Gothenburg, Sweden; [2]Institute of Communications and Navigation of the German Aerospace Center (DLR), Munich, Germany
We analyze achievable information rates (AIRs) for coherent fiber-optic systems with hard decision decoding and show that binary codes achieve higher rates than nonbinary codes, which translates into larger transmission reach. This result is confirmed by simulation of staircase codes.

15:15 M.1.D.5
Improved Low-Power LDPC FEC for Coherent Optical Systems
Kevin Cushon; Per Larsson-Edefors; Peter Andrekson, Chalmers University of Technology, Gothenburg, Sweden
We propose and demonstrate a low-complexity LDPC FEC system for coherent optical applications. Implementation results show an estimated NCG of 11.0 dB with 20% overhead, 160 Gbps throughput, and energy consumption of 3.4 pJ per bit.

M.1.E: SDM Transmission 1
Room F5 (SC6)
Chair: Krummrich Peter, Technische Universität Dortmund, Germany

14:00 M.1.E.1 Invited
Ultra-High Spectral Efficiency Few-Mode Multicore Fibre Transmission
Yuta Wakayama; Daiki Soma; Takehiro Tsuritani; Itsuro Morita, KDDI Research, Inc., Fujimino, Japan
This paper reviews recent progress on space-division multiplexed (SDM) transmission with focusing on aggregate spectral efficiency (SE) and discusses current issues with SDM transmission toward ultra-high SE.

14:30 M.1.E.2
Transmission of 256Gb/s PM-16QAM Signal through 7-Core MCF and MC-EDFA with Common Cladding and Variable Shared Core Pumping for Reduction of Power Consumption
Emmanuel Le Taillandier De Gabory; Keiichi Matsumoto; Sadao Fujita; Hitoshi Takeshita; Shigeyuki Yanagimachi, NEC Corporation, Kawasaki, Japan
We transmit 256Gb/s PM-16QAM signal through 385km with 7-core MCF, passing 7 times a MC-EDFA with common cladding and variable shared core pumping. The MC-EDFA enables 23% reduction of power consumption while received Q value varied within ±0.17dB.

14:45 M.1.E.3
Hybrid Cladding-pumped EDFA/Raman for SDM Transmission Systems Using Core-by-core Gain Control Scheme
Takayuki Mizuno; Akira Isoda; Kohki Shibahara; Hirotaka Ono; Mitsunori Fukutoku; Yutaka Miyamoto, NTT Corporation, Yokosuka, Japan
We propose and demonstrate hybrid cladding-pumped/Raman amplification for multicore fiber transmission systems. 46WDM PDM-16QAM signals were transmitted over a 7-core transmission line and Q-factor enhancement is demonstrated using the core-by-core gain control scheme.

15:00 M.1.E.4
Spectrally-Efficient Seed-Lightwave-Distribution System using Space-Division-Multiplexed Distribution Channel for Multi-core 3-Mode-Multiplexed DP-64QAM Transmission
Jun Sakaguchi; Werner Klaus; Benjamin Puttnam; José Manuel Delgado Mendinueta; Yoshinari Awaji; Naoya Wada, National Institute of Information and Communications Technology, Koganei, Japan
We demonstrate the possibility to eliminate carrier phase estimation DSP in mode-multiplexed DP-64QAM transmission by distributing low-phase-noise seed lightwave through MCF cores. Penalty of seed distribution over 90 km MCF with ambient data signals was sufficiently small.

15:15 M.1.E.5
50 ch x 250 Gbit/s 32-QAM Transmission over a Fully Integrated 7-core Multicore Link
Carlos Castro[1]; Saurabh Jain[2]; Yongmin Jung[2]; Erik De Man[3]; Stefano Calabrò[3]; Klaus Pulverer[3]; Marc Bohn[3]; John Hayes[3]; Shaif-Ul Alam[2]; David J Richardson[2]; Yusuke Sasaki[4]; Takayuki Mizuno[4]; Yutaka Miyamoto[4]; Toshio Morioka[4]; Werner Rosenkranz[3]
[1]University of Kiel, Kiel, Germany; [2]Optoelectronics Reseach Centre University of Southampton, Southampton, UK; [3]Coriant R&D GmbH, Munich, Germany; [4]Fujikura, Sakura, Japan; [5]NTT Corporation, Yokosuka, Japan; [6]Technical University of Denmark, Lyngby, Denmark
A transmitted distance of 180 km over an integrated multicore link is demonstrated for a C-band 32-QAM WDM system, where the complete usable amplification region of the integrated 7-core amplifiers, supporting 50 channels per core, is exploited.

M.1.F: High-Capacity Subsystems
Room F6 (SC4)
Chair: Boffi Pierpaolo, Politecnico di Milano, Italy

14:00 M.1.F.1
Signal-Quality Balancing and Dispersion-Tolerance Enhancement Using Multi-Channel-Coded Modulation for Short-Reach Optical Transmission
Shuto Yamamoto; Akira Masuda; Shingo Kawai; Mitsunori Fukutoku, NTT corporation, Yokosuka, Japan
We propose Walsh-coded PAM that moderates the signal-quality imbalance between WDM channels and enhances the total performance in muti-lane transmissions. Simulation and transmission experiment results show that the proposed technique improves the chromatic-dispersion tolerance in multi-channel-coded IM-DD transmissions.

14:15 M.1.F.2
A New Optical Phase-Locked System Between Ultrashort Pulses for 640 Gbaud Nyquist OTDM Coherent QAM Transmission
Kosuke Kimura; Junpei Nitta; Masato Yoshida; Keisuke Kasai; Toshihiko Hirooka; Masataka Nakazawa, Tohoku University, Sendai, Japan
We demonstrate an optical phase-locked system for a 640 Gbaud optical Nyquist pulse transmission with a mode-locked laser based local oscillator. Carrier-phase synchronization with a phase noise of as low as 0.65 degrees was achieved after a 150 km transmission.

14:30 M.1.F.3
Photonic-Chip-Enabled 25 Tb/s Optical Superchannel using Cyclic Spectra
Bill Corcoran[1]; Zihan Geng[2]; Valery Rozental[2]; Leimeng Zhuang[2]; Mads Lillieholm[1]; Arthur Lowery[2]
[1]Dept. Elec.& Comp. Sys. Eng, Monash University, Centre for Ultrahigh-bandwidth Devices for Optical Systems (CUDOS), Melbourne, Australia; [2]Dept. of Elec. & Comp. Sys. Eng., Monash University, CUDOS, CUDOS, Melbourne, Australia; [3]Dept. of Elec. & Comp. Sys. Eng., Monash University, Melbourne, Australia; [4]DTU Fotonik, Copenhagen, Denmark
We demonstrate the all-optical generation of a 3.8-THz wide superchannel, using a photonic-chip-based filter for sub-channel definition. The photonic chip is able to shape and aggregate 304xNRZ-32-QAM sub-channels, carrying 10-Gbd data, with an effective data-rate of 24.79 Tb/s.

14:45 M.1.F.4
Single-Carrier 400G Unrepeatered WDM Transmission over 443.1 km
Joao Januario[1]; Sandro Rossi[2]; José Hélio Junior[2]; Andrea Chiuchiarelli[2]; Andre Souza[2]; Alexandre Felipe[3]; Aldário Bordonalli[2]; Sergejs Makovejs[4]; Cristiano Mornatta[4]; Alessandro Festa[5]; Ekaterina Golovchenko[5]; George Buabbud[6]; Jacklyn Reis[2]
[1]CPqD, State University of Campinas, State University of Campinas, Campinas, Brazil; [2]CPqD, Campinas, Brazil; [3]State University of Campinas, Campinas, Brazil; [4]Corning Incorporated, Corning, USA; [5]IPG Photonics, Milan, Italy
A record single-carrier 400 Gb/s unrepeatered WDM transmission over 443.1 km with 73.1-dB span loss is demonstrated. By employing an optimized transmission path design with Raman pump lasers, ROPAs and pump delivery fibers, transmission is achieved for 24x64/66 GBd--DP-16QAM.

15:00 M.1.F.5 Upgraded
10.3bits/s/Hz Spectral Efficiency 54x24GBaud PM-128QAM Comb-Based Superchannel Transmission Using Single Pilot
Mikael Mazur; Abel Lorences-Riesgo; Jochen Schröder; Peter Andrekson; Magnus Karlsson, Chalmers University of Technology, Gothenburg, Sweden
We demonstrate transmission of a 14.2Tbit/s comb-based superchannel using a single shared optical pilot tone. The pilot tone allows for locking the central line between the transmitter and receiver combs, enabling blind carrier recovery and a spectral efficiency of 10.3bits/s/Hz.

15:30 - 16:00 COFFEE EXHIBITION HALL

M.2.A: 5G Transport
Room F1 (SC7)
Chair: Bjørnstad Steinar, Norwegian University of Science, Norway

16:00 M.2.A.1 Invited
Optical networking: An important enabler for 5G
Tzanakaki Anna1; Anastasopoulos Markos2; Dimitra Simeonidou21 National and Kapodistrian University of Athens, University of Bristol, University of Bristol, Bristol, UK; 2University of Bristol, Bristol, UK
This paper focuses on converged optical-wireless 5G infrastructures and proposes the novel architecture of "Dis-Aggregated RAN" adopting "disaggregation" of hardware and software components across wireless, optical and compute/ storage domains. The proposed approach is evaluated through a purposely developed modelling framework

16:30 M.2.A.2
Experimental Demonstration of 100 Gb/s Optical Packet Network for Mobile Fronthaul with Load-independent Ultra-low Latency
Raimena Veisllari1; Steinar Bjornstad2; Jan Petter Braute1 1TransPacket, Oslo, Norway; 2TransPacket, Norwegian University of Science and Technology, Norwegian University of Science and Technology, Oslo, Norway
Mobile fronthaul networks put very strict demands on latency. This first 100Gbps integrated packet/circuit hybrid optical network experiment demonstrates a load independent low latency Ethernet path supporting time sensitive traffic through a mixed traffic network.

16:45 M.2.A.3
Flexible RAN: a Radio Access Network Concept with Flexible Functional Splits and a Programmable Optical Transport
Yajie Li1; Jonas Mårtensson2; Matteo Fiorani3; Björn Skubic3; Zere Ghebretensaé3; Yongli Zhao4; Jie Zhang4; Lena Wosinska1; Paolo Monti11KTH Royal Institute of Technology, Stockholm; 2RISE Acreo, Stockholm; 3Ericsson, Stockholm; Sweden 4Beijing University of Posts and Telecommunications, Beijing, China
We present the flexible RAN concept and evaluate its performance in different radio coordination scenarios considering an optical transport network. Results show the benefits of flexible RAN compared to C-RAN in terms of wavelength usage and transponder cost.

17:00 M.2.A.4
Demonstration of Lightpath Reconfiguration for BBU aggregation in the SDN-Enabled Optical Fronthaul Networks
Hao Yu1; Jiawei Zhang1; Dexue Song2; Xingang Huang3; Yuefeng Ji1 1Beijing University of Posts and Telecommunications (BUPT), Beijing University of Technology (BJUT), Beijing University of Technology (BJUT), Beijing; 2Beijing University of Posts And Telecommunications (BUPT), Beijing, China; 3ZTE Cooperation, Shanghai, China
The BBU aggregation for mobile tidal traffic is proposed, which is achieved by a SDN-enabled flexible optical fronthaul network. Two lightpath reconfiguration strategies for the BBU aggregation are experimentally demonstrated on the cloud radio over flexible optical fronthaul transport networks.

17:15 M.2.A.5 Highly ranked paper
Experimental Validation of a Converged Metro Architecture for Transparent Mobile Front-/Back-Haul Traffic Delivery using SDN-enabled Sliceable Bitrate Variable Transceivers
Josep Fabrega1; Michela Svaluto Moreolo1; Laia Nadal1; Javier Vilchez1; Ramon Casellas1; Ricard Vilalta1; Ricardo Martínez1; Raul Muñoz1; Juan Pedro Fernández-Palacios2; Luis Contreras2 1CTTC/CERCA, Castelldefels; 2Telefónica I+D, Madri, Spain
We experimentally demonstrate transparent/dynamic delivery of mobile front-/back-haul in converged optical metro architecture, employing SDN-enabled S-BVTs based on adaptive multicarrier modulation. Network testbed experiments show successful BBU-RRU connectivity at distances up to 175km and capacities beyond 30Gb/s per flow.

M.2.B: Long-Wavelength Fibre Lasers and Amplifiers
Room F2 (SC1)
Chair: Schmauß Bernhard, Universität Erlangen-Nürnberg, Germany

16:00 M.2.B.1 Invited
Low Power Amplified Mid IR Parametric Conversion in Tapered Chalcogenide Photonic Crystal Fibres
Camille-Sophie Brès Ecole Polytechnique Fédérale de Lausanne, Lausanne, Switzerland
We present a tapered GeAsSe photonic crystal fibre geometry for efficient parametric processes at 2um. We measure amplified (3.5dB) conversion efficiency with 125mW of coupled CW power, establishing such taper as promising all-fibered, parametric converter for advanced applications in mid-infrared.

16:30 M.2.B.2
Broadband 2 W Output Power Tandem Thulium-doped Single Clad Fibre Amplifier for Optical Transmission at 2µm
Robert Tench1; Clement Romano2; Jean-Marc Delavaux3 1Cybel LLC, 1195 Pennsylvania Avenue, 1195 Pennsylvania Avenue, Bethlehem; 2Cybel LLC, Alexandria; 3Cybel LLC, Bethlehem, USA
We report experimental and simulated performance of a tandem Tm-doped silica fibre amplifier with a high signal output power of 2.6 W. Combined high dynamic range, high gain, low noise figure, and high OSNR are acheived with our design.

16:45 M.2.B.3
Stable 2.1 µm near 100% polarized Ho-doped all-fiber laser based on a polarizer-free cavity scheme
Sida Xing; Svyatoslav Kharitonov; Jiangi Hu; Davide Grassani; Camille-Sophie Brès, École Polytechnique Fédérale de Lausanne, Lausanne, Switzerland
A highly polarized Ho-doped truly all-fibre laser was demonstrated without in-cavity polarizer. Utilizing PM-FBG and loop mirror, maximum 0.5W output power with 30% slope efficiency, 70dB ASE suppression and 99.997% degree of polarization was recorded at 2.1 µm

17:00 M.2.B.4 Highly ranked paper
Ultra-wideband Operation of a Tunable Thulium Fibre Laser offering Tunability from1679-1992 nm
Chen Shaoxiang1; Yongmin Jung1; Shafi-Ul Alam1; Wang Junjia1; R Sidharthan2; Ho Darly2; Saurabh Jain1; Seongwoo Yoo2; David J Richardson1 1University of Southampton, Southampton; 2Nanyang Technological University, Singapore
We demonstrate a tuneable thulium-doped fibre laser incorporating in-house fabricated Tm/Ge co-doped fibre capable of accessing the sub 1700nm wavelength band. An ultra-wide operating bandwidth of over 310nm is realized using an external cavity grating.

17:15 M.2.B.5
Multi-Core Fibre with Concaved Double-D Shape Cross Section
Takuji Nagashima; Shuhei Toyokawa; Tetsuya Hayashi; Tetsu Morishima; Hirotaka Sakuma; Tetsuya Nakanishi, Sumitomo Electric Industries, Ltd., Yokohama 244-8588, Japan
We developed a multi-core fibre with a concaved double-D shape cladding for passive fibre alignment. The cladding dimensions were well controlled in longitudinal and transverse directions, with 150-m/min drawing speed which is the highest ever reported for the rectangular-like fibre.

M.2.C: III-V/Si Hybrid Integration
Room F3 (SC2)
Chair: Guina Mircea, Tampere University of Technology, Finland

16:00 M.2.C.1 Invited
Transceivers for 400G Based on Hybrid Integrated Thick SOI and III/V Chips
Timo Aalto1; Mikko Harjanne1; Tapani Vehmas1; Mikko Karppinen2; Aila Sitomaniemi2; Antonio Malacarne3; Christian Neumeyr4; Johan Bauwelinck5 1VTT Technical Research Centre of Finland, Espoo, Finland; 2VTT Technical Research Centre of Finland, Oulu, Finland; 3Scuola Superiore Sant'Anna, TeCIP Institute, CNIT, National Laboratory of Photonic Networks, CNIT, National Laboratory of Photonic Networks, Pisa, Italy; 4Vertilas GmbH, Garching; 5Ghent University - imec, IDLab, Department of Information Technology, Ghent, Belgium
We present results from 400G transceiver development based on the hybrid integration of vertical-cavity surface emitting lasers and photodiode arrays on 12µm silicon-on-insulator (SOI) chips. The integration of waveguide circuits, amplifiers and modulators on 3µm SOI is also reported.

16:30 M.2.C.2 Highly ranked paper
32-Gbit/s Heterogeneously Integrated Mach-Zehnder Modulator with 250-um-long III-V/Si MOS-capacitor Phase Shifter
Tatsurou Hiraki; Takuma Aihara; Koichi Hasebe; Takuro Fujii; Koji Takeda; Takaaki Kakitsuka; Tai Tsuchizawa; Hiroshi Fukuda; Shinji Matsuo, NTT Device Technology Labs., Kanagawa, Japan
A heterogeneously integrated InGaAsP/Si MOS-capacitor Mach-Zehnder (MZ) modulator achieves around four times smaller VpiL (0.09 Vcm) than that of the conventional Si MOS-capacitor MZ modulators. The eye opened at 32 Gbit/s using a 250-u ¬m-long phase shifter.

16:45 M.2.C.3
2 × 56 Gbps Electroabsorption Modulated III-V-on-Silicon DFB Laser
Amin Abbasi1; Leili Abdollahi Shiramin1; Bart Moeneclaey2; Jochem Verbist2; Xin Yin2; Johan Bauwelinck2; Dries Van Thourhout1; Gunther Roelkens1; Geert Morthier11Photonics research group, Imec/UGent, Ghent; 2IDLab, Ghent University - imec, Ghent, Belgium
We present an InP-on-Si DFB laser integrated with electro-absorption modulators on each side, using a single epitaxial structure for laser and modulators. Two electrically isolated tapers couple the light to the Si waveguide, while simultaneously acting as modulators.

17:00 M.2.C.4
Hybrid III-V / Silicon Laser with Integrated Athermal Wavelength Locker
Argishti Melikyan1; Guilhem De Valicourt1; Kwangwoong Kim1; Nicolas Fontaine1; Young-Kai Chen2; Po Dong11Nokia - Bell Labs, Holmdel; 2Nokia - Bell Labs, New Providence, USA
Hybrid III-V/silicon laser with an integrated athermal wavelength locker is reported. The locker shows an athermal operation over temperature fluctuations of 40C and in a frequency bandwidth of 2THz. Frequency setting and locking with an accuracy of 1GHz are discussed.

17:15 M.2.C.5
Low-Power 1.3-µm VCSEL Transmitter for Data Center Interconnects and Beyond
Antonio Malacarne1; Fabio Falconi2; Christian Neumeyr3; Wouter Soenen4; Claudio Porzi5; Timo Aalto6; Juergen Rosskopf3; Marco Chiesa7; Johan Bauwelinck4; Antonella Bogoni1 1Scuola Superiore Sant'Anna, TeCIP Institute, CNIT, National Laboratory of Photonic Networks, CNIT, National Laboratory of Photonic Networks, Pisa, IT; 2CNIT, National Laboratory of Photonic Networks, Pisa, IT; 3Vertilas GmbH, Garching, Germany; 4Ghent University - imec, IDLab, Department of Information Technology, Ghent, Belgium; 5Scuola Superiore Sant'Anna, TeCIP Institute, Pisa, IT; 6VTT - Technical Research Centre of Finland, Espoo, Finland; 7Scuola Superiore Sant'Anna, TeCIP Institute, Pisa, Italy
Unprecedented standard single-mode fiber reach of 20km and 4.5km respectively for 28Gb/s and 40Gb/s VCSEL-based intensity-modulation/ direct detection optical transmission was obtained with a low-power transmitter assembly including a 4-channel 0.13-um SiGe driver wire-bonded to a novel 2x1 1.3µm-VCSEL array

17:30 M.2.C.6
Fiber-to-Waveguide Connector for Co-Packaged Optics
Lars Brusberg1; Michael Dejong2; Margaret Allen3; Ramsey Selim3; Douglas Butler1; Jeffrey Clark1; Clifford Sutton1; Grahame Wood3; Henk Bulthuis3; Drew Lundsten3; Jamie Stokes3 1Corning Research & Development Corporation, Corning, NY; 2Corning Optical Communications LLC, Forth Worth, TX; 3Kaiam Corporation, Newark, CA, USA
Co-packaging high-density optical engines with high-speed electronic switch chips can cut interconnect power consumption in half. Our novel, de-matable, low-profile connector helps by coupling transceivers waveguides to single-mode fiber arrays.

18:30 - 20:30 WELCOME RECEPTION UNIVERSEUM

Room F4 (SC3)
Chair: Grießer Helmut, ADVA Optical Networking, Germany

16:00 M.2.D.1 Tutorial
Capacity Bounds in Optical Communications
Erik Agrell, Chalmers University of Technology, Gothenburg, Sweden
The fundamental concept of channel capacity and related information-theoretic metrics are reviewed and some techniques to quantify them by means of lower and upper bounds are explained. The importance of properly discretizing the channel model is highlighted.

17:00 M.2.D.2
Normalized Generalized Mutual Information as a Forward Error Correction Threshold for Probabilistically Shaped QAM
Junho Cho1; Laurent Schmalen2; Peter Winzer1 1Nokia Bell Labs, Holmdel, USA; 2Nokia Bell Labs, Stuttgart, Germany
We show that the normalized generalized mutual information represents an excellent forward error correction (FEC) threshold for uniform as well as for probabilistically shaped QAM and hence allows to accurately predict post-FEC performance from measured pre-FEC data.

17:15 M.2.D.3
Post-FEC BER Prediction Accuracy for Probabilistically Shaped Signaling in Fiber-Optic Communications
Tsuyoshi Yoshida1; Magnus Karlsson2; Erik Agrell2 1Chalmers University of Technology, Mitsubishi Electric Corporation, Mitsubishi Electric Corporation, Gothenburg; 2Chalmers University of Technology, Gothenburg, Sweden
We analyze performance metrics to predict the post-FEC BER for probabilistically-shaped signaling. Numerical simulations over a fiber-optic channel show that the metric based on symmetrized and mixed LLRs predicts >10^2 times more accurate post-FEC BER than GMI.

M.2.E: SDM Transmission 2
Room F5 (SC6)
Chair: Essiambre René-Jean, Nokia Bell-Labs, US

16:00 M.2.E.1 Invited
Long-haul Transmission Over Multi Core Fiber with Coupled Cores
Roland Ryf, Nokia Bell Labs, USA
Coupled-core multicore fibers provide significant advantages for long-haul high capacity fiber optics communication: Cores with large effective areas can be densely packed, and show a better tolerance to nonlinear effects compared to single-mode fibers with equivalent cores.

16:30 M.2.E.2
10×10 MDM Transmission over 24 km of Ring-Core Fibre using Mode Selective Photonic Lanterns and Sparse Equalization
Kai Shi1; Yongmin Jung2; Zahoora Sanjabi Eznaveh3; Juan Carlos Alvarado Zacarias3; Jose Enrique Antonio-Lopez3; Hongyan Zhou4; Rui Zhang4; Su Chen4; Honghai Wang4; Yucheng Yang4; Rodrigo Amezcua Correa3; David J Richardson2; Benn Thomsen11University College London, UK 2University of Southampton, Southampton, UK; 3University of Central Florida, Orlando, USA; 4YOFC, Wuhan, China
Transmission of 1.12Tb/s/lambda and 560Gb/s/lambda 28Gbaud Nyquist DP-16QAM and DP-QPSK signals, across the C-band, over a 1 km and 24 km ring-core fibre supporting 5 spatial modes with all-fibre mode-selective photonic lanterns (MSPL) is demonstrated.

16:45 M.2.E.3 Highly ranked paper
257-Tbit/s Partial MIMO-based 10-Mode C+L-band WDM Transmission over 48-km FMF
Daiki Soma1; Shohei Beppu1; Yuta Wakayama1; Yu Kawaguchi1; Koji Igarashi2; Takehiro Tsuritani1 1KDDI Research, Inc., Saitama; 2Osaka University, KDDI Research, Inc., KDDI Research, Inc., Osaka, Japan
A 10-mode multiplexed 336-WDM transmission of dual-carrier 12-Gbaud DP-QPSK signals over 48-km was successfully demonstrated only with 2x2 or 4x4 MIMOs by using weakly-coupled few-mode fibre. We achieved the record fibre capacity of 257-Tbit/s per single-core fibre.

17:00 M.2.E.4 Highly ranked paper
3500-km Mode-Multiplexed Transmission Through a Three-Mode Graded-Index Few-Mode Fiber Link
Georg Rademacher1; Roland Ryf2; Nicolas Fontaine2; Haoshuo Chen2; René-Jean Essiambre2; Benjamin Puttnam1; Ruben Luis1; Yoshinari Awaji1; Naoya Wada1; Simon Gross3; Nicolas Riesen4; Michael Withford3; Yi Sun5; Robert Lingle5 1National Institute of Information and Communications Technology, Koganei, Japan; 2Nokia Bell Labs, Holmdel, USA; 3MQ Photonics Research Centre, Sydney, Australia; 4University of South Australia, Mawson Lakes; 5OFS, Norcross, USA
We transmit 33 WDM channels over 3500-km three-mode fiber at record post-FEC spectral-efficiency-distance product of 31500 bit/s/Hz · km. This was facilitated by building a DGD compensated fiber span with low MDL and coherent 6 x 6 MIMO processing.

17:15 M.2.E.5
Crosstalk Analysis of 32-Core Dense Space Division Multiplexed System for Higher Order Modulation Formats Using an Integrated Cladding-Pumped Amplifier
Carlos Castro1; Saurabh Jain2; Yongmin Jung2; Erik De Man3; Stefano Calabrò3; Klaus Pulverer3; Marc Bohn3; John Hayes2; Shaif-Ul Alam2; David J Richardson2; Yusuke Sasaki4; Takayuki Mizuno5; Kohki Shibahara5; Takayuki Kobayashi5; Yutaka Miyamoto5; Toshio Morioka6; Werner Rosenkranz71University of Kiel, Munich, Germany; 2Optoelectronics Research Centre University of Southampton, Southampton, UK; 3Coriant R&D GmbH, Munich, Germany; 4Fujikura, Sakura, Japan; 5NTT Corporation, Yokosuka, Japan; 6Technical University of Denmark, Lyngby, Denmark; 7University of Kiel, Kiel, Germany
We analyze the crosstalk performance of a fully integrated inline amplified 32-core link for 100G QPSK, 150G 8QAM, 200G 16-QAM, and 250G 32QAM in a recirculating loop. Transmission distances over 1000 km are confirmed for 8-QAM and QPSK channels.

M.2.F: Transceivers and Monitoring
Room F6 (SC4)
Chair: Inoue Takashi, National Institute of Advanced Industrial Science and Technology (AIST), Japan

16:00 M.2.F.1
Intensity-directed Equalizer for Chirp Compensation Enabling DML-based 56Gb/s PAM4 C-band Delivery over 35.9km SSMF
Kuo Zhang1; Qunbi Zhuge2; Haiyun Xin3; Mohamed Morsy-Osman4; Eslam El-Fiky4; Lilin Yi3; Weisheng Hu3; David Plant4 1McGill University, Shanghai Jiao Tong University, Shanghai Jiao Tong University, Montreal, CA; 2McGill University, Ciena Corporation, Ciena Corporation, Montreal, CA; 3Shanghai Jiao Tong University, Shanghai, China 4McGill University, Montreal, CA
We propose an intensity-directed equalizer to address chirp induced eye skewing and inter-symbol interference in DML-DD systems, and experimentally demonstrate a transmission of 56Gb/s PAM4 signals using a 16.8GHz C-band DML over 35.9 km SSMF.

16:15 M.2.F.2
Fiber Nonlinear Noise-to-Signal Ratio Monitoring Using Artificial Neural Networks
Aazar Kashi1; Qunbi Zhuge2; John Cartledge1; Andrzej Borowiec2; Charlton Douglas2; Charles Laperle2; Maurice O'sullivan2 1Ciena Corporation, Queen's University, Queen's University, Ottawa; 2Ciena Corporation, Ottawa, Canada
An artificial neural network model to estimate fiber nonlinear noise-to-signal ratio based on amplitude noise covariance of received symbols is proposed. Standard deviation of 0.2 dB is obtained in simulation, and estimation error of <0.6 dB is verified in experiment.

16:30 M.2.F.3 Invited
Optical Transceivers for Mobile Front-Haul and PON Applications
Michael Eiselt1; Jim Zou1; Mirko Lawin1; Christoph Wagner1; Jörg-Peter Elbers2 1ADVA Optical Networking SE, Meiningen; 2ADVA Optical Networking SE, Martinsried, Germany
Low-cost tuneable lasers for PON transceivers are reviewed. Laser tuning is based on a remote signal from the OLT. The message channel is realized by envelope modulation with limited impact on the payload signal.

17:00 M.2.F.4
Mitigating Nonlinear Crosstalk from In-service Line Monitoring Equipment for Undersea Communication Systems
Lothar Moeller1; Robert Behringer2; Bamdad Bakhshi2; Miguel Rodriguez2; Dean Pappas1; Brian Jander2 1Te Connectivity, Eatontown; 2TE Connectivity, Eatontown, USA
We demonstrate a novel technique that provides a monitoring gain (relative to launch power) of up to 10 dB for in-service supervisory channels. Fast polarization spinning mitigates NL crosstalk which would otherwise instigate uncorrectable block errors in FEC-supported PolMux signals.

17:15 M.2.F.5
Autonomous and Real-time Controlled Transceiver Prototype with FSK Supervisory Signal and Performance Monitoring
Yi Ge1; Shoichiro Oda2; Ying Zhao3; Guoxiu Huang2; Setsuo Yoshida2; Hisao Nakashima2; Yuichi Akiyama2; Yoshio Hirose1; Zhenning Tao3; Takeshi Hoshida2 1Fujitsu Laboratories Ltd., Kawasaki, Japan; 2Fujitsu Limited, Kawasaki, Japan; 3Fujitsu R&D Centre Co., Ltd., Beijing, China
We present an autonomous control system based on FSK supervisory signal and experimentally demonstrate that a real-time transceiver prototype autonomously detects the frequency shift of adjacent channels due to failure and escapes from it to keep the signal quality high.

18:30 - 20:30 WELCOME RECEPTION UNIVERSEUM

Tu.1.A: Fibre Characterisation and Sensing
Room F1 (SC1)
Chair: Mégret Patrice, University of Mons, Belgium

08:30 Tu.1.A.1 Invited
Ultralow Thermal Sensitivity of Phase and Propagation Delay in Hollow-Core Fibres
Radan Slavik; Eric Numkam Fokoua; Marco Petrovich; Natalie Wheeler; Thomas Bradley; Francesco Poletti; David J Richardson, University of Southampton, UK
Propagation time through standard optical fibres changes with temperature at a rate of 40ps/km/K. This change is significantly lower in Hollow Core Fibres, where we reported 2ps/km/K. Recently we showed this sensitivity can be completely eliminated.

09:00 Tu.1.A.2 Highly ranked paper
Lotus Shaped Negative Curvature Hollow Core Fibre with 10.5 dB/km at 1550 nm Wavelength
Mubassira Nawazuddin; Natalie Wheeler; John Hayes; Thomas Bradley; Seyed Reza Sandoghchi; Gregory Jasion; Marcelo Gouveia; David J Richardson; Francesco PolettiUniversity of Southampton, UK
We present a novel negative curvature antiresonant hollow core fibre with the potential for low loss and very wide bandwidth. A low loss of 10.5 dB/km at 1550 nm is demonstrated, showing its potential for data transmission applications.

09:15 Tu.1.A.3
Temperature and Strain Sensitivity of Two-Mode Interference and Waveguide Dispersion
Hans Limberger; Soham Basu, EPFL, Lausanne, Switzerland
Two-mode interference and fibre Bragg grating were used to characterize the strain and temperature sensitivity of a few-mode fibre around the group velocity matching wavelength. The sensitivity increase near the group velocity matching wavelength was characterized.

09:30 Tu.1.A.4 Highly ranked paper
Closed-loop Controlled Brillouin Optical Time-Domain Analysis
Zhisheng Yang; Marcelo Soto; Luc Thévenaz, EPFL, Lausanne, Switzerland
A closed-loop controlled BOTDA distributed optical fibre sensor is proposed for tracking fast temperature-strain evolution. The measurement time is reduced by two orders of magnitude with respect to classical BOTDA sensing, while keeping the same accuracy and measurement conditions.

09:45 Tu.1.A.5
Distributed Spatial Mode Dispersion Measurement Along Strongly Coupled Multicore Fibre with C-OFDR
Shingo Ohno; Daisuke Iida; Kunihiro Toge; Tetsuya Manabe, NTT, Tsukuba, Japan
We propose the distributed measurement of spatial mode dispersion (SMD) along strongly coupled multicore fibres (SC-MCFs) using C-OFDR. We observe the SMD evolution, which increases in proportion to the square root of distance, along 4 km-SC-MCFs with a 40-m accuracy.

Tu.1.B: Radio-Over-Fiber
Room F2 (SC8)
Chair: Carpintero Guillermo, Universidad Carlos III de Madrid, Spain

08:30 Tu.1.B.1
Simultaneous Transmission of Aggregated Microwave and Millimeter-wave Signals over Fiber with Parallel IM/PM Transmitter for Mobile Fronthaul Links
Shota Ishimura1; Byunggon Kim2; Kazuki Tanaka1; Kosuke Nishimura1; Hoon Kim2; Yun Chul Chung2; Masatoshi Suzuki1KDDI research Inc., 2-1-15 Ohara, Fujimino-shi, Saitama, Japan; 2Korea Advanced Institute of Science and Technology, 291 Daehak-ro Yuseong-gu, Daejeon, Republic of Korea
We propose simultaneous transmission of microwave and millimeter-wave signals by using parallel IM/PM transmitter to overcome dispersion-induced RF power fading. We successfully transmit twenty-four 180-MHz-bandwidth microwave signals and two 720-MHz-bandwidth millimetre-wave signals corresponding to CPRI-equivalent data rate of 393.2 Gbps.

08:45 Tu.1.B.2
Non-Orthogonal Multiple Access and Carrierless Amplitude Phase Modulation for 5G Mobile Networks
Jose Altabas1; Simon Rommel2; Rafael Puerta2; David Izquierdo3; Ignacio Garces1; Jose Lazaro4; Juan José Vegas Olmos5; Idelfonso Tafur Monroy2 1Aragon Institute of Engineering Research (I3A), Universidad de Zaragoza, Spain; 2Department of Photonics Engineering, Technical University of Denmark (DTU), Denmark; 3Centro Universitario para la Defensa (CUD), Zaragoza, Spain; 4Universitat Politècnica de Catalunya, Barcelona, Spain; 5Mellanox Technologies, Roskilde, Denmark
A combined NOMA and multiCAP scheme is proposed for capacity enhancement of 5G mobile networks and experimentally tested over a W-band millimeter-wave radio-over-fiber system. The evaluated NOMA CAP system provides an aggregated transmission rate of 30Gbps.

09:00 Tu.1.B.3
Optoelectronics Enabled Dense Patch Antenna Array for Future 5G Cellular Applications
Zhongxia Simon He1; Tamas Lengyel2; Jian Yang3; Marcus Gavell1; Anders Larsson2; Herbert Zirath1 1Chalmers University of Technology, Microwave Electronics Laboratory, Microwave Electronics Laboratory, Göteborg; 2Chalmers University of Technology, Photonic Laboratory, Photonic Laboratory, Göteborg; 3Chalmers University of Technology, Department of Signals and Systems, Department of Signals and Systems, Göteborg, Sweden
Interconnection between densely-spaced antenna array elements to separated signal processors is a challenge in practical systems of future 5G applications. We present an interconnect concept based on optoelectronic link and a proof-of-concept experiment demonstrates successful 6-Gbps 64-QAM data transmission.

09:15 Tu.1.B.4
Novel Chromatic-Dispersion-Induced Power Fading Compensation Technique for Broadband RoF Systems based on Dual-Frequency Driving of DP-MZM
Abdelmoula Bekkali; Shota Ishimura; Kazuki Tanaka; Kosuke Nishimura, KDDI Research Inc., Saitama, Japan
We present and experimentally validate a simple and efficient technique to overcome the chromatic-dispersion-induced power-fading for broadband RoF systems. Using DP-MZM, the dispersion compensation is obtained by a complementary power-fading of the resulting electrical output from the two parallel MZMs.

09:30 Tu.1.B.5
294-Gb/s CPRI-Equivalent-Rate Radio-over-Fiber Mobile Fronthaul Network Using a 1.55-mm DML and Dispersion-Induced CSO cancellation
Byunggon Kim1; Sung Hyun Bae2; Yun Chul Chung2 1KAIST, 291, Daehak-ro, Yuseong-gu, Daejeon, Korea, 2KAIST, Daejeon, Republic of Korea
We demonstrate the transmission of twelve 360-MHz filtered-OFDM signals in 64-QAM format over 20 km of SSMF by using a 1.55-mm directly modulated laser and a DSP-based composite second-order cancellation technique.

09:45 Tu.1.B.6
Period-one Nonlinear Semiconductor Laser Dynamics Enhanced Homodyne Detection in Photonic Millimeter-Wave Carrier Recovery for OFDM-RoF Uplinks
Yu-Han Hung1; Jhih-Heng Yan2; Kai-Ming Feng2; Sheng-Kwang Hwang1 1Department of Photonics, National Cheng Kung University, Tainan; 2Institute of Communications Engineering, National Tsing Hua University, Hsinchu, Taiwan
Homodyne detection for OFDM-RoF links using all-optical millimeter-wave carrier recovery through nonlinear semiconductor laser dynamics is proposed and demonstrated. A 1.9x10-9 BER is achieved for a millimeter-wave carrier at 32-GHz carrying a 16-QAM OFDM signal.

Tu.1.C: High-Density Integration and Packaging
Room F3 (SC2)
Chair: Yikai Su, Shanghai Jiao Tong, China

08:30 Tu.1.C.1 Invited
Integrated Quantum Photonic Circuits with Electrically Driven Light Sources
Wolfram Pernice1; Feliks Pyatkov2; Ralph Krupke2; Carsten Rockstuhl2 1University of Münster, Münster; 2Karlsruhe Institute of Technology, Karlsruhe, Germany
Electrically driven single photon sources coupled to waveguide devices offer exciting prospects for quantum photonic applications. Such emitters based on semiconducting carbon nanotubes allow scalable integration with nanophotonic circuits and can be characterized on chip using superconducting detectors.

09:00 Tu.1.C.2
2.5-dB loss, 100-nm Operating Bandwidth, and Low Power Consumption Strictly-Non-Blocking 8 × 8 Si Switch
Keijiro Suzuki; Ken Tanizawa; Satoshi Suda; Hiroyuki Matsuura; Kazuhiro Ikeda; Shu Namiki; Hitoshi Kawashima, AIST, Tsukuba, Japan
We present a design- and process-optimized 8x8 silicon photonic switch exhibiting an ultra-low on-chip loss, an ultra-wide -30-dB crosstalk bandwidth and low power consumption. A fully-integrated polarization-diversity 8x8 switch is also fabricated and characterized to promise its practical uses.

09:15 Tu.1.C.3 Highly ranked paper
Low Crosstalk Simultaneous 16-channel x 25 Gb/s Operation of High Density Silicon Photonics Optical Transceiver
Tsuyoshi Aoki1; Shigeaki Sekiguchi1; Takasi Simoyama2; Shinsuke Tanaka1; Motoyuki Nishizawa2; Nobuaki Hatori2; Yohei Sobu2; Akio Sugama3; Tomoyuki Akiyama1; Akinori Hayakawa1; Hidenobu Muranaka3; Yanfei Chen4; Toshihiko Mori5; Seok-Hwan Jeong2; Yu Tanaka2; Ken Morito1 1PETRA, Fujitsu Ltd., Fujitsu Ltd., Atsugi; 2PETRA, Tsukuba; 3Fujitsu Laboratories Ltd., Atsugi; 4Contributed to this work while employed by Fujitsu Laboratories Limited, Kawasaki; 5PETRA, Fujitsu Ltd., Fujitsu Ltd., Kawasaki, Japan
We successfully developed a high density broadband 16-channel x 25 Gb/s silicon photonics optical transceiver. The flip chip bonded structure realized the density of about 363 Gb/s/cm2. We demonstrated the simultaneous multichannel error free operations with low crosstalk penalties.

09:30 Tu.1.C.4
Broadband High Channel Count Optical Fiber Interface for Silicon Photonics using Polymer Waveguides
Antonio La Porta; Roger Dangel; Daniel Jubin; Norbert Meier; Folkert Horst; Bert Offrein IBM Research - Zurich, Rueschlikon, Switzerland
We present an optical interface for silicon photonics based on adiabatic optical coupling to polymer waveguides, polarization insensitive and scalable to high optical channel count systems. Coupling losses below 1.5 dB were achieved for the entire O- and C-band.

09:45 Tu.1.C.5
Experimental Study of Adjustable Single-Mode Optical-Coupling Using Movable Micro-Mirror Array
Takanori Suzuki; Koichiro Adachi; Shigehisa Tanaka, Oclaro Japan, Inc., Kanagawa, Japan
A movable micro-mirror array is proposed for high-density multi-channel single-mode optical sub-assembly. Adjustable optical-coupling loss of over 2 dB was confirmed from experiments of 4-ch array optical-coupling between DFB lasers and single-mode fibers using the micro-mirrors.

Tu.1.D: Geometric Shaping
Room F4 (SC3)
Chair: Benn Thomsen, Microsoft, UK

08:30 Tu.1.D.1 Upgraded
Adaptive Rates of High-Spectral-Efficiency WDM/SDM Channels Using PDM-1024-QAM Probabilistic Shaping
Hao Hu1; Metodi Yankov1; Francesco Da Ros1; Yoshimichi Amma2; Yusuke Sasaki2; Takayuki Mizuno3; Yutaka Miyamoto3; Michael Galili1; Søren Forchhammer1; Leif Katsuo Oxenløwe1; Toshio Morioka1 1Technical University of Denmark, Kgs. Lyngby, Denmark; 2Fujikura Ltd., Sakura; 3NTT Corporation, Hikarinooka, Japan
We demonstrate adaptive rates and spectral efficiencies in WDM/SDM transmission using probabilistically shaped PDM-1024-QAM signals, achieving up to 7-Tbit/s data rates per spatial-super-channel and up to 297.8-bit/s/Hz aggregate spectral efficiency using a 30-core fiber on 12.5 and 25-GHz WDM grids.

09:00 Tu.1.D.2
Coded Modulation based on 56APSK with Hybrid Shaping for High Spectral Efficiency Transmission
Hussam Batshon; Matt Mazurczyk; Jin-Xing Cai; Oleg Sinkin; Milen Paskov; Carl Davidson; Ding Wang; Maxim Bolshtyansky; Dmitri Foursa, TE SubCom, Eatontown, USA
We discuss a multi-dimensional coded modulation format with hybrid constellation shaping (4D-PS-9/12-56APSK). The proposed format is designed to approach Shannon limit and to improve the performance of nonlinearity compensation over conventional and probabilistically shaped 2D formats.

09:15 Tu.1.D.3
Multidimensional Geometric Shaping for QAM Constellations
Ahmed Abd El-Rahman; John Cartledge, Queen's University, Kingston, Canada
A novel multidimensional geometric shaping technique for QAM formats is proposed. Optimized constellations at 6 bits/4D symbol and 4 bits/8D symbol are obtained by optimized subset selection of DP-16QAM and DP-QPSK constellations, respectively.

09:30 Tu.1.D.4
Design and Performance Evaluation of a GMI-Optimized 32QAM
Shaoliang Zhang1; Fatih Yaman1; Eduardo Mateo2; Takanori Inoue2; Kohei Nakamura2; Yoshihisa Inada2 1NEC Corporation, Princeton, USA; 2NEC Corporation, Tokyo, Japan
An optimized 32QAM with quasi-Gray bits mapping is designed to improve GMI capacity over a nonlinear optical channel, and is experimentally demonstrated to outperform 32QAM by ~0.5dB SNR between 3 and 4 b/s GMI capacity.

09:45 Tu.1.D.5 Highly ranked paper
Experimental Comparison of 64-QAM and Combined Geometric-Probabilistic Shaped 64-QAM
Fanny Jardel1; Tobias Eriksson1; Fred Buchali1; Wilfried Idler1; Amirhossein Ghazisaeidi2; Cyril Measson2; Joseph Boutros3 1Nokia Bell-Labs Stuttgart, Stuttgart, Germany; 2Nokia Bell-Labs Paris, Paris, France; 3Texas A&M, Doha, Qatar
We present a novel format of combined geometric-probabilistic shaped QAM constellation. We measure about 1 dB sensitivity gain compared to conventional 64-QAM at 54.2 GBaud and 25% of overhead under different scenarios including back-to-back, single-channel and WDM transmissions.

Tu.1.E: Submarine Transmission
Room F5 (SC6)
Chair: Gabriel Charlet, Nokia Bell-Labs, France

08:30 Tu.1.E.1 Invited
The Role of SDM in Future Transoceanic Transmission Systems
Alexei Pilipetskii1; Oleg Sinkin1; Alexey Turukhin2; Maxim Bolshtyansky1; Dmitri Foursa3 1TE SubCom, Eatontown, New Jersey; 2TE SubCom, Eatowntown, NJ; 3TE SubCom, Eatowntown, New Jersey, USA
The paper is focused on SDM as a method to make significant increase in undersea cable capacity while managing optical power efficiently. The experimental and theoretical results supporting the concept are discussed.

09:00 Tu.1.E.2 Highly ranked paper
Near Capacity 24.6 Tb/s Transmission over 10,285km Straight Line Testbed at 5.9 b/s/Hz Spectral Efficiency Using TPCS-64QAM and C-Band EDFA-Only
Omar Ait Sab1; Yvan Fernandez De Jauregui Ruiz2; Amirhossein Ghazisaeidi2; Philippe Plantady2; Alain Calsat2; Suwimol Bubost2; Laurent Schmalen3; Jeremie Renaudier2; Vincent Letellier2 1Alcatel Submarine Networks, Nozay; 2Nokia Bell Labs, Nozay, France; 3Nokia Bell Labs, Stuttgart, Germany
We report on a C-band 10,285 km straight line testbed transmission using capacity-approaching truncated probabilistic constellation shaping 64QAM (TPCS-64QAM). Seven FEC code rates allow 24.6 Tb/s transpacific transmission with spectral efficiency of 5.9 bit/s/Hz.

09:15 Tu.1.E.3
Transmission of 200Gb/s PM-16QAM and 150Gb/s PM-8QAM DWDM Signals over Long-haul and Transoceanic Distance at 100km Span Length with EDFA-only
Benyuan Zhu1; Peter Borel2; Tommy Geisler2; Rasmus Jensen2; David Peckham3; Robert Lingle3; Durgesh Vaidya4; Man Yan1; Patrick Wisk1; David Digiovanni1; Junwen Zhang5; Jianjun Yu5 1OFS Labs, Somerset, NJ, USA; 2OFS, Broendby, Denmark; 3OFS, Norcross, GA; 4OFS, Sturbridge, MA; 5ZTE (TX), Morristown, NJ, USA
We demonstrate transmission of 78x256Gb/s PM-16QAM over 4800km, and 78x192Gb/s PDM-8QAM over 7200km with 100km span length at spectral-efficiency 6.0 and 4.5 b/Hz/s, respectively. This is achieved by ultra-large effective area (Aeff) fibre with ultra-low-loss using EDFA-only for amplification.

09:30 Tu.1.E.4
Maximum Cable Capacity in Submarine Systems with Power Feed Constraints and Implications for SDM Requirements
John Downie, Corning, Corning, USA
We examine submarine cable capacity in the context of power feed constraints. Higher capacity is achieved with low powers, low SNR, and large spatial multiplicity. However, practical SNR limits may suggest modest SDM requirements satisfied simply by multiple fibres.

09:45 Tu.1.E.5
Submarine Cable Cost Reduction Through Massive SDM
Ronen Dar1; Peter Winzer1; Andrew Chraplyvy1; Szilard Zsigmond2; K.-Y. Huang2; Herve Fevrier3; Stephen Grubb3 1Nokia Bell Labs, Holmdel, NJ; 2Nokia Corporation, Murray Hill, NJ; 3Facebook Inc., Menlo Park, CA, USA
We show significant cost savings for high-capacity submarine systems using massive space-division multiplexing (SDM) for a fixed electrical power supply. Advanced submarine fiber, low-noise amplification, and digital nonlinearity compensation are shown to provide little benefit for such systems.

Tu.1.F: Space-Division Multiplexing Subsystems
Room F6 (SC4)
Chair: Jochen Schröder, Chalmers University of Technology, Sweden

08:30 Tu.1.F.1 Invited
Peta Bit Per Second Optical Transmission with Spatial Division Multiplexing
Masatoshi Suzuki; Itsuro Morita; Takehiro Tsuritani, KDDI Research, Inc., Fujimino, Japan
Recent progress on space division multiplexed optical transmission is reviewed. 2.05 peta bit/s transmission with 114 spatial multiplecity, ultra-high aggregate spectral efficiency of 947 bit/s/Hz and long haul transmission over 6160km with 200 Gbit/s channel bit rate have been achieved.

09:00 Tu.1.F.2
Scalable Orbital Angular Momentum Mode-Division-Multiplexed Transmission over 10-km Graded-Index Ring-Core Fiber
Guoxuan Zhu1; Jiangbo Zhu2; Xiong Wu1; Jie Liu1; Cheng Du3; Haozhe Yan4; Ziyang Hu2; Xuyang Wang2; Yujie Chen1; Wenyong Luo3; Shangyuan Li4; Xiaoping Zheng4; Xinlun Cai1; Siyuan Yu2 1Sun Yat-sen University, Guangzhou, China; 2University of Bristol, UK; 3Fiberhome Telecommunication Technologies Co. Ltd, Wuhan; 4Tsinghua University, Beijing, China
We demonstrate a scalable MDM scheme using modular 4X4 MIMO with only 15 taps, transmitting 8 high-order OAM modes each carrying 10 wavelengths over 10-km graded-index ring-core fiber, delivering 3.2-Tbit/s aggregated capacity and 6.4 bit/s/Hz spectral efficiency.

09:15 Tu.1.F.3
Experimental Demonstration of 8.4-Tbit/s Data Transmission over an 18-km Orbital Angular Momentum (OAM) Fiber using WDM and OAM based Mode Division Multiplexing (MDM)
Long Zhu1; Andong Wang1; Lulu Wang1; Jianzhou Ai1; Cheng Du2; Qi Mo1; Jian Wang1; Jun Liu1; Shuhui Li1 1Huazhong University of Science and Technology, Wuhan; 2Fiberhome Telecommunication Technologies, Wuhan, China
By combining WDM with orbital angular momentum (OAM) based mode division multiplexing (MDM), we experimentally demonstrate 8.4-Tbit/s data transmission over an 18-km OAM fiber without MIMO DSP. All of the channels achieve a BER below 20% HD-FEC limit.

09:30 Tu.1.F.4
Design of High Order Mode-Multiplexers using Multiplane Light Conversion
Nicolas Fontaine1; Roland Ryf1; Haoshuo Chen1; David Neilson1; Joel Carpenter2 1Nokia Bell Labs, Holmdel, USA; 2The University of Queensland, Brisbane, Australia
We design a spatial mode multiplexer using multi-plane light conversion which can address all 45 modes of a 50-μm graded index multi-mode fiber at 1550~nm with 14 phase planes. The mode-dependent loss is below 2-dB across 100 nm.

09:45 Tu.1.F.5
Spatial Coherent Matched Detection Using High-Speed Two-Dimensional Photo-Diode Array for Full-Channel Demultiplexing and Demodulation of Mode-Division-Multiplexed Signals
Takahide Sakamoto1; Toshimasa Umezawa1; Guo-Wei Lu2; Kouichi Akahane1; Atsushi Matsumoto1; Atsushi Kanno1; Naokatsu Yamamoto1; Tetsuya Kawanishi3 1National Institute of Information and Communications Technology, Tokyo; 2Tokai University, Kanagawa; 3Waseda University, Tokyo, Japan
We propose and demonstrate spatial coherent matched detection using two-dimensional high-speed photodiode array. Capturing amplitude and phase distribution, all tributaries of 3x20-Gb/s MDM-QPSK are simultaneously demultiplexed and coherently demodulated without using optical modal fan-out devices.

10:00 - 10:30 COFFEE EXHIBITION HALL
10:00 - 12:00 EXHIBITION ONLY TIME
12:00 - 13:30 LUNCH BREAK

Tu.1.G: Control and Orchestration
Room G4 (SC7)
Chair: Hiroaki Harai, National Institute of Information and Communications Technology (NICT), Japan

08:30 Tu.1.G.1 Tutorial
Control, Management and Orchestration of Optical Networks: An Introduction, Challenges and Current Trends
Ramon Casellas; Ricardo Martínez; Ricard Vilalta; Raul Muñoz
CTTC/CERCA, Optical Networks and Systems Dept., Optical Networks and Systems Dept., Castelldefels, Spain
This tutorial is an introduction to control and management; focusing on main drivers, key benefits and functional/protocol architectures. It covers multi-domain and multi-layer networks and includes complex use cases and current trends such as joint IT/network orchestration and slicing

09:30 Tu.1.G.2
Software-Defined Networking Control Plane for Seamless Integration of Silicon Photonics in Datacom Networks
Yiwen Shen; Payman Samadi; Ziyi Zhu; Alexander Gazman; Erik Anderson; David Calhoun; Maarten Hattink; Keren Bergman, Columbia University, New York, USA
We present a scalable Software-Defined-Networking (SDN) control-plane to integrate Silicon Photonics (SiP) with conventional Ethernet/InfiniBand networks and simultaneously perform packet and circuit switching. Experimental evaluations demonstrate this unique solution with 224 microseconds control plane latency for data-center and high-performance-computing platforms.

09:45 Tu.1.G.3
Priority-Aware Service Orchestration Using Big Data Analytics for Dynamic Slicing in 5G Transport Networks
Muhammad Rehan Raza1; Ahmad Rostami2; Allan Vidal3; Mateus Augusto Silva Santos3; Lena Wosinska1; Paolo Monti1
1KTH Royal Institute of Technology, Kista; 2Ericsson Research, Kista, Sweden; 3Ericsson Research, Indaiatuba, Brazil
We demonstrate how to efficiently scale up/down resource slices allocated to tenants with different service priorities. Experimental results show that our proposed strategy--based on big data analytics--lowers service degradation by more than 51%, compared to priority unaware approaches.

10:00 - 10:30 COFFEE EXHIBITION HALL
10:00 - 12:00 EXHIBITION ONLY TIME
12:00 - 13:30 LUNCH BREAK

Tu.2.A: Transceivers for Datacom
Room F1 (SC5)
Chair: Gordon Ning Liu, Huawei Technologies Co. Ltd, China

13:30 Tu.2.A.1 Invited
Silicon Photonics Integration Platform for High Performance Interconnects
Dazeng Feng1; Mehdi Asghari2
1Mellanox Technologies Inc, Monterey Park, USA; 2Mellanox Technologies Inc, Monterey Park, USA
We will discuss the recent development of micron-scale silicon photonics platform for parallel and WDM optical engines and transceivers. Both NRZ and PAM-4 modulation schemes for high-performance interconnections and data center applications at 100, 200 and 400Gbps are reviewed.

14:00 Tu.2.A.2 Invited
Monolithic Silicon Photonic WDM Transceivers
Jessie Rosenberg1; Folkert Horst2; Marwan Khater1; Frederick Anderson3; Roberg Leidy3; Tymon Barwicz1; Douglas Gill1; Edward Kiewra3; Yves Martin1; Jason Orcutt1; Andreas Stricker3; Charles Whiting3; Kate Mclean3; Bruce Porth3; Chi Xiong1; Natalie Feilchenfeld3; Kenneth Giewont4; Karen Nummy4; Bert Offrein2; Wilfried Haensch1; William Green1
1IBM Watson Research Center, Yorktown Heights, USA; 2IBM Research Zurich, Rüschlikon, Switzerland; 3GLOBALFOUNDRIES, Essex Junction, USA; 4GLOBALFOUNDRIES, Hopewell Junction, USA
Monolithic silicon photonic technology provides high bandwidth and large volume for datacom applications, while maintaining the low-cost assembly and waferscale test readiness characteristic of CMOS. Monolithic integration and high-yield CMOS processing enables complex, high-performance WDM architectures for CWDM4 transceivers.

14:30 Tu.2.A.3
Fully Monolithic Integrated Silicon Photonics Slave Transceiver for Short-Reach Network
Guilhem De Valicourt1; Joseph Kakande2; Chia-Ming Chang2; Jeffrey Sinsky2; Young-Kai Chen3; Bob Tkach2; Po Dong2
1Nokia Bell Labs, Holmdel; 2Nokia Bell-Labs, Holmdel; 3Nokia Bell-Labs, Murray Hill, USA
We demonstrate an integrated silicon-based slave transceiver integrating a DPSK receiver and a polarization diversity reflective modulator. We successfully achieved up to 40 Gbit/s OOK-NRZ modulation and 25 Gbit/s DPSK detection over more than 20 nm and 10 km.

14:45 Tu.2.A.4
100G Flexible IM-DD 850 nm VCSEL Transceiver with Fractional Bit Rate Using Eight-Dimensional PAM
Xiaofeng Lu1; Vladimir S. Lyubopytov1; Łukasz Chorchos2; Grzegorz Stepniak2; Mikel Agustin3; Jörg-R. Kropp3; Nikolay N. Ledentsov3; Vitaly A. Shchukin3; Nikolay Ledentsov Jr.3; JarostAw P. Turkiewicz2; Idelfonso Tafur Monroy1 1Technical University of Denmark, Kgs. Lyngby, Denmark; 2Warsaw University of Technology, Warsaw, Poland; 3VI-Systems GmbH, Berlin, Germany
We demonstrate a novel optical transceiver scheme with a net flexible bit rate up to 100Gbit/s with 5 Gbit/s granularity, using an eight-dimensional modulation format family, and investigate its performance on capacity, reach, and power tolerance.

Tu.2.B: Optical Wireless
Room F2 (SC8)
Chair: Eduward Tangdiongga, COBRA – TU Eindhoven, Netherlands

13:30 Tu.2.B.1 Tutorial
Optical Wireless Systems: Technology, Trends and Applications
Ton Koonen, Eindhoven University of Technology, Institute for Photonic Integration, Institute for Photonic Integration, Netherlands
Optical Wireless Communication can resolve the imminent crunch of wireless service delivery networks. This tutorial addresses OWC application domains, wide coverage visible light and beam-steered infrared light communication technologies, techniques for wide field-of-view receivers, device localisation, and hybrid optical/radio networks.

14:30 Tu.2.B.2
Visible-Light Communication Link With Integrated Energy Feed for Nomadic Gb/s-Capable Burst-Mode Reception
Bernhard Schrenk; Hannes Hübel, AIT Austrian Institute of Technology, Vienna, Austria
LED-based visible-light communication with 3 Gb/s Nyquist-shaped multi-band QAM is experimentally demonstrated. Extension to joint transmission of energy and data enables burst-mode data reception with periodic access to Gb/s rates, remotely powered at an irradiance of 240 W/m2.

14:45 Tu.2.B.3
Distributed 8x6 MIMO Experiments for Optical Wireless Communications
Pablo Wilke Berenguer; Dominic Schulz; Johannes Karl Fischer; Volker Jungnickel, Fraunhofer Heinrich Hertz Institute, Berlin, Germany
We experimentally investigate antenna diversity schemes for robust optical wireless communications with large coverage in industrial manufacturing environments. Our proposed scheme improves the average and peak data rates by up to 28 % and 75 %, respectively.

Tu.2.C: PICs for Signal Processing
Room F3 (SC2)
Chair: Pascual Muñoz, VLC Photonics, Spain

13:30 Tu.2.C.1
Silicon RF-Photonics Processor Reconfigurable Core
Daniel Pérez1; Ivana Gasulla1; Lee Crudgington2; David Thomson2; Ali Khokhar2; Ke Li2; Wei Cao2; Goran Mashanovich2; José Capmany1
1Universidad Politécnica de Valencia, ITEAM Research Institute, ITEAM Research Institute, Valencia, Spain; 2University of Southampton, Optoelectronics Research Centre, Optoelectronics Research Centre, Southampton, UK
We demonstrate a programmable core for a microwave photonic processor integrated in silicon on insulator. Based on a hexagonal mesh of tunable couplers, it enables reconfigurability of circuit topology and design parameters for signal filtering and dispersive time delaying applications.

13:45 Tu.2.C.2
16x25 GHz Optical OFDM Demultiplexer in a 220nm Silicon Photonics Platform using a Parallel-Serial Filter Approach
Abdul Rahim1; Bahawal Haq1; Muhammad Muneeb1; Antonio Ribeiro1; Roel Baets2; Wim Bogaerts2 1Ghent University, Ghent; 2Ghent University-imec, Ghent, Belgium
A multi-arm Mach-Zehnder interferometer based filter architecture is employed to demonstrate a 16-channel demultiplexer for optical Orthogonal Frequency Division Multiplexed signals. The fabricated filter shows average cross-talk of <25 dB (best cross-talk of <35 dB) for all channels.

14:00 Tu.2.C.3 Invited
Ultra-Low Loss Si3N4 Planar Waveguide Platform and Applications
Daniel Blumenthal; Taran Huffman; Michael Belt; Sarat Gundavarapu, UCSB, Santa Barbara, USA
The ultra low-loss Si3N4/Oxide on silicon waveguide platform has yielded a wide range of passive and active components. Delay lines, 3D stacking, gratings, filters, gain, ultra high-Q resonators and switches impact application including lasers, dispersion compensators, filters and optical gyros.

14:30 Tu.2.C.4
Linearized LiNbO3 Modulator with Dual Mach-Zehnder Interferometer and Branched Asymmetric CPW Electrode
Yuya Yamaguchi1; Atsushi Kanno1; Naokatsu Yamamoto1; Tetsuya Kawanishi2; Hirochika Nakajima3 1National Institute of Information and Communications Technology, Tokyo; 2National Institute of Information and Communications Technology, and Waseda University, Tokyo; 3Waseda University, Tokyo, Japan
We propose a transfer-function-transformed optical modulator by introducing a branched asymmetric coplanar waveguide electrode. The structure has the potential to achieve low half-wave voltage and large bandwidth while maintaining its flexibility. We confirmed a linearity improvement with the fabricated modulator.

14:45 Tu.2.C.5
Low Loss and Low Vpi Thin Film Lithium Niobate on Quartz Electro-optic Modulators
Vincent Stenger1; Jim Toney1; Andrea Pollick1; Dean Brown2; Benjamin Griffin3; Robert Nelson3; Sri Sriram1 1SRICO, Inc., Columbus; 2UES, Inc., Dayton; 3US Air Force Research Laboratory, Dayton, USA
Thin film lithium niobate (TFLN) electro-optic modulators have potential for superior gain, bandwidth, linearity and impedance matching relative to semiconductor technologies. This paper reports TFLN modulators with optical loss < 0.5 dB/cm, Vpi-length of 2.2 V-cm, and 67 GHz operation.

Tu.2.D: Probabilistic Shaping
Room F4 (SC3)
Chair: Giancarlo Gavioli, Nokia, Italy

13:30 Tu.2.D.1
Spectrally Efficient Probabilistically Shaped Square 64QAM to 256 QAM
Fred Buchali; Wilfried Idler; Roman Dischler; Tobias Eriksson; Laurent Schmalen, Nokia Bell Labs, Stuttgart, Germany
We demonstrate operation close to Shannon limit at high spectral efficiency supported by square higher order QAM from 64QAM up to 256QAM. We present limitations for the spectral efficiency, the bitrate per channel and the reach derived by experiments.

13:45 Tu.2.D.2
Short-Block-Length Shaping by Simple Mark Ratio Controllers for Granular and Wide-Range Spectral Efficiencies
Tsuyoshi Yoshida1; Magnus Karlsson2; Erik Agrell2
1Chalmers University of Technology, Mitsubishi Electric Corporation, Mitsubishi Electric Corporation, Gothenburg; 2Chalmers University of Technology, Gothenburg, Sweden
We propose a simple mark ratio controller for probabilistic shaping. It realizes granular spectral efficiencies from 1 to 9 b/s/Hz/polarization and 0.2 dB lower required SNR than CCDM under a much shorter block length of 64.

14:00 Tu.2.D.3 Invited
Fast Probabilistic Shaping Implementationfor Long-Haul Fiber-Optic Communication Systems
Georg Böcherer; Fabian Steiner; Patrick Schulte, Technical University of Munich, Germany
Fast probabilistic shaping is proposed using the probabilistic amplitude shaping (PAS) architecture to combine SC-LDPC codes with Streaming Distribution Matching (sDM). The parallelization factor of sDM is 100 times higher than for Constant Composition Distribution Matching (CCDM), at similar performance.

14:30 Tu.2.D.4
56 Gbaud Probabilistically Shaped PAM8 for Data Center Interconnects
Tobias Eriksson1; Mathieu Chagnon1; Fred Buchali1; Karsten Schuh1; Stephan Ten Brink2; Laurent Schmalen1 1Nokia Bell Labs, Stuttgart; 2Stuttgart University, Germany
We apply probabilistic shaping in direct detection pulse amplitude modulation (PAM) systems. We show that the achievable information rate can be increased by up to 0.19 bit/symbol over conventional PAM4 solutions. In transmission experiments we demonstrate 8.96Gbit/s higher net bitrate.

14:45 Tu.2.D.5
Probabilistically-Shaped Coded Modulation with Hard Decision Decoding for Coherent Optical Systems
Alireza Sheikh1; Alexandre Graell I Amat1; Gianluigi Liva2
1Chalmers University of Technology, Gothenburg, Sweden; 2Institute of Communications and Navigation of the German Aerospace Center (DLR), Munich, Germany
We consider probabilistic shaping to maximize the achievable information rate of coded modulation (CM) with hard decision decoding. The proposed scheme using binary staircase codes outperforms its uniform CM counterpart by more than 1.3 dB for 64-QAM and 5 bits/symbol.

Tu.2.E: Direct-Detection and Freespace Transmission
Room F5 (SC6)
Chair: Beatriz Ortega, Universitat Politecnica de Valencia, Spain

13:30 Tu.2.E.1 Highly ranked paper
168 Gb/s/ Direct-Detection 64-QAM SSB Nyquist-SCM Transmission over 80 km Uncompensated SSMF at 4.54 b/s/Hz net ISD using a Kramers-Kronig Receiver
Zhe Li; M. Sezer ErkılınÇ; Kai Shi; Eric Sillekens; Lidia Galdino; Benn Thomsen; Polina Bayvel; Robert Killey, University College London, UK
Using the recently-proposed Kramers-Kronig receiver DSP scheme, we achieved 4×168 Gb/s 35 GHz-spaced WDM single-polarization direct-detection 64-QAM SSB Nyquist-SCM transmission over 80 km of uncompensated SSMF at a record net ISD of 4.54 b/s/Hz.

13:45 Tu.2.E.2
Field-Trial of Layered/Enhanced ACO-OFDM
Binhuang Song; Bill Corcoran; Qibing Wang; Arthur Lowery, Monash university, Melbourne, Australia
L/E-ACO-OFDM and DCO-OFDM are compared in a 20-km field fibre transmission experiment with high-order QAM. L/E-ACO-OFDM can provide a 0.7-dB benefit in maximum achievable Q-factor over DCO-OFDM using 3.5-GBaud 16QAM without dispersion. Sources of signal distortion are also analysed.

14:00 Tu.2.E.3
High Sensitivity Receiver Demonstration Using Phase Sensitive Amplifier for Free-Space Optical Communication
Ravikiran Kakarla; Kovendhan Vijayan; Abel Lorences-Riesgo; Peter Andrekson Chalmers university of technology, Gothenburg, Sweden
For the first time, phase sensitive amplifier is demonstrated as a pre-amplifier in free-space optical communication. Record sensitivity of 4.5 photons/bit (signal+idler+pump) at 10-3 BER for 10GBd-QPSK data is achieved, and is 2.5 dB higher than an EDFA pre-amplified receiver.

14:15 Tu.2.E.4 Highly ranked paper
Turbulence-Resistant Free-Space Optical Communication Using Few-Mode Preamplified Receivers
Bin Huang1; Christian Carboni1; Huiyuan Liu1; Juan Carlos Alvarado Zacarias1; Fangling Peng1; Yun-Han Lee1; Haoshuo Chen1; Nicolas Fontaine2; Roland Ryf2; Jose Enrique Antonio-Lopez1; Rodrigo Amezcua Correa1; Guifang Li1
1University of Central Florida, Orlando; 2Nokia Bell Labs, Holmdel, USA
We propose and demonstrate turbulence-resistant free-space optical communication using a 10-mode pre-amplified receiver. A 6-dB improvement over a single-mode preamplified receiver in power budget was achieved for a wavefront distortion of 4π across the receiving aperture.

14:30 Tu.2.E.5
Evaluation of Blind Diversity Combining of Severely Faded Signals for High-Speed Free-Space Optical Communication under Atmospheric Turbulence
Manabu Arikawa; Yoshimasa Ono; Toshiharu Ito, NEC Corporation, Kawasaki, Japan
We experimentally evaluated performance of a mode diversity receiver in severe fading channels of emulated LEO-to-ground link. Digital combining of three modes using adaptive filters tolerated to 10-kHz variation and relaxed the required power of 10-Gb/s QPSK by 9 dB.

Tu.2.F: Node & Network Architectures
Room F6 (SC7)
Chair: Lena Wosinska, KTH Royal Institute of Technology, Sweden

13:30 Tu.2.F.1 Invited
Realization and Application of Large-scale Fast Optical Circuit Switch for Data Center Networking
Ken-Ichi Sato, Nagoya University, Nagoya, Japan
Data centre networks place very different requirements on optical systems than communication networks. Grasping the right direction to proceed is of paramount importance. The role of large-scale optical circuit switches and realization technologies are presented.

14:00 Tu.2.F.2 Highly ranked paper
First Demonstration of Subsystem-Modular Optical Cross-Connect Using Single-Module 6x6 WSS
Ryota Hashimoto1; Shuhei Yamaoka1; Yojiro Mori1; Hiroshi Hasegawa1; Ken-Ichi Sato1; Keita Yamaguchi2; Kazunori Seno2; Kenya Suzuki3
1Nagoya University, Nagoya; 2NTT Device Technology Laboratories, Atsugi; 3NTT Network Innovation Laboratories, Yokosuka, Japan
We demonstrate a highly scalable subsystem-modular OXC, where a newly developed single-module 6x6 WSS is utilized as a sub-OXC. Network simulations in dynamic-traffic scenarios assure its good applicability. Its technical feasibility is confirmed by transmission experiments using 32-Gbaud DP-QPSK signals.

14:15 Tu.2.F.3
Semi Filter-Less Drop & Waste Network Demonstration with Integrated SOI Optical Filter
Giovanni Serafino1; Antonio Malacarne1; Claudio Porzi2; Francesco Fresi2; Gianluca Meloni2; Philippe Velha1; Luca Poti2; Antonella Bogoni3; Filippo Cugini2
1Scuola Superiore Sant'Anna di Pisa, Istituto TeCIP, Istituto TeCIP, Pisa; 2Consorzio Nazionale Interuniversitario per le Telecomunicazioni (CNIT), Istituto TeCIP, Istituto TeCIP, Pisa; 3Scuola Superiore Sant'Anna di Pisa, CNIT, CNIT, Pisa, Italy
An integrated silicon-on-insulator optical filter, tunable over the whole C-band, is designed and fabricated for semi filter-less networks applications. Experimental validation demonstrates significant power margin improvement compared to fully filter-less solutions, successfully overcoming design issues of drop&waste networks.

14:30 Tu.2.F.4
Power Consumption in Multi-core Fibre Networks
Md Nooruzzaman1; Saurabh Jain2; Yongmin Jung3; Shaif-Ul Alam3; David J Richardson3; Yutaka Miyamoto4; Toshio Morioka5 1Technical University of Denmark, Department of Photonics Engineering, Department of Photonics Engineering, Lyngby, Denmark; 2Optoelectronics Research Centre, University of Southampton, Southampton, UK; 3University of Southampton, Southampton, UK; 4NTT Corporation, Kanagawa, Japan; 5Technical University of Denmark, Kongens Lyngby, Denmark
We study potential energy savings in MCF-based networks compared to SMF-based ones in a Pan-European network topology based on the power consumption of recently fabricated cladding-pumped multi-core optical fibre amplifiers.

14:45 Tu.2.F.5
Hybrid Circuit and Packet Switching SDM Network Testbed Using Joint Spatial Switching and Multi-Core Fibers
Ruben Luis; Hideaki Furukawa; Georg Rademacher; Benjamin Puttnam; Naoya Wada NICT, Koganei, Japan
We demonstrate a 3-node, hybrid circuit and packet switching network test bed using 19-core multi-core fiber connections. 10 Tb/s joint spatial circuit and 1 Tb/s packet switching is shown to support multi-granular spacex frequency channel plans

15:00 - 15:30 COFFEE EXHIBITION HALL

SC1 - FIBRES, FIBRE DEVICES AND FIBRE AMPLIFIERS HALL F

P1.SC1.1
Brillouin Gain Spectra of Few Mode Fibres
Lars Grüner-Nielsen[1]; Søren Herstrøm[2]
[1]Danish Optical Fiber Innovation, Brønshoj; [2]OFS Fitel Denmark ApS, Brøndby, Denmark
Brillouin gain spectra of few mode fibres are modelled and compared to measurements. Spectral differences for various optical modes are explained by the different overlaps with the guided acoustic modes.

P1.SC1.2
Characterization of the 3F4 -- 3H6 Transition in Thulium-doped Silica Fibres and Simulation of a 2µm Single Clad Amplifier
Clement Romano[1]; Robert Tench[2]; Jean-Marc Delavaux[2]; Yves Jaouen[3]
[1]Cybel, Institut Télécom/Télécom ParisTech, Institut Télécom/Télécom ParisTech, Alexandria; [2]Cybel, Bethlehem, USA; [3]Institut Télécom/Télécom ParisTech, Paris, France
We report measurements of absorption, gain and lifetime for two commercially available Tm-doped single clad silica fibres for the transition 3H6 -- 3F4. Comparison of simulation and experimental results for a single stage amplifier at 1952 nm yields good agreement.

P1.SC1.3
Sub-250 fs, 650 kW Peak Power Harmonic Mode-Locked Fiber Laser with InN-based SESAM
Francesca Gallazzi[1]; Marco Jimenez-Rodriguez[2]; Eva Monroy[1]; Pedro Corredera1; Miguel González-Herráez[2]; Fernando B. Naranjo[2]; Juan Diego Ania-Castañón[1]
[1]Instituto de Óptica - CSIC, Madrid, Spain; [2]Photonics Engineering Group, Electronics Dept (EPS), Alcalá University, Alcalá de Henares, Spain; [3]University Grenoble-Alpes, CEA-Grenoble, INAC-PHELIQS, CEA-Grenoble, INAC-PHELIQS, Grenoble, France
We demonstrate ultrafast harmonically mode-locked fiber lasing in up to 6-km-long rings at 1.56µm with InN SESAM. Fundamental mode-locking with pulse width of 239fs, pulse energy of 155nJ and peak power of 650kW is achieved with a 1-km-long cavity.

P1.SC1.4
Impulse Response of Multicore Fibre Measured by High-Dynamic Range Linear Optical Sampling with Picosecond Resolution
Takuya Arakawa[1]; Naoto Kono[1]; Fumihiko Ito[1]; Daisuke Iida[2]; Tetsuya Manabe[2]
[1]Graduate School of Shimane University, Matsue; [2]NTT Access Service Systems Laboratories, Tsukuba, Japan
The impulse responses of homogeneous multicore fibre are investigated: the differential group delays are observed at sub-ps accuracy, and the inter-core couplings are measured with 70-dB dynamic range. The results suggest that local group delays fluctuate considerably throughout the fibre.

P1.SC1.5
Optical Subcarrier Processing for Nyquist SCM via Coherent Spectrum Overlapping in FWM with Coherent Pump
Guo-Wei Lu[1]; Ruben Luis[2]; José Manuel Delgado Mendinueta[2]; Takahide Sakamoto[2]; Naokatsu Yamamoto[2] 1Tokai University, National Institute of Info. and Comm. Tech., National Institute of Info. and Comm. Tech., Kanagawa; [2]National Institute of Info. and Comm. Tech., Tokyo, Japan
We propose coherent spectrum overlapping through FWM with coherent multi-carrier pump, for coherently combining low-level subcarriers to high-level ones in Nyquist SCM. 16QAM subcarriers are obtained with <1dB sensitivity variation and no error floor at up to 10-5 BER.

P1.SC1.6
Transmission Performance of Large Aeff Ultra-Low-Loss Terrestrial Fibre in 200 Gb/s EDFA and Raman-Assisted Systems
John Downie[1]; Sergejs Makovejs[2]; Nikolay Kaliteevskiy[3]; Jason Hurley[1]; Stephen Wright[1]; Christopher Towery[4]
[1]Corning, Corning, USA; [2]Corning Incorporated, Ewloe, UK; [3]Corning Scientific Center, Saint Petersburg; [4]Corning Incorporated, Corning, USA
We demonstrate that ultra-low-loss, 125 µm2 effective area terrestrial fibre can achieve 55% longer reach compared to generic 82 µm2 fibre, enabling 200 Gb/s PM-16QAM transmission over ~4,500 km (with no margin) or ~2,100 km (with 3dB margin).

P1.SC1.7
Microscopic deformation analysis of PC connector endfaces using multicore fiber
Katsuyoshi Sakaime; Kenta Arai; Ryo Nagase, Chiba Institute of Technology, Graduate School of Engineering, Graduate School of Engineering, 2-17-1 Tsudanuma, Narashino-shi, Japan
Stable PC connection is realized by elastically deformed spherical convex polished ferrule ends. However, microscopic deformation of the ferrule endface was not clarified yet. We analyzed ferrule endface deformation by FEM and return loss measurement of multicore fiber connectors.

P1.SC1.8
Group Delay Spread Analysis of Few-Mode, Coupled 3-core Fibres: Optimum Index Profile and Maximum Transmission Distance for Strong Coupling Regime
Kazuki Yoshida; Takeshi Fujisawa; Takanori Sato; Kunimasa Saitoh, University of Hokkaido, Sapporo, Japan
Group delay spread of few-mode, coupled 3-core fibres is theoretically investigated. An optimum index profile of cores for minimizing the group delay spread between two mode groups and the maximum transmission distance for strong coupling regime are discussed.

P1.SC1.9
Ultrafast Temperature Extraction Using Support Vector Machine Based Data Classifier for BOTDA Sensors
Liang Wang[1]; Huan Wu[1]; Nan Guo[2]; Chester Shu[1]; Chao Lu[2]
[1]The Chinese University of Hong Kong, Shatin; [2]The Hong Kong Polytechnic University, Hung Hom, Hong Kong SAR
SVM has been successfully employed in BOTDA system to extract temperature information along fiber. It shows good robustness to a wide range of experiment parameters and its processing speed is 100 times faster than that of conventional Lorentzian fitting technique.

P1.SC1.10
Mode Coupling Analysis of Hollow Ring-Core Fibers for OAM Transmission
Matteo Lonardi[1]; Gianluca Guerra[2]; Leonardo Marcon[2]; Reza M. Nejad[3]; Marco Santagiustina[2]; Andrea Galtarossa[2]; Leslie A. Rusch[3]; Alberto Bononi[1]; Luca Palmieri[2]
[1]University of Parma, Department of Information Engineering, Department of Information Engineering, Parma, Italy; [2]University of Padova, Department of Information Engineering, Department of Information Engineering, Padova, Italy; [3]Laval University, Department of Electrical and Computer Engineering, Department of Electrical and Computer Engineering, Québec City, Canada
We present an analytical and numerical description of coupling between OAM modes in hollow ring-core fibers affected by stress birefringence and ellipticity. The analysis paves the way to a better modeling of propagation in these fibers.

P1.SC1.11
First Multi-Terabit DWDM Transmission and Inline Amplification using a Black-Box Polarisation-Insensitive Fibre Optical Parametric Amplifier (PI FOPA)
Marc Stephens; Nick Doran, Aston University, Birmingham, UK
We demonstrate a 'black-box' PI-FOPA operating with 16dB net-gain within a DWDM transmission system for the first time, amplifying a record 45x127Gb/s equivalent PDM-QPSK signals over 4x75km. Bit error rate performance is evaluated and compared with an all-EDFA system.

P1.SC1.12
Novel Fiber Design for Wideband Conversion and Amplification in Multimode Fibers
Massimiliano Guasoni; Francesca Parmigiani; Peter Horak; David J Richardson Optoelectronics Research Centre, University of Southampton, Southampton, UK
We propose an operating principle to achieve broadband and highly tunable mode conversion and amplification exploiting inter-modal four wave mixing in a multimode fiber. A bandwidth of 30 nanometers is demonstrated by properly designing a simple step-index silica fiber.

P1.SC1.13
Evaluation of RIN Mitigated Dual Order Bidirectional Distributed Raman Amplification Using a Broadband First Order Forward Pump
Md Asif Iqbal; Mingming Tan; Paul Harper, AIPT, Aston University, Birmingham, UK
We propose a dual-order distributed Raman amplifier using a novel broadband first-order pump which reduces signal RIN by >10dB and improves OSNR simultaneously, compared with conventional pumps. We amplify 1Tb/s DP-QPSK WDM signals and improve Q factor by >0.6dB.

P1.SC1.14
Analysis of Potential Terrestrial System Effects from Raman Pumps below Cable Cut-off in G.654.E Fibre
Michal Mlejnek[1]; John Downie1; Maurice O'sullivan[2]
[1]Corning, Corning; [2]Ciena, Ottawa, Canada
The new G.654.E fibre standard moves the cable cut-off specification to 1530 nm. We analyse potential signal impairments that may arise from Raman amplification with pump wavelengths below cable cut-off. We find negligible effects are expected even under worst-case conditions.

P1.SC1.15
Highly Selective 7 Orbital Angular Momentum Mode Multiplexer Based on Multi-Plane Light Conversion
Rawad Saad; Matthieu Meunier; Gauthier Trunet; Nicolas Barré; Pu Jian; Jean-François Morizur; Guillaume Labroille, CAILabs, Rennes, France
In this paper, we report two pairs of 7-OAM-mode multiplexers based on Multi-Plane Light Conversion over different sets of mode orders. The multiplexers present average 3.35 dB insertion loss and -28.2 dB mode selectivity over the full C-band.

P1.SC1.16
Gain Spectrum Shaping Technique for One-Pump Fibre Optical Parametric Amplifier (FOPA)
Vladimir Gordienko; Marc Stephens; Filipe Ferreira; Nick Doran Aston University, Birmingham, UK
We experimentally demonstrate and simulate a novel technique employing pump polarisation to improve/flatten a one pump FOPA gain spectrum by as much as 2 dB from peak and to enable ultra-flat (<0.5 dB gain variation) operation over >100 nm gain bandwidth.

P1.SC1.17
Multicore Fibre Fan-In/Fan-Out Device using Fibre Optic Collimators
Yongmin Jung; John Hayes; Shaif-Ul Alam; David J Richardson University of Southampton, Southampton, UK
We present a new approach in realizing multicore fibre fan-in/fan-out (FIFO) device. Using simple image demagnification by two fibre optic collimators a compact FIFO device for 4-core multicore fibre is fabricated with low crosstalk.

P1.SC1.18
Few Mode Ring-Core Fibre Amplifier for Low Differential Modal Gain
Yongmin Jung[1]; Qiongyue Kang[1]; Lei Shen[2]; Su Chen[2]; Honghai Wang[2]; Yucheng Yang[2]; Kai Shi[2]; Benn Thomsen[2]; Rodrigo Amezcua Correa[4]; Zahoora Eznaveh[4]; Juan Carlos Alvarado Zacarias[4]; Jose Enrique Antonio-Lopez[4]; Pranabesh Barua[1]; Jayanta K Sahu[1]; Shaif-Ul Alam[1]; David J Richardson[1] [1]University of Southampton, Southampton, UK; [2]Yangtze Optical Fiber and Cable Joint Stock Limited Company, Wuhan, China; [3]University College London, London, UK; [4]The University of Central Florida, Florida, USA
We report a few-mode ring-core fibre amplifier for mode division multiplexed transmission. We achieve very low differential modal gain (<1dB) for 5 spatial modes over the C-band highlighting the benefits of the ring core approach.

SC2 - INTEGRATED OPTOELECTRONIC DEVICES AND OPTICAL PROCESSORS HALL F

P1.SC2.19
A Platform for 2-Dimensional 48-Channel Optical Interconnects Based on Wet Etched Silicon Interposer
Chenhui Li; Teng Li; Ripalta Stabile; Oded Raz, Eindhoven University of Technology, Dept. of Electrical Engineering, Dept. of Electrical Engineering, Netherlands
We demonstrate co-integration of 1D arrays of VCSELs into a 2D matrix with a single 48-channel connector. Error-free operation for a sub-group is measured and coupling losses across all 48 VCSELs through the common connector are below 4.6dB.

P1.SC2.20
Multi-Layered Asymmetric Waveguide Structure for Gain-Chip and its Application to Polymer-Based Waveguide Grating for High Power Tunable Laser
Dong Churl Kim; Dong Hoon Lee; Young-Tak Han; Byung-Seok Choi; Sang-Ho Park; Jang-Uk Shin; Won Seok Han; Yong-Hwan Kwon; Jong-Hoi Kim; Yongsoon Baek Electronics and Telecommunications Research Institute, Dejeon, Republic of Korea
We present InP-based multi-layered asymmetric waveguide gain-chip for high gain medium. Using the gain-chip and a polymer-based tunable waveguide grating, we can make a tunable laser with >17 mW output power, ~43 dB SMSR and <100 kHz linewidth in C-band.

P1.SC2.21
High-sensitivity Autocorrelation Measurement of Ultrafast Optical Pulses Using Silicon Wire P-I-N Waveguides
Guangwei Cong; Yuriko Maegami; Morifumi Ohno; Makoto Okano; Koji Yamada AIST, Tsukuba, Japan
We demonstrate the high-sensitivity measurement of ultrafast optical pulses using optical interferometric autocorrelation in silicon wire p-i-n waveguides. The sensitivity was evaluated to be about 0.46x10^-8 W^2, >100 times higher than that of the commercial two-photon conductivity type autocorrelation photodetector.

P1.SC2.22
Bandwidth Enhancement Scheme Demonstration (from 5 GHz to 34 GHz) on Direct Modulation Laser Diode using Multiple PPR (Photon-Photon Resonance) Active MMI
Bingzhou Hong; Takuya Kitano; Tomotaka Mori; Haisong Jiang; Kiichi Hamamoto Kyushu University, Fukuoka-shi, Japan
Multiple cavity active-Multimode Interferometer Laser Diode demonstrates multiple photon-photon resonances (8 GHz, 10 GHz, 13 GHz, 19 GHz, 23 GHz and 36 GHz) for the first time. Modulation bandwidth of at least 34 GHz was confirmed.

P1.SC2.23
Ultra-low Loss Arrayed Waveguide Grating Using Deep UV Lithography on a Generic InP Photonic Integration Platform
Jeroen Bolk[1]; Huub Ambrosius[1]; Prometheus Dasmahapatra[1]; Patty Stabile[1]; Sylwester Latkowski[1]; Domenico D'Agostino[1]; Elton Bitincka[1]; Luc Augustin[2]; Didier Marsan[2]; Rutger Voets[4]; Kevin Williams[1]
[1]Eindhoven University of Technology, Eindhoven; [2]SMART Photonics, Eindhoven; [3]InPACT, Saint Marcel; [4]ASML, Veldhoven, Netherlands
ArF deep UV (193 nm) lithography was successfully applied to fabricate Arrayed Waveguide Gratings in generic Indium Phosphide technology. The sub-dB transmission losses demonstrate the advantages of scaling down the minimum feature size to 100 nm.

P1.SC2.24
Compact Size and Low Cost Hermetic Sealed 100Gbps (25Gbps x 4Ch) Receiver Optical Sub-Assembly (ROSA) Design Using AlN Substrate and Si Optical Bench (SiOB) Cover
Kisung Park; Gil Dong Lee; Sang No Lee; Hyung-Gi Park; Wol-Yon Hwang; Jinsoo Choi; Kuk-Hyun Yang, IOSolution Co., Ltd., Daejeon, Republic of Korea
Compact size and low cost hermetic sealed 100 Gb/s ROSA using AlN substrate and SiOB cover without expensive ceramic package and mechanical machining components have been designed and fabricated. The fabricated ROSA satisfies IEEE 100GBASE Ethernet LR4 specifications.

P1.SC2.25
A Thin Silicon Photonic Platform for Telecommunication Wavelengths
Marc De Cea Falco[1]; Amir Atabaki[2]; Luca Alloatti[2], Mark Wade[4]; Milos Popovic[5]; Rajeev Ram[2]
[1]Massachusetts Institute of Technology, Universitat Politecnica de Catalunya - BarcelonaTech, Universitat Politecnica de Catalunya - BarcelonaTech, Cambridge, USA; [2]Massachusetts Institute of Technology, Cambridge, USA; [3]Massachusetts Institute of Technology, ETH Zurich, ETH Zurich, Cambridge, USA; [4]University of Colorado Boulder, Ayar Labs, Ayar Labs, Boulder, USA; [5]Boston University, University of Colorado Boulder, University of Colorado Boulder, Boston, USA
In this work, we present a high speed resonant modulator at 1550nm fabricated in the thin (<100nm) silicon device layer in a standard microelectronics SOI CMOS process. Data transmission at 25Gbps over short distances and 12.5Gbps over 50km is demonstrated.

P1.SC2.26
Towards Polarization-Independent Four-Wave Mixing in Dispersion Engineered AlGaAs-on-Insulator Nano-Waveguide
Minhao Pu; Luisa Ottaviano; Elizaveta Semenova; Kresten Yvind, Technical University of Denmark, Kgs. Lyngby, Denmark
We demonstrate a polarization-independent continuous wave four-wave mixing conversion bandwidth of 70 nm (1530-1600 nm) in a dispersion engineered high-index contrast AlGaAs-on-insulator nano-waveguide. We obtain constant conversion efficiency over 175 nm for the TE mode.

P1.SC2.27
Compact and Low-Loss PBS-integrated Coherent Mixer Using ZrO2-SiO2 PLC
Shintaro Yamasaki[1]; Masanori Takahashi[2]; Junichi Hasegawa[2]
[1]FURUKAWA ELECTRIC, TELECOMMUNICATIONS & ENERGY Lab., TELECOMMUNICATIONS & ENERGY Lab., CHIBA; [2]FURUKAWA ELECTRIC, CHIBA, JP
We developed a PBS-integrated coherent mixer using a ZrO2-SiO2 PLC. Small chip size of 2.3mmx7.0mm , low insertion loss of 7.7dB and 10.3dB for signal and LO ports, and high polarization extinction ratio of more than 20dB are achieved.

P1.SC2.28
Room Temperature 1.55 µm Lasing of Sub-wavelength Quantum-dot Lasers Epitaxially Grown on (001) Silicon
Si Zhu[1]; Bei Shi[1]; Qiang Li1; Yating Wan[1]; Evelyn Hu[2]; Kei May Lau[1]
[1]Hong Kong University of Science and Technology, Hong Kong; [2]Harvard University, Cambridge, USA
Sub-wavelength quantum dot microdisk lasers were directly grown on (001) silicon by MOVPE. Lasing in C-band up to 60 was achieved with a low RT threshold of 3.7 µW and a high T0 of 130 K.

P1.SC2.29
Dense SDM 32-pixel 2-D Photodetector Array
Toshimasa Umezawa[1]; Tadashige Sakamoto[1]; Atsushi Kanno[1]; Ken Kusakata[2]; Kouichi Akahane[1]; Atsushi Matsumoto[1]; Naokatsu Yamamoto[1]; Tatsuya Kawanishi[2]
[1]National Institute of Information and Communications Technology, Tokyo; [2]Waseda University, Tokyo, Japan
We present a newly developed 32-pixel, high-speed 2D photodetector array operated at 25 Gbps (NRZ) with SMF and MCF, targeting direct coupling to MCF and FMF in dense SDM communications.

P1.SC2.30
Resonant Wavelength Variation Modelling for Microring Resonators based on Fabrication Deviation Analysis
Tsuyoshi Horikawa[1]; Daisuke Shimura[2]; Hiroyuki Takahashi[2]; Jun Ushida[2]; Yohei Sobu[2]; Akemi Shina[2]; Masatoshi Tokushima[2] Seok-Hwan Jeong[2]; Keizo Kinoshita[2]; Tohru Mogami[2] [1]PETRA, AIST, Tsukuba; [2]PETRA, Tsukuba, Japan
We propose a model to consistently interpret the resonant wavelength and group index variation behaviour in numbers of microring resonators, based on fabrication deviation analysis, and demonstrated that the model precisely derives fabrication variations for waveguides in 300-mm wafer processes.

P1.SC2.31
Reduction of Relative Intensity Noise of Optical Multicarrier Sources Using External Injection Based Optical Demultiplexer
Vidak Vujicic[1]; María Deseada Gutiérrez Pascual[2]; Jules Braddell[3] Vivek Panapakkam[4]; Cosimo Calò[3]; Romain Brenot[6]; Abderrahim Ramdane[4]; Prince Anandarajah[5]; Frank Smyth[5]; Liam P Barry[5]
[1]Dublin City University, Dublin; [2]Dublin City University, Pilot Photonics Ltd, Pilot Photonics Ltd, Dublin; [3]Pilot Photonics Ltd, Dublin; [4]Centre for Nanosciences and Nanotechnologies, Marcoussis; [5]III-V Lab, Marcoussis; 6Dublin City University, Dublin, Ireland
In this paper we demonstrate a reduction of relative-intensity noise of a mode-locked laser and a gain-switched comb source based on external injection employing a novel optical demultiplexer. Significant performance improvement is demonstrated in 3.125GBaud, 12.5GBaud and 28GBaud PAM-4 systems.

P1.SC2.32
Wavelength-Selective External-Cavity Laser Using an Optical Switch Integrated Arrayed-Waveguide Grating for T-band Communications
Yudai Okuno[1]; Hideaki Shibutani[1]; Katsumi Yoshizawa[2]; Yasunori Tomomatsu[2]; Hiroyuki Tsuda1
[1]Keio University, Yokohama; [2]Pioneer Micro Technology Corporation, Kofu; [3]Koshinkogaku Corporation, Hadano, Japan
An external-cavity laser using a 1×16 optical switch integrated arrayed-waveguide grating is configured. Error-free transmissions of 12.5-Gbps signal for 16 channels within the wavelength range of 1049.7-1071.9 nm, and a switching time of less than 10 ms are confirmed.

P1.SC2.33
Monolithically Integrated 4x4 Optical Switch with Cascaded MZIs and EAM-Gate Array
Yusuke Muranaka[1]; Tatsushi Nakahara[1]; Salah Ibrahim[1]; Takuro Fujii[1]; Toru Segawa[1]; Toshikazu Hashimoto[1]; Ryo Takahashi[2]
[1]Nippon Telegraph and Telephone Corporation, Atsugi, Kanagawa; [2]National Institute of Information and Communications Technology, Koganei, Tokyo, Japan
Based on the combination of cascaded MZIs and an EAM-gate array, we have developed an InP monolithically integrated very-small-footprint 4x4 optical switch that exhibits high-extinction ratio of 40 dB, low-loss of 21 dB, and high-switching-speed of 2 ns.

SC3 - DIGITAL TECHNIQUES FOR OPTICAL COMMUNICATION SYSTEMS HALL F

P1.SC3.34
Experimental Demonstration of Simplified Adaptive Equalizer for Fractionally Sampled 120-GBaud Signal
Fukutaro Hamaoka; Seiji Okamoto; Masanori Nakamura; Asuka Matsushita; Takayuki Kobayashi; Hiroshi Yamazaki; Munehiko Nagatani; Yoshiaki Kisaka; Akira Hirano; Yutaka Miyamoto, Nippon Telegraph and Telephone Corporation, Yokosuka, Japan
We propose a fractionally spaced adaptive equalizer (AEQ) using sets of FIR filter taps. Experimental results show that a 3T/4-spaced AEQ can effectively equalize the inter symbol interference of a 120-GBaud signal compared to the conventional T/2-spaced AEQ.

P1.SC3.35
An Accurate and Robust In-phase/Quadrature Skew Measurement for Coherent Optical Transmitter by Image Spectrum Analyzing
Hao Chen1; Xiaofei Su[2]; Zhenning Tao[2]; Tomofumi Oyama[2]; Hisao Nakashima[2]; Takeshi Hoshida[2]; Kazutoshi Kato[4]
[1]Fujitsu R&D Center, Kyushu University, Kyushu University, Beijing; [2]Fujitsu R&D Center, Beijing, China; [3]Fujitsu Laboratories Ltd., Kawasaki; [4]Kyushu University, Fukuoka, Japan
An accurate and robust in-phase/quadrature skew measurement method for coherent optical transmitter based on analyzing the shape of image spectrum is proposed. Experiments under various bias deviations of child/parent Mach-Zehnder modulators demonstrate the standard deviation of measured skew is 0.3ps.

P1.SC3.36
Miscorrection-free Decoding of Staircase Codes
Christian Häger[1]; Henry Pfister[2]
1Chalmers University of Technology, Duke University, Duke University, Gothenburg, Sweden; [2]Duke University, Durham, USA
We propose a novel decoding algorithm for staircase codes which reduces the effect of undetected component code miscorrections. The algorithm significantly improves performance, while retaining a low-complexity implementation suitable for high-speed optical transport networks.

P1.SC3.37
Maximum Likelihood Carrier Phase Estimation Based on Monte Carlo Integration
Rafael Rios-Müller[1]; Bertold Ian Bitachon[2]
[1]Nokia Bell Labs, Paris-Saclay, France; [2]ETH Zürich, Zürich, Swizerland
The mean-squared error performance and phase noise variance tolerance of a maximum likelihood carrier phase estimation based on Monte Carlo integration is evaluated and used as a baseline for comparison with two relaxed versions of this estimator.

P1.SC3.38
81.7% Complexity Reduction of Volterra Nonlinear Equalizer by Adopting L1 Regularization Penalty in an OFDM Long-Reach PON
Shao-Yu Lu[1]; Chia-Chien Wei[2]; Chun-Yen Chuang[3]; Young-Kai Chen[4]; Jyehong Chen[1]
[1]National Chiao Tung University, Hsinchu City, Taiwan; [2]National Sun Yat-sen University, Department of Photonics, Department of Photonics, Kaohsiung City, Taiwan; [3]National Chiao Tung University, Department of Photonics, Department of Photonics, Hsinchu City, Taiwan; [4]Bell Labs, Alcatel-Lucent at Murray Hill, New Jersey, USA
We successfully reduce 81.7% complexity of 3rd-order Volterra nonlinear equalizer and the data rate has only 2% reduction by adopting the L1 regularization penalty in a 60-km OFDM long-reach PON.

P1.SC3.39
Low-complexity Joint Sub-carrier Phase Noise Compensation for Digital Multi-carrier Systems
Metodi Yankov[1]; Luca Barletta[2]; Darko Zibar[1]
[1]Technical University of Denmark, Kgs. Lyngby, Denmark; [2]Department of Electronics Information and Bioengineering, Politecnico di Milano, Milan, Italy
Joint sub-carrier phase noise processing is proposed which recovers the SNR penalty related to decreased sub-carrier baudrate w.r.t. single carrier systems. The method enables digital sub-banding to be safely employed for nonlinear mitigation for modulation formats of up to 256-QAM.

P1.SC3.40
Feedforward Weighted-Samples based Carrier Frequency Offset Compensation in Optical Coherent M-QAM Systems
Trung-Hien Nguyen[1]; Pascal Scalart[2]; Mathilde Gay[3]; Laurent Bramerie[3]; Christophe Peucheret[3]; Michel Joindot[3]
[1]OPERA department, Universite libre de Bruxelles, Brussels, Belgium [2]INRIA/IRISA, University of Rennes 1, Rennes; [3]FOTON laboratory, CNRS, ENSSAT, University of Rennes 1, Lannion, France
A low-complexity feedforward CFO compensation method is proposed and numerically validated for square and cross M-QAM modulation in optical coherent systems. The proposed method is compared to state-of-the-art methods and its effectiveness is experimentally verified in a 10-GBaud 16-QAM system.

P1.SC3.41
Time Skew Estimator for Dual-Polarization QAM Transmitters
Júlio César Medeiros Diniz; Francesco Da Ros; Rasmus Jones; Darko Zibar Technical University of Denmark, Kongens Lyngby, Denmark
A simple method for joint estimation of transmitter's in-phase/quadrature and inter-polarization time skew is proposed and experimentally demonstrated. The method is based on clock tone extraction of a photodetected signal and genetic algorithm. The maximum estimation error was 0.5 ps.

P1.SC3.42
Convolutional Neural Network-based Deep Learning for Intelligent OSNR Estimation on Eye Diagrams
Danshi Wang; Min Zhang, Beijing University of Posts and Telecommunications, State Key Laboratory of Information Photonics and Optical Communications, State Key, China
A convolutional neural network-based deep learning technique is proposed for intelligent OSNR estimation on eye diagrams. Compared with other machine learning methods, the optimal performances and 100% accuracies are achieved for four widely-used modulation formats.

P1.SC3.43
Experimental Demonstration of Encryption and Steganography in Optical Fiber Communications

Eyal Wohlgemuth[1]; Tomer Yeminy1; Zeev Zalevsky[2]; Dan Sadot[1]
[1]Ben-Gurion University of the Negev, Beer Sheva; [2]Bar Ilan University, Ramat Gan, Israel

Encryption and steganography of the physical layer are experimentally demonstrated. We show a coherent stealthy transmission of 16 Gbps under negative -15 dB OSNR with pre-FEC BER of 1e-3 , co-transmitted with public channel.

P1.SC3.44
Fractal Dimension Aided Modulation Formats Identification Based on Support Vector Machines

Huibin Zhou; Ming Tang; Xi Chen; Zhenhua Feng; Qiong Wu; Songnian Fu; Deming Liu
Huazhong University of Science and Technology, Wuhan, China

We proposed and demonstrated a fractal dimension aided modulation formats identification method based on support vector machines. The overall identification accuracies above 98.05% are achieved for six commonly-used modulation formats under different practical channel conditions.

P1.SC3.45
Joint Pre-, Inline-, and Post-Compensation of Spectrum Narrowing Caused by Traversing Multiple Optical Nodes

Yojiro Mori; Hiroshi Hasegawa; Ken-Ichi Sato, Nagoya University, Nagoya, Japan

We propose a novel scheme to compensate the spectrum narrowing caused by optical nodes. Simulations show that our combination of jointly optimized pre- and post-compensation filters and inline power compensation can drastically enlarge the maximum node-hop count and transmission distance.

P1.SC3.46
Digital Dispersion Pre-compensation and Nonlinearity Impairments Pre- and Post-processing for C-band 400G PAM-4 Transmission over SSMF Based on Direct-Detection

Junwen Zhang1; Jianjun Yu[1]; Jianyang Shi[2]; Hung Chang Chien[1]
[1]ZTE TX INC, Morristown; [2]ZTE TX INC, Fudan University, Fudan University, Morristown, USA

We demonstrate the transmission record of 4 lines of C-band 112-Gb/s PAM-4 signals over 400-km SSMF based on direct-detection without any optical dispersion compensation, thanks to the digital CD pre-compensation and advanced nonlinearity distortion compensations.

P1.SC3.47
Single IFFT Augmented Spectral Efficiency DMT Transmitter

Qibing Wang; Binhuang Song; Bill Corcoran; Leimeng Zhuang; Arthur Lowery
Monash University, Melbourne, Australia

The computational load for ASE-DMT can be reduced to that of DCO-OFDM by mapping of the inverse fast Fourier transform's (IFFTs) inputs and extraction of signals from within the IFFT. A real-time transmitter enables 9.2 Gbit/s over 20-km SSMF.

P1.SC3.48
Pilot Distributions for Phase Tracking in Space-Divison Multiplexed Systems

Arni Alfredsson; Erik Agrell; Henk Wymeersch; Magnus Karlsson
Chalmers University of Technology, Gothenburg, Sweden

Several pilot distributions are compared for pilot-aided joint-core phase tracking in space-division multiplexed transmission affected by correlated phase noise. Results show that the best choice of distribution can reduce the bit error rate by a factor up to 170.

P1.SC3.49
Matrix Receiving Scheme Supporting Arbitrary Multiple-Wavelength Reception for Optical Interconnects

Xuezhi Lu[1]; Xuezhi Agrell[2]; Xuezhi Pang[3]; Xuezhi Ozolins[4]; Xuezhi Hong[3]; Xuezhi Lin[3]; Xuezhi Cheng[3]; Xuezhi Udalcovs[4]; Xuezhi Poppv[3]; Xuezhi Jacobsen[4]; Xuezhi Chen[3]
[1]School of ICT, KTH Royal Institute of Technology, Kista, Sweden, Stockholm, Sweden; [2]Department of Electrical Engineering, Chalmers University of Technology, Göteborg, Sweden; [3]School of ICT, KTH Royal Institute of Technology, Stockholm, Sweden; [4]Networking and Transmission Laboratory, RISE Acreo AB, Stockholm, Sweden

An arbitrary multiple-wavelength reception scheme using only a few fixed-wavelength filters is proposed for optical interconnects. Filter matrices design based on error-control coding theory is devised. The feasibility of the proposed scheme is demonstrated in a four-wavelength reception experiment.

P1.SC3.50
Beating Bandwidth Limitation for High-speed PAM-4 Transmission Based on Turbo Equalizer

Qian Hu; Roman Dischler; Karsten Schuh; Henning Buelow; Laurent Schmalen; Fred Buchali, Nokia Bell Labs, Stuttgart, Germany

To transmit high-speed PAM-4 signal in a low-cost IMDD system, inter-symbol interference (ISI) is induced by the limited component bandwidth. We cancel the ISI and improve the tolerance to bandwidth limitation by a reduced-complexity turbo equalizer.

P1.SC3.51
Low Complexity Blind Phase Recovery Algorithm with Increased Robustness Against Cycle-Slips

Valery Nobl Rozental; Deming Kong; Benjamin Foo; Bill Corcoran; Arthur Lowery
Monash University, Clayton, Australia

We present a non-data-aided recursive digital phase recovery algorithm for mQAM optical systems, which uses a priori information about the laser phase noise, and has very low computational complexity. Experimental validation shows extremely high robustness against cycle-slips.

P1.SC3.52
Distributed Transmission and Spatially Coupled Forward Error Correction in Regenerative Multipoint-to-Point Networks

Laurent Schmalen; Tobias Eriksson; Fred Buchali; Roman Dischler; Ulrich Gebhard
Nokia Bell Labs, Stuttgart, Germany

We investigate the performance of coded modulation for multi-hop regenerative optical networks. We analyze options for computing decoder input LLRs, show reach increases by optimized regenerator placement and experimentally compare strategies and guidelines for distributed FEC.

P1.SC3.53
Single-step Perturbation-based Nonlinearity Compensation of Intra- and Inter-Subcarrier Nonlinear Interference

Felix Frey[1]; Lutz Molle2; Robert Emmerich[2]; Colja Schubert[1]; Johannes Karl Fischer[2]; Robert Fischer[1]
[1]University of Ulm, Fraunhofer Heinrich-Hertz Institute, Berlin, Fraunhofer Heinrich-Hertz Institute, Berlin, Berlin; [2]Fraunhofer Heinrich-Hertz Institute, Berlin; [3]University of Ulm, Ulm, Germany

We experimentally demonstrate a decision-directed, intra- and inter-subcarrier nonlinearity mitigation scheme based on first order perturbation. We achieve 0.9 dB Q2-factor improvement over linear compensation in a 200G dual-carrier PDM-16QAM transmission over 1200 km.

P1.SC3.54
Experimental demonstration of signal quality equalization in vector domain to mitigate core-to-core Q-difference for SDM transmission

Hidenori Takahashi; Takehiro Tsuritani, KDDI Research, Inc., Saitama, Japan

The vector-based signal quality equalization is demonstrated to mitigate the core-to-core Q-difference. Two signals are combined and separated using transfer function in vector domain. It is confirmed that the method can equalize signal quality and is better than bit-based equalization.

P1.SC3.55
Training-Aided Channel Estimation and Equalization in SDM Systems with MISO Pre-convergence under Strong Coupling

Christian Sanchez[2]; Filipe Ferreira1; Jinlong Wei[2]; Stylianos Sygletos[1]; Andrew Ellis[1]
[1]Aston University, Aston Institute of Photonic Technologies, Aston Institute of Photonic Technologies, Birmingham, UK; [2]Huawei Technologies Duesseldorf, European Research Center, European Research Center, Düsseldorf, Germany

A simple DSP scheme receiver is proposed to circumvent laser frequency-offset effects in DA-CE based SDM systems using a MISO CMA pre-convergence stage. Numerical results demonstrate a successful operation for 12-mode fiber transmission under MDL, using QPSK and 16QAM mapping

SC4 - TRANSMISSION SUBSYSTEMS AND OPTICAL NETWORK ELEMENTS HALL F

P1.SC4.56
Dynamic Range of Coherent Optical Time-Domain Reflectometer with Golay Coded ASK Probes

Maria Ionescu; Steve Desbruslais, Xtera, Romford, UK

Improvements to COTDR based on Golay codes through DSP frequency tracking, jitter and noise suppression allow a number of averages as low as 400. 256-bit ASK modulated complementary Golay codes achieve 17.1dB dynamic range and 200m spatial resolution.

P1.SC4.57
Multilevel Amplitude Regeneration of PAM-4 Signals using a Nonlinear Optical Loop Mirror

Feng Wen[1]; Christos Tsekrekos[1]; Xingyu Zhou[2]; Yong Geng[2]; Baojian Wu[2]; Kun Qiu[2]; Sergei Turitsyn[1]; Stylianos Sygletos[1]
[1]Aston University, Birmingham, UK; [2]University of Electronic Science and Technology of China, Chengdu, China

Multilevel amplitude regeneration of return-to-zero PAM-4 signals is experimentally demonstrated using a single NOLM unit. The noise suppression capability at each amplitude level is characterized, and Q2-factor improvement of 0.92dB is achieved by optimizing input signal power and distortion strength.

P1.SC4.58
10 Gbps Tuneable VCSEL-based SFP+ with Integrated G.METRO Functionality for Front haul Access Networks

Hung Kai Chen; Christopher Chase; Michael Huang, Bandwidth10, Berkeley, USA

1550-nm DWDM tuneable SFP+ modules based on an HCG-VCSEL are demonstrated with an embedded communications channel for wavelength tuning and locking using a draft ITU-T G.METRO specification for low cost front haul network applications.

P1.SC4.59
SSBI-Free 100Gb/s Direct Detection Based on Fused-Type Mode-Selective Fiber Coupler

Ying Qiu[1]; Ming Luo1; Xiang Li[2]; Zhixue He[2]; Qi Yang[2]
[1]Wuhan Research Institute of Posts and Telecommunications, Huazhong University of Science and Technology, Huazhong University of Science and Technology, Wuhan; [2]Wuhan Research Institute of Posts and Telecommunications, Wuhan, China

We propose and demonstrate a novel approach to achieve 100-Gb/s direct detection in two-mode fiber transmission based on fused-type mode-selective fiber coupler. The signal-to-signal beating noise can be eliminated based on the proposed scheme without requirement of guard band.

P1.SC4.60
Single Carrier 168 Gb/s PAM8 over 80 km Below HD-FEC Using Simple Receiver Equalization for Data Centre Interconnects

Mathieu Chagnon[1]; Tobias Eriksson[1]; Fred Buchali[1]; Henning Buelow[1]; Stephan Ten Brink[2]
[1]Nokia Bell Labs, Stuttgart; [2]University of Stuttgart, Stuttgart, Germany

We demonstrate the first single carrier, single polarization PAM8 intensity modulation direct detection system delivering 168 Gb/s over 80km of SMF below the hard-decision FEC threshold of 3.8x10-3, with a receiver processing relying only on a 3-tap FFE

P1.SC4.61
Single-carrier 552 Gbit/s, 46 Gbaud 64 QAM Coherent Transmission over 100 km with Co-propagating 10 Gbit/s-OOK Signals Through a Deployed ROADM Network

Keisuke Kasai[1]; Toshihiko Hirooka[1]; Masato Yoshida[1]; Masataka Nakazawa[1]; Masaki Shiraiwa[2]; Yoshinari Awaji[2]; Naoya Wada[2] [1]Tohoku University, Sendai; [2]National Institute of Information and Communications Technology, Koganei, Japan

We demonstrate the add/drop operation and transmission of single-carrier, polarisation-multiplexed, 46 Gbaud 64 QAM signals in a deployed ROADM network. 552-Gbit/s data were successfully transmitted over a 100-km ring-network with co-propagating 6x10 Gbit/s-OOK WDM signals without an ROADM penalty.

P1.SC4.62
Introducing DSP-based Coherent Receivers for Wide-area Reference Frequency Distribution in Metrology Applications

Vittorio Curri[2]; Anna Tampellini[2]; Cecilia Clivati[2]; Marco Pizzocaro[2]; Davide Calonico[2]; Stefano Straullu[2]; Roberto Gaudino[1]
[1]Politecnico di Torino, Torino; [2]Istituto Nazionale di Ricerca Metrologica, Torino; 3Istituto Superiore Mario Boella, Torino, Italy

We present the advantages of dual-polarization coherent receivers and digital signal processing in metrology applications for high accuracy frequency distribution over long-distance fiber links. We experimentally demonstrate optical frequency distribution at 10-16 accuracy on 300 km installed fiber.

P1.SC4.63
Detection and Compensation of Power Imbalance and Modulation Imperfection in Coherent IQ Transmitter

Qiang Wang; Yang Yue; Xuan He; Andre Vovan; Jon Anderson, Juniper Networks, Sunnyvale, USA

By sweeping gain scaling factor of finite impulse filter and monitoring the coherent IQ transmitter output power, power-imbalance, modulation-depth and bias-point are detected in real time simultaneously. Power-imbalance is compensated by adjusting gain of radio frequency amplifier.

P1.SC4.64
Polarization Dependent Loss Monitor with Visualization on Poincarä Sphere in Digital Coherent System

Guoxiu Huang[1]; Shoichiro Oda[1]; Yuichi Akiyama[2]; Hiroyuki Irie[1]; Setsuo Yoshida[1]; Hisao Nakashima[2]; Takeshi Hoshida[1]
[1]Fujitsu Limited, Kawasaki; [2]Fujitsu Laboratories Ltd., Kawasaki, Japan

For digital coherent system, Mueller matrix based polarization dependent loss monitor has been firstly proposed by inserting specific state of polarization training sequences. The experimental demonstration confirmed that the monitored error could be less than Â±0.3dB with commercialized micro ICR.

P1.SC4.65
Characterization of Spectral Magnification based on Four-Wave Mixing in Nonlinear Fibre for Advanced Modulation Formats

Mads Lillieholm[1]; Bill Corcoran[2]; Michael Galili[1]; Lars Grüner-Nielsen[3]; Leif Katsuo Oxenløwe[1]; Arthur Lowery[2]
[1]Technical University of Denmark, SPOC, SPOC, Kgs. Lyngby, Denmark; [2]Monash University, CUDOS, CUDOS, Clayton, Australia; 3Danish Optical Fiber Innovation, Brønshøj, Denmark

We characterize the performance of 4x spectral magnification based on four-wave mixing in optimized nonlinear fibres, for 4/8/16-QAM formats, and report >19-nm operational bandwidth. Predominantly OSNR penalties of ~1 dB per bit/QAM-symbol from aberrations non-intrinsic to time lenses are observed.

P1.SC4.66
Impact of Signal-Conjugate Wavelength Shift on Optical Phase Conjugation-based Transmission of QAM Signals

Francesco Da Ros; Mads Lillieholm; Metodi Yankov; Pengyu Guan; Hao Hu; Søren Forchhammer; Michael Galili; Leif Katsuo Oxenløwe
Technical University of Denmark, Lyngby, Denmark

The impact of signal-conjugate wavelength shift on nonlinearity compensation through optical phase conjugation is investigated for 64- and 256-QAM. Wavelength-shift independent achievable rate improvements between 0.2 and 0.3 bit/symbol are reported for shifts up to 30 nm in 500-km transmission.

P1.SC4.67
Broadband Inter-Core Optical Multicasting within Multicore Fibre

Ruoxu Wang[1]; Qiong Wu[2]; Xi Chen[2]; Ming Tang[2]; Songnian Fu[2]; Zhenhua Feng[2]; Xuan Zhan[2]; Weijun Tong[2]; Perry Shum[4]; Deming Liu[1]
[1]Huazhong University of Sci.& Tech., South 5 building, 1037 Luoyu Road, South 5 building, 1037 Luoyu Road, Wuhan, China; [2]Huazhong University of Sci.& Tech., S5 building 1037 Luoyu Road, S5 building 1037 Luoyu Road, Wuhan, China; [3]YOFC, Yangtze Optical Fiber and Cable Joint Stock Limite, Yangtze Optical Fiber and Cable Joint Stock Limite, Wuhan, China; [4]Nanyang Technological University, Singapore, Singapore

We fabricated paralleled long period grating array to enable efficient C-band broadband inter- core coupling in seven core fibres with advanced electrical arc discharge technique. A 1:2 inter-core multicasting of 5×224Gb/s coherent OFDM signals is then experimentally achieved.

P1.SC4.68
Post-processing of Long-haul and Ethernet Optical Transmission Signals Using Photonic Reservoir Computing

Apostolos Argyris; Julián Bueno; Ingo Fischer
Instituto de Física Interdisciplinar y Sistemas Complejos IFISC (CSIC-UIB), Palma de Mallorca, Spain

We show the potential of reservoir computing to serve as a fast post-processing tool for improving the incoherent detection performance of critically degraded signals after fiber transmission. A photonic reservoir implementation based on semiconductor lasers with time-delayed feedback is considered.

P1.SC4.69
200-Gb/s Polarization Multiplexed Doubly Differential QPSK Signal Transmission over 80-km SSMF Using Tandem SSB without Optical Amplification

Tingting Zhang; Christian Sanchez; Ian Phillips; Stylianos Sygletos; Andrew Ellis
Aston Institute of Photonic Technologies (AIPT), Aston University, Birmingham, UK

We propose 200-Gb/s polarization multiplexed tandem SSB DDQPSK with intradyne detection for 80-km SSMF transmission. Without optical amplification, dispersion compensation or carrier recovery, the simulated receiver sensitivity for 80-km transmission was below -25.5 dBm (at 7% HD-FEC threshold).

P1.SC4.70
The EML as Coherent Optical Receiver

Bernhard Schrenk
AIT Austrian Institute of Technology, Vienna, Austria

Phase-agnostic coherent reception of intensity modulated and OFDM signals over loss budgets of more than 30 dB is experimentally demonstrated with a commercial off-the-shelf externally modulated laser. Wavelength locking is supported for this monolithic-integrated transceiver device.

P1.SC4.71
Mode Multiplexing and Demultiplexing by a Standard Single-Mode Coupler for 850 nm Few-Mode Transmission Systems

David García[1]; María Morant[1]; Juan Luis Corral[1]; Roberto Llorente[1]
[1]Universitat Politecncia de Valencia, Centro de Tecnología Nanofotónica de Valencia, Centro de Tecnología Nanofotónica de Valencia, Valencia; [2]Universitat Politecncia de Valencia, Escuela Politécnica Superior de Gandia, Escuela Politécnica Superior de Gandia, Gandia, Spain

A mode multiplexer/demultiplexer for 850 nm few-mode links based on a standard single-mode coupler designed for 1550 nm operation is reported obtaining a efficiency higher than 98% for LP01 and 100% efficiency for LP11 with 94% LP11 mode profile purity

15:30 - 17:00 POSTER REFRESHMENTS HALL F

17:45 - 19:00 CONCERT, GOTHENBURG CONCERT HALL

W.1.A: Advanced Modulation for Data Centre Interconnects
Room F1 (SC5)
Chair: Christoph Schulien, Ranovus GmbH, Germany

08:30 W.1.A.1
Duobinary IQ Modulation Schemes for C- and O-band PAM4 Direct Detect Systems
Mathieu Chagnon1; Tobias Eriksson1; Roman Dischler1; Fred Buchali1; Henning Buelow1; Stephan Ten Brink2 1Nokia Bell Labs, Stuttgart; 2University of Stuttgart, Stuttgart, Germany
We present two novel modulation schemes for PAM4 direct detection employing duobinary signals as least and most significant bit. One format, for C-band, is experimentally demonstrated at 70 GBaud. The other, for O-band, is simulated and compared against conventional PAM4

08:45 W.1.A.2
Polybinary Coding for Low Complexity High Speed Error-Free VCSEL-MMF Links
Siddharth Varughese1; Justin Lavrencik1; Johan Gustavsson2; Erik Haglund2; Anders Larsson2; Stephen Ralph1 1Georgia Institute of Technology, Atlanta, USA; 2Chalmers University of Technology, Goteborg, Sweden
We demonstrate and analyze polybinary signaling as a low complexity alternative to PAM-4 for achieving higher bitrates in VCSEL-MMF links. Experimental results demonstrate that duobinary and polybinary-3 achieves similar performance as PAM-4 through 105m of wideband fiber at 10-12 BER.

09:00 W.1.A.3
Error-Free 100Gbps PAM-4 Transmission over 100m Wideband Fiber using 850nm VCSELs
Justin Lavrencik1; Siddharth Varughese1; Johan Gustavsson2; Erik Haglund2; Anders Larsson2; Stephen Ralph1 1Georgia Institute of Technology, Atlanta, USA; 2Chalmers University of Technology, Göteborg
We experimentally demonstrate error-free rates beyond 100Gbps over 100m WBMMF. Power penalties and maximum data rates of PAM-2 and PAM-4 using shaped and unshaped pulses were studied. The link includes unpackaged 850nm VCSELs with different apertures and only transmitter equalization.

09:15 W.1.A.4
10 km CWDM Transmission using 56 Gb/s PAM-4 Directly Modulated Lasers for 200G/400G Transceivers
Prashant Baveja; Mingshan Li; Huanlin Zhang; Yi Wang; Yongxuan Liang; Hao-Hsiang Liao; I Lung Ho; Jun Zheng, Applied Optoelectronics Inc., 13139 Jess Pirtle Blvd., 13139 Jess Pirtle Blvd., Sugarland, USA
56 Gb/s PAM-4 modulation and 10 km transmission of CWDM, low RIN DFB lasers, based on high volume manufacturing capable, ridge waveguide (RWG) platform, operating up to 70 C, is experimentally demonstrated.

09:30 W.1.A.5 Invited
New Paradigm Shift to PAM4 Signaling at 100/400G for Cloud Data Centers: A Performance Review
Frank Chang; Sudeep Bhoja, Inphi Corp, Westlake Village & Santa Clara, USA
In this presentation, we review the applications and performance of PAM4 signaling with real-time processing at 200G/400G for cloud data centers, with emphasis on various distance objectives from 100m MMF, up to 10/40km SMF and even 80km OSNR limited connectivity

W.1.B: Space-Division Multiplexing Fibres
Room F2 (SC1)
Chair: Ivana Gasulla, Universitat Politècnica de Valencia, Spain

08:30 W.1.B.1 Invited
Propagation Effects in SDM Fibers
Cristian Antonelli1; Antonio Mecozzi1; Ori Golani2; Mark Shtaif2 1University of L'Aquila, L'Aquila, Italy; 2Tel Aviv University, Tel Aviv, Israel
We review the main propagation effects that take place in multi-mode fiber structures for Space-Division Multiplexing, as well as their impact on system performance. These include Modal Dispersion, Mode-Dependent Loss, and Nonlinear distortions.

09:00 W.1.B.2
Zero-Dispersion Wavelength Optimized Single-Mode Multi-Core Fiber for High-Speed Gigabit Ethernet
Takashi Matsui; Taiji Sakamoto; Kazuhide Nakajima, NTT Corporation, Tsukuba, Japan
We demonstrated a single-mode 8-core fiber with the optimum zero-dispersion wavelength for a high-speed GbE system using 175-um cladding and 250-um coating diameters. The fabricated 8-core fiber is potentially applicable to 40-km bi-directional 1.6TbE transmission on one fiber.

09:15 W.1.B.3
125 µm-cladding 2LP-mode and 4-core Multi-core Fibre with Air-hole Structure for Low Crosstalk in C+L Band
Saki Nozoe1; Taiji Sakamoto1; Takashi Matsui1; Yoshimichi Amma2; Katsuhiro Takenaga2; Yoshiteru Abe1; Kyozo Tsujikawa1; Shinichi Aozasa1; Kazuhiko Aikawa2; Kazuhide Nakajima1
1NTT Corporation, Tsukuba, Japan; 2Fujikura, Sakura, Japan
We realized a 125 um-cladding 4-core fibre that supports 2LP mode in the C+L band. A low crosstalk characteristic of -30 dB/100km and the 12 spatial channels were realized simultaneously by intentionally constructing four-air-holes using an over-cladding bundled rod technique.

09:30 W.1.B.4
Evaluation of Inter-Core Skew in an Uncoupled Multicore Fibre
Yusuke Sasaki1; Keisuke Hirakawa1; Itaru Ishida2; Shoichiro Matsuo2; Kazuhiko Aikawa1 1Fujikura Ltd., Sakura; 2Fujikura Ltd., Suzuka, Japan
The inter-core skew (ICS) in an uncoupled multicore fibre is investigated theoretically and experimentally. The ICS of a non-twisted MCF is estimated more precisely by considering the photoelastic effect. It is experimentally confirmed that intentional fibre-twisting reduces ICS.

09:45 W.1.B.5
Unrepeated LP02 Mode Transmission over 205 km Few-mode Fibre with Selective Mode Excitation
Takayoshi Mori; Taiji Sakamoto; Masaki Wada; Azusa Urushibara; Takashi Yamamoto; Kazuhide Nakajima, NTT Corporation, Tsukuba, Japan
We reveal LP02 mode has the lowest modal crosstalk in the longitudinal direction of four-LP mode pure silica core step-index fibre. 205 km unrepeated transmission over eight spools is successfully achieved using LP02 mode selective launching.

W.1.C: Integrated Si Photonics I
Room F3 (SC2)
Chair: John Donegan, Trinity College, Dublin Ireland

08:30 W.1.C.1 Tutorial
Integrated Silicon Photonics
Chris Doerr, Acacia, USA
Silicon photonics is a planar arrangement of silicon optical waveguides and devices on a substrate. It is useful because the defect density is low, the fabrication and packaging are leveraged from the electronics industry, the guidance is compact, and the performance is high. We start from the basic physics and end with communication and sensor devices.

09:30 W.1.C.2
Three-channel Thermal Adaptation of Polarization Insensitive Silicon Photonics WDM Receiver
Robert Gatdula1; Kwangwoong Kim1; Argishti Melikyan1; Young-Kai Chen2; Po Dong1
1Nokia Bell Labs,, Holmdel, New Jersey; 2Nokia Bell Labs,, Murray Hill, New Jersey, USA
We demonstrate simultaneous multiple-wavelength locking of a silicon photonic polarization insensitive microring-based wavelength division multiplexing receiver. Using a single monitoring photodetector, we thermally adapt over a temperature range >20°C and demultiplex 3x25 Gb/s on-off-keying modulation with 150 GHz channel spacing.

09:45 W.1.C.3
Integrated Widely Tunable Broadband Optical Isolator in Silicon Photonics
Paolo Pintus1; Duanni Huang1; Mj Kennedy1; Paul Morton2; Yuya Shoji3; Tetsuya Mizumoto3; John Bowers1
1Uni. of California Santa Barbara, Santa Barbara, USA; 2Morton Photonics, West Friendship (MD), USA; 3FIRST, Tokyo Institute of Technology, Tokyo, Japan
We experimentally demonstrate a Mach-Zehnder based optical isolator in silicon photonics. A maximum isolation ratio larger than 30dB is measured, while more than 18dB of isolation is guaranteed over 15nm-wide bandwidth. Finally, the isolation wavelength is effectively tuned over 72nm.

10:00 - 10:30 COFFEE EXHIBITION HALL

W.1.D: Nonlinear Compensation
Room F4 (SC3)
Chair: Ezra Ip, NEC Labs, USA

08:30 W.1.D.1
Volterra Series Digital Backpropagation Accounting for PMD
Cristian B. Czegledi1; Ronen Dar2
1Nokia Bell Labs, Chalmers University of Technology, Chalmers University of Technology, Holmdel; 2Nokia Bell Labs, Holmdel, USA
We propose a modified Volterra series digital backpropagation algorithm that accounts for polarization-mode dispersion (PMD) effects. The algorithm accounts only for nonlinear terms that are PMD-insensitive, leading to both performance enhancement and substantial complexity reduction.

08:45 W.1.D.2
Finite-Precision Optimization of Time-Domain Digital Back Propagation by Inter-Symbol Interference Minimization
Christoffer Fougstedt; Lars Svensson; Mikael Mazur; Magnus Karlsson; Per Larsson-Edefors, Chalmers University of Technology, Gothenburg, Sweden
We consider the effects of limited-resolution arithmetic on the performance of Time-Domain Digital Back Propagation. By minimizing resulting ISI of the quantized FIR impulse responses, we can achieve floating-point performance using 9-bit pairwise optimized filter coefficients.

09:00 W.1.D.3
Nonlinear Compensation Using Digital Back-Propagation in Few-Mode Fibre Spans with Intermediate Coupling
Filipe Marques Ferreira; Christian Sanchez; Stylianos Sygletos; Andrew Ellis Aston University - AIPT, Birmingham, UK
We investigate for the first time the performance of virtual back-propagation using multimode Manakov equations, derived for the weak- and strong-coupling regimes, after forward-propagation using a fully stochastic model over all linear coupling regimes.

09:15 W.1.D.4
Prediction of Second-Order Moments of Inter-Channel Interference with Principal Component Analysis and Neural Networks
Rasmus Jones1; Júlio César Medeiro Diniz2; Metodi Yankov2; Piels Molly2; Darko Zibar2; Andy Doberstein3
1Technical University of Denmark, Department Of Photonics Engineering, \O rsteds Plads, B. 343, 2800 Kgs. Lyngby, Denmark, Department Of Photonics Engineering, \O rsteds Plads, B. 343, 2800 Kgs. Lyngby, Denmark, Kgs. Lyngby, Denmark; 2Technical University of Denmark, Department Of Photonics Engineering, O rsteds Plads, B. 343, 2800 Kgs. Lyngby, Denmark, Department Of Photonics Engineering, O rsteds Plads, B. 343, 2800 Kgs. Lyngby, Denmark, Kgs. Lyngby, Denmark; 3Keysight Technologies, Hamburg, Germany
A machine learning framework for predicting auto-correlation functions of inter-channel nonlinearities within the uncompensated optical fiber link is proposed. Low generalization error is obtained on the test data.

09:30 W.1.D.5 Invited
Fiber Nonlinearity Mitigation in WDM Systems: Strategies and Achievable Rates
Marco Secondini1; Erik Agrell2; Enrico Forestieri1; Domenico Marsella3
1TeCIP Institute, Scuola Superiore Sant'Anna, Pisa, Italy; 2Department of Electrical Engineering, Chalmers University of Technology, Gothenburg, Sweden; 3Nokia (with Scuola Superiore Sant'Anna at the time of this research), Vimercate (MB), Italy
After reviewing models and mitigation strategies for interchannel nonlinearity, the synergic effect of symbol-rate optimization and phase-noise compensation is investigated. This effect can be practically exploited for nonlinearity mitigation and for the computation of capacity lower bounds.

W.1.E: Advances in Multi-Wavelength PON
Room F5 (SC8)
Chair: Philippe Chanclou Orange Labs, France

08:30 W.1.E.1
TWDM PON Preamble Engineering for Burst-Mode Frequency Drift Reduction Through Mitigation of a DFB Turn-On Blue Shift
Robert Borkowski; Wolfgang Poehlmann; Thomas Pfeiffer, Nokia Bell Labs, Stuttgart, Germany
We demonstrate two new schemes for DFB optical frequency drift reduction up to 13-GHz, which address issues of previously described methods. Density increase scheme requires only modification of digital data in the preamble and is therefore well-suited for product implementation.

08:45 W.1.E.2
Experimental Investigation into Burst-Mode Wavelength Drift of a Mass-Produced 10 Gbit/s EML for TWDM-PON
Takanori Kawanaka1; Tetsuro Ashida2; Satoshi Yoshima1; Masaki Noda1; Kuniaki Motoshima3 1Mitsubishi Electric Corporation, Information Technology R&D Center, Information Technology R&D Center, Kamakura; 2Mitsubishi Electric Corporation, Communication Network Center, Communication Network Center, Kamakura; 3Mitsubishi Electric Corporation, Communication System Group, Communication System Group, Kamakura, Japan
We demonstrate experimentally the burst-mode wavelength drift of a mass-produced 10Gbit/s EML for TWDM-PON. The peak drift of 36GHz satisfied the spectral mask defined in G.989.2 by adopting both a ramped 500ns turn-on signal and an initially red-shifted central wavelength.

09:00 W.1.E.3
Colourless Self-Seeded Source for CPRI3 Mobile Fronthaul over 70 km Reach
Mathilde Gay1; Kamal Hussain2; Claude Le Bouëtté3; Jean-Luc Pamart3; Laurent Schoch3; Christelle Aupetit-Berthelemot4; Li Ao4; Vahid Meghdadi4; Romain Brenot5; Anahélle Maho5; Philippe Chanclou6; Sylvain Barthomeuf6; Fabienne Saliou6 1Foton laboratory, UMR 6082, CNRS, University of Rennes 1, UMR 6082, CNRS, University of Rennes 1, Lannion; 2Foton laboratory, UMR 6082, CNRS, University of Rennes 1, UMR 6082, CNRS, University of Rennes 1, lannion; 3Ekinops, lannion; 4Xlim, Limoges; 5III-V Labs, Marcoussis; 6Orange Labs, lannion, France
We demonstrate field trial CPRI3 error-free transmission over field fibre at 2.5 Gbit/s with DWDM self-seeded RSOAs in the O-band. The use of FEC in transponders enables to achieve 30 dB optical budget and up to 70 km reach.

09:15 W.1.E.4
Performance Evaluation of Next-Generation Elastic Backhaul with Flexible VCSEL-based WDM Fronthaul
K Kondepu1; J Zou2; Arash Farhadi Beldachi1; Hung Kai Chen3; Christopher Chase3; Michael Huang3; Emilio Hugues Salas1; J Garcia Espin4; A Tzanakaki5; R Nejabati1; Michael Eiselt2; D Simeonidou1
1University of Bristol, Bristol, UK; 2ADVA Optical Networking SE, Meiningen, Germany; 3Bandwidth10, LTD, Berkeley, USA; 4Bristol Is Open LTD, Bristol, UK; 5University of Bristol, National & Kapodistrian University of Athens, GR, National & Kapodistrian University of Athens, GR, Bristol, UK
We experimentally demonstrate that 5G network stringent delay and bandwidth requirements can be satisfied adopting a novel optical network architecture, utilising flexible optical time slot switching, programmable optical interfaces and VCSEL-based WDM technologies, in a city-based field trial.

09:30 W.1.E.5
Remote Management and Control of WDM-PON System for Fronthaul in Cloud-Radio Access Networks
Kyosuke Sone1; Goji Nakagawa1; Shoichiro Oda2; Motoyuki Takizawa1; Yoshio Hirose1; Takeshi Hoshida1
1Fujitsu Limited, Kawasaki; 2Fujitsu Laboratories Ltd., Kawasaki, Japan
We develop an evaluation platform of remote management and control for WDM-PON system and successfully demonstrate an ONU activation operation by means of exchanging AMCC signals superimposed on both downstream and upstream main signals.

09:45 W.1.E.6
Development of Evaluation Platform of AMCC Superimposition on CPRI Signal Transmission for Mobile Fronthaul Network
Goji Nakagawa1; Kyosuke Sone1; Shoichiro Oda2; Setsuo Yoshida2; Yoshio Hirose1; Motoyuki Takizawa1; Takeshi Hoshida1
1Fujitsu Limited, Kawasaki; 2Fujitsu Laboratories Ltd., Kawasaki, Japan
We developed the FPGA based evaluation platform of AMCC superimposition that communicate to CPRI transport tester, and systematically clarified the superimposition characteristics by evaluating several types of superimposition and detection scheme.

W.1.F: High-Performance ICs for Photonics
Room F6 (SC4)
Chair: Niels Quack, École Polytechnique Fédérale de Lausanne, Switzerland

08:30 W.1.F.1 Invited
High Performance Electronics for High-speed Optical Transceivers in Datacom and Telecom Applications
Jean-Yves Dupuy; Agnieszka Konczykowska; Filipe Jorge; Muriel Riet; Virginie Nodjiadjim, III-V Lab, PALAISEAU, France
We review latest performances, barriers and trends ahead in high performance electronics for terabit optical transceivers in datacom and telecom applications. Relevant semiconductor technologies are benchmarked and the advantages of InP DHBT for performance-critical applications are highlighted through selected circuits.

09:00 W.1.F.2
Ultra-Low Power SiGe 2-bit DAC Driver for InP-IQ Mach-Zehnder Modulator
Jung Han Choi; Marko Gruner; Xiao Jiang; Alexander Batoulis Fraunhofer Heinrich-Hertz-Institute, Berlin, Germany
A small footprint InP-IQ Mach-Zehnder Modulator TOSA with an ultra-low power SiGe 2-bit DAC driver with a power efficiency of 2.27 pJ/bit is demonstrated. EVM of 4.76 % was obtained for 16-QAM at 32 GBd. Each DAC driver consumes 146mW.

09:15 W.1.F.3
A 180-mW Linear MZM Driver in CMOS for Single-Carrier 400-Gb/s Coherent Optical Transmitter
Shinsuke Nakano1; Munehiko Nagatani1; Kenji Tanaka1; Yoshihiro Ogiso2; Josuke Ozaki2; Hiroshi Yamazaki1; Hideyuki Nosaka1
1NTT Device Technology Labratories, Atsugi; 2NTT Device Innovation Center, Atsugi, Japan
We developed a 56-GHz-bandwidth 2.0-Vppd linear MZM driver in 65-nm CMOS. It consumes only 180 mW for driving a 50-ohm impedance. We demonstrated the feasibility of drivers with less than 1 W for dual-poralization IQ modulation in 400-Gb/s systems.

09:30 W.1.F.4 Invited
Advanced Silicon Photonics Transceivers
Yannick De Koninck; Peter De Dobbelaere; Attila Mekis Luxtera Inc, Carlsbad, USA
In this paper we discuss the different aspects of designing and manufacturing advanced silicon photonics transceivers and focus on utilizing the experience and infrastructure from the CMOS industry. As an example, we discuss the implementation of a 100G CWDM-2 transceiver.

10:00 - 10:30 COFFEE EXHIBITION HALL

W.2.A: Cloud and Data Centre Networking
Room F1 (SC7)
Chair: Tom Issenhuth, Microsoft, USA

10:30 W.2.A.1 Invited
Could the Transformation to Cloud-Optimized Networking be Opening a New Era for Dynamic Optical Networking?
Kevin Sparks, Nokia Bell Labs, Westford, Massachusetts, USA
Poised to elevate the automated digital economy, new high performance global-scale applications will leverage distributed clouds, network programmability and multi-operator federation. Effective realizations require cohesive multi-layer management of agile reusable resources, driving the necessity for a dynamic optical networking foundation.

11:00 W.2.A.2
Hadoop-based Application Triggered Automatic Flow Switching in Electrical/Optical Hybrid Data-Center Network
Masayuki Hirono; Wataru Muro; Shu Sekigawa; Takehiro Sato; Satoru Okamoto; Naoaki Yamanaka, University of Keio, Yokohama, Japan
A Hadoop-based application triggered automatic flow switching method is proposed and examined in the hybrid electrical/optical data-center network environment. How to determine a shuffle-heavy job in the Hadoop cluster is investigated.

11:15 W.2.A.3 Highly ranked paper
Cloud-BOSS Intra-Data Center Network: on-Demand QoS Guarantees via us Optical Slot Switching
Jose Manuel Estaran Tolosa1; Eric Dutisseuil1; Haik Mardoyan1; Guilhem De Valicourt2; Arnaud Dupas1; Quan Pham Van1; Dominique Verchere1; Bogdan Uscumlic1; Po Dong2; Young-Kai Chen2; Sébastien Bigo1; Yvan Pointurier1
1Nokia Bell Labs, Nozay, France; 2Nokia Bell Labs, Holmdel, USA
We propose Cloud-BOSS, an intra-data center network leveraging original optical components and custom SDN control to enable sub-wavelength network slicing and on-demand QoS guarantees. We demonstrate a 3-ToR real-time prototype

11:30 W.2.A.4
COSIGN : A Complete SDN Enabled All-Optical Architecture for Data Centre Virtualisation with Time and Space Multiplexing
Chris Jackson1; Koteswararao Kondepu1; Yanni Ou1; Arash Farhadi Beldachi1; Albert Pagès Cruz2; Fernando Agraz2; Francesca Moscatelli3; Wong Miao4; Valerija Kamchevska5; Nicola Calabretta4; Giada Landi3; Salvatore Spadaro2; Reza Nejabati6; Dimitra Simeonidou1
1University of Bristol, Bristol, UK; 2Universitat Politècnica de Catalunya, Barcelona, Spain; 3Nextworks, Pisa, Italy; 4Technische Universiteit Eindhoven, Eindhoven, Netherlands; 5Danmarks Tekniske Universiteit, Copenhagen, Denmark; 6University of Bristol, University of Bristol, University of Bristol, Bristol, UK
We present a Data Centre Virtualisation architecture with an SDN-controlled all-optical data plane combining OCS and TSON. Orchestration dynamically translates and provisions Virtual Data Centres requests onto the optical layer. We describe an implementation and characterisation of the data plane.

11:45 W.2.A.5 Highly ranked paper
IoT-aware Multi-layer Transport SDN and Cloud Architecture for Traffic Congestion Avoidance Through Dynamic Distribution of IoT Analytics
Raul Muñoz1; Ricard Vilalta1; Noboru Yoshikane2; Ramon Casellas1; Ricardo Martínez1; Takehiro Tsuritani2; Itsuro Morita2
1CTTC, Castelldefels, Spain; 2KDDI Research, Saitama, Japan
We present and experimentally assess the first IoT-aware SDN and cloud architecture that deploys IoT flow monitoring and traffic-congestion avoidance techniques in order to dynamically and efficiently distribute the processing of IoT analytics from core datacentres to the network edge

W.2.B: Access Technologies for 25 G and Beyond
Room F2 (SC8)
Chair: Derek Nesset, Huawei, UK

10:30 W.2.B.1 Highly ranked paper
A 25 Gb/s All-Digital Clock and Data Recovery Circuit for Burst Mode Applications in PONs
Marijn Verbeke1; Pieter Rombouts2; Hannes Ramon1; Guy Torfs1; Johan Bauwelinck1; Xin Yin1
1Department of Information Technology (INTEC), IDLab, Ghent University - imec, Gent; 2Department of Electronics and Information Systems (ELIS), Ghent University, Gent, Belgium
This all-digital clock and data recovery circuit avoids the need of a system clock or a start-of-burst signal and provides a burst-mode lock time of 35ns. The circuit occupies a compact active chip area of 0.050mm2 and consumes only 46mW.

10:45 W.2.B.2 Highly ranked paper
Hybrid III-V on Silicon Integrated Distributed Feedback Laser and Ring Resonator for 25 Gb/s Future Access Networks
Antonin Gallet; Guillaume Levaufre; Alain Accard; Dalila Make; Jean-Guy Provost; Romain Brenot; Alexandre Shen; Nadine Lagay; Jean Decobert; Stéphane Malhouitre; Ségolène Olivier; Guang-Hua Duan
3-5 Lab, Palaiseau, France
We report on a fully integrated hybrid III-V on silicon distributed feedback laser integrated with a ring resonator, which enables direct modulation at 25 Gb/s with 20dB optical budget at 20km and 5dB extinction ratio

11:00 W.2.B.3
Improvement on Received Optical Power Based Flexible Modulation in a PON by the Use of Non-Uniform PAM
Robbert Van Der Linden1; Nguyen-Cac Tran2; Eduward Tangdiongga3; Ton Koonen3
1Eindhoven University of Technology, Genexis B.V., Genexis B.V., Eindhoven; 2Genexis B.V., Eindhoven; 3Eindhoven University of Technology, Eindhoven, Netherlands
Non-uniform PAM4 utilizes unequal distances between constellation points. The MSB can be decoded with lower SNR than the LSB. In PONs with a spread in received optical powers, more ONUs are able to decode non-uniform PAM4 compared to normal PAM4.

11:15 W.2.B.4
Demonstration of 50Gbps IM/DD PAM4 PON over 10GHz Class Optics Using Neural Network Based Nonlinear Equalization
Chenhui Ye; Dongxu Zhang; Xiaoan Huang; Hanlin Feng; Kaibin Zhang
Nokia Shanghai Bell, Shanghai, China
We apply digital back propagation based neural network regression algorithms as the nonlinear equalization approach, and realize up to 50Gb/s PAM4 IM/DD PON transmission for 20km fibre using 10GHz optics within an overall end-to-end 3.6GHz 3-dB bandwidth.

11:30 W.2.B.5
Raman Amplification for O-band 25Gbps PAM-4 and Duobinary Using 10G Optics
Cleitus Antony; Marco Dalla Santa; Giuseppe Talli; Paul Townsend
Tyndall National Institute, University College Cork, University College Cork, Cork, Ireland
We demonstrate a 42dB loss budget, enabling 40km transmission in O-band and 1:64 splits, with 25Gb/s PAM-4 and EDB modulation using 10G-Class DML and Raman amplification provided by quantum dot based laser diode pumps.

11:45 W.2.B.6
15-Gbaud PAM4 Digital Mobile Fronthaul with Enhanced Differential Pulse Coding Modulation supporting 122 LTE-A Channels with up to 4096QAM
Lu Zhang1; Xiaodan Pang1; Oskars Ozolins2; Aleksejs Udalcovs2; Richard Schatz3; Urban Westergren3; Gunnar Jacobsen2; Sergei Popov3; Shilin Xiao4; Jiajia Chen1
1KTH Royal Institute of Technology, School of ICT, School of ICT, Kista, Sweden; 2RISE Acreo AB, Networking and Transmission Laboratory, Networking and Transmission Laboratory, Kista, Sweden; 3KTH Royal Institute of Technology, School of SCI, School of SCI, Kista, Sweden; 4Shanghai Jiao Tong University, State Key Laboratory of Advanced Optical Communica, State Key Laboratory of Advanced Optical Communica, Shanghai, China
By employing enhanced DPCM, 15-Gbaud PAM4 digital mobile fronthaul is experimentally demonstrated to support 122 LTE-A channels with up to 4096QAM. Compared to PCM based CPRI, the supported number of channels increases 5 times and EVM is obviously improved.

W.2.C: Integrated Si Photonics II
Room F3 (SC2)
Chair: Takuo Tanemura, University of Tokyo, Japan

10:30 W.2.C.1
Ultra-Compact Silicon Multimode Bent Waveguide with Ultralow Inter-Mode Crosstalk
Chunlei Sun; Yu Yu; Songnian Fu; Xinliang Zhang, Huazhong University of Science and Technology, Wuhan, China
We experimentally demonstrate a sharply bent (5 μm radius) multimode waveguide with inter-mode crosstalk of < -22 dB from 1500 to 1600 nm. By contract, a comparable performance can be equivalently achieved using conventional scheme with 40 μm radius.

10:45 W.2.C.2
Monolithically Integrated Silicon Hybrid Demultiplexer with Improved Loss and Crosstalk Suppression
Jing Wang; Shupeng Deng; Chi Yan Wong; Yida Wen; Wei Wei; Tao Wang; Gordon Ning Liu; Lei Liu, Huawei Technologies Co., Ltd., Shenzhen, China
We reported a high-performance silicon hybrid demultiplexer which simultanously enables 4 mode channels and 8 wavelength channels. Double-etched mode converter and wide arrayed waveguide are used to improve AWG performances while the counter-tapered coupler is optimized for broadband mode multiplexing.

11:00 W.2.C.3
On-chip Silicon Three-mode (De)Multiplexer Employing Subwavelength Grating Structure
Yu He; Yong Zhang; Xinhong Jiang; Ciyuan Qiu; Yikai Su
Shanghai Jiao Tong University, Shanghai, China
We propose and experimentally demonstrate a silicon three-mode (de)multiplexer using subwavelength grating structure. The three channels show < -16.3 dB crosstalk values and <3.8 dB insertion losses at 1550 nm.

11:15 W.2.C.4
Mach-Zehnder Mode/Wavelength (De)Multiplexer for WDM/MDM Optical Transmission
Shun Ohta1; Takeshi Fujisawa1; Shuntaro Makino1; Taiji Sakamoto2; Takashi Matsui2; Kyozo Tsujikawa2; Kazuhide Nakajima2; Kunimasa Saitoh1
1Graduate School of Information Science and Technology, Hokkaido University, Sapporo; 2NTT Access Network Service Systems Laboratories, NTT Corporation, Tsukuba, Japan
We propose and experimentally demonstrate a low-loss and low-crosstalk Mach-Zehnder mode/wavelength multi/demultiplexer for WDM/MDM transmission. A broadband 3dB mode divider, which is also newly devised here, makes it possible to compose Mach-Zehnder filter for “mode” and “wavelength” simultaneously.

11:30 W.2.C.5 Invited
Challenges in Silicon Photonics Process Technology
Frederic Boeuf1; Nathalie Vulliet1; Charles Baudot1; Sonia Messaoudene2; Elise Baylac1; Sebastien Cremer1
1STMicroelectronics, Crolles; 2CEA Grenoble, LETI-DOPT, LETI-DOPT, Crolle, France
In this paper we discuss the specific challenges of process integration of Si-Photonics for the current and future applications, including lithography, etching and heterogeneous materials integration.

W.2.D: DSP for Short-Reach Transmission
Room F4 (SC3)
Chair: Dan Sadot, Ben Gurion University, Israel

10:30 W.2.D.1 Invited
DSP for Short Reach Optical Links
Jens Rasmussen1; Tomislav Drenski2
1Socionext Europe GmbH, Langen; 2Socionext Europe GmbH, Maidenhead, UK
Digital Signal Processor (DSP) topologies and associated technologies for optical transceivers using data-rates ≥100Gbit/s to enable SMF transmission of 10 to 100km are reviewed and trade-offs discussed in the context of evolving requirements and future technical advances.

11:00 W.2.D.2
Employing Deep Neural Network for High Speed 4-PAM Optical Interconnect
Chun-Yan Chuang1; Chia-Chien Wei2; Tien-Chien Lin1; Kai-Lun Chi3; Li-Chun Liu1; Jin-Wei Shi3; Young-Kai Chen4; Jyehong Chen5 1National Chiao Tung University, Department of Photonics, Department of Photonics, Hsinchu City, Taiwan; 2National Sun Yat-sen University, Department of Photonics, Department of Photonics, Kaohsiung City, Taiwan; 3National Central University, Department of Electrical Engineering, Department of Electrical Engineering, Taoyuan, Taiwan; 4Bell Labs, Alcatel-Lucent at Murray Hill, New Jersey, USA; 5National Chiao Tung University, Hsinchu City, Taiwan
We implement a deep neural network (DNN) to attain a 64-Gbps 4-PAM, 4-km MMF link by using 850-nm VCSEL, with BER of 4.41x10^-5. The data-rate-distance product achieves recorded high of 256-Gbps km for Inter-data center applications.

11:15 W.2.D.3
Joint Optimisation of Resampling Rate and Carrier-to-Signal Power Ratio in Direct-Detection Kramers-Kronig Receivers
Zhe Li; M. Sezer ErkılınÇ; Kai Shi; Eric Sillekens; Lidia Galdino; Benn Thomsen; Polina Bayvel; Robert Killey, University College London, London, UK
We investigate the effect of varying the DSP resampling rate and the carrier-to-signal power ratio on the performance of direct-detection Kramers-Kronig receivers, through experiments on 4×112 Gb/s SSB Nyquist-SCM transmission over 240 km.

11:30 W.2.D.4 Highly ranked paper
4 x 240 Gb/s Dense WDM and PDM Kramers-Kronig Detection with 125-km SSMF Transmission
Xi Chen1; Cristian Antonelli2; Sethumadhavan Chandrasekhar1; Greg Raybon1; Antonio Mecozzi2; Mark Shtaif3; Peter Winzer1 1Nokia Bell Labs, Holmdel, USA; 2University of L'Aquila, L'Aquila, Italy; 3Tel Aviv University, Tel Aviv, Israel
We demonstrate dense wavelength- and polarization-multiplexed (WDM/PDM) 125-km standard single-mode fiber (SSMF) transmission using Kramers-Kronig receivers. The 4 x 240-Gb/s system at 5.3 bits/s/Hz on a 37.5-GHz grid is tolerant to a ±8.5-GHz filter frequency drift

11:45 W.2.D.5
Twin-SSB Direct Detection Transmission over 80km SSMF Using Kramers-Kronig Receiver
Sujie Fan1; Qunbi Zhuge2; Mohammed Sowailem3; Mohamed Osman3; Thang Hoang3; Fangyuan Zhang3; Meng Qiu3; Yan Li4; Jian Wu4; David Plant3
1Beijing University of Posts and Telecommunications, McGill University, McGill University, Beijing, China; 2McGill University, Ciena Corporation, Ciena Corporation, Montreal, Canada; 3McGill University, Montreal, Canada; 4Beijing University of Posts and Telecommunications, Beijing, China
We propose a spectrally efficient and cost-effective twin-SSB system based on Kramers-Kronig optical phase reconstruction, and demonstrate an 88.3Gbit/s net bitrate with 40GSa/s DACs over 80km SSMF at 1550nm with a BER threshold of 3.8e-3.

W.2.E: Nonlinear Transmission and Compensation
Room F5 (SC6)
Chair: Magnus Karlsson, Chalmers University of Technology, Sweden

10:30 W.2.E.1 Tutorial
Nonlinear Fourier Transform Based Transmission
Sergei Turitsyn, Aston University, Aston Institute of Photonic Technologies, Aston Institute of Photonic Technologies, Birmingham, UK
The nonlinear Fourier transform is a transmission and signal processing technique that makes positive use of the nonlinearity of fibre channels. This tutorial provides an introduction into the NFT-based methods and overview of recent progress and challenges in this field.

11:30 W.2.E.2 Invited
Distributed Nonlinear Compensation using Optoelectronic Circuits
Arthur Lowery; Benjamin Foo, Monash University, Dept. Elec. & Comp. Syst. Eng., Dept. Elec. & Comp. Syst. Eng., Clayton, Australia
We review our progress in using few-gigahertz-bandwidth optoelectronic circuits to compensate for cross-phase modulation between widely spaced WDM channels. This technique is suitable for distributed nonlinearity compensation, so suits networks with ROADMs.

W.2.F: Few-Mode Fibres and Amplifiers
Room F6 (SC1)
Chair: Kunimasa Saitoh, Hokkaido University, Japan

10:30 W.2.F.1 Invited
Weakly-coupled Few-Mode Fibers and their Applications
Guifang Li1; He Wen2; Huang Yu3; Pierre Sillard4; Rodrigo Amezcua Correa1
1University of Central Florida, Orlando, USA; 2Tianjin University, Tianjin, China; 3Wuhan Research Institute of Posts and Telecommunications, Wuhan, China; 4Prysmian, Flandres, France
We present design strategies for weakly-coupled few-mode fibers and their representative applications in passive optical networks, interconnects for datacenters and transmission of analog signals.

11:00 W.2.F.2
Polarization Insensitive Wavelength Conversion in a Few Mode Fibre
Francesca Parmigiani1; Massimiliano Guasoni1; Omar Anjum1; Peter Horak1; Yongmin Jung1; Lars Grüner-Nielsen2; Periklis Petropoulos1; David J Richardson1
1Optoelectronics Research Centre, University of Southampton, University of Southampton, Southampton, UK; 2Danish Optical Fiber Innovation, Brønshøj, Denmark
We experimentally demonstrate stable inter-modal four-wave-mixing in a 1-km-long elliptical-core three mode fibre in the C- and L-bands. The chosen asymmetric pump configuration allows for a signal conversion efficiency sensitivity to polarisation of less than 2 dB.

11:15 W.2.F.3
Demonstration of Mode Scramblers Supporting 6 Spatial Modes to Reduce Differential Group Delays
Haoshuo Chen1; Nicolas Fontaine1; Bin Huang1; Roland Ryf1; Ian Giles2
1Nokia Bell Labs, 791 Holmdel Rd., 791 Holmdel Rd., Holmdel, USA; 2Phoenix Photonics Ltd., Kent, Uk
We demonstrate a mode scrambler for mixing 6 spatial modes. We present the characterization results of mode-dependent loss and modal transfer matrix using a swept-wavelength interferometer and verify group-delay spread reduction through principal mode analysis.

11:30 W.2.F.4
Dual C+L-Band Six-Mode Optical Amplifier with Widely Erbium-Doped Fibre
Yuta Wakayama1; Daiki Soma1; Koji Igarashi2; Hidenori Taga1; Takehiro Tsuritani1
1KDDI Research, Inc., Fujimino; 2Osaka University, Suita, Japan
We develop and characterize a cladding-pumped C+L-band six-mode EDFA with wide-area erbium-doped EDF. More than 16 dB gain was obtained with a differential modal gain of less than 5 dB across C+L band.

11:45 W.2.F.5 Highly ranked paper
Gain-Clamped 4-LP mode Erbium Doped Fibre Amplifier with Low Modal Gain Variation
Masaki Wada1; Shinichi Aozasa1; Taiji Sakamoto1; Takayoshi Mori1; Takashi Yamamoto1; Kazuhide Nakajima2
1NTT, Ibaraki; 2NTT, Iabraki
A ring resonator based gain-clamped 4-LP mode EDFA is demonstrated for the first time. Low modal gain variation, less than 1 dB, is achieved for surviving channel for all modes when one of the modal channels is activated/deactivated.

12:00 - 13:30 LUNCH BREAK

W.3.A: Machine Learning and Artificial Intelligence
Room F1 (SC7)
Chair: Dimitris Apostolopoulos, National Technical University of Athens, Greece

13:30 W.3.A.1
Quality of Transmission Prediction with Machine Learning for Dynamic Operation of Optical WDM Networks
Payman Samadi1; Djamel Amar2; Catherine Lepers2; Mounia Lourdiane2; Keren Bergman1
1Columbia University, New York, USA; 2Telecom SudParis, Paris, France
We propose a cognitive scalable method based on neural networks to address dynamic and agile provisioning of optical physical layer without prior knowledge of network specifications. Experimental demonstrations on a mesh network achieve 90th percentile OSNR prediction of 0.25dB Root-Mean-Squared-Error.

13:45 W.3.A.2
Robust Self-learning Physical Layer Abstraction Utilizing Optical Performance Monitoring and Markov Chain Monte Carlo
Fanchao Meng; Shuangyi Yan; Rui Wang; Yanni Ou; Yu Bi; Reza Nejabati; Dimitra Simeonidou, University of Bristol, Bristol, UK
We model and experimentally demonstrate a self-learning abstraction process based on statistical assessment of the real-time monitoring data, both amplifier and non-linear noise parameters are periodically updated which further enables an accurate QoT estimator.

14:00 W.3.A.3
Leveraging Deep Learning to Achieve Knowledge-based Autonomous Service Provisioning in Broker-based Multi-Domain SD-EONs with Proactive and Intelligent Predictions of Multi-Domain Traffic
Xiaoliang Chen1; Jiannan Guo2; Zuqing Zhu2; Alberto Castro1; Roberto Proietti1; Hongbo Lu1; Mohammadsadegh Shamsabardeh1; S.J.Ben Yoo1
1University of California, Davis, Davis, USA; 2University of Science and Technology of China, Hefei, China
This paper demonstrates a knowledge-based autonomous service provisioning framework enabled by a deep learning based traffic estimator for broker-based multi-domain SD-EONs. Simulation results show that the proposed framework achieves ~ 91% traffic prediction accuracy and ~ 9x blocking reduction.

14:15 W.3.A.4 Upgraded
TSDN-Enabled Network Assurance: A Cognitive Fault Detection Architecture
Danish Rafique; Thomas Szyrkowiec; Helmut Grießer; Achim Autenrieth; Jörg-Peter Elbers, ADVA OPTICAL NETWORKING, Fraunhoferstr. 9a, Munich/Martinsried, Germany
We propose and demonstrate a cognitive fault detection architecture for intelligent network assurance. Our framework both detects and identifies significant faults, and outperforms conventional fixed threshold-triggered operations, both in terms of detection accuracy and proactive reaction time.

14:45 W.3.A.5
Experimental Assessment of A Flow Controller for Dynamic Metro-Core Predictive Traffic Models Estimation
Fernando Morales1; Lluis Gifre2; Francesco Paolucci3; Marc Ruiz1; Filippo Cugini4; Luis Velasco1; Piero Castoldi3
1Universitat Politècnica de Catalunya (UPC), Barcelona, Spain; 2Universidad Autónoma de Madrid (UAM), Spain, Madrid; 3Scuola Superiore Sant'Anna, Pisa, Italy; 4CNIT, Pisa, Italy
A Flow Controller is proposed and experimentally assessed to share updated metro-flow predictive traffic models among metro and core controllers. The proposed controller allows a fast core flow traffic models re-estimation after flow traffic re-routing in metro areas.

W.3.B: Single-Core and Multi-Core Fibre Transmission
Room F2 (SC1)
Chair: Pierre Sillard, Prysmian Group, France

13:30 W.3.B.1 Invited
Frequency Stabilization and its Implication in Optical Networks
Stojan Radic, University of California San Diego, La Jolla, USA
Stable carrier frequency is taken for granted in wireless networks. With advent of optical frequency comb technology, it is possible not only to mimic established wireless techniques in optical domain but also to introduce new, hybrid processing technology.

14:00 W.3.B.2
Experimental Investigation on the Effect of Central Wavelength Tuning of FBG-Based Phase Shifter for Raman-Assisted Phase Sensitive Amplifier
Yinwen Cao1; Haoqian Song1; Youichi Akasaka2; Ahmed Almaiman1; Amirhossein Mohajeri Ariaei1; Changjing Bao1; Peicheng Liao1; Fatemeh Alishahi1; Ahmad Fallahpour1; Tadashi Ikeuchi2; Dmitry Starodubov1; Joe Touch3; Alan Willner1
1University of Southern California, Los Angeles; 2Fujitsu Laboratories of America, Richardson; 3Information Sciences Institute, Marina del Rey, USA
A FBG-based pump-phase-shifter is used in the Raman-assisted PSA. By actively tuning the FBG central-wavelength to enable pump phase optimization, up-to-5.6dB signal gain is observed. An improvement of ~6% EVM and ~4dB system sensitivity is observed by 20/25-Gbaud QPSK signals.

14:15 W.3.B.3
Long-Haul Optical Transmission of 16-QAM Signal with In-Line Phase-Sensitive Amplifiers
Samuel Olsson1; Magnus Karlsson2; Peter Andrekson2
1Nokia Bell Labs, Chalmers University of Technology, Chalmers University of Technology, Holmdel, USA; 2Chalmers University of Technology, Gothenburg, Sweden
We demonstrate transmission of a 10 GBd 16-QAM signal with low-noise in-line phase-sensitive amplifiers in a recirculating loop experiment. A fourfold reach improvement is obtained at optimal launch powers using phase-sensitive amplification compared to phase-insensitive amplification.

14:30 W.3.B.4
Characteristic of Splicing Misalignment Induced Mode Dependent Loss for Coupled Multi-core Fibre
Taiji Sakamoto; Takayoshi Mori; Masaki Wada; Azusa Urushibara; Takashi Yamamoto; Shinichi Aozasa; Saki Nozoe; Yuto Sagae; Kyozo Tsujikawa; Kazuhide Nakajima, NTT Corporation, Tsukuba, Japan
We have revealed numerically and experimentally that coupled multi-core fibre can realize a smaller mode dependent loss than few-mode fibre as regards splicing misalignment, which is beneficial for constructing large capacity and high spatial density transmission links.

14:45 W.3.B.5
Analysis of Few-Mode Multi-Core Fiber Splice Behavior Using an Optical Vector Network Analyzer
Simon Rommel1; José Manuel Delgado Mendinueta2; Werner Klaus2; Jun Sakaguchi2; Juan José Vegas Olmos3; Yoshinari Awaji2; Idelfonso Tafur Monroy4; Naoya Wada2 1National Institute of Information and Communications Technology (NICT), Technical University of Denmark, Technical University of Denmark, Koganei, Japan; 2National Institute of Information and Communications Technology (NICT), Koganei, Japan; 3Mellanox Technologies, Roskilde, Denmark; 4Technical University of Denmark, Kgs. Lyngby, Denmark
The behavior of splices in a 3-mode 36-core fiber is analyzed using optical vector network analysis. Time-domain response analysis confirms splices may cause significant mode-mixing, while frequency-domain analysis shows splices may affect system level mode-dependent loss both positively and negatively.

W.3.C: Eigenvalue Communication Systems
Room F3 (SC3)
Chair: Darko Zibar, Technical University of Denmark, Denmark

13:30 W.3.C.1
Discrete Darboux based Fast Inverse Nonlinear Fourier Transform Algorithm for Multi-solitons
Shrinivas Chimmalgi; Sander Wahls, Delft Center for Systems and Control, TU Delft, Delft, Netherlands
A fast algorithm for constructing multi-solitons with linear complexity in the number of samples and eigenvalues is introduced. The algorithm is shown to be significantly faster than the conventional Darboux transform in a numerical example, with acceptable error.

13:45 W.3.C.2
Experimental Demonstration of Dual Polarization Nonlinear Frequency Division Multiplexed Optical Transmission System
Simone Gaiarin1; Auro Perego2; Edson Porto Da Silva1; Francesco Da Ros1; Darko Zibar1 1Technical University of Denmark, Kogens Lyngby, Denmark; 2Aston University, Birmingham, UK
Multi-eigenvalues transmission with information encoded simultaneously in both orthogonal polarizations is experimentally demonstrated. Performance below the HD-FEC limit is demonstrated for 8-bits/symbol 1-GBd signals after transmission up to 207 km of SSMF.

14:00 W.3.C.3 Highly ranked paper
125 Gbps Pre-Compensated Nonlinear Frequency-Division Multiplexed Transmission
Son Le; Vahid Aref; Henning Buelow, Nokia Bell Labs, Stuttgart, Lorenzstrasse 10, Germany
Record-high data rate of 125 Gb/s and SE over 2 bits/s/Hz in burst-mode single-polarization NFDM transmissions were achieved over 976 km of SSMF with EDFA-only amplification by transmitting and processing 222 32 QAM-modulated nonlinear subcarriers simultaneously

14:15 W.3.C.4
Comparison of the Nonlinear Frequency Division Multiplexing and OFDM in Experiment
Mansoor Yousefi1; Wasyhun Gemechu1; Mengdi Song1; Yves Jaouen1; Stefan Wabnitz2
1Telecom ParisTech, Paris, France; 2Università degli Studi di Brescia, Brescia, Italy
Nonlinear frequency-division multiplexing is compared with OFDM in experiment. NFDM exhibits a peak Q-factor gain of 0.7 dB (1 dB in SNR) over OFDM, in an experiment using normal dispersion fiber with 16QAM modulation, 16 Gbd, 32 sub-carriers and 1400km.

14:30 W.3.C.5
Optimal Launch and Detection Points for the NFT-based Communication System with Lumped Amplification
Morteza Kamalian Kopae1; Jaroslaw Prilepsky1; Son Le2; Sergei Turitsyn1
1Aston University, Aston Institute of Photonic Technologies, Aston Institute of Photonic Technologies, Birmingham, UK; 2Nokia Bell Labs, Stuttgart, Germany
Based on the path-average theory, we define the optimal launch and detection points in nonlinear Fourier transform based communication systems with lumped amplification to minimise the distortions of the non-ideal channel and to improve significantly the overall transmission performance.

14:45 W.3.C.6
Generation of Time-Limited Signals in the Nonlinear Fourier Domain via b-Modulation
Sander Wahls, TU Delft, Delft, Netherlands
Current modulation techniques for the nonlinear Fourier spectrum do not offer explicit control over the pulse duration in the time domain. To address this issue, it is proposed to modulate the b-coefficient instead of the reflection coefficient.

W.3.D: Emerging Trends for Future Access Networks
Room F4 (SC8)
Chair: Eduward Tangdiongga, COBRA – TU Eindhoven, Netherlands

13:30 W.3.D.1 Invited
Flexible Access System Architecture to Support Diverse Requirements and Agile Service Creation
Jun-Ichi Kani; Manabu Yoshino; Toshikiyo Tanaka; Kota Asaka; Hirotaka Ujikawa; Ken-Ichi Suzuki; Akihiro Otaka, NTT Access Network Service Systems Laboratories, Yokosuka, Japan
This paper summarizes our studies on the Flexible Access System Architecture (FASA) which will support a wide range of services and stimulate new services in the next generation; its overview and technical challenges are described.

14:00 W.3.D.2 Highly ranked paper
Long-reach TWDM PON for Fixed-Line Wireless Convergence
Cedric Lam; Xiangjun Zhao; Liang Du; Shuang Yin; Tao Zhang; Adam Barratt; Joy Jiang, Google Access, Mountain View, USA
We present a TWDM super-PON network with 768 users per-fibre and 60-km transmission distance; including a successful field trial of 606 production users. The proposed architecture also supports eight point-to-point users, enabling support of wireless sites and high-bandwidth applications.

14:15 W.3.D.3 Highly ranked paper
First-time Demonstration of Automatic Service Restoration by Using Inter-Central-Office OLT handover and Optical Path Switching in Metro-Access Network
Takuya Kanai1; Yumiko Senoo1; Kota Asaka1; Jun Sugawa2; Hideaki Tamai3; Hiroyuki Saito3; Naoki Minato3; Atsushi Oguri4; Seiya Sumita5; Takehiro Sato6; Nobuhiko Kikuchi2; Shun-Ichi Matsushita4; Takehiro Tsuritani5; Satoru Okamoto6; Naoaki Yamanaka6; Ken-Ichi Suzuki1; Akihiro Otaka1 1NTT Corporation, Kanagawa, Japan; 2Hitachi Ltd., Kanagawa, Japan; 3OKI Electric Industry Co., Ltd., Saitama, Japan; 4Furukawa Electric Co., Ltd., Chiba, Japan; 5KDDI Research, Inc., Saitama, Japan; 6Keio University, Kanagawa, Japan
The first demonstration of the service restoration technique for metro-access networks successfully shows that ONU accommodated by the disaster-stricken central office is automatically re-connected within 10 sec to another office 20-km away with the same throughput as before disaster.

14:30 W.3.D.4
Automatic Recovery from Estimation Error for Accommodation of TDD-based Fronthaul and Secondary Service in a TDM-PON
Daisuke Hisano; Hiroyuki Uzawa; Yu Nakayama; Tatsuya Shimada; Jun Terada; Akihiro Otaka, NTT Corporation, Yokosuka-city, Japan
We propose a novel automatic detection and recovery scheme for estimation error when accommodating TDD-based fronthaul and secondary services in a TDM-PON. We demonstrate experimentally that normal operation is restored in less than 14 ms.

14:45 W.3.D.5
Burst-Mode Coherent Detection Using Fast-Fitting Pilot Sequence for 100-Gb/s/lambda Coherent TDM-PON System
Ryosuke Matsumoto; Keisuke Matsuda; Naoki Suzuki, Mitsubishi Electric, Kamakura, Japan
We proposed a novel burst-mode coherent detection scheme for receiving 100-Gb/s DP-QPSK upstream signals. In 100 Gb/s/lambda-based coherent TDM-PON, a fast 816-ns burst-mode reception on individual wavelength ONUs was demonstrated with achieving a 33.0-dB loss budget.

W.3.E: Propagation and Characterisation
Room F5 (SC6)
Chair: Rob Smets, SURFnet, Netherlands

13:30 W.3.E.1
On the Accumulation of Non-Linear Interference in Multi-Subcarrier Systems
Andrea Carena; Fernando Guiomar, Politecnico di Torino, Torino, Italy
We study the accumulation of non-linear interference generated in uncompensated links by multi-subcarrier channels: at optimum symbol-rate we found an almost linear growth. This results allow a simplified non-linear modeling for this class of systems.

13:45 W.3.E.2
Experimental Investigation of the Impact of Minimizing Fourth-order Modulation Factor using Dispersion Optimization
Tobias Eriksson; Fred Buchali, Nokia Bell Labs, Stuttgart, Germany
We show that optimizing pre- and post-dispersion compensation can increase the section of low fourth-order modulation factor in the transmission link. In experiments, we demonstrate reach increase for 32 Gbaud PM-16QAM by using 25% to 50% pre-compensation of the dispersion.

14:00 W.3.E.3
Experimental Characterization of the Time Correlation Properties of Nonlinear Interference Noise
Ori Golani1; Daniel J Elson2; Domaniç Lavery2; Lidia Galdino2; Robert Killey2; Polina Bayvel2; Mark Shtaif1
1Tel Aviv University, Tel Aviv, Israel; 2University College London, London, UK
We demonstrate a method for experimentally characterizing the time-evolution statistics of NLIN. For the first time in an experimental setting strong temporal correlations are observed beyond the phase-noise NLIN component. Measuring these correlation is imperative for designing NLIN mitigation schemes.

14:15 W.3.E.4
Inter-Channel Crosstalk Compensation for Time-Frequency Packing Systems
Qian Hu; Fred Buchali; Laurent Schmalen; Wilfried Idler; Roman Dischler; Vahid Aref; Henning Buelow, Nokia Bell Labs, Stuttgart, Germany
We implement joint DSP to compensate the interference cross the channels in time-frequency packing system based on cross-channel equalization. The experiment shows 1.2 dB gain in OSNR penalty and 37% increase in reach with inter-channel interference compensation.

14:30 W.3.E.5
Inter-Core Crosstalk Spectrum and Penalty Measurements in 7-core Fiber
Benjamin Puttnam1; Georg Rademacher2; Ruben Luis2; Werner Klaus2; Yoshinari Awaji2; Naoya Wada2
1NICT, 4-2-1 Nukui-Kita, Koganei, 4-2-1 Nukui-Kita, Koganei, Tokyo, Japan; 2NICT, Tokyo, Japan
High-resolution spectrum measurements of inter-core crosstalk in a multi-core fiber show large power variation (>7 dB) in frequency components across the bandwidth of a 24.5 GBaud, but the subsequent performance penalty consistent with interference added in a coupler.

14:45 W.3.E.6
Two-dimensional quantum key distribution (QKD) protocol for increased key rate fiber-based quantum communications
Beatrice Da Lio; Davide Bacco; Yunhong Ding; Daniele Cozzolino; Kjeld Dalgaard; Karsten Rottwitt; Leif Katsuo Oxenløwe, DTU Fotonik, Kgs. Lyngby, Denmark
We experimentally prove a novel two-dimensional QKD scheme, relying on differential phase-time shifting (DPTS) of strongly attenuated weak coherent pulses. We demonstrate QKD transmission up to $170 km standard fiber, and even include a classical channel up to $90 km.

W.3.F: Mode-Division Multiplexing
Room F6 (SC4)
Chair: Michael Galili, Technical University of Denmark, Denmark

13:30 W.3.F.1 Tutorial
Components For Space-Division Multiplexing
Nicolas Fontaine, Nokia Bell Labs, USA
Amplifiers, spatial multiplexers, and routing elements that exploit spatial integration will reduce costs and complexity of future space-division multiplexed transmission systems. Managing spatial modes requires new components such as mode multiplexers, mixers, equalizers, and unscramblers.

14:30 W.3.F.2 Invited
Principal Modes in Multimode Fibre
Joel Carpenter, The University of Queensland, Brisbane, Australia
Principal modes are a unique basis which is free of first-order spatial mode dispersion. Although theoretically proposed decades ago, these special modes have only recently been observed experimentally. In this paper, principal mode theory, experimental results and applications are discussed.

15:00 - 15:30 COFFEE EXHIBITION HALL

SC5 - DATACOM AND COMPUTERCOM HARDWARE HALL F

P2.SC5.1
Bidirectional PAM-4 Experimental Proof-of-Concept to Double Capacity per Fiber in 2-km Data Center Links

Antonino Nespola[1]; Luca Bertignono[2]; Dario Pilori[2]; Fabrizio Forghieri[3]; Marco Mazzini[3]; Roberto Gaudino[2]
[1]Istituto Superiore Mario Boella, Torino; [2]Politecnico di Torino, Torino; [3]Cisco Photonics Italy srl, Vimercate (MB), Italy

We propose the use of bidirectional transmission to double the effective capacity over (each available) fiber in short-reach (2km) data-center links using direct-detection PAM-4. In particular, we experimentally show the conditions under which spurious reflections give a limited power penalty.

P2.SC5.2
A Simple Circuit-Level Model of Vertical-Cavity Surface-Emitting Lasers Working Over a Broad Temperature Range

Krzysztof Szczerba[1]; Chris Kocot[2]; Gary Landry[2]
[1]Finisar Corporation, Sunnyvale; [2]Finisar Corporation, Allen, USA

In this paper, we present a simple circuit-level VCSEL model working over a broad range of ambient temperatures, while accounting for self-heating effects. We present the static, dynamic small signal and dynamic large signal performance compared to measurement results.

P2.SC5.3
Low Power 15 Gbaud Silicon Photonic Link for Data Centres

Mark Power; Brian Murray; Stefano Facchin; Shiyu Zhou; Cleitus Antony; Cormac Eason; Carmelo Scarcella; Giuseppe Talli; Peter O'Brien; Peter Ossieur; Paul Townsend, Tyndall National Institute, University College Cork, University College Cork, Cork, Ireland

Novel low power silicon photonic PAM-4 transmitter and receiver, both operating at 15 Gbaud and with a combined power consumption of 10.1 pJ/Bit are demonstrated in an optical link with up to 40 km of SSMF using electronic dispersion compensation

P2.SC5.4
Tunable Orbital Angular Momentum (OAM) Conversion on 100Gb/s Real Data Traffic by Exploiting Concentric Waveguide Emitters

Mirco Scaffardi[1]; Ning Zhang[2]; Muhammad Nouman Malik[3]; Veronica Toccafondo[1]; Charalambos Klitis[2]; Martin Lavery[2]; Emma Lazzeri[4]; Andrea Sgambelluri[4]; Diego Marini[4]; Jiangbo Zhu[2]; Xinlun Cai[2]; Siyuan Yu6; Gianni Preve[1]; Marc Sorel[2]; Antonella Bogoni[3]
[1]CNIT, Pisa, Italy; [2]University of Glasgow, Glasgow, UK; [3]CNIT, Scuola Superiore Sant'Anna, Scuola Superiore Sant'Anna, Pisa, Italy; [4]Scuola Superiore Sant'Anna, Pisa, Italy; [5]University of Glasgow, Università di Bologna, Università di Bologna, Glasgow, UK; [6]University of Bristol, Bristol, UK; [7]Sun Yat-sen University, Guangzhou, China

We propose an OAM converter exploiting an innovative integrated OAM multiplexer based on concentric omega-shaped waveguides. The OAM converter, which can operate on signals multiplexed both in OAM and wavelength domain, is successfully tested up to 100Gb/s with real data-traffic.

P2.SC5.5
56-Gb/s VSB-PAM-4 over 80-km Using 1550-nm EA-DFB Laser and Reduced-Complexity Nonlinear Equalization

Nikolaos Panteleimon Diamantopoulos; Wataru Kobayashi; Hidetaka Nishi; Koji Takeda; Takaaki Kakitsuka; Shinji Matsuo, NTT Device Technology Labs, NTT Corporation, NTT Corporation, Atsugi, Kanagawa, Japan

Enabled by vestigial sideband modulation (VSB) and low-complexity nonlinear equalization, 28-GBaud PAM-4 is demonstrated using electro-absorption modulated laser and pin-photodiode at 80-km of standard single-mode fiber. The proposed scheme targets low-cost solutions for data-center interconnects and extended-reach 400GbE links.

P2.SC5.6
100 Gbaud 4PAM Link for High Speed Optical Interconnects

Ozolins Oskars[1]; Xiaodan Pang[2]; Aleksejs Udalcovs[1]; Richard Schatz[3]; Urban Westergren[3]; Jaime Rodrigo Navarro[4]; Aditya Kakkar[4]; Fredrik Nordwall[4]; Klaus M. Engenhardt[4]; Jiajia Chen[2]; Sergei Popov[2]; Gunnar Jacobsen[1]
[1]RISE Acreo AB, Kista, Sweden; [2]KTH Royal Institute of Technology, RISE Acreo AB, RISE Acreo AB, Kista, Sweden; [3]KTH Royal Institute of Technology, Kista, Sweden; [4]RISE Acreo AB, KTH Royal Institute of Technology, KTH Royal Institute of Technology, Kista, Sweden; [5]Tektronix AB, Stockholm, Sweden; [6]Tektronix GmbH, Stuttgart, Germany

We demonstrate 100 Gbaud 4PAM transmission over 400 meters SMF with monolithically integrated 1550 nm DFB-TWEAM having 100 GHz 3-dB bandwidth with 2 dB ripple. We evaluate its capabilities to enable two lanes 400 GbE client-side links for optical interconnects.

P2.SC5.7
Low Latency Parallel Schedulers for Photonic Integrated Optical Switch Architectures in Data Centre Networks

Paris Andreades; Philip Watts, University College London, London, UK

Using speculative transmission combined with a novel parallel scheduler design for practical photonic integrated switches based on the Clos architecture, we demonstrate a minimum latency of 47.2 ns in a rack scale 32x32 optically switched system.

P2.SC5.8
112-Gbit/s Single Side-Band PAM-4 Transmission over Inter-DCI Distances Without DCF Enabled by Low-complexity DSP

Sjoerd Van Der Heide[1]; Aaron Albores-Mejia[2]; Fausto Gomez Agis[1]; Boudewijn Docter[2]; Chigo Okonkwo[1]
[1]Institute for Photonic Integration (IPI), Eindhoven University of Technology, Eindhoven; [2]EFFECT Photonics B.V., Eindhoven, Netherlands

We present a chromatic dispersion and bandwidth pre-compensated 112-Gbit/s single side band signal transmitter over 93 km SSMF at 1550 nm using a dual-drive MZM. The proposed scheme is computationally efficient utilising only 21 linear and 11 quadratic taps.

P2.SC5.9
Automated Thermal Stabilization of Cascaded Silicon Photonic Ring Resonators for Reconfigurable WDM Applications

Alexander Gazman[1]; Colm Browning[2]; Ziyi Zhu1; Liam P Barry[2]; Keren Bergman[1]
[1]Columbia University, New York, USA; [2]Dublin City University, Dublin, Ireland

We describe a universal FPGA-based feedback algorithm for thermal stabilization of cascaded silicon photonic micro-ring resonators based subsystem-on-chip. Scalability is demonstrated through the successful simultaneous optimization of 10Gb/s/λ WDM uni/multicast data.

SC6 - POINT-TO-POINT TRANSMISSION LINKS HALL F

P2.SC6.10
High-Rate Continuous-Variables Quantum Key Distribution with Piloted-Disciplined Local Oscillator

Bernhard Schrenk[1]; Fabian Laudenbach[1]; Fred Fung[2]; Christoph Pacher[1]; Andreas Poppe[2]; Roland Lieger[1]; David Hillerkuss[3]; Edwin Querasser[1]; Gerhard Humer[1]; Michael Hentschel[1]; Momtchil Peev[2]; Hannes Hübel[1]
[1]AIT Austrian Institute of Technology, Vienna, Austria; [2]Huawei Technologies Duesseldorf GmbH, Munich, Germany

We present a pilot-disciplined coherent intradyne reception methodology for 250 Mbaud CV-QKD with frequency/phase-matched local oscillator. Experimental measurements indicate a secure key rate of 2.9 Mb/s over a link length of 12.8 km and >30 Mb/s for shorter-reach scenarios.

P2.SC6.11
Spectrally Efficient DMT Transmission over 40 km SMF Using an Electrically Packaged Silicon Photonic Intensity Modulator

Cosimo Lacava[1]; Iosif Demirtzioglou[1]; Ivan Cardea[2]; Alaa Khoja[1]; Ke Li[1]; Dave Thomson[1]; Xiaoke Ruan[3]; Fan Zhang[3]; Graham Reed[1]; David J Richardson[1]; Periklis Petropoulos[1]
[1]Optoelectronics Research Centre, Southampton, UK; [2]Photonics Systems Laboratory EPFL, Lausanne, Swizerland; [3]State Key Laboratory of Advanced Optical Communication Systems and Networks, Beijing, China

We demonstrate a record-high spectral efficiency (5b/s/Hz) DMT transmission by using a fully electrically-packaged silicon photonic intensity modulator. We transmit over a 40-km single mode fibre link at a rate of 49.6 Gb/s without the need for any dispersion compensation.

P2.SC6.12
Digital Coherence Enhancement in Space-Division Multiplexed Transmission

Marco Secondini[1]; Cristian Antonelli[2]
[1]TECIP Institute, Scuola Superiore Sant'Anna, Pisa, Italy; [2]University of L'Aquila, L'Aquila, Italy

We demonstrate a simple scheme for digitally enhancing the coherence of the local oscillator in MIMO receivers for SDM transmission. The proposed scheme yields a substantial relaxation of the coherence requirements set by the effects of chromatic and modal dispersion.

P2.SC6.13
Single Channel Probe Utilizing the EGN Model to Estimate Link Parameters for Network Abstraction

David Ives[1]; Hou-Man Chin[2]; Francisco Javier Vaquero Cabellaro[1]; Seb Savory[1]
[1]University of Cambridge, Cambridge, UK; [2]Orange Polska, Warsaw, Poland

We experimentally demonstrate multi-span link parameter abstraction using a single channel 11.5GBd probe. EGN based abstraction gave gamma=1.14/W/km c.f. 0.72/W/km for a GN based abstraction. The GN model overestimates the abstracted SNR by 0.4dB c.f. the EGN model at 1000km.

P2.SC6.14
Four-Span Dispersion Map Optimization for Improved Nonlinearity Mitigation in Phase-Sensitive Amplifier Links

Egon Astra[1]; Henrik Eliasson[2]; Peter Andrekson[2]
[1]Tallinn University of Technology, Tallinn, Estonia ; [2]Chalmers University of Technology, Gothenburg, Sweden

The first investigation of a four-span dispersion map optimization for PSA links is presented. We show numerically, that the maximum transmission reach improves 2.1 times, if four-span optimized dispersion maps are used repeatedly instead of single-span optimized maps.

P2.SC6.15
High-Order Mode-Group Multiplexed Transmission over a 24km Ring-Core Fibre with OOK Modulation and Direct Detection

Feng Feng[1]; Yongmin Jung[2]; Hongyan Zhou[1]; Rui Zhang[1]; Su Chen[1]; Honghai Wang[3]; Yucheng Yang[3]; Shaif-Ul Alam[2]; David J Richardson[2]; Timothy Wilkinson[1]
[1]University of Cambridge, Cambridge, UK; [2]University of Southampton, Southampton, UK; [3]Yangtze Optical Fibre and Cable Joint Stock Limited Company, Wuhan, China

We demonstrate 2x10Gbit/s error-free (BER<10-12) mode-group multiplexed transmission over a 24km step-index ring-core fibre using two high-order mode-groups with OOK modulation and direct detection. All-optical (de)multiplexing is enabled by inherent low mode-coupling of the fibre and mode-selective SLM based spatial

P2.SC6.16
Performance Fluctuations in Direct Detection Multi-Core Fiber Transmission Systems

Georg Rademacher; Ruben Luis; Benjamin Puttnam; Yoshinari Awaji; Naoya Wada, National Institute of Information and Communications Technology, Koganei, Japan

We investigate random crosstalk-power and polarization variations and the resulting performance fluctuations in short distance multi-core fiber transmission. For an average crosstalk of -12 dB, an outage probability of up to 7.8% results in systems designed using the average XT.

P2.SC6.17
400G-over-80km Connections Powered by Probabilistically Shaped PM-256QAM Wavelengths at 34 GBaud

Hung-Chang Chien; Jianjun Yu; Yi Cai; Junwen Zhang; Xinying Li; Xin Xiao ZTE TX Inc., Morristown, USA

Single-carrier 400G PM-256QAM transmission at 34 GBd over 80 km SSMF is proposed and experimentally demonstrated for the first time, which is enabled by both probabilistic shaping and digital nonlinearity compensation techniques.

P2.SC6.18
Performance of Coherent Optical Communication Systems With Hybrid Fiber Spans

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[1]MSU-Bozeman, Bozeman MT; [2]Montana State University, Bozeman; [3]Corning, Sullivan Park, Sullivan Park, Corning, NY, USA

We theoretically study the performance of coherent optical communication systems using quasi-single-mode fiber in the beginning of each span, to reduce the bulk of nonlinearities, followed by single-mode fiber, to limit multipath interference penalty within acceptable levels.

P2.SC6.19
Generation of 153.6Gbaud (614.4Gbps) PDM-QPSK Signals and Transmission of over 1200km SMF-28 with EDFA-only

Jianjun Yu[1]; Junwen Zhang[1]; Xinying Li[2]; Hung-Chang Chien[1]
[1]ZTE TX Inc., Morristown, USA; [2]Fudan Uni., Shanghai, China

Record of ETDM-based 153.6-Gbaud (614.4-Gb/s) PDM-QPSK optical signal is generated and coherently detected. The signals have been successfully transmitted over 1200-km SMF-28 with EDFA-only amplification.

P2.SC6.20
A Tighter Upper Bound on the Capacity of the Nondispersive Optical Fiber Channel

Kamran Keykhosravi; Giuseppe Durisi; Erik Agrell
Chalmers University of Technology, Göteborg, Sweden

An upper bound on the capacity of the nondispersive optical fiber channel is presented. This bound, which is valid for arbitrary launch powers, confines the capacity within a much narrower range compared to what the previously known upper bound provided.

P2.SC6.21
Amplifier-Less Transmission of Single Channel 112Gbit/s PAM4 Signal Over 40km Using 25G EML and APD at O band

Kangping Zhong[1]; Xian Zhou[2]; Jiahao Huo[1]; Hongyu Zhang[3]; Yuan Jinhui[2]; Yanfu Yang[4]; Changyuan Yu[1]; Alan Pak Tao Lau[1]; Chao Lu[1]
[1]The Hong Kong Polytechnic University; [2]University of Science & Technology Beijing, BEIJING; [3]HUAWEI, Shenzhen; [4]Habbin Institute of Technology, Shenzhen, China

For the first time, we experimentally demonstrated an amplifier-less transmission of a single lane 112Gbit/s PAM4 signal over 40km using 25G EML and APD at O band with a record receiver sensitivity of -14.8dBm.

P2.SC6.22
Field Trial of a Scheme to Overcome Channel Contention using All-Optical Wavelength Conversion

Kyle Bottrill; Francesca Parmigiani; David J Richardson; Periklis Petropoulos University of Southampton, Southampton, UK

We demonstrate channel contention resolution across the C-band in a field trial utilising two simple all-optical wavelength converters. The power penalty of the scheme is found to be a constant 1 dB across the band.

P2.SC6.23
Imperfection Induced Bandwidth Limitation in Nonlinearity Compensation

Son Le[1]; Hung Nguyen Tan[2]; Henning Buelow[3]
[1]Nokia Bell Labs, Stuttgart, Lorenzstrasse 10, Lorenzstrasse 10, Stuttgart, Germany; [2]The University of Danang - University of Science and Technology, Danang, Vietnam; [3]Nokia-Bell-Labs, Stuttgart, Germany

We show that performance improvement of nonlinear compensation techniques, such as DBP, OPC, PCTW subjected to practical-non-perfect implementations, is significantly reduced when the bandwidth is increased. This phenomenon imposes a significant challenge for the nonlinearity compensation in high baudrate transmissions.

P2.SC6.24
Assessing the Ability to Demultiplex Co-Propagating Orthogonal Modes

Mehdi Nouri[1]; Sahil Sakpal[2]; Hiva Shahoei[2]; Tim Lafave[2]; Solyman Ashrafi[2]; Duncan Macfarlane[2]
[1]Southern Methodist University, Dallas, TX,; [2]Southern Methodist University, Dallas; [3]NxGen Partners LLC., Dallas, USA

The ability to separate multiplexed optical modes is assessed for three orthogonal basis sets. The results herein may assist in mode family selection for spatial division multiplexed communication systems.

P2.SC6.25
Enhanced Long-haul Transmission Using Forward Propagated Broadband First Order Raman Pump

Md Asif Iqbal; Mingming Tan; Paul Harper, Aston University, Birmingham, UK

We demonstrate a novel broadband first-order pump which enables forward-propagated distributed Raman amplification by mitigating RIN-related penalty and reducing ASE noise. This allows a minimum 25% increase in reach for 1Tb/s DP-QPSK WDM transmission, compared with other commercially available pumps.

P2.SC6.26
Influence of the SNR of Pilot Tones on the Carrier Phase Estimation in Coherent Quantum Receivers

Sebastian Kleis; Christian Schaeffer, Helmut Schmidt University, Hamburg, Germany

In Continuous-Variable Quantum Key Distribution, pilot noise degrades the secret key rate. We provide a quantitative analysis on this, based on simulations. At 40 MBd and 100 kHz total linewidth, the power of the pilot signal should be 30 dB

P2.SC6.27
Constant SNR-Error Step-Size Selection Rule for Numerical Simulation of Optical Transmissions

Simone Musetti; Paolo Serena; Alberto Bononi
University of Parma, dept. Ingegneria e Architettura, dept. Ingegneria e Architettura, Parma, Italy

We propose a novel power-independent step size selection rule for the split-step Fourier method which targets a desired simulation error on the signal to noise ratio of coherently received signals.

P2.SC6.28
Numerical Investigation and Scaling Rules for the Estimation of Nonlinear Interference Variability of Dispersion Managed and Systems in Presence of PMD and Kerr Effects

Sina Fazel[1]; Nicola Rossi[2]; Petros Ramantanis[2]; Yann Frignac[1]
[1]Telecom SudParis, Evry; [2]Nokia Bell Labs, Nozay, France

We estimate the Kerr nonlinear noise variance for WDM-PDM QPSK links and its variability in presence of PMD. Results specify rules giving the PMD-based NLI statistics and its evolution with distance for both legacy and recent coherent link designs.

P2.SC6.29
Characterization of ICXT in DD-OFDM MCF-based Systems

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We experimentally show that the intercore-crosstalk (ICXT) in DD-OFDM MCF-based systems is characterized by the carrier-crosstalk transfer function (CXTF). Mean and variance expressions of the CXTF are proposed and used to predict how the ICXT impacts the system performance.

P2.SC6.30
Nonlinearity Compensation and Information Rates in Fully-Loaded C-band Optical Fibre Transmission Systems

Tianhua Xu[1]; Nikita Shevchenko[1]; Boris Karanov[1]; Domaniç Lavery[1]; Lidia Galdino[1]; Alex Alvarado[2]; Robert Killey[1]; Polina Bayvel[1]
[1]University College London, London, UK; [2]Eindhoven University of Technology, Eindhoven, Netherlands

Nonlinearity compensation and achievable information rates were investigated in fully-loaded C-band communication systems considering transceiver limitations. It is found that the efficacy of nonlinearity compensation in enhancing the achievable information rates depends on the modulation formats and transmission distances.

P2.SC6.31
4 Gbps PAM-4 and DMT Free Space Transmission using A 4.65-μm Quantum Cascaded Laser at Room Temperature

Xiaodan Pang[1]; Oskars Ozolins[2]; Lu Zhang[2]; Richard Schatz[1]; Aleksejs Udalcovs[2]; Joakim Storck[1]; Gregory Maisons[2]; Mathieu Carras[2]; Shilin Xiao[2]; Gunnar Jacobsen[2]; Sergei Popov[1]; Jiajia Chen[1]; Sebastian Lourdudoss[1]
[1]KTH Royal Institute of Technology, RISE Acreo AB, RISE Acreo AB, Kista, Sweden; [2]RISE Acreo AB, Kista, Sweden; [3]KTH Royal Institute of Technology, Shanghai Jiao Tong University, Shanghai Jiao Tong University, Kista, Sweden; [4]KTH Royal Institute of Technology, Kista, Sweden; [5]mirSense, Centre d'intégration NanoInnov, Palaiseau, France; [6]State Key Laboratory of Advanced Optical Communication System and Networks, Shanghai Jiao Tong Unive, Shanghai, China

We experimentally demonstrate 4Gbps PAM-4 and DMT transmissions using a quantum cascaded laser (QCL) emitting at mid-wavelength infrared of 4.65-μm and a commercial infrared photovoltaic detector. The QCL is directly modulated and operated at room temperature with Peltier Cooling.

P2.SC6.32
Approaching Gb/s Secret Key Rates in a Free-Space Optical CV-QKD System Affected by Atmospheric Turbulence

Zhen Qu; Ivan Djordjevic, University of Arizona, Tucson, USA

We experimentally demonstrate an eight-state modulated free-space optical CV-QKD link. By multiplexing orbital angular momentum modes, polarization states and wavelengths, a total secret key rate of > 580 Mbit/s can be achieved at mean channel transmittances in medium-turbulence regime.

P2.SC6.33
Andre Richter[1]; Hadrien Louchet[2]; Stefanos Dris[1]
[1]VPIphotonics, Berlin; [2]Keysight Technologies, Boeblingen, Germany

We show how the correlation of Kerr-induced nonlinear interference noise affects the performance of Low-Density Parity Check codes, and present a simple analytical method predicting this correlation enabling optimized digital carrier phase recovery for mitigation.

SC 7 - CORE, METRO, AND DATA CENTRE NETWORKS HALL F

P2.SC7.34
Joint Allocation of IT and Connectivity Resources for Survivable Services in Geographically Distributed Metro Data Centers

Ajmal Muhammad[1]; Paolo Monti[1]; Payman Samadi[2]; Lena Wosinska[1]; Keren Bergman[2]
[1]KTH Royal Institute of Technology, Stockholm, Sweden; [2]Columbia University, New York, USA

The paper proposes a survivable and programmable metro-scale converged inter- and intra-datacenter network architecture and exploits its unique features for allocating jointly IT and connectivity resources. The proposed dynamic provisioning strategy offers a substantial reduction of service request blocking.

P2.SC7.35
Interoperable Long-Haul Optical Networks Exploiting Optimized ROADM Vendor Allocation

António Eira; Nelson Costa; João Pedro, Coriant Portugal, Amadora, Portugal

We assess the potential of combining common and proprietary performance data in multi-vendor interoperable networks to bridge the gap between closed and open line systems. Optimizing the ROADM allocation to different vendors can substantially reduce the amount of regenerators required.

P2.SC7.36
First Experimental Demonstration of the Time and Spectral Optical Aggregation Solution

Bing Han; Paulette Gavignet; Erwan Pincemin, Orange Labs, LANNION, France

We experimentally demonstrate the feasibility of the TISA concept for the first time. Transmission of both DP-QPSK and DP-16QAM CO-OFDM bursts is performed through the TISA network. BER versus OSNR measurements show less than 1 dB penalty for both formats.

P2.SC7.37
On the Performance Improvement and Cost Effectiveness Resulting from the Placement of Novel Architectures of Interconnected Transponders in Elastic Optical Networks

Chris Matrakidis[1]; Ioannis Tomkos[2]
[1]OpenLightComm ltd., London, UK; [2]Athens Information Technology (AIT), Marousi, Greece

We showcase that the availability of coherent transponders with separate lasers for transmitter and receiver allows their use in novel interconnected transponder blocks, providing signal regeneration and wavelength conversion at core network nodes, resulting in significant cost savings.

P2.SC7.38
Application-Centric Dynamic Multi-layer Resource Allocation in Availability-aware SDN-Orchestrated Networks

Ciril Rozic1; Marco Savi[2]; Chris Matrakidis[1]; Dimitrios Klonidis[1]; Domenico Siracusa[2]; Ioannis Tomkos[1]
[1]Athens Information Technology (AIT), Marousi, Greece; [2]Fondazione Bruno Kessler (FBK), CREATE-NET Research Center, Povo, Italy

We evaluate our method for dynamically accommodating applications that require more than just bandwidth. Our simulations show the advantages of two availability-aware approaches on a network equipped with an SDN orchestrator.

P2.SC7.39
Real-Time Demonstration of an SDN-Based Gridless Routing/Protection over a Remote Optically Pumped Passive Optical Add/Drop Network

Ezra Ip[1]; Yue-Kai Huang[1]; Philip Ji1; Shuji Murakami[2]; Shaoliang Zhang[1]; Yoshiaki Aono[2]; Tsutomu Tajima[2]
[1]NEC Laboratories America, Princeton, USA; [2]NEC Corporation, Abiko, Japan

We demonstrated a passive optical add/drop network for full C-band transmission over four passive nodes and 204.5 km of fiber using real-time 100/200-GbE transponders. We also demonstrate SDN-enabled wavelength protection, and system compatibility with superchannel transmision.

P2.SC7.40
Optical Node with Passband Overlapped Filter and Impairment Aware Least Slot Count Path First Algorithm for Guardband-less Elastic Optical Network

Hitoshi Takeshita[1]; Takefumi Oguma[2]; Shinsuke Fujisawa[1]; Baku Yatabe[2]; Yuta Suzuki[2]; Akio Tajima[1]; Emmanuel Le Taillandier De Gabory[2]
[1]NEC, Kawasaki, Kanagawa; [2]NEC, Abiko, Chiba, Japan

We propose a novel optical band-pass filter device and a dedicated optical path design algorithm to reduce guardband use in EON. Simulation and experimental results demonstrate twice the spectral efficiency of EON and applicability to actual networks.

P2.SC7.41
Fast and Hitless Topology Management of AWGR-Based Optical Networking for Data Centers

Jialiang Guo[1]; Shaolong Zhang[1]; Roberto Proietti[2]; Zheng Cao[1]; Guojun Yuan[1]; S.J.Ben Yoo[2]
[1]University of Chinese Academy of Sciences, Beijing, China; [2]University of California, Davis, California, USA

We designed and demonstrated fast and hitless data center topology reconfiguration(FHTR) management that greatly reduces the traffic loss while only requiring microsecond-scale reconfiguration time. Even in a small-scale testbed, FHTR can improve the traffic loss rate more than 50%.

P2.SC7.42
Performance Analysis of Dynamic Routing in Elastic Optical Networks with Back-to-Back Regeneration

Krzysztof Walkowiak[1]; Miroslaw Klinkowski[2]
[1]Wroclaw University of Science and Technology, Wroclaw, Poland; [2]National Institute of Telecommunications, Wroclaw, Poland

We examine potential performance gains resulting from a flexible use of signal regeneration achieved by means of transceivers in back-to-back configurations and along with

modulation conversion in translucent elastic optical networks (EONs) under dynamic routing.

P2.SC7.43
Regenerator Site Predeployment in Nonlinear Dynamic Flexible-Grid Networks

Li Yan[1]; Yuxin Xu[2]; Maite Brandt-Pearce[2]; Nishan Dharmaweera[1]; Erik Agrell[1]
[1]Chalmers University of Technology, Gothenburg, Sweden; [2]University of Virginia, CHARLOTTESVILLE, USA

A regenerator predeployment algorithm is proposed in dynamic translucent flexible-grid networks based on the GN model. The randomness of traffic bandwidth requests is exploited to allocate regenerators efficiently. Our method accommodates 30% more demands than benchmark methods.

P2.SC7.44
Optimally-driven Online Reservations in Elastic Optical Networks

Polyzois Soumplis[1]; Panagiotis Kokkinos[1]; Emmanuel Varvarigos[2]
[1]University of Patras, CTI Diophantus, Patra; [2]School of Electrical and Computer Engineering, National Technical University of Athens, CTI Diophantus, Athens, Greece

We present an admission control and solution validation-based online, routing, spectrum allocation approach for elastic optical networks. This is parameterized periodically by an optimal offline mechanism that drives the blocking of traffic requests, which if served would negatively affect network

P2.SC7.45
Experimental Evaluation of a PCE Transport SDN Controller for Dynamic Grooming in Packet over Flexi-Grid Optical Networks

Ricardo Martínez; Ramon Casellas; Ricard Vilalta; Raul Muñoz, CTTC, Castelldefels, Spain

We validate the implementation of a unified PCE-based Transport SDN controller for Multi-Layer Networks (packet over optical flexi-grid). A novel on-line MLN routing algorithm targeting grooming strategies is experimentally evaluated under dynamic and heterogeneous data-rate packet traffic.

P2.SC7.46
First Experimental Demonstration of Physical-Layer Network Coding in PAM4 System for Passive Optical Interconnects

Rui Lin[1]; Yang Lu[2]; Xiaodan Pang[3]; Oskars Ozolins[4]; Yuxin Cheng[4]; Aleksejs Udalcovs[4]; Sergei Popov[4]; Gunnar Jacobsom[4]; Ming Tang[5]; Deming Liu[5]; Jiajia Chen[6]
[1]School of Optics and Electronic Information, Huazh, School of Optics and Electronic Information, Huazh, Stockholm, Sweden; [2]Hangzhou Dianzi University, Hangzhou Dianzi University, Stockholm, Sweden; [3]Networking and Transmission Laboratory, RISE Acreo, Networking and Transmission Laboratory, RISE Acreo, Stockholm, Sweden; [4]RISE Acreo AB, Stockholm, Sweden; [5]RISE Acreo AB, Wuhan, China; [6]School of ICT, KTH Royal Institute of Technology, Stockholm, Sweden

We propose to implement physical-layer network coding (PLNC) in coupler-based passive optical interconnects. The PLNC over PAM4 system is for the first time experimentally validated, where simultaneous mutual communications can be kept within the same wavelength channel, doubling spectrum efficiency.

P2.SC7.47
Significance of Adaptive Co-operation of Modulation Format and FEC for Energy Saving in Optical Networks

Soichiro Kametani; Kazuo Kubo; Kenji Ishii; Keisuke Dohi; Takashi Sugihara Mitsubishi Electric Corp., Kamakura, Kanagawa, Japan

Switching between modulation formats varies the energy used for impairment compensation in the coherent DSP significantly. This energy variation is used to save energy during off-peak traffic periods. A numerical study shows a reduction of energy consumption down to 18%.

P2.SC7.48
Impact of Software Defined Contention in OXC at Network Level

Thierry Zami, Nokia, Nozay, France

This study quantifies how software defined contention influences the number of MCS-based add/drop blocks needed to serve a given set of connections, over 2 distinct WDM network topologies.

P2.SC7.49
32-degree OXC With Very Low Add/drop Contention

Thierry Zami, Nokia, Nozay, France

This study reports a colorless/directionless wavelength routing Optical Cross-Connect (OXC) based on multicast switch partially equipped with variable splitters, to achieve a 32-degree OXC with nevertheless reasonable intermediate amplification and with negligible add/drop contention probability.

P2.SC7.50
A Novel Traffic Grooming Scheme for Nonlinear Elastic Optical Network

Rui Wang; Fanchao Meng; Reza Nejabati; Dimitra Simeonidou, University of Bristol, Bristol, UK

We propose a traffic grooming enabled nonlinearity-aware resource allocation scheme for elastic optical networks. The results show that proposed approach outperforms the benchmarks by providing higher service acceptance ratio and up to 50% reduction in number of transceivers.

SC8 ACCESS, LOCAL AREA AND INDOOR NETWORKS HALL F

P2.SC8.51
Fabry-Perot Filtered Emission for 25 Gbit/s Single-Side Band NRZ and ODB Transmissions in C-band up to 20 km

Bertrand Le Guyader[1]; Ye Zhicheng[2]; Dai Jing[2]; Li Shengping[2]; Justine Konopacki[1]; Fabienne Saliou[1]; Philippe Chanclou[1]; Sylvain Barthomeuf[1]; Didier Erasme[2]
[1]ORANGE, Lannion, UK; [2]Huawei, Wuhan, China; [3]Télécom ParisTech, Université Paris-Saclay, Paris, France

VSB-NRZ and VSB-ODB emitters based on an etalon Fabry-Perot filter is combined to a 12 GHz photodiode and electrical post-equalization to allow transmission performances at 25 Gbit/s in C-band up to 30 km

P2.SC8.52
Real-Time Gigabit-Ethernet Transmission over Optical Wireless Using Off-the-Shelf Components

Giulio Cossu; Wajahat Ali; Alessandro Sturniolo; Alessandro Messa; Ernesto Ciaramella, Scuola Superiore Sant'Anna, Istituto TeCIP, Istituto TeCIP, Pisa, Italy

We experimentally demonstrate real-time Gigabit-Ethernet optical wireless transmission exploiting commercially available components. The system does not require amplification or emphasis stages and works at 2 m distance with good robustness to misalignment (> 10 cm).

P2.SC8.53
64-Gb/s/λ Downstream Transmission for PAM-4 TDM-PON with Centralized DSP and 10G Low-Complexity Receiver in C-band

Junwen Zhang[1]; Jianyang Shi[1]; Jun Shan Wey[1]; Jianjun Yu[1]; Xingang Huang[2]; Ma Zhuang[2]; Yong Guo[2]; Mingsheng Li[2]
[1]ZTE TX INC, Morristown, USA; [2]ZTE, Shanghai, China

Using centralized DSPs and low complexity 10G receiver, we experimentally demonstrated 50 and 64-Gb/s/λ PAM4 TDM-PON downstream transmission in C-band. Link budgets of 31 and 29-dB after 20-km SSMF at BER of 3.8E-3 are achieved.

P2.SC8.54
Real-Time 20 and 25 Gbit/s Pre-Equalized C-band Transmission With Electrical Duo-binary Detection

Justine Konopacki[2]; Bertrand Le Guyader[1]; Naveena Genay[2]; Luiz Anet Neto[1]; Fabienne Saliou[1]; Sylvain Barthomeuf[1]; Philippe Chanclou[1]; Didier Erasme[2]
[1]Orange Labs, Lannion; [2]LTCI Télécom ParisTech, Paris, France

We experimentally demonstrate real-time C-band transmissions with up to 29 dB optical budget after 25 km propagation at 20 Gbit/s and 25 Gbit/s. Our solution uses pre-equalization and electro-optical components dedicaded for 10 Gbit/s transmissions.

P2.SC8.55
Bi-directional Visible Light Communication Using a Single 682-nm Visible Vertical-Cavity Surface-Emitting Laser (VCSEL) and Signal Remodulation

Liang-Yu Wei[1]; Chin-Wei Hsu[1]; Yung Hsu[1]; Chien-Hung Yeh[2]; Chi-Wai Chow[1]
[1]Department of Photonics and Institute of Electro-Optical Engineering, National Chiao Tung University, Hsinchu; [2]Department of Photonics, Feng Chia University, Taichung

We demonstrate a bi-directional signal-remodulated visible light communication (VLC), using 8.148-Gbit/s orthogonal-frequency-division-multiplexed (OFDM) downstream and signal remodulated 2-Mbit/s on-off-keying (OOK) upstream, with 3-m free-space transmission distance.

P2.SC8.56
Delay-Constrained Framework for Road Safety and Energy-Efficient Intelligent Transportation Systems

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We propose a novel approach that exploits a delay-constrained framework to meet stringent delay requirements and achieves energy-savings in Intelligent Transportation Systems (ITS). Analytical results show 40% energy-savings in a network that delivers delay-sensitive safety information over ITS

P2.SC8.57
Impact of Second-order Intermodulation Distortion on Analogue Optical Link to Bandwidth Efficient Multi-IF-over-fibre based Mobile Fronthaul

Minkyu Sung; Hwan Seok Chung; Seung-Hyun Cho; Joonyoung Kim; Joon Ki Lee; Jong Hyun Lee, Electronics and Telecommunications Research Institute (ETRI), Optical Network Research Group, Optical Network Research Group, Daejeon, Republic of Korea

We analyse carrier-to-noise and distortion ratio (CNDR) of IF-over-fibre based mobile fronthaul for second-order intermodulation distortions. We experimentally confirm the good agreement between theoretically calculated CNDRs curves and measured CNDR for 48-IF carrier LTE-A signal transmission

P2.SC8.58
High-Capacity Tier-II Fronthaul Network with SSB-DD Multiband OQAM/QAM-CAP

Mu Xu[1]; Jianyang Shi[2]; Junwen Zhang[2]; Jianjun Yu[2]; Gee-Kung Chang[1]
[1]Georgia Institute of Technology, Atlanta; [2]ZTE Lab USA, Morristown, New Jersey, USA

A 128-Gb/s 20/80-km edge-node compatible mobile fronthaul with single-side-band OQAM-CAP is demonstrated. Digital pre-equalization and power loading are jointly applied to mitigate the ISI and SSBI. Compared with QAM-CAP, spectral and computational efficiencies are improved by 8% and 50% respectively.

P2.SC8.59
Effects of Contention and Delay in a Switched Ethernet Evolved Fronthaul for Future Cloud-RAN Applications

Philippos Assimakopoulos; Gurtej Singh Birring; Nathan Gomes, University of Kent, Canterbury, UK

A Switched-Ethernet fronthaul transporting data generated by a Long-Term Evolution software base station with a MAC/PHY functional split is presented. Contention effects arising from the Ethernet fronthaul and the effects of priority-based scheduling are characterised.

P2.SC8.60
Experimental Demonstration of Elastic RF-Optical Networking (ERON) for 5G mm-wave Systems

Roberto Proietti; Hongbo Lu; Gengchen Liu; Alberto Castro; Mohammadsadegh Shamsabardeh; S.J.Ben Yoo, University of California, Davis, Davis, USA

This paper experimentally demonstrates an elastic RF-Optical C-RAN based on mm-wave MIMO systems. An RF-Optical SBVT in the CO generates 1-GBd signals which are elastically assigned (in time and frequency) by the C-RAN controller to multiple remote antenna units.

P2.SC8.61
Modular Dynamic Bandwidth Allocation for a Flexible PON: Concept and Evaluation

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Modularization of the DBA function provides flexibility, enables new use cases, and can be combined with virtual DBA. The challenge, however, is increased queuing delay. Simple prediction methods fall short. Improved prediction is needed, for example, by utilizing traffic history.

P2.SC8.62
Effect of Blue Filter on the SNR and Data-Rate for Indoor Visible Light Communication system

Shokoufeh Mardani[1]; Amir Masood Khalid[2]; Frans Mj Willems[1]; Jean Paul Linnartz[2]
[1]Eindhoven university of technology, EINDHOVEN; [2]Philips Lighting Research,, Eindhoven; [3]Philips Lighting Research,, EINDHOVEN, Netherlands

For an indoor Visible Light Communication system with phosphorescent LEDs, we show a blue receive filter is particularly suitable for cool-white LEDs but less attractive for warm-white LEDs. Distance and sunlight also influence whether a blue filter should be used.

P2.SC8.63
Experimental Investigation of Optical OFDMA for Vehicular Visible Light Communication

Runyao Yang; Xianqing Jin; Meiyu Jin; Zhengyuan Xu
University of Science and Technology of China, Hefei, China

Optical OFDMA uplink transmission for vehicular visible light communication systems with commercial blue-LEDs and APDs is experimentally and numerically investigated, which shows that LED nonlinear-distortion and shot noise significantly affect EVM penalty due to the inter-user interference by out-of-band interference/noise.

P2.SC8.64
Experimental Comparative Investigation of 10G-Class and 25G-Class Receivers in 100G-EPON with O-band DML

Xin Miao[1]; Meihua Bi[2]; Longsheng Li[2]; Yan Fu[1]; Weisheng Hu[1]
[1]Shanghai Jiao Tong University, Shanghai; [2]Shanghai Jiao Tong University, Hangzhou Dianzi University, Hangzhou Dianzi University, Hangzhou, China

We compare the performance of 10G-class receiver with post-equalisation and 25G-class receiver for 25Gb/s transmission with O-band DML. Results show that the 25G-class one is more cost-efficient, and 25.4dB/24.4dB power budget is achieved for NRZ/PAM4 after 20km SSMF.

P2.SC8.65
Optimization of Modulation Formats for High Performance Millimetre Wave RoF Transmission System

Xinying Li[1]; Miao Kong[2]; Jianjun Yu[2]; Gee-Kung Chang[4]
[1]Georgia Institute of Technology, ZTE (TX) Inc. Atlanta, USA; [2]Fudan University, Shanghai, China; [3]ZTE (TX) Inc., Fudan University, Fudan University, Morristown, USA; [4]Georgia Institute of Technology, Atlanta, USA

We experimentally compare 12QAM with 8QAM/16QAM in a 60-GHz RoF system with 25-km SMF-28 link and up to 70-m wireless link, and demonstrate 12QAM brings a better trade-off than 8QAM/16QAM as a solid all-around candidate in both spectral-efficiency and wireless-distance.

P2.SC8.66
Experimental Demonstration of "PON + Embedded-Hardware-Switch" for Low-latency Communication in Dual-stage 5G Fronthaul Network Architecture

Yunxiang Fu[1]; Rentao Gu[1]; Yuefeng Ji[2]
[1]Beijing Lab. of Advanced Information Network, Sch. of Inf. and Commun. Eng.,Beijing Univ. of Posts a, Beijing; [2]State Key Lab. of Inf. Photon. and Optical Commun., Sch. of Inf. and Commun. Eng., Beijing Univ. of, Beijing, China

We demonstrated a "PON + embedded-hardware-switch" system to accelerate data transmission in 5G fronthaul within the 8.5 us total processing latency. The switch processing rate ranges from 15.63Mpps to 2.64Mpps when packet length ranges from 64Bytes to 1518Bytes.

P2.SC8.67
Capacity-Increasing 3D Spatial Demultiplexer Design for Optical Wireless MIMO Transmission

Adrian Krohn; Gilbert Forkel; Peter Hoeher; Stephan Pachnicke
Kiel University, Kiel, Germany

A novel passive link-blocking device is presented that provides the ability to separate spatially multiplexed data streams in VLC MIMO systems. A typical indoor scenario has been simulated and real measurements for verification with a 3D-printed specimen have been done.

P2.SC8.68
Impairment Assessment due to Raman Crosstalk in Coexistence of Coherent UDWDM-PON with GPON technologies

Berta Neto[1]; Berta Neto[2]; Ali Shahpari[2]; Zoran Vujicic[2]; André Barros[2]; João Pinho[2]; Natasa Pavlovic[2]; António Teixeira[3]
[1]Instituto de Telecomunicacoes, Campus Universitario de Santiago, Aveiro; [2]Instituto de Telecomunicacoes, Aveiro; [3]Instituto de Telecomunicacoes, University of Aveiro, Portugal

The SRS induced impairments due to coexistence of UDWDM-PON and GPON technologies are assessed both experimentally and by simulation, targeting a spectral optimization of UDWDM-PON. Additional coexistence with XG-PON and RF video is presented for several UDWM spectral zones

P2.SC8.69
Experimental Evaluation of Fast Adaptive Bandwidth Allocation Algorithm for Elastic Lambda Aggregation Network

Hiroyuki Saito; Naoki Minato; Hideaki Tamai; Hironori Sasaki, Oki Electric Industry Co., Ltd., Saitama, Japan

A fast adaptive bandwidth allocation algorithm is proposed for WDM/OFDM-PON-based elastic network and implemented on FPGA based platform. We experimentally demonstrate the processing time less than 21 ms with 256 ONUs while keeping high spectrum efficiency.

P2.SC8.70
NG-PON2 Demonstration with Small Delay Variation and Low Latency for 5G Mobile Fronthaul

Keita Takahashi; Hirotaka Nakamura; Hiroyuki Uzawa; Kenji Miyamoto; Yu Nakayama; Tatsuya Shimada; Jun Terada; Akihiro Otaka
NTT Corporation, NTT Access Network Service Systems Laboratories, 1-1 Hikarinooka Yokosuka-Shi, Japan

We demonstrate NG-PON2 with small delay variation and low latency for 5G mobile fronthaul for the first time. We experimentally confirm the proposed fixed delay function and the implemented mobile DBA are greatly effective to delay performances.

P2.SC8.71
Demonstration of High-capacity 50 Gb/s (2 x 25 Gb/s) EPON over Two Lanes using Low complexity RS-based FEC

Kim Kwang Ok; Han Han Hyub; Doo Kyeong Hwan; Kim Seung Hwan; Hwan Seok Chung, Electronics and Telecommunications Research Institute, Optical Network Research Group, Daejeon, Republic of Korea

We experimentally demonstrate multilane-based 50-Gb/s EPON system using O-band wavelength bands and RS(255,223) code. The packet throughput of 40-Gb/s and 16-Gbp/s at a downstream and upstream direction is presented on 20-km reach with 1:64 split ratios.

P2.SC8.72
YANG Model based Optical Access SDN Control Architecture for Accommodating Heterogeneous Multi-vendor PON Systems

Jung-Yeol Oh[1]; Yeon Chel Ryoo[2]; Kim Kwang Ok[2]; Kyeong Hwan Doo[2]; Hwan Seok Chung[2]
[1]Electronics and Telecommunications Research Institute (ETRI), 218 Gajeong-ro, Yuseong-gu, 218 Gajeong-ro, Yuseong-gu, Daejeon; [2]Electronics and Telecommunications Research Institute (ETRI), Daejeon, Republic of Korea

YANG model based optical access SDN architecture that can accommodate heterogeneous multi-vendor PON systems is proposed. The implemented Access-SDN system is verified by applying the down/up-stream 25G/10G EPON system of the IEEE 802.3ca standard.

15:30 - 17:00 POSTER REFRESHMENTS HALL F

19:00 - 00:00 CONFERENCE DINNER KAJSKJUL 8

Th.1.A: Elastic Networks
Room F1 (SC7)
Chair: Achim Autenrieth, ADVA Optical Networking, Germany

08:30 Th.1.A.1
Power-Aware Regeneration Algorithm in Flex-grid Networks
Matthieu Kanj1; Esther Le Rouzic2; Bernard Cousin3
1bcom, Network Interfaces Lab, Cesson-Sevigne; 2Orange Labs Lannion, Lannion; 3IRISA Labs, University of Rennes 1, Rennes, France
Flex-grid technology increases network links capacity and optical power levels, creating power saturation problem in legacy amplifiers. We demonstrate that optimizing regeneration sites allows reducing the optical power of highly loaded links, avoiding amplifiers saturation over the existing fixed-grid networks.

08:45 Th.1.A.2
Partial Signal Overlap with Cancellation-based Detection for Spectrally-efficient EONs
Marc Ruiz1; Filippo Cugini2; Tommaso Foggi2; Luis Velasco1; Piero Castoldi3
1Universitat Politècnica de Catalunya (UPC), Barcelona, Spain; 2CNIT, Pisa; 3Scuola Superiore Sant'Anna, Pisa, Italy
The cancellation-based detection strategy is exploited to enable the partial overlap of two slightly-detuned 100G PM-QPSK signals, effectively sharing the same frequency slot. Results show benefits in overall network usage compared to fully overlapped signals and 200G 16QAM.

09:00 Th.1.A.3
Demonstration of Real-time Modulation-Adaptable Transmitter
Shuangyi Yan1; Arash Farhadi Beldachi1; Fengchen Qian2; Koteswararao Kondepu1; Yan Yan1; Chris Jackson1; Reza Nejabati1; Dimitra Simeonidou1
1University of Bristol, High performance networks group, High performance networks group, Bristol, UK; 2Xi'an Institute of Optics and Precision Mechanics, Xi'an, China
We demonstrate a 26 Gbaud real-time quick-reconfigurable 16QAM/QPSK-adaptable transmitter. The modulation format can be switched in less than a second by an RMAT agent. The FPGA-driven reconfigurable transmitter can work as a generic edge-node interface for traffic aggregation.

09:15 Th.1.A.4
Optimized Regenerator Placement in Elastic Optical Networks
Annalisa Morea1; Thierry Zami2
1Nokia Italy, Vimercate, Italy; 2Nokia, Nozay, France
This paper illustrates the relevance of specific allocation of flexible opto-electronic regeneration for ultimate spectral efficiency in the core elastic WDM networks: up to 2.5 times more traffic can be transported with sophisticated regeneration strategies versus basic 100Gb/s routing.

09:30 Th.1.A.5 Invited
Control and Management of Sliceable Transponders
Nicola Sambo1; Alessio Giorgetti1; Filippo Cugini2; Matteo Dallaglio1; Piero Castoldi1 1Scuola Superiore Sant 'Anna, Pisa; 2CNIT, Pisa, Italy
This paper presents control and management of sliceable transponders through NETCONF and YANG. Three OAM schemes are also presented and evaluated with simulations: centralized, hierarchical, and a scheme based on pre-instructions. Hierarchical and pre-instruction provide faster reaction time to degradations.

Th.1.B: Coherent Technologies in Access Networks
Room F2 (SC8)
Chair: Dora Van Veen, Nokia Bell-Labs, USA

08:30 Th.1.B.1 Invited
100G to 1T Based Coherent PON Technology
Naoki Suzuki; Hiroshi Miura; Keisuke Matsuda; Ryosuke Matsumoto; Kuniaki Motoshima, Mitsubishi Electric Corporation, Kamakura, Japan
We review the recent progress of the latest 100G to 1T class coherent PON technology using a simplified DSP suitable for forthcoming 5G MFH/MBH. The highlight is the presentation of the first demonstration of 100 Gb/s/lamda x 8 based PON.

09:00 Th.1.B.2 Highly ranked paper
Hardware-efficient Adaptive Equalization and Carrier Phase Recovery for 100 Gb/s/ -based Coherent WDM-PON Systems
Keisuke Matsuda; Ryosuke Matsumoto; Naoki Suzuki, Mitsubishi Electric Corporation, Kamakura, Japan
We propose a 100 Gb/s/lambda-based coherent WDM-PON with hardware-efficient DSP. By introducing a 1-tap butterfly filter and an inter-polarization phase offset estimation, multiplications are reduced 40%. Downstream loss budget of 39.7 dB supporting 8 ONU over 80 km was demonstrated.

09:15 Th.1.B.3
High Sensitivity and Wide Dynamic Range Burst-Mode Coherent Receiver that Controls Gains of a SOA and TIAs for Long-Reach and High-Splitting-Ratio PON
Ryo Koma; Masamichi Fujiwara; Jun-Ichi Kani; Ken-Ichi Suzuki; Akihiro Otaka NTT, Yokosuka-shi, Japan
10-Gb/s single polarization QPSK burst signals transmitted over 40-km SMF are successfully received at -44.1 dBm with dynamic range of 30.1 dB by using our proposed burst-mode coherent receiver even though a normal 6-bit ADC is used.

09:30 Th.1.B.4
Coherent UDWDM Transceivers Based on Adaptive Stokes Space-Polarization Demultiplexing in Real-time
Somayeh Ziaie1; Ricardo Ferreira1; Muga Nelson1; Fernando Guiomar2; Ali Shahpari1; António Teixeira1; Armando Pinto1
1Department of Electronics, Telecommunications and Informatics, University of Aveiro and Instituto de, Aveiro, Portugal; 2Dipartimento di Elettronica e Telecomunicazioni, Politecnico di Torino,, Torino, Italy
We experimentally demonstrate for the first-time a dual-polarization coherent-UDWDM system supported by adaptive Stokes space polarization-demultiplexing implemented in real-time. Transceiver performance in terms of complexity and sensitivity is evaluated while the system supports optical power budget in excess of 38dB.

09:45 Th.1.B.5
80 Gbit/s/ch, 256 QAM Digital Coherent Optical Transmission System with Injection-Locking for Next Generation Mobile Fronthaul Network
Keisuke Kasai1; Yixin Wang1; Masato Yoshida1; Toshihiko Hirooka1; Katsumi Iwatsuki2; Masataka Nakazawa1
1Research Institute of Electrical Communication, Tohoku University, Sendai; 2Research Organization of Electrical Communication, Tohoku University, Sendai, Japan
We demonstrate a simple digital coherent transmission system with an injection-locking technique for next-generation mobile fronthaul. With this system, both up- and downlink 80 Gbit/s, 256 QAM-data were bi-directionally transmitted over 26 km with a loss budget of 10 dB.

Th.1.C: Low-Power Transmitters
Room F3 (SC2)
Chair: Andreas Umbach, Finisar Corporation, Germany

08:30 Th.1.C.1 Upgraded
Ultra-Low-Power (1.59 mW/Gbps), 56-Gbps PAM4 Operation of Si Photonic Transmitter Integrating Segmented PIN Mach-Zehnder Modulator and 28-nm CMOS Driver
Shinsuke Tanaka1; Takasi Simoyama2; Tsuyoshi Aoki1; Toshihiko Mori3; Shigeaki Sekiguchi1; Seok-Hwan Jeong4; Tatsuya Usuki2; Yu Tanaka4; Ken Morito1 1PETRA, Fujitsu Laboratories Ltd., Fujitsu Laboratories Ltd., Atsugi; 2PETRA, Fujitsu Limited, Fujitsu Limited, Tsukuba; 3PETRA, Fujitsu Laboratories Ltd., Fujitsu Laboratories Ltd., Kawasaki; 4PETRA, Fujitsu Laboratories Ltd., Fujitsu Laboratories Ltd., Tsukuba, Japan
A highly-power-efficient PAM4 silicon photonic transmitter was developed by integrating segmented PIN Mach-Zehnder modulator and CMOS inverter driver. A passive RC equalizing technique successfully enabled clear eye-opening of PAM4 signal up to 56Gbps together with a record-high-efficiency of 1.59 mW/Gbps.

09:00 Th.1.C.2
20-Gbps QPSK Signal Generation Using a Silicon Dual-Drive Mach-Zehnder Modulator Operating in the O-Band
Laurent Bramerie1; Diego Pérez Galacho2; Charles Baudot3; Mohamed Chaibi4; Sonia Messaoudene3; Nathalie Vulliet3; Laurent Vivien2; Delphine Marris-Morini2; Christophe Peucheret5 1FOTON LABORATORY, UMR 6082, CNRS, University of Rennes 1, UMR 6082, CNRS, University of Rennes 1, LANNION; 2Centre de Nanosciences et de Nanotechnologies, CNRS, Univ. Paris-Sud, Université Paris-Saclay, C2, CNRS, Univ. Paris-Sud, Université Paris-Saclay, C2, Orsay; 3ST Microelectronics, Crolles; 4FOTON laboratory, UMR6082, CNRS, University of Rennes 1, UMR6082, CNRS, University of Rennes 1, Lannion; 5FOTON Laboratory, UMR 6082, CNRS, University of Rennes 1, UMR 6082, CNRS, University of Rennes 1, Lannion, France
20-Gbps QPSK modulation in the O-band is experimentally demonstrated using a simple transmitter structure based on a silicon dual-drive Mach-Zehnder modulator. A power penalty of only 1.5 dB was obtained with respect to the same transmitter structure in LiNbO 3

09:15 Th.1.C.3
112 Gb/s PDM-PAM4 Generation and 80 Km Transmission Using A Novel Monolithically Integrated Dual-Polarization Electro-Absorption Modulator InP PIC
Moritz Baier1; Francisco Soares2; Zhennan Zheng2; Carsten Schmidt-Langhorst2; Robert Elschner2; Felix Frey2; Marko Gruner2; Johannes Karl Fischer2; Colja Schubert2; Martin Moehrle2; Norbert Grote2; Martin Schell2
1Fraunhofer HHI, Berlin; 2Fraunhofer HHI, Einsteinufer 37, Einsteinufer 37, Berlin, Germany
We demonstrate PDM-PAM4 generation for the first time from an integrated EAM-based chip with 0.5 sqmm footprint. The device is used in 112 Gbit/s transmission over 80 km of SSMF.

09:30 Th.1.C.4
112-Gbit/s/ PAM4 Transmission enabled by a Negatively-Chirped InP-MZ Modulator
Aaron Albores-Mejia1; Sjoerd Van Der Heide2; Muhammad Usman Sadiq1; Saeed Tahvili1; Chigo Okonkwo2; Boudewijn Docter1
1EFFECTPhotonics, Eindhoven; 2Institute of Photonic Integration, Eindhoven University of Technology, Eindhoven, Netherlands
A negatively-chirped InP-MZM modulated by a 1-Vpp PAM4 signal enables 112Gbit/s/lambda data transmission with reduced digital processing complexity. SSMF-links longer than 3-km (KP4-preFEC) or 4-km (HD-preFEC) without digital dispersion pre/post compensation are successfully demonstrated.

09:45 Th.1.C.5
Low Power Optical Transmitter with DFB-Laser Mach-Zehnder Modulator PIC and Co-Designed 2-Bit DAC Driver
Sophie Lange; Jung Han Choi; Gruner Marko; Xiao Jiang; Martin Schell Fraunhofer HHI, Berlin, Germany
We present a novel 1300 nm transmitter subassembly with an InP-based DFB-laser Mach-Zehnder modulator (DFB-MZM) PIC and a SiGe 2-bit DAC driver and demonstrate up to 25 km 56 GBd PAM4 transmission with a low 332 mW transmitter power consumption.

Th.1.D: Digital Signal Processing
Room F4-F5 (SC3)
Chair: Antonella Bogoni, CNIT, Italy

08:30 Th.1.D.1 Invited
Does the Cross-Talk Between Nonlinear Modes Limit the Performance of NFDM Systems?
Vahid Aref; Son Le; Henning Buelow, Nokia Bell Labs, Stuttgart, Germany
We show a non-negligible cross-talk between nonlinear modes in Nonlinear Frequency-Division Multiplexed system when data is modulated over the nonlinear Fourier spectrum and transmitted over a lumped amplified fiber link. We evaluate the performance loss if the cross-talks are neglected.

09:00 Th.1.D.2 Highly ranked paper
Beam-Forming Transmission Enabled by Transmitter-Side MIMO Using Spatial Pilots
Haoshuo Chen; Nicolas Fontaine; Roland Ryf; Sethumadhavan Chandrasekhar; Bin Huang; Peter Winzer, Nokia Bell Labs, 791 Holmdel Rd., 791 Holmdel Rd., Holmdel, USA
Single-ended fiber transfer matrix measurements are enabled employing spatial pilots, which differentiate different spatial and polarization modes using end reflections. We measure transfer matrices of single-mode and multimode fibers and realize transmitter-side MIMO preprocessing for beam-forming transmission

09:15 Th.1.D.3
Joint Carrier Recovery for DSP Complexity Reduction in Frequency Comb-Based Superchannel Transceivers
Lars Lundberg; Mikael Mazur; Abel Lorences-Riesgo; Magnus Karlsson; Peter Andrekson, Chalmers University of Technology, Gothenburg, Sweden
We experimentally demonstrate a master-slave carrier recovery scheme by joint processing of 10GBd PM-64QAM phase-locked wavelength carriers. We measure negligible penalty up to a frequency spacing of 275GHz, showing the potential for effective resource utilization among many wavelength channels.

09:30 Th.1.D.4
LDPC-Coded FMF Transmission Employing Unreplicated Successive Interference Cancellation for MDL-Impact Mitigation
Kohki Shibahara; Takayuki Mizuno; Yutaka Miyamoto, NTT Network Innovation Laboratories, Yokosuka, Japan
A novel MIMO signal processing technique is proposed that successively cancels intermodal crosstalk for MDL-impaired mode-multiplexed signals. Experimental evaluation revealed it provides MDL-tolerance improvement of 3.3 dB and OSNR gain of > 4.5 dB even under a 39ns-DMD FMF link.

Th.1.E: High Spectral Efficiency Modulation Techniques
Room F6 (SC6)
Chair: Robert Killey, UCL, UK

08:30 Th.1.E.1 Invited
High Spectral Efficiency Transmission with Probabilistic Shaping
Junho Cho; Sethumadhavan Chandrasekhar; Xi Chen; Greg Raybon; Peter Winzer, Nokia Bell Labs, Holmdel, USA
We discuss the concept of probabilistic shaping (PS) of constellations, and show that PS allows for flexibly tunable spectral efficiencies at improved transmission performance. We review the application of PS in long-haul laboratory and submarine field experiments.

09:00 Th.1.E.2
Flexible Data-rate and Reach Transmission Employing Hybrid Modulation and Scrambled Coherent Superposition
Talha Rahman1; Bernhard Spinnler1; Stefano Calabrò1; Erik De Man1; Antonio Napoli1; Bernd Sommerkorn-Krombholz1; Ton Koonen2; Chigo Okonkwo2; Huug De Waardt2
1Coriant R&D GmbH, Munich, Germany; 2Eindhoven University of Technology, Eindhoven, Netherlands
Subcarrier multiplexing hybrid QAM combined with coherent superposition is proposed to achieve flexibility in spectral efficiency (SE) and reach. Experimental evaluation over SSMF shows scalable SE from 4.9 to 1.2 bit/s/Hz with maximum reach from 2000 to 15500 km, respectively.

09:15 Th.1.E.3
Comparing Different Options for Flexible Networking: Probabilistic Shaping vs. Hybrid Subcarrier Modulation
Fernando Guiomar1; Luca Bertignono2; Dario Pilori2; Antonino Nespola3; Gabriella Bosco2; Andrea Carena1; Fabrizio Forghieri4
1Politecnico di Torino, Corso Duca degli Abruzzi, 24, Corso Duca degli Abruzzi, 24, Torino; 2Politecnico di Torino, Torino; 3Istituto Superiore Mario Boella, Torino; 4Cisco Photonics Italy srl, Vimercate, Italy
Multi-subcarrier frequency-domain hybrid modulation formats (MSC-FDHMF) are experimentally compared against single-carrier probabilistic-shaped (SC-PS) 64QAM to achieve 12.5G bit-rate granularity at 32 Gbaud. We found maximum reach gains of SC-PS over MSC-FDHMF in the range of 0.4-1 dB.

09:30 Th.1.E.4 Invited
Long Haul Transmission at High Baud Rates toward over 100-GBaud with Coded Modulation
Masanori Nakamura1; Fukutaro Hamaoka1; Asuka Matsushita1; Hiroshi Yamazaki2; Munehiko Nagatani2; Akira Hirano1; Yutaka Miyamoto1
1NTT, Network Innovation Laboratories, Network Innovation Laboratories, 1-1 Hikarinooka Yokosuka-Shi Kanagawa; 2NTT, Device Technology Laboratories, Device Technology Laboratories, 3-1 Morinosato-Wakamiya Atsugi-Shi Kanagawa, Japan
We discuss long haul transmission based on coded multi-dimensional modulation techniques and iterative soft output decoding schemes for high-baud rate signals. 120-GBaud 8D-16QAM with iterative decoding is shown to enable 1,000 km transmission reach expansion over conventional PDM-8QAM.

Th.1.F: Optical Signal Processing
Room G4 (SC4)
Chair: Andrew Ellis, Aston University, UK

08:30 Th.1.F.1 Invited
Ultra-Wideband Digital-to-Analog Conversion Technologies for Tbit/s Channel Transmission
Hiroshi Yamazaki1; Munehiko Nagatani1; Fukutaro Hamaoka2; Shigeru Kanazawa1; Hideyuki Nosaka1; Toshikazu Hashimoto1; Yutaka Miyamoto2
1NTT Corporation, Atsugi; 2NTT Corporation, Yokosuka, Japan
We review technologies to extend the analog bandwidth of electronic digital-to-analog converters (DACs) using an analog multiplexer for advanced optical transmission systems. Arbitrary signals with electronic bandwidth of up to ~60 GHz can be generated with two CMOS DACs.

09:00 Th.1.F.2
Optical Phase Conjugation for Simultaneous Dispersion and Nonlinearity Compensation Performed over an 800-km long Field-installed Transmission Link
Yujia Sun; Kyle Bottrill; Francesca Parmigiani; David J Richardson; Periklis Petropoulos, University of Southampton, Optoelectronics Research Center, Optoelectronics Research Center, Southampton, UK
We use optical phase conjugation to perform simultaneous dispersion and nonlinearity compensation of six PDM-16QAM channels in an 800-km long, non-dispersion-managed, field-installed transmission link using commercially available lumped amplifiers.

09:15 Th.1.F.3 Highly ranked paper
Fiber Nonlinearity Mitigation in 800-km Transmission of a 1.6-Tb/s Superchannel Using Waveband-Shift-Free Optical Phase Conjugation
Carsten Schmidt-Langhorst1; Isaac Sackey1; Robert Elschner1; Tomoyuki Kato2; Takahito Tanimura2; Shigeki Watanabe2; Takeshi Hoshida2; Colja Schubert1
1Fraunhofer Heinrich-Hertz-Institute, Berlin, Germany; 2Fujitsu Laboratories Ltd., Kawasaki, Japan
We demonstrate polarization-insensitive optical phase conjugation of a 300-GHz wide 1.6-Tb/s superchannel without a shift of the occupied wavelength band. We experimentally achieve up to 0.7-dB Q-factor improvement after 800-km transmission using eight PDM-16QAM sub-channels.

09:30 Th.1.F.4
Performance Enhancement Prediction for Optical Phase Conjugation in Systems with 100km Amplifier Spacing
Mohammad Ahmad Zaki Al-Khateeb1; Mary Elizabeth Mccarthy2; Andrew Ellis1
1Aston University, Aston Institute of Photonic Technologies, Birmingham, UK; 2Oclaro Technologies, Paignton, UK
We report, and experimentally validate, an analytical expression that predicts the nonlinearity compensation of links with large EDFA spacing and mid-link optical phase conjugation. The experimental results show excellent agreement with the analytical predictions.

09:45 Th.1.F.5
Polarization Multiplexing without Wavelength Control
Di Che; Jian Fang; Hamid Khodakarami; William Shieh
The University of Melbourne, Parkville, Australia
We propose the polarization-multiplexing (POL-MUX) using free-running TOSAs, with the direct-detection receiver required only the baseband bandwidth. A >100-Gb/s POL-MUX direct modulation is realized by 10G-class TOSA/ROSA with TOSA frequency offset from 0 to 250 GHz.

10:00 - 10:30 COFFEE HALL F

Th.2.A: Fibre Connectivity for Data Centres
Room F1 (SC5)
Chair: Carlo Mariotti, Cisco Photonics, Italy

10:30 Th.2.A.1 Invited
Application-driven Requirements for Next-Generation Data Center Interconnects
Hans-Juergen Schmidtke, Facebook, USA

11:00 Th.2.A.2
56-Gbaud PAM4 Transmission over 2-km 125-um-Cladding 4-Core Multicore Fibre for Data Centre Communications
Shohei Beppu1; Hidenori Takahashi1; Takehiro Tsuritani1; Tomohiro Gonda2; Katsunori Imamura2; Kengo Watanabe2; Ryuichi Sugizaki2
1KDDI Research, Inc., Fujimino-shi; 2Furukawa Electric Co., Ltd., Ichihara, Japan
We demonstrate single-wavelength and single-fibre 400-Gb/s transmission using 4 cores is achieved without parallel SMFs. In addition, 1.6-Tb/s transmissions using 56-Gbaud PAM4 LAN- and C-WDM signals across O and C/L-band over 2-km 125-um-cladding 4-core MCF is achieved.

11:15 Th.2.A.3 Highly ranked paper
14.5Tb/s Mode-Group and Wavelength Multiplexed Direct Detection Transmission over 2.2 km OM2 Fiber
Kaoutar Benyahya1; Christian Simonneau2; Amirhossein Ghazisaeidi3; Nicolas Barré4; Pu Jian4; Jean-François Morizur4; Guillaume Labroille4; Marianne Bigot-Astruc5; Pierre Sillard5; Jeremie Renaudier6; Gabriel Charlet6
1Nokia Bell Labs, Nozay, France; 2Nokia Bel-Labs, Nozay, France; 3Nokia Bell-Labs, Nozay, France; 4CAILabs, Rennes, France; 5Prysmian Group, Haisnes, France; 6Nokia Bell-Lbas, Nozay, France
We demonstrate 14.5Tb/s bidirectional transmission over 2.2km of OM2 fiber using selective excitation of 4 mode groups, WDM multiplexing and direct detection. This is the highest throughput transmitted over multimode fibers using direct detection.

11:30 Th.2.A.4 Highly ranked paper
End-to-End Multi-Core Fibre Transmission Link Enabled by Silicon Photonics Transceiver with Grating Coupler Array
Tetsuya Hayashi1; Attila Mekis2; Tetsuya Nakanishi1; Mark Peterson2; Subal Sahni2; Peng Sun2; Steven Freyling2; Gene Armijo2; Chang Sohn2; Dennis Foltz2; Thierry Pinguet2; Michael Mack2; Yasuomi Kaneuchi1; Osamu Shimakawa1; Tetsu Morishima1; Takashi Sasaki3; Peter De Dobbelaere2 1Optical Communications Laboratory, Sumitomo Electric Industries, Ltd., Yokohama, Japan; 2Luxtera Inc., Carlsbad; 3Innovation Core SEI, Inc., San Jose, USA
We present an end-to-end multi-core fibre transmission link where the 8-core fibre and the corresponding 200 Gb/s silicon photonics transceiver chip were co-designed. We demonstrate equivalent performance between the MCF and a parallel SMF transmission links.

11:45 Th.2.A.5
200-Gbps DMT Transmission over 1.6-km SSMF with A Single EML/DAC/PD for Optical Interconnects at C-Band
Xuezhi Hong1; Lu Zhang2; Xiaodan Pang3; Oskars Ozolins4; Aleksejs Udalcovs4; Changjian Guo5; Fredrik Nordwall6; Klaus M. Engenhardt7; Aditya Kakkar3; Jaime Rodrigo Navarro8; Richard Schatz9; Urban Westergren9; Gunnar Jacobsen4; Sergei Popov9; Shilin Xiao10; Jiajia Chen11KTH Royal Institute of Technology, South China Normal University, South China Normal University, Kista, Sweden; 2KTH Royal Institute of Technology, Shanghai Jiao Tong University, Shanghai Jiao Tong University, Kista, Sweden; 3KTH Royal Institute of Technology, RISE Acreo AB, RISE Acreo AB, Kista, Sweden; 4RISE Acreo AB, Kista, Sweden; 5South China Normal University, Guangzhou, China; 6Tektronix AB, Stockholm, Sweden; 7Tektronix GmbH, Stuttgart, Germany; 8RISE Acreo AB, KTH Royal Institute of Technology, KTH Royal Institute of Technology, Kista, Sweden; 9KTH Royal Institute of Technology, Kista, Sweden; 10Shanghai Jiao Tong University, Shanghai, China
We report on the first experimental demonstration of 200-Gbps (net rate 166.7-Gbps) 1.55-μm DMT IMDD transmission over 1.6 km fiber using a single monolithically-integrated-EML, DAC and photodiode, achieving an effective electrical spectrum efficiency of 4.93 bit/s/Hz.

Th.2.B: Local Area Networks
Room F2 (SC8)
Chair: Kota Asaka NTT, Japan

10:30 Th.2.B.1
112 Gbit/s Transmission in a 2D Beam Steering AWG-Based Optical Wireless Communication System
Fausto Gomez Agis1; Sjoerd Van Der Heide2; Chigo Okonkwo1; Eduward Tangdiongga1; Ton Koonen1 1Eindhoven University of Technology, Eindhoven; 2 Institute of Photonic Integration, Eindhoven University of Technology, Eindhoven, Netherlands
112 Gbit/s transmission in a 2D infrared AWG-based beam steering system is demonstrated by employing PAM-4 modulation, pulse-shaping, pre-compensation and equalisation techniques in a SOA-based pre-amplified direct-detection scheme. BER performances below HD-FEC (3.8E-3) have been achieved.

10:45 Th.2.B.2
50 Gb/s Indoor Optical Wireless Communication Equipped with Millimeter-wave Backup System and Localization and Tracking
Ketemaw Addis Mekonnen; Zicheng Cao; Nicola Calabretta; Eduward Tangdiongga; Ton Koonen, Eindhoven University of Technology, Eindhoven, Netherlands
Using photonic integrated circuits, we propose a full-duplex optical-wireless system backed up by a simple 60GHz-radio system to realize highly reconfigurable and reliable wireless links equipped with localization and tracking functionalities which provide transmission rates of 50Gb/s per user.

11:00 Th.2.B.3 Invited
ATTO: Wireless Networking at Fiber Speed
Guy Torfs; Haolin Li; Sam Agneessens; Johan Bauwelinck; Olivier Caytan; Wout Joseph; Hendrik Rogier; Arno Thielens; Dries Vande Ginste; Xin Yin; Piet Demeester, Ghent University - imec, Ghent, Belgium
To provide a tremendous wireless capacity (100Gbps/m2) and latencies <10 microseconds, ultra-small floor-integrated cells are proposed. RF-over-fiber, coherent communication and a dedicated 2D PON structure support the interconnection and selection of the cells and allow to minimize the transceiver electronics.

11:30 Th.2.B.4
Experimental Demonstration of 4K-UHD Video Transmission Using T-Band Wavelength Routing System for Passive Optical Local Area Networks
Ryogo Kubo1; Hiroyuki Tsuda1; Makoto Sudo2; Tadashi Hajikano2; Yasunori Tomomatsu3; Katsumi Yoshizawa4 1Keio University, Kanagawa, JP; 2Optoquest Co., Ltd., Saitama, JP; 3Koshin Kogaku Co., Ltd., Kanagawa, JP; 4Pioneer Micro Technology Corporation, Yamanashi, Japan
We demonstrate uncompressed 4K-UHD video transmission in the optical communication wavelength range known as T-band. The experiments using quantum-dot semiconductor devices and an arrayed waveguide grating router show the feasibility of T-band passive optical local area networks.

11:45 Th.2.B.5
WiFi, Multiband Clipped LTE-A and Gbps 4-PAM Simultaneous Transmission over 50m Thick-core POF and Wireless Link for Home Area Networks
Federico Forni1; Yan Shi2; Henrie Van Den Boom3; Eduward Tangdiongga3; Ton Koonen3 1Eindhoven university of technology, Genexis, Genexis, Eindhoven; 2Genexis,, Eindhoven; 3Eindhoven university of technology, Eindhoven, Netherlands
An IEEE802.11n-compliant 40MHz WiFi, 9 bands 64-QAM LTE-A with reduced PAPR by clipping and 1.7Gb/s 4-PAM signals were successfully transmitted over 50m PMMA GI-POF and 12m wireless. This proves that POF is suitable for multi-standard wireless-wired in-home networks.

Th.2.C: Software Defined Networks (SDN)
Room F3 (SC7)
Chair: Raul Muñoz, Centre Technologic de Telecommunicacions de Catalunya, Spain

10:30 Th.2.C.1 Invited
SDN Control of Optical Networks
Marc De Leenheer1; Yuta Higuchi2; Toru Furusawa3; Guru Parulkar4
1ON.Lab, Menlo Park, USA; 2NEC, Tokyo, Japan; 3NTT Communications, Tokyo, Japan; 4Stanford University, ONF, ONF, Stanford, USA
ONOS is a scalable and highly available open source network OS for multi-layer transport networks. It enjoys industry-wide vendor support and is being deployed in production at some of the biggest service providers in the world.

11:00 Th.2.C.2
Network Slicing Using Dynamic Flex Ethernet over Transport Networks
Ricard Vilalta1; Ricardo Martínez1; Ramon Casellas1; Raul Muñoz1; Young Lee2; Li Fei3; Pengcheng Tang3; Victor López4
1Centre Tecnològic de Telecomunicacions de Catalunya (CTTC/CERCA), Castelldefels, Spain; 2Huawei, Plano, TX, USA; 3Huawei, Shanghai, China; 4Telefónica, Madrid, Spain
This paper proposes the introduction of Flex Ethernet and its integration in an optical SDN/NFV architecture to support dynamic deterministic network slicing. Protocol extensions are experimentally validated for the management and control of Flex Ethernet network equipment.

11:15 Th.2.C.3
Demonstration of gRPC Telemetry for Soft Failure Detection in Elastic Optical Networks
Francesco Paolucci1; Andrea Sgambelluri1; Matteo Dallaglio1; Filippo Cugini2; Piero Castoldi1 1Scuola Superiore Sant'Anna, Pisa; 2CNIT, Pisa, Italy
Streaming-oriented telemetry allowing on-demand live monitor of EON is exploited for fast soft failures localization. SDN control and management is extended with telemetry modules based on the gRPC protocol. Experimental results show telemetry efficiency in terms of detection accuracy.

11:30 Th.2.C.4
Network Capacity Improvement by Quality of Transmission Estimator with Learning Process
Shoichiro Oda1; Martin Bouda2; Olga Vassilieva2; Yoshio Hirose1; Takeshi Hoshida1; Ikeuchi Tadashi2
1Fujitsu Laboratories Ltd., Kawasaki, Japan; 2Fujitsu Laboratories of America, Inc, Richardson, USA
We experimentally demonstrate the benefit of a quality of transmission estimator with learning process for modulation format provisioning. Monitoring BERs of provisioned signals enables more efficient assignment of modulation format, resulting in 15% capacity increase in 6 CD-ROADMs network test-bed.

11:45 Th.2.C.5
Experimental Demonstration of Network Automation Based on QoT Estimation and Monitoring in Both Single- and Multi-Domains
Nicola Sambo1; Pietro Giardina2; Ippokratis Sartzetakis3; Andrea Sgambelluri1; Francesco Fresi1; Matteo Dallaglio1; Gianluca Meloni4; Giacomo Bernini2; Kostas Christodoulopoulos3; Piero Castoldi1; Emmanuel Varvarigos3 1Scuola Superiore Sant'Anna, Pisa; 2Nextworks, Pisa; 3Computer Technology Institute and Press - Diophantus, Athens; 4CNIT, Pisa, Italy
We experimentally demonstrate the integration of 100-200Gb/s data plane with NETCONF agents, SDN-controllers, and management plane exploiting monitoring and QoT estimations. We report on successful experiments for provisioning and reliability in single- and multi-domains

Th.2.D: Optical Amplifiers for SDM
Room F4-F5 (SC1)
Chair: Hans Limberger, École Polytechnique Fédérale de Lausanne, Switzerland

10:30 Th.2.D.1 Tutorial
Optical Amplifiers for Space-Division-Multiplexed Systems
David J Richardson; Saurabh Jain; Yongmin Jung; Shafi-Ul Alam Optoelectronics Research Centre, University of Southampton, UK
We review progress in optical amplifier technology for SDM systems, considering both multi-core and few-mode based technological approaches (and their combination). We will present the state-of-the-art in terms of underpinning active and passive components, amplifier performance and associated transmission experiments.

11:30 Th.2.D.2
Improved cladding-pumped 32-core multicore fiber amplifier
Saurabh Jain1; Takayuki Mizuno2; Yongmin Jung1; Akira Isoda2; Kohki Shibahara2; John Hayes1; Yusuke Sasaki3; Katsuhiro Takenaga3; Yutaka Miyamoto2; Shaif-Ul Alam1; David J Richardson1
1Optoelectronics Research Centre, University of Southampton, University of Southampton, Southampton, UK; 2NTT Network Innovation Laboratories, NTT Corporation, NTT Corporation, Yokosuka, Kanagawa, Japan; 3Fujikura Ltd, Mutsuzaki, Sakura, Chiba, Japan
We present an improved cladding pumped high-core-count 32-core multicore-fiber amplifier. A gain of >17dB and average NF of 6.5dB with <2dB variation is obtained for -4dBm input signal power over all cores in the wavelength range 1534nm-1561nm.

11:45 Th.2.D.3
Increase of Cladding Pump Power Efficiency by a 19-Core Erbium Doped Fibre Amplifier
Shigehiro Takasaka1; Koichi Maeda1; Kawasaki Kohei1; Yoshioka Kazuaki1; Oshio Hajime1; Sugizaki Ryuichi1; Yu Kawaguchi2; Hidenori Takahashi2; Takehiro Tsuritani2; Masato Shiino1
1Furukawa Electric Co., Ltd., Ichihara; 2KDDI research, Inc., Fujimino, Japan
We demonstrate that a cladding pumped 19-core EDFA has 2.5-dB higher pump power efficiency than a cladding pumped 7-core EDFA. The 19-core EDFA with pump power of 22.8 W has gain of 12.7 dB and output power of 22.2 dBm.

Th.2.E: Nonlinear Characterisation and Compensation
Room F6 (SC6)
Chair: Alexii Pilipetskii, Subcom, USA

10:30 Th.2.E.1 Highly ranked paper
Performance of Nonlinear Compensation Techniques in a 71.64 Tb/s Capacity Demonstration Over 6970 km
Matt Mazurczyk; Jin-Xing Cai; Hussam Batshon; Milen Paskov; Oleg Sinkin; Ding Wang; William Patterson; Carl Davidson; Patrick Corbet; Gregory Wolter; Timothy Hammon; Maxim Bolshtyansky; Dmitri Foursa
TE SubCom, a TE Connectivity business unit, Eatontown, USA
We show the benefits of using a combination of DSP algorithms to compensate transmission nonlinearities. We measure an average total benefit of 1.4dBQ at nominal power using digital back propagation together with adaptive linear filters aided by coded modulation decisions.

10:45 Th.2.E.2
Digital Back-Propagation Performance in Wideband Transmission Systems
Lidia Galdino1; Gabriel Saavedra1; Daniel Semrau1; Daniel J Elson1; Domaniç Lavery1; Mingming Tan2; Paul Harper2; Md Asif Iqbal2; Robert Killey1; Polina Bayvel1 1University College London, London; 2Aston University, Birmingham, UK
Single channel digital back-propagation (SC-DBP) performance with different transmission bandwidths is experimentally and theoretically investigated. The SC-DBP gain reduces with transmission bandwidth; from 1.2 b/sym for single channel to 0.2 b/sym for C-band transmission at 2000 km,

11:00 Th.2.E.3
10-WDM 64-GBaud PDM-64QAM Transmission over all-Raman amplified 840 km SSMF using Digital Back Propagation
Asuka Matsushita; Masanori Nakamura; Hideki Nishizawa; Yoshiaki Kisaka; Akira Hirano, NTT, Yokosuka, Japan
1.2Tbit (2Ã—64GBaud PDM-64QAM) data transmission is successfully demonstrated over 840km SSMF. The characteristics of transmitter and receiver was precisely calibrated and non-linear effect was compensated by digital back propagation in all-Raman amplification configuration by Q-factor improvement of 0.7dB.

11:15 Th.2.E.4
Nonlinear Characterization of Fiber Optic Submarine Cables
Eduardo Mateo; Kohei Nakamura; Takanori Inoue; Yoshihisa Inada; Takaaki Ogata, NEC Corporation, Tokyo, Japan
We introduce a method to characterize the nonlinear properties of submarine cables. Based on the inverse back-to-back method and the GN model, the fiber effective area has been estimated with excellent accuracy in independent 9000km-QPSK and 3240km-16QAM experiments.

11:30 Th.2.E.5
Faster Open Submarine Cable
Valey Kamalov1; Ljupcho Jovanovski1; Vijay Vusirikala1; Eduardo Mateo2; Yoshihisa Inada3; Takaaki Ogata3; Kenichi Yoneyama3; Pascal Pecci4; David Seguela4; Olivier Rocher4; Hidenori Takahashi3
1Google, Mountain View, USA ; 2NEC, Tokyo, Japan; 3NEC Corporation, Tokyo, Japan; 4Alcatel Submarine Networks, Paris, France
Open Cable design enables the most efficient modulation. We transport 8QAM over 10,940 km. Also, we achieved a record 4 b/s/Hz for Trans-Pacific production system. Using G-OSNR, we estimate the potential capacity of FASTER cable with Probabilistic Constellation Shaping solutions.

Th.2.F: DSP Subsystems
Room G4 (SC4)
Chair: Norbert Hanik, TU München, Germany

10:30 Th.2.F.1
Proactive Fiber Damage Detection in Real-time Coherent Transceiver
Fabien Boitier1; Vincent Lemaire2; Jelena Pesic1; Lucia Chavarría1; Patricia Layec1; Sébastien Bigo1; Eric Dutisseuil 1Nokia Bell Labs, Nozay; 2Orange Labs, Nozay, France
We develop an algorithm extension for a coherent receiver, coupled with machine learning to monitor mechanical stress to an optical fiber, for recognizing fiber breaks before they occur. We demonstrate event classification with 95% accuracy over a real-time PDM-QPSK testbed.

10:45 Th.2.F.2
On the Use of High-Order MIMO for Long-Distance Homogeneous Single-Mode Multicore Fiber Transmission
Ruben Luis; Benjamin Puttnam; Georg Rademacher; Yoshinari Awaji; Naoya Wada, NICT, Koganei, Japan
We investigate the use of high-order MIMO to compensate inter-core crosstalk penalty over long-distance transmission using homogeneous single-mode multicore fibers. We show that the MIMO improves reach by 8% but may require excessive DSP resources and inter-core skew compensation.

11:00 Th.2.F.3
On the Bit Error Rate of Optical Transmission Systems Corrupted by Bivariate Additive White Gaussian Noise
Petros Ramantanis1; Camille Delezoide1; Philippe Jennevé1; Patricia Layec1; Yann Frignac2; René-Jean Essiambre3; Sébastien Bigo1
1Nokia Bell-Labs, Paris, France; 2TÉlécom SudParis, Paris, France; 3Nokia Bell-Labs, Holmdel, USA
We derive in an integral form the BER for QPSK constellations corrupted by elliptic AWGN and discuss its properties compared to circular AWGN. Then we confront our theory with transmission experiments in configurations with elliptic noise caused by strong nonlinearity

11:15 Th.2.F.4 Highly ranked paper
Geometrically Shaped 16QAM Outperforming Probabilistically Shaped 16QAM
Zhen Qu; Ivan Djordjevic, University of Arizona, Tucson, USA
We compare the proposed geometrically-shaped(GS) 16QAM with the probabilistic shaped(PS) 16QAM formats in both numerical simulation and experimental setup. The results show that GS-16QAM outperforms PS-16QAM.

11:30 Th.2.F.5
Reach Extension with Lattice Precoding for Optical PAM Transmission in Data Center Networks
Toshiaki Koike-Akino; David S. Millar; Kieran Parsons; Keisuke Kojima, MERL, Cambridge, USA
We apply an improved version of THP, called lattice precoding (LP), to IM/DD short-reach optical fiber communications for data center network (DCN). We show that LP offers 6dB gain and 21% reach extension over conventional methods.

12:00 - 13:30 LUNCH BREAK
13:30 - 15:00 POST DEADLINE PAPER SESSIONS
15:00 - 15:30 COFFEE HALL F
15:30 - 16:00 AWARDS AND CLOSING CEREMONY ROOM F4-F5

12:00 - 13:30 LUNCH BREAK
13:30 - 15:00 POST DEADLINE PAPER SESSIONS
15:00 - 15:30 COFFEE HALL F
15:30 - 16:00 AWARDS AND CLOSING CEREMONY ROOM F4-F5

AUTHOR LIST

AUTHOR LIST

AUTHOR LIST

AUTHOR LIST

Conference Venue

Svenska Mässan, The Swedish Exhibition & Congress Center
ECOC – Entrance number 2
Mässans gata 24, Gothenburg
www.svenskamassan.se

Closest tram/bus stop: Korsvägen
Conference Secretariat
Sweden Meetx – Entrance number 2
ecoc2017@meetx.se
www.ecoc2017.org

Conference App

The conference app "ECOC 2017" is available to download for Apple devices and Android devices. The app contains a lot of useful general information, technical programme, my schedule and much more. Once downloaded, a lot of the information is available in the app off-line.

Wifi

There is a free wifi in the conference venue called "ECOC2017", no password needed.

Gothenburg

To make the most out of your visit to Gothenburg, the website www.goteborg.com or the app "Gothenburg" is very informative and useful.

Travel information

Airport buses

Costs SEK 95 single way and SEK 185 return, no cash accepted on the bus only credit cards. It takes 20 minutes to travel between the airport called Landvetter and the venue Svenska Mässan, the bus stop is called "Korsvägen/Svenska Mässan" and is located right outside the entrance of the venue. For information and timetable please visit www.flygbussarna.se

Airport Taxi

Costs approximately SEK 420 to/from Landvetter Airport. Ask for a fixed price. The driver should have a taxi ID card clearly displayed in the vehicle. Service is included in the taximeter price. Avoid unlicensed taxis.
We recommend:
Taxi Göteborg: +46 (0) 31 650 00
Taxi Kurir: +46 (0) 31 27 27 27

When in Gothenburg

In Gothenburg we walk! The venue is located right in the city center, all hotels and social venues are located by walking distance from each other – walk and explore the city, use the public transportations or the city bikes instead of taking taxis.

Local Transportation

The Swedish Exhibition Center or "Svenska Mässan" is located on Mässans gata. The closest tram stop is called "Korsvägen". From the train station you will find a tram stop just outside at Drottningtorget. Take tram No. 2 or 13 to tram stop "Korsvägen".

For travel information and travel planner visit the website www.vasttrafik.se or download the app "To Go".
You can buy tickets in most convenience stores such as Pressbyrån, 7-eleven etc. or pay with credit card on the trams (not on the bus). No cash is accepted.

Göteborg City Card

Göteborg City Card gives you free admission to lots of entertainment, sights, excursion, Liseberg amusement park (located opposite the conference venue) and many museums. Travel with trams, buses and boats are included in the city card. You'll also get shopping booklets with discounts in selected stores. Maximise your stay in Gothenburg. The card is valid for 24, 48 or 72 h.
More information: www.goteborg.com/en/citycard/

Bike rental: Styr & Ställ

Gothenburg is a bike friendly city. Throughout the city you will find bike stands with rental bikes. For a small cost you can rent a bicycle as often as you wish. The first half hour of each journey is always free, regardless of the number of journeys per day. Short time visitors can choose the 3-Day Pass, which can be purchased from any of the credit card terminals. It is also included in the Göteborg City Card.
More information: en.goteborgbikes.se/

Onsite Registration

The Conference Registration desk is located in entrance number 2 at Svenska Mässan. You do not need to register for the exhibition as the Conference badge gives you full access to it.

Registration opening hours:

Sunday 17 September	08:00–19:30
Monday 18 September	08:00–18:00
Tuesday 19 September	07:30–17.30
Wednesday 20 September	07:30–17:30
Thursday 21 September	07:30–16:30

Location: Svenska Mässan, Entrance number 2, Mässans gata 24

Badges

To collect your badge onsite you need to bring the email confirmation (electronically in the phone works fine) or the text message that has been sent to you in advance, containing the bar code that you will be scanning in the self-service desks in the registration area.
Delegate badges must be worn at all times to gain access to the conference sessions, exhibition and social events. Please note that we cannot replace lost badges.

Cloakroom

There are cloakroom facilities in the registration area. The organisers cannot be held responsible for damage to or loss of their personal property howsoever caused.

Cloakroom opening hours:

Sunday 17 September	08:00–20:00
Monday 18 September	08:00–18:00
Tuesday 19 September	07:30–18.30
Wednesday 20 September	07:30–18:00
Thursday 21 September	07:30–16:30

Catering

Delegate coffee breaks

Coffee is included in the conference registration and will be held in the following places and times:

Sunday 17 Sept., Hall F	10:00-11:30 and 15:00-16:00
Monday 18 Sept., Congress Foyer	09:00-10:00
Monday 18 Sept., Exhib. area	15:30-16:00
Tuesday 19 Sept., Exhib. area	10:00-10:30 and 15:00-15:30
Wednesday 20 Sept., Exhib. area	10:00-10:30 and 15:00-15:30
Thursday 21 Sept., Hall F	10:00-10:30 and 15:00-15:30

Lunch

Lunch is NOT included in conference registration fees. However there are a variety of "Food Beverage selling points" and Restaurants in the venue as well as inside the Exhibition Hall.

Information about catering

For information about catering during ECOC 2017, Gothia Towers restaurants and table reservations please visit www.gothiatowers.com/ecoc2017/

Lunch Buffet Restaurant - Seasons

Where: Located at level 2
When: Sunday–Thursday 11:30-15:00
Lunch buffet with 3 different main courses (fish, meat and vegetarian option). Chef's choice of salads and cold cuts as starter.
Price: 169 SEK includes water and coffee

Food & Drinks – Corner Café

Where: Located in the exhibition hall
Opening hours: Monday-Tuesday 09:30-17:00, Wednesday 09:30-16:00
- Wraps, Sandwiches & Salads, Pastries
- Coffee & Tea
- Soft drinks & water
- Beer, Wine & Cider

Food & Drinks – Centre Café

Where: Located in the exhibition hall
Opening hours: Monday-Wednesday 11:30-15:00
- Sausages & Hot Dogs
- Soft drinks & Water
- Beer, Wine & Cider

Food & Drinks – Asia

Where: Located in the exhibition hall
Opening hours: Monday-Wednesday 11:30-15:00
- Noodles, Wraps & Salad
- Coffee & Tea
- Soft drinks & Water
- Beer, Wine & Cider

Food & Drinks – Delegate Coffee Area

Where: Located in the exhibition hall
Opening hours: Monday-Tuesday 09:30-17:00, Wednesday 09:30-16:00
(closed when delegate coffee is taking place)
- Wraps, sandwiches & Pastries
- Pastries
- Coffee & Tea
- Soft drinks & Water

Gothia Tower's Resraurants

Twentyfourseven

A café & bar with a "grab 'n' go" concept, located in the middle of the hotel lobby of Gothia Towers.

Open every day of the week from 06:30 to 03:00. No reservations at this café.

Heaven 23

Seasonal contemporary cuisine with mile-high views in all directions from the top floor of Tower 1. Open every day of the week from 12:00 to late. Reservations can be made.

Ristoria

Gothia Towers new dazzling restaurant, market and meeting place where every taste experience conveys a story from our great Italian food trip. Located by korsvägen by the main entrance to the venue. Ristoria is open every day from breakfast to late evening. Reservations can be made.

West Coast

A modern bistro with a focus on local cuisine, seafood, serves Swedish meat and locally produced and organic ingredients. Offers well-selected Swedish beer brands and Sunday dinner. You will find the restaurant in the lobby of Tower 2, close to the hotel lobby of the Gothia Towers hotel.
West Coast is open Monday–Friday 11:30-22.30, Saturday 12:0-22:30, Sunday 13:00-21:00. Reservations can be made.

Upper House Dining

A critically acclaimed gourmet restaurant that takes you on a culinary journey that lasts a whole evening, located at the top floor of Tower 2 in our 5-star sister hotel Upper House. It's also possible to book a table at Upper House Lounge. The restaurant has a star in the Michelin Guide.

For reservations at the Gothia Towers Restaurants

Visit: www.gothiatowers.com/ecoc2017/
Phone: +46 (0)31 750 88 05
Email: restaurants@gothiatowers.com

Social Events

Get Together
Date: Sunday 17 September
Time: 18:00-19:30
Place: Svenska Mässan, Hall F
Price: Included in the registration fee
Pre-registration is mandatory.

ECOC Conference 2017 has the pleasure to invite you to attend the Get Together where you will get the opportunity to meet and socialize with colleagues that are attending the conference.
The Get Together includes snacks and drinks.

City of Gothenburg

universeum

Welcome Reception
Date: Monday 18 September
Time: 18:30-20:30
Place: Universeum, Södra Vägen 50, Gothenburg (opposite the conference venue).
Website: www.universeum.se
Price: No cost (Sponsored by the city of Gothenburg together with the conference)
Pre-registration is mandatory.

ECOC and the City of Gothenburg has the pleasure to invite you to the Welcome reception where you will find ample opportunity to meet old friends and make new acquaintances.
The ECOC2017 Welcome reception will take place at Universeum, Scandinavia's largest Science Centre which is located just nearby the conference venue. You will get the opportunity to explore the house on guided tours, e.g. the Water's Way which is a living model of the Swedish landscape from north to south, allowing you to dive into life in and around Sweden's waters. There is also the opportunity to visit the tropical sharks aquarium and the steaming rain forest with exotic animals. The exhibition Teknoteket offers you technical challenges.

The Welcome reception includes food and drinks.
Please note that the welcome reception starts no earlier than 18:30 due to the museum closing for the public at 18:00. It is better to be late than early!

Concert
Date: Tuesday 19 September
Time: 17:45-19:00
Place: Gothenburg Concert Hall, Götaplatsen
Price: SEK 100 excl. vat
Pre-registration is mandatory

Classical concert with musicians from the Gothenburg Symphony Orchestra. Music by Philip Glass (String Quartet No 2) and Edvard Grieg (String Quartet no 1 G minor op 27).

Conference Dinner
Date: Wednesday 20 September
Time: 19:00-24:00
Place: Kajskjul 8, Packhuskajen 11
Website: www.kajskjul8.se
Price: SEK 500 excl.vat
Pre-registration is mandatory.

The ECOC 2017 Conference Dinner will take place at Kajskjul 8, a venue located in the harbor area in the city center. Kajskjul 8 was built on the quays along the railroad tracks around 1870. Originally used as a warehouse, the shed was then filled with all kinds of products, such as spices imported from the Orient as well as lumber from the forests of Värmland (region north of Gothenburg), which would then be transported down to southern Europe and other places. It is a building with a lot of interesting history, nowadays used for events and dinners.
Dinner includes a 3 course dinner, beverages, and entertainment.
Closest tram/bus stop: Stenpiren or Lilla Bommen

Exhibition

The Exhibition will take place in Hall A and B. The conference participants have automatically access to the exhibition. On Tuesday 19 September, the conference will have exhibition only time between 10:00-12:00 to allow the Conference participants to visit the Exhibition. For information about the exhibition: www.ecocexhibition.com

Exhibition opening hours:

Monday 18 September	09:30–17:00
Tuesday 19 September	09:30–17:00
Wednesday 20 September	09:30–16:00

ECOC 2017 Programme

Details of times and technical sessions can be found on the ECOC website: www.ecoc2017.org/Programme. A printed copy of the programme will be included in the conference bags upon registration. A digital copy of the programme and papers will also be included on the USB memory stick (proceedings) as well as in the conference app.

Post Deadline Papers Proceedings
Post deadline papers will be published on Tuesday 19 September on the conference website and in the detailed programme on both the website and in the conference app.

They will also be announced on the Message board in Hall F.

Opening and Plenary Session
Monday 18 September, 10:00 – 12:30
Place: Congress Hall
The plenary session is open to delegates, exhibitors, visitors and the general public.

Closing Ceremony
Thursday 21 September, 15:30 – 16:00.
Place: Hall F, Room F4-F5
The closing ceremony, including the Best Student Paper Award sponsored by ADVA is open to delegates, exhibitors, visitors and the general public.

Presentations & Speaker Preview Room
The speakers Preview Room is located in Room R11-12
Opening hours:

Sunday 17 September	13:00-19:30
Monday 18 September	08:00-18:30
Tuesday 19 September	07:30-17:30
Wednesday 20 September	07:30-17:30
Thursday 21 September	07:30-16:00

Presenters must report to the Speaker Preview Room and hand in the presentation at least 1 hour prior to your talk! The presentation will then be sent to the room and each room has a technician that will assist and start the presentation for you.

For authors scheduled on Sunday 17 September during a workshop, they should bring their memory stick directly to their workshop room in good time before the workshop starts. Each room has a technician.

Please bring your presentations on a USB memory stick in MS-Power Point or Adobe PDF format.

Note that there will be no presentation uploads in the conference rooms. All presentations must be uploaded in the Speaker Preview Room prior to your presentation. Technical personnel will test-check your oral presentation for compatibility. Please give the technical personnel any special instructions you may have when you are in the Speaker Preview Room, not during your lecture. There will be one technician in each room, the computers will be PC. No use of personal computers can be accommodated.

In order to avoid any problems with your presentation please make sure that it fulfills the necessary requirements for the following software:

MS Office 2013 or later version (Word, Excel, PowerPoint)
Windows Media Player
Adobe Acrobat Reader

The standard format of the projectors in the conference rooms is 16:9 (wide screen).

Posters
The poster area will be located in the conference area in Hall F. Poster presenting authors can display their poster during the day it will be presented between 09:00-17:00. Please remove your poster after your session, posters not withdrawn after the day will not be saved.

Poster Session I: Tuesday 19 September, 15:30 – 17:00
Poster Session 2: Wednesday 20 September, 15:30-17:00

Beverages will be served during the poster sessions.

We would like to call the attention of poster presenters to the following items:
- Each poster board is marked with a poster ID-number. Please find your poster ID-number in the Programme.
- Authors are requested to use only the boards provided for their poster.
- Posters should be fixed to the poster board using pins which will be provided on site.
- Authors are required to stand by their posters during their whole scheduled poster session time on Wednesday and Thursday.
- The maximum size of your poster should be 90cm (width) by 120cm (height), portrait style.

Other useful information

Messages
A message board is available in the conference are in Hall F to leave messages to your colleagues and friends.

Currency & ATM Machine
The currency in Sweden is Swedish Krona (kr) / SEK. The venue has an ATM Machine located by the main entrance number 5. Some places do not accept cash, credit card is the most common way to pay in Sweden.

Press Room
The Press Room is located in the Exhibition Hall. Only press representatives correctly identified will be allowed to use this room.

First Aid
There is a paramedic in the venue. In case of medical need, please come to the onsite registration desk or go to the Exhibitor Service Desk and we will help you. If medical emergency please call 112.

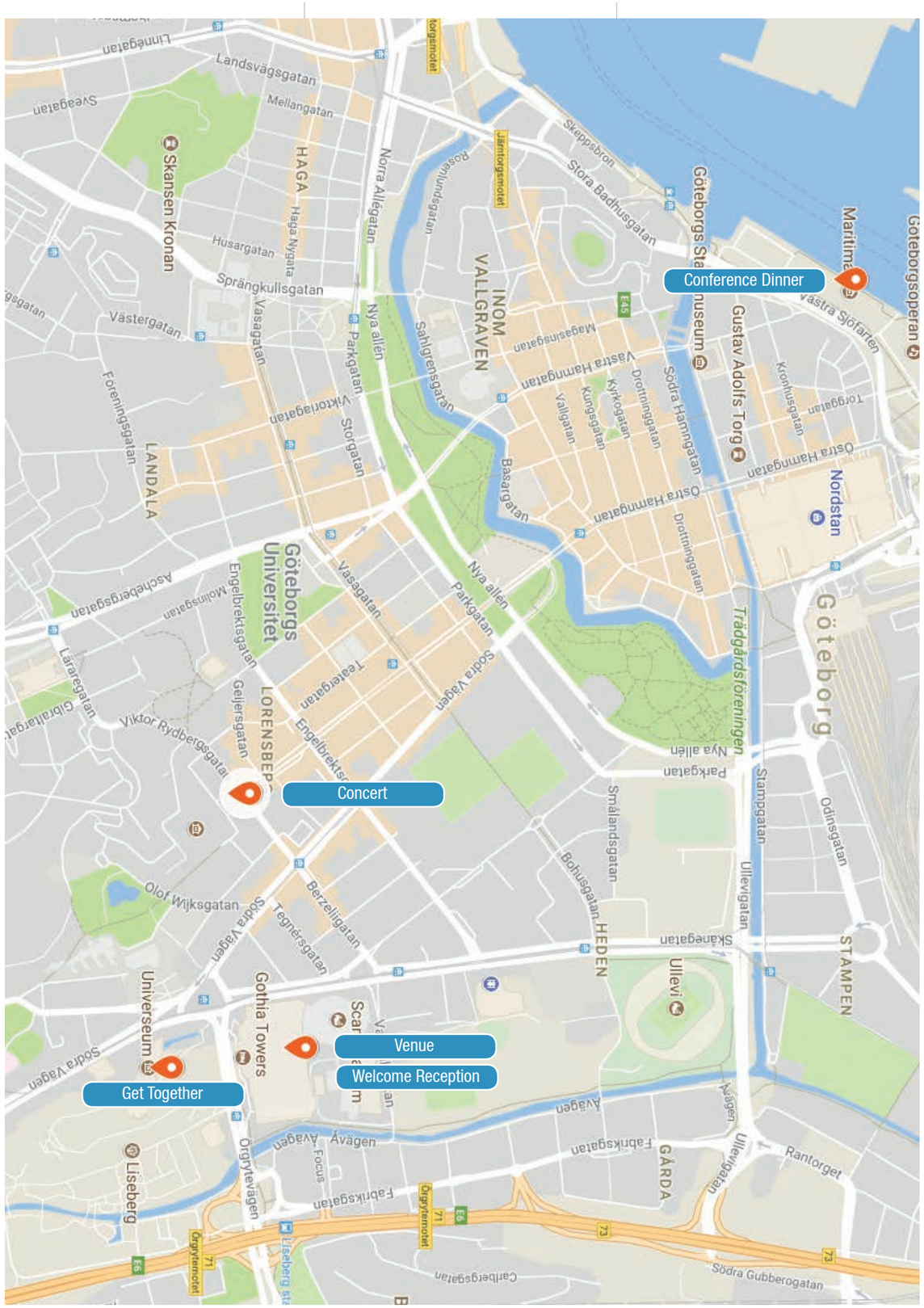
No smoking policy
According to Swedish law smoking is prohibited inside any building, venue, hotels, busses, etc. Smoking is only allowed at open air zones.

Lost-and-Found
Lost-and-Found will be collected in the registration.

Insurance
The Organisers cannot be held responsible for accidents to participants or for damage to or loss of their personal property howsoever caused.

Venue and Conference Floorplan
Please see the floorplan at the last page of this book.

MAP OF CENTRAL GOTHENBURG



ECOC 2017 cares about sustainability!

As an organiser, ECOC 2017 has been working hard when planning the conference to reduce the impact on the environment and climate. However, a conference of this size always affects the environment due to the amount of people participating in the conference e.g. the increased travel, food and waste et cetera.

ECOC conference 2017 is environmentally certified according to the Swedish Environmental Base standard. This means that we have implemented around 50 actions to reduce the negative impact on the environment and be socially responsible. This also means that we encourage our partners to act in a sustainable way.

Some of the things we do:

- The organiser has environmentally certified the conference according to the Swedish Environmental Base standard.
- The organiser will climate compensate parts of the delegates journeys for the Conference.
- The venue Svenska Mässan, the hotels and social events are all located in the city center and you can walk between them all.
- The Hotels are chosen that have effective and comprehensive environmentally–friendly policies and operations.
- For sponsorship we offer a green sponsorship package and have active communication with all sponsors regarding the ECOC 2017 sustainability policy.
- For most conference meals that are provided by the conference we choose not to serve red meat.
- At all catering points in the venue we offer vegetarian alternatives for all lunches.
- All coffee/tea served at the “fika” breaks (coffee breaks) are organic and Fairtrade. All sandwiches and sweets served together with the coffee during the fikas has two main ingredients that are organic.
- All social events venues has been chosen that are considering the environment, serving MSC certified fish and using locally produced products if possible.
- Swedish tap water is of such a high quality and tap water stations will be available throughout the venue.
- The venue are providing waste separation bins in the conference area and the waste from other bins will be sorted later at the waste station.
- Printed materials are kept to a minimum and all printed paper provided by the conference such as the programme is made of certified paper (Svanen). Conference materials such as abstracts and proceedings are provided online.
- Gifts and giwe aways are minimised. ECOC 2017 will instead of delegate gifts donate money to a solar lamp project in the third world via the Swedish organisation “Barnfonden”.
- Conference bags are chosen with a sustainable thought, they are made from recycled cotton and are corporate social responsibility approved (CRS), meaning we care about the people that provided us with the conference bags.
- Conference delegate badges made of paper (FSC certified) and no plastic.

What you as a visitor can do:

- There are excellent bus shuttles between the airport Göteborg Landvetter Airport and the venue, stopping just outside the venue. The bus stop is called “Korsvägen”
- In Gothenburg we walk! The venue is located in the city center, all hotels and social venues are located by walking distance from each other – walk and explore the city, use the public transportations or the city bikes instead of taking taxis.
- Please follow the waste separation instructions at the venue and at your accommodations when available.
- Swedish tap water is of such a high quality, choose this instead of bottled water. Tap water stations will be available throughout the venue. Bring your own bottles and fill them up with tap water.
- Choose vegetarian options for your lunches and other meals if possible, Gothenburg is a great city for vegetarian food. There are vegetarian options at all catering areas in the venue.
- If you are shopping, the city s providing a “Sustainable shopping guide”. Read about this at www.goteborg.com

Please participate in a climate friendly way!

Read more about sustainability and the work at www.ecoc2017.org/general–info/sustainability

Green Sponsors

CHALMERS UNIVERSITY OF TECHNOLOGY

RI. SE

Instead of buying gifts for delegates and speakers, ECOC 2017 has bought 340 solar-powered lamps for a total sum of 100 000 SEK through the Swedish organization Barnfonden. The solar-powered lamps will be delivered to and used by children and families in remote areas in India, where life without light is a daily reality. In these areas many are forced to use dangerous kerosene lamps or fires. Darkness makes even the simplest activities difficult, even dangerous.

The solar-powered lamps allow children to read, do homework or other activities after the sun goes down. They also allow children to stay safe every night, when walking home from school or friends.

Barnfonden is a Swedish organisation that enables vulnerable children in Africa, Asia, and Latin America to go to school, get access to health care and be protected from violence and exploitation. We give families the opportunity to support themselves and, together with the children, we create sustainable development in the community.

BARNFONDEN

EXHIBITOR INDEX

43RD EUROPEAN CONFERENCE ON OPTICAL COMMUNICATION

EXHIBITOR INDEX

Exhibitor	Stand
Optomark GmbH	580
Optoplast SpA	203
Optoscribe Ltd	124
Optoway Technology Inc	285
OPTRAL	430
Otrans Communications Technologies Co Ltd	505
OZ Optics Limited	269
P	
Pacific Microchip Corp	550
Phenix Fiber Optic Co Ltd	251
Philips GmbH U–L–M Photonics	321
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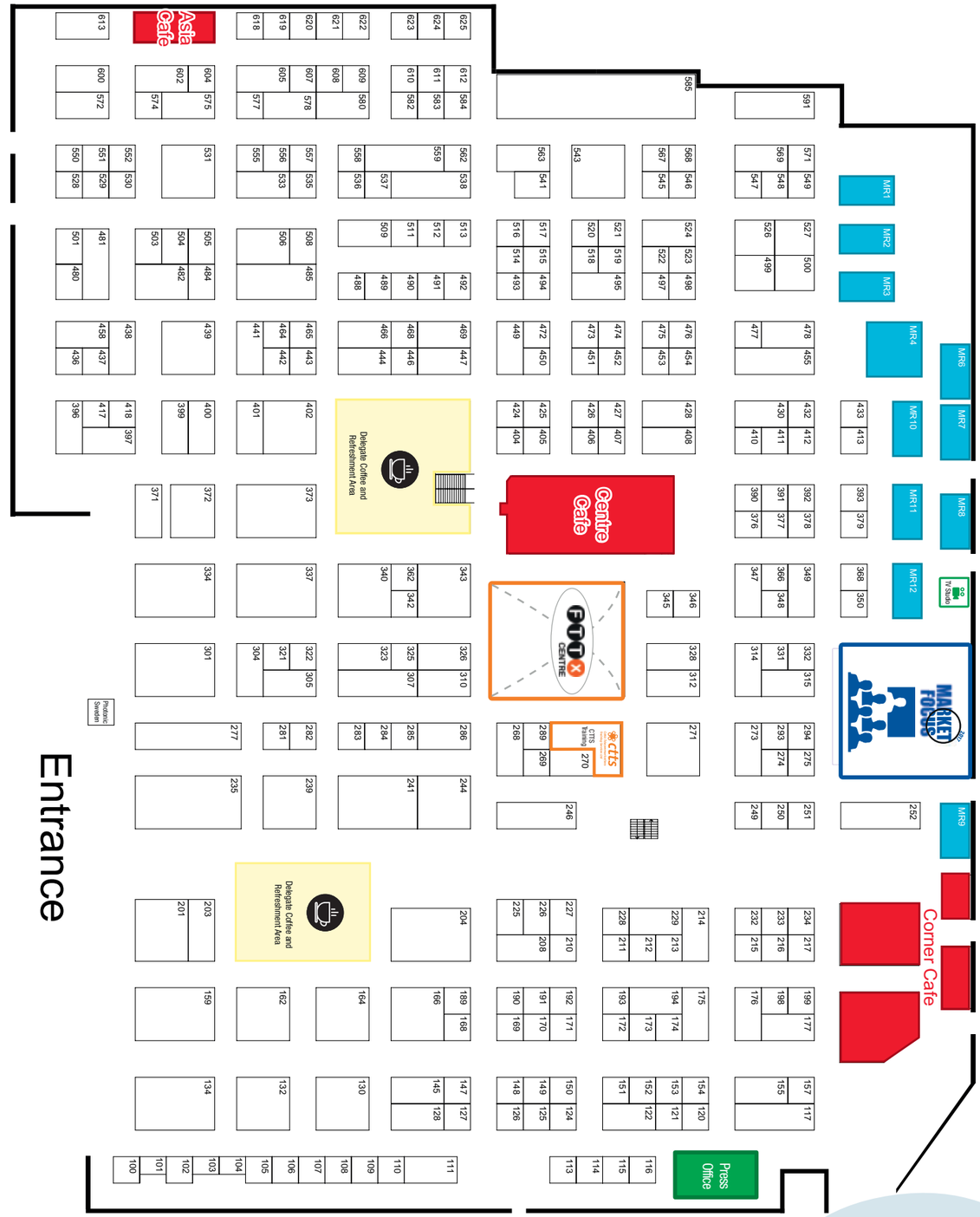
EXHIBITION FLOORPLAN



ROMA 2018

44th EUROPEAN CONFERENCE ON OPTICAL COMMUNICATION

Rome (Italy), September 23-27, 2018

Nuova Fiera di Roma - www.fieraroma.it

ECOC is the leading European conference in the field of optical communication and related applications and technologies.

Papers are solicited on, but not limited to, the following areas:
- Fibres, fibre devices and fibre amplifiers
- Integrated photonic devices and modules
- Digital techniques for optical communication systems
- Point-to-point optical transmission systems, subsystems and technologies
- Photonic and microwave photonic subsystems for telecom and non-telecom applications
- Datacenters architectures, technologies and future hardware platforms
- Core, metro, and convergence networks
- Optical networks for 5G

New emerging applications linked to integrated photonics will also be considered:
- Photonics for Space
- Photonics in quantum communications
- Graphene in photonics

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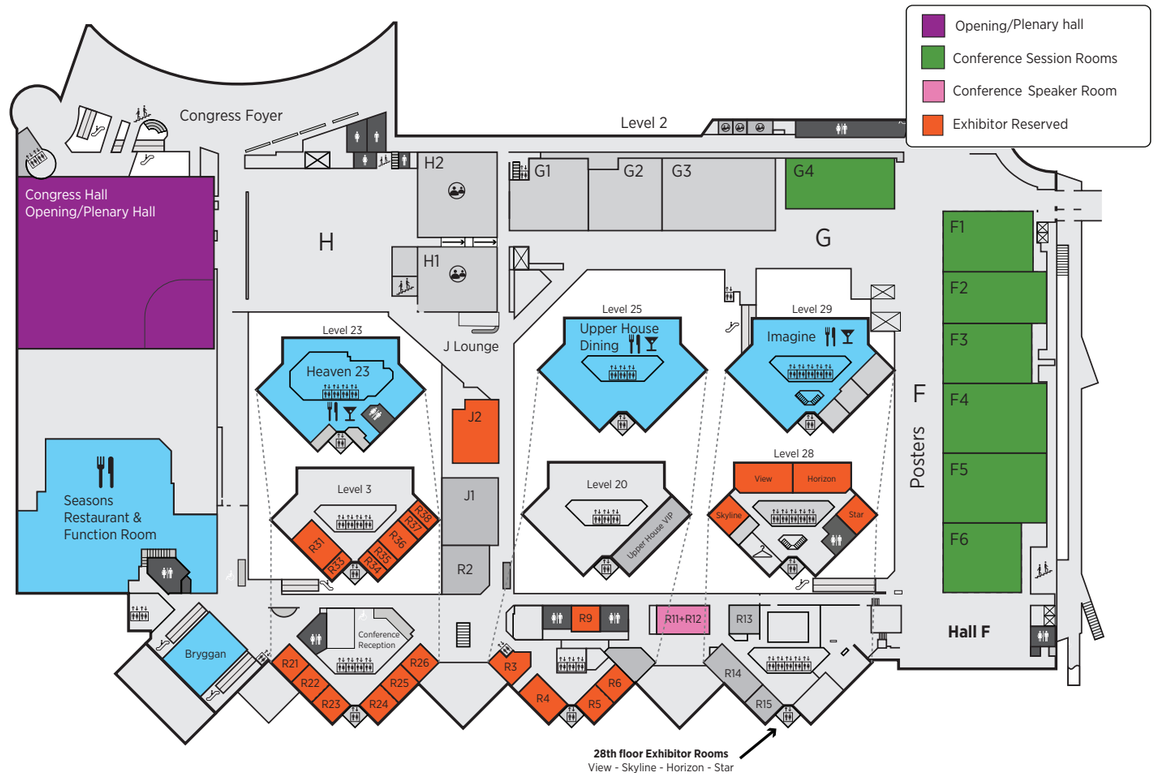
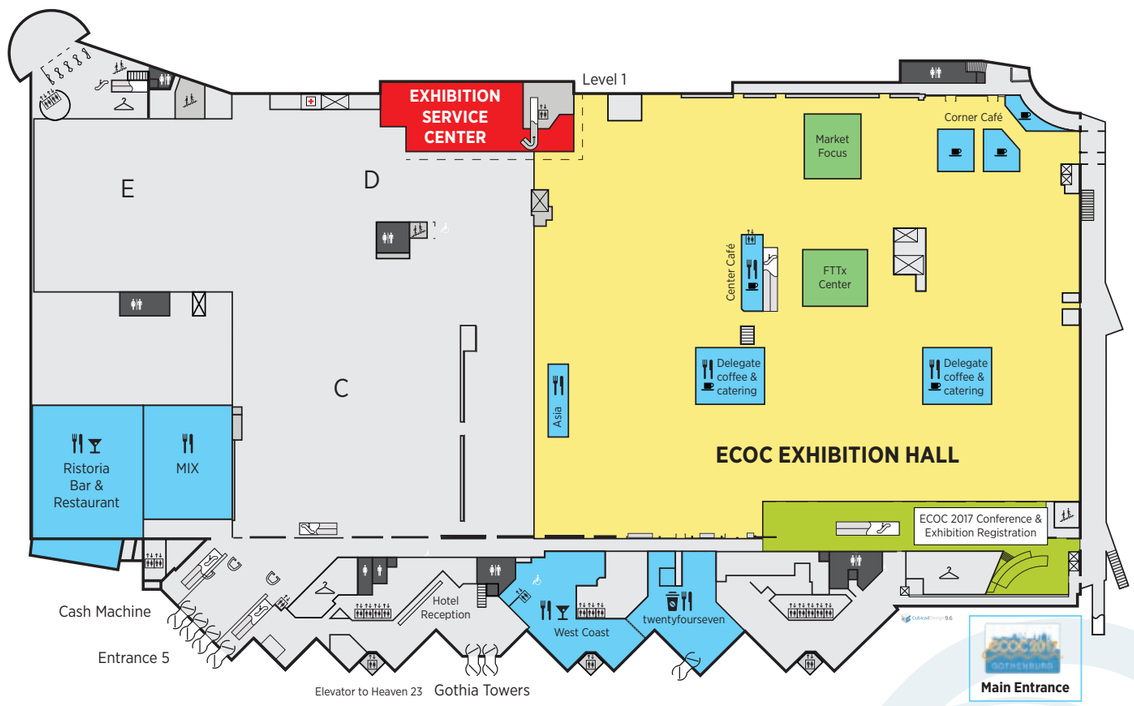
Paper submission deadline : April 16, 2018
Early registration deadline : July 19, 2018

CONFERENCE FLOORPLAN





43rd European Conference on Optical Communication

ecoc2017

GOTHENBURG
17-21 SEPTEMBER

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