Special Issue on All-Optically Routed Networks

Guest Editorial

The evolution of communication networks is driven by a huge increase of end user traffic and bandwidth demands due to the recent massive deployment of broadband access technologies as well as the outburst of new network applications and emerging service oriented applications. The observed trends are accompanied by the advances in optical technologies which have enabled the development of long-distance and high-capacity transmission systems. Nowadays the role of optics in communication networks is mainly restricted to transmission and some limited switching functions. However, next generation optical networks are foreseen to perform extended switching and control processing operations in the optical domain such as fast provisioning of high bandwidth services, dynamic management of end-to-end resources in an efficient and reliable manner, support of a wide range of service granularities, design and development of power-efficient protocols and equipment, guarantee of both quality of service and transmission for various user applications, and support of network and user data security. Apart from answers to existing technology challenges, the development of all-optically routed networks imposes the need for novel approaches and solutions to meet the requirements dictated by the evolving and new services that are becoming available to the end users. In this context, several issues need to be addressed so that to overcome the limited scalability and flexibility of today's network infrastructures as well as insufficient network manageability and increased overall capital and operational expenditure leading to high network services costs.

Born as a small conference in Poland, the International Conference on Transparent Optical Networks (ICTON) is today a reference meeting point thanks to the initiative and continuous support of Prof. Marian Marciniak. ICTON, now at its 11th edition, gathers each year around 500 researchers from 5 continents: experts in different fields like optical processing, optical networking, nanophotonics, photonic crystals, photonic components, etc. interchange their knowhow and experience with novel researchers and PhD students. This special issue presents fourteenth selected papers from ICTON 2009 addressing most of such heterogeneous topics. The papers are organized in three groups according to the approach followed i.e. physical layer modeling and simulations, networking aspects (design, provisioning and protocols) and experimental demonstrations and test-beds.

The first group consists of two papers.

The paper entitled *Trigonometric transforms for high-speed optical networks: all-optical architectures and optical OFDM* by M. Svaluto et al. discuss the use of all-optical discrete Hartley transform (DHT) and discrete Cosine transform (DCT) architectures for high-speed optical signal processing, filtering in optical communication systems which in some cases can advantageously replace the Fourier transform for both all-optical and electronic signal processing. The authors instantiate the benefits of the proposed methodology through an orthogonal frequency division multiplexing (OFDM) system example. Furthermore, the implications and inherent benefits of the approach are further developed.

The paper entitled *Analyzing power consumption in optical cross-connect equipment for future large-capacity optical networks* by M. Murakami focuses on energy consumption of the equipment used in WDM optical networks. The equipment under consideration and comparison are optical cross-connects supporting Tb/s capacities based either on electronic or photonic switching. Results indicate that the electronic solution introduces power consumption requirements exceeding 50kW, while the photonic counterpart requires 8-30kW. In the photonic switching case the power requirements are mainly determined by the power consumption of the associated transponders.

The second group consists of five papers.

The paper entitled *A simple generalized approach to node failure recovery with span-protecting p-cycles* by D. P. Onguetou and W. D. Grover proposes a new strategy based on the concept of p-cycles to recover a single node failure in optical networks. This new strategy, called two-hop flow, is based on a generalization of how nodes in an ordinary p-cycle derive survivability through loop-back at the nearest two neighbor-nodes on the same cycle. An ILP formulation as well as a faster heuristic algorithm for the two-hop strategy is given. The performance of the two-hop flow method is finally compared with other p-cycle-based node failure recovery methods such as Node-Encircling p-Cycles, Flow-Protecting p-Cycles, and Failure-Independent Path-Protecting p-Cycles.

The second and third papers of this group address a similar problem, i.e. how to incorporate the physical layer impairments constraints into the network protocol decisions. The paper entitled *Impairment aware RWA in optical networks: over-provisioning or cross optimization?* by K. Christodoulopoulos et al. focuses on the evaluation of the overall network performance following two different impairment aware routing approaches: one considering worst case physical performance assumptions independent of the actual status of the network at the time of routing and a second considering the current network utilization and perform a cross layer optimization between the network and physical layers. Simulation results indicate that the second approach provides improved network performance at the expense of increased complexity, which however does not significantly increase the corresponding execution times. The paper entitled *ICBR-Diff: an Impairment Constraint Based Routing Strategy with Quality of Signal Differentiation* by A. Jirattigalachote et al. propose a

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novel impairment constraint based routing (ICBR) algorithm with differentiation of services based on the BER of a lightpath. Presented results reveal that significant network performance improvement in terms of connection blocking can be achieved, compared to non-differentiated conventional RWA and ICBR algorithms.

The paper entitled *Feedback based load balancing, deflection routing and admission control in OBS networks* by S. Rumley et al. focuses on Optical Burst Switching (OBS) and proposes a unified scheme supporting adaptive deflection routing and admission control to handle various types of traffic variations aiming at simplifying the OBS network architecture and enhancing its flexibility. Simulation results evaluate the performance of the proposed solution and compare it to traditional deflection routing indicating specific benefits.

The last paper of this group entitled *Design and development of a semantic information modelling framework for a service oriented optical Internet* by C. E. Abosi et al. focuses on the new concept of service plane architecture which is considered as an architectural enhancement promising to simplify the management of heterogeneous, dynamic and complex emerging service requirements in distributed IT systems. In particular, the authors propose a rich descriptive semantic framework and common vocabulary for the description of network and IT resources.

The last group consists of seven papers.

The paper entitled *Reducing complexity and consumption in future networks* by G. Tosi-Beleffi et al. reports the main results of the EU FP7 SARDANA project which targets the performance enhancement of dense Fibre-to-the-Home networks by providing large bandwidth to the end user in a flexible and intelligent way. Main features of the SARDANA network proposal are described, namely remote amplification for network reach extension, remote monitoring of the network infrastructure, and remote ONUs powering.

The paper entitled *Decrease of the link PMD by fiber exchange and investigation of the PMD distribution along buried optical fibers with a POTDR* by A. Ehrhardt et al. reports field trial results of the cumulative PMD distribution in deployed fiber sections which are obtained using a novel POTDR prototype instrument. The presented measurement technique can be applied both for old fibers in order to replace bad pieces selectively and for newly installed cables directly after installation to check the quality and the adherence of the fibers to predetermined physical limits. This information is particularly important for network operators who want to improve their networks in order to install systems at 40 Gbit/s and beyond.

The paper entitled *Deployment and validation of GMPLS-controlled multi-layer integrated routing over the ASON/GMPLS CARISMA test-bed* by F. Agraz et al. addresses the problem of grooming connection requests with fine granularity into optical channels. Firstly, the authors design a GMPLS-controlled multi-layer architecture with grooming-capable transport network. Then, they test experimentally the proposed multi-layer solution highlighting its good trade-off between network blocking probability and E/O port usage when compared to all-optical and opaque solutions.

The paper entitled *Enhancing performance of optical communication systems with advanced optical signal processing* by I. Glesk et al. describes two applications of advanced optical signal processing techniques. On one hand, optical XOR gates are used to apply one-time pad encrypted algorithm ensuring data security directly in the optical layer. On the other hand, an ultra fast optical signal conditioning technique is introduced in an OCDMA system to improve its scalability. Both signal processing techniques are successfully demonstrated in experimental platforms. Currently, the authors are working on the monolithic integration of such techniques.

The paper entitled *Advanced test-beds to validate physical estimators in heterogeneous long haul transparent optical networks* by A. Morea et al. present novel diverse experimental set-ups required in transparent optical networks to replace the old point-to-point test-bed set-ups. In particular, the authors propose a Quality of Transmission (QoT) estimator to evaluate the accumulation of the physical layer impairments in a lightpath and verify its feasibility by emulating the networks with double loop experiments. The proposed QoT estimator is assessed and refined through the realization of diverse experiments under different network uncertainties (eg. Dispersion maps, fiber types heterogeneity and number of neighbor channels travelling).

The paper entitled *All-optical label swapping techniques for optical packets at bit-rate beyond 160 Gb/s* by N. Calabretta et al. present two different techniques based on optical signal processing to realize a scalable all-optical packet switch with label swapping. For both techniques, the authors report experimental results showing the routing operation of the 160 Gb/s packets and beyond. A comparison between the techniques in terms of devices, bit-rate scalability, latency, power consumption, power penalty performance and cascadability is also made.

The last paper entitled *Tb/s transmission and routing systems using integrated micro-photonic components* by E. Kehayas et al. report recent advances in the development of photonic switching and transmission systems that exploit high and low index contrast integration materials. Based on functional examples of the refereed techniques, the authors group the applications in two sets: the transmission/regeneration prone and the more compact and efficient which are more prone to photonic routing platforms. The diverse presented technologies are enablers for the future systems-on-chip.

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Guest Editors:

Antonio Teixeira, *Institute of Telecommunications/DETI, Universidade de Aveiro, Portugal*
Anna Tzanakaki, *Athens Institute of Technology, Greece*
Davide Careglio, *Universitat Politècnica de Catalunya, Spain*
Mirosław Klinkowski, *National Institute of Telecommunications, Poland*

Antonio Teixeira (http://www.it.pt/person_detail_p.asp?ID=703) is an associate professor at the Electronics, telecommunications and informatics department of the Universidade de Aveiro, researcher at the Insitituto the Telecomunicações and Senior specialist at the industrial environment team for standardization in Nokia Siemens Networks. He received the BsC and MsC in electronics engineering and telecommunications, in July 1994 at U. Aveiro and the Ph.D. degree in electrical engineering in 1999 also from the University of Aveiro but partly developed at the institute of Optics, U. of Rochester, NY, USA. He was an engineer at the research branch of Portugal Telecom in 95 and visitor researcher at several institutes like NICT in Japan. He is a co-author of over 300 publications in international journals and conferences and 6 chapters in books. He is a co-inventor of 7 national and international patents. He is a member of the IEEE and participated in several Technical Program Committees and has chaired some national and international conferences. His research interests include optical access networks, all-optical processing, radio over fiber, network consolidation, monitoring. He has a long list of participations in national and international projects where he acted both as participant or leader.

Anna Tzanakaki is an Associate Professor at the Athens Information Technology, where she is leading the Network Design and Services research group. She is also an adjunct faculty member of Carnegie Mellon University, USA. She has obtained a BSc degree from the University of Crete, Greece, an MSc and a PhD both from the University of Essex, UK. She was a co-founder and a senior engineer of ilotron ltd, a spin-off from the University of Essex, involved in the design of systems for WDM optical networks. Following ilotron, she joined Altamar Networks, a subsidiary of Ditech Communications, as a principal engineer responsible for optical architecture and system design. She is a co-author of over 100 publications in international journals and conferences. She is a co-inventor of 1 granted and 11 published patents. She is a senior member of the IEEE and several Technical Program Committees. Her research interests include optical wavelength, burst and packet switched networks, cross-layer network design and traffic provisioning as well as network convergence in support of telecommunications and IT services.

Davide Careglio (http://people.ac.upc.edu/careglio) is an Associate Professor in the Department of Computer Architecture at the UPC, Barcelona, Spain. He received the M.Sc. (2000) and Ph.D. (2005) degrees in Telecommunications Engineering both from UPC. He also received the Laurea degree in Electrical Engineering from Politecnico di Torino (2001). Since 2000 he is a staff member of the CCABA (Advanced Broadband Communication Center). His research interests are in the fields of networking protocols with emphasis on optical switching technologies, and algorithms and protocols for traffic engineering and QoS provisioning. He is a co-author of over 80 publications in international journals and conferences. He has participated in many European and national projects in the field of optical networking and green communication. He is a member of the IEEE and participated in the Technical Program Committees of several conferences, including IEEE ICC and IEEE Globecom.

Mirosław Klinkowski is an Assistant Professor in the Department of Transmission and Optical Technology at the National Institute of Telecommunications in Warsaw, Poland, and is a Collaborating Researcher at the Universitat Politècnica de Catalunya (UPC), Barcelona, Spain. He received his M.Sc. and Ph.D. degrees, respectively, from Warsaw University of Technology in 1999 and from UPC in 2008. His publications include several book chapters and more than 50 papers in relevant research journals and refereed international conferences. He has participated in many European projects dealing with topics in the area of Optical Networking. He is currently involved in the COST 2100 action. His research interests include optical and wireless networking with emphasis on network modeling, design, and performance analysis.