Guest Editorial

Next-Generation Spectrum-Efficient and Elastic Optical Transport Networks

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Improving capacity utilization of the optical transport network has been an important research challenge for many years. Extensive research efforts have been devoted to developing approaches of grooming subwavelength traffic demand onto large wavelength capacity pipes. These efforts, however, only focus on efficiently utilizing the capacity pipes, without addressing the issue of fixed ITU-T grid and frequency spacing in the DWDM layer. Under the fixed frequency spacing, optical spectrum is often over-provisioned for a low-rate optical channel, and this inefficiency becomes even prominent when more advanced modulation formats are employed. Advanced optical transmission and networking techniques are needed to provide flexibilities for optical channel spectrum allocation and to develop the related network control system so as to cater to the bandwidth elasticity of Internet traffic and improve fiber optical spectral usage.

Significant attention has been given to develop spectrum-efficient and elastic optical transport networks in both academia and industry in the past few years, and currently there are many research efforts underway targeting at the development of appropriate solutions for future dynamic elastic and scalable photonic infrastructures and network architectures, efficient new algorithms that determine how optical frequency resources can be matched to traffic demands in an optimized way, and a more flexible control and management plane. The technical issues that remain open for such elastic optical transport networks include efficient architecture, spectrum-efficient transmission technique, reconfigurable optical add/drop multiplexer (ROADM), routing and spectrum assignment (RSA), spectrum de-fragmentation, traffic grooming, new protocols and control plane, and more.

Our objective of this special issue is to identify various challenges posed by the spectrum-efficient and elastic optical transport networks and explore research avenues for addressing them. We have received a total of 27 papers, and after multi-round careful reviews by both reviewers and guest-editors, we have accepted six papers for this special issue. The accepted articles span various topics ranging from routing and spectrum assignment (RSA), traffic grooming, elastic optical network testbeds, and CO-OFDM optical transmission systems.


In “Adaptive Spectrum Control and Management in Elastic Optical Networks,” K. Christodouloupolous, I. Tomkos, and E. Varvarigos propose and analyze three spectrum expansion/contraction (SEC) policies for modifying the spectrum allocated to each service connection. They also derive exact formulas for calculating the blocking probability for a connection and for the whole network.

In “Elastic Spectrum Allocation for Time-Varying Traffic in FlexGrid Optical Networks,” M. Klinkowski, M. Ruiz, L. Velasco, D. Careglio, V. Lopez, and J. Comellas formulate a Multi-Hour Routing and Spectrum Allocation (MHRSA) optimization problem and solve it by means of both Integer Linear Programming (ILP) and efficient heuristic algorithms.

In “Adaptive Spectrum Control and Management in Elastic Optical Networks,” K. Wen, X. Cui, Y. Yin, D. J. Geisler, R. Proietti, R. P. Scott, N. K. Fontaine, and S. J. B. Yoo present an adaptive spectrum control and management scheme, which includes: dynamic on-demand spectral defragmentation, adaptive combinational quality of transmission (QoT) restoration (ACQR) and supervisory channel-assisted active restoration.

In “Design and Experimental Validation of a GMPLS/PCE Control Plane for Elastic CO-OFDM Optical Networks,” R. Casellas, R. Muñoz, J. M. Fabrega, M. S. Moreolo, R. Martinez, L. Liu, T. Tsuritani, and I. Morita design and deploy a GMPLS control plane for flexible optical networks with coherent optical orthogonal frequency division multiplexing (CO-OFDM) transmission; the functional control architecture combines a centralized entity that performs path routing and modulation assignment, with a distributed spectrum allocation.

Finally, in “Spectrum-Efficient Coherent Optical OFDM for Transport Networks,” L. Dai, C. Zhang, Z. Xu, and Z. Wang propose a flexible coherent zero padding OFDM (CO-ZPOFDM) scheme with signaling-embedded preambles and polarization-time-frequency (PTF) coded pilots to improve...
spectral efficiency and system reliability for high-speed optical transport networks.

We would like to thank all of the authors for contributing their important works to this special issue, and many reviewers for their help in the evaluation process. We would like to thank Laurel Greenridge, Bruce Worthman, and Sue Lange for their exceptional efforts in putting this issue together. We would also like to express our sincere gratitude to Moshe Zukerman and Martha Steenstrup for their excellent leadership and invaluable advice in launching this special issue. Finally, we hope this special issue is interesting to our readers and can spark more research interest in the area of spectrum-efficient elastic optical networks.

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His research interests include spectrum efficient optical networks, green optical networks, and integrated optical and wireless networks. He has authored and co-authored more than 65 peer-reviewed technical papers. He is an editorial board member of Optical Switching and Networking. He received the Young Researcher New Star Scientist Award in the “2010 Scopus Young Researcher Award Scheme” in China. He was a recipient of the Izaak Walton Killam Memorial Award from the University of Alberta and the Canadian NSERC Industrial &R&D Fellowship.

**Ken-ichi Sato** is currently a professor at the graduate school of Engineering, Nagoya University, and he is an NTT R&D Fellow. Before joining the university in April 2004, he was an executive manager of the Photonic Transport Network Laboratory at NTT. His R&D activities cover future transport network architectures, network design, OAM (operation administration and maintenance) systems, photonic network systems including optical cross-connect/ROADM and photonic IP routers, and optical transmission technologies. He has authored/co-authored more than 300 research publications in international journals and conferences. He holds 35 granted patents and more than 100 pending patents. He received his B.S., M.S., and Ph.D. degrees in electronics engineering from the University of Tokyo, Tokyo, Japan, in 1976, 1978, and 1986, respectively. He received the Young Engineer Award in 1984, the Excellent Paper Award in 1991, the Achievement Award in 2000, and the Distinguished Achievement and Contributions Award in 2012 from the Institute of Electronics, Information and Communication Engineers (IEICE) of JAPAN, and the Best Paper Awards in 2007 and 2008 from IEICE Communications Society. He was also the recipient of the distinguished achievement Award of the Ministry of Education, Science and Culture in 2002. His contributions to ATM (Asynchronous Transfer Mode) and optical network technology development extend to co-editing five IEEE JSAC special issues and the IEEE JLT special issue once, organizing several Workshops and Conference technical sessions, serving on numerous committees of international conferences including OFC and ECOC, authoring a book, Advances in Transport Network Technologies (Artech House), and co-authoring fourteen other books. He is a Fellow of the IEICE of JAPAN and a Fellow of the IEEE.

**William Shieh** (S’96, M’96) received the M.S. degree in electrical engineering and the Ph.D. degree in physics from the University of Southern California, Los Angeles, in 1994 and 1996, respectively. Since 2004, he has been with the Department of Electrical and Electronic Engineering, University of Melbourne, Melbourne, Australia. His current research interests include OFDM techniques in both wireless and optical communications, coherent optical communication systems, and optical packet switching. He has published more than 130 journal and conference papers, and submitted 14 U.S. patents (nine issued) covering areas of optical OFDM, polarization controller, wavelength stabilization in WDM systems, and Raman amplifier-based systems and subsystems. He has been elected a Fellow of the Optical Society of America (OSA).

**Joannis Tomkos** is with the Athens Information Technology Center (AIFT), since Sep 2002. In the past, he was Adjunct Faculty member at the Information Networking Institute of Carnegie-Mellon University, USA (2002 - 2010); senior scientist (1999 - 2002) at Corning Inc, USA and research fellow (1995 - 1999) at University of Athens, Greece. Dr. Tomkos is representing AIFT as Principal Investigator in many EU funded research projects (including 9 active) and has a consortium-wide initiator/leader role.

Dr. Tomkos was elected in 2007 as Distinguished Lecturer of IEEE Communications Society for the topic of transparent optical networking. Together with his colleagues and students he has authored about 450 peer-reviewed archival articles, including over 120 Journal/Magazine/Book publications and 330 conference/workshop proceedings papers. Dr. Tomkos has served as the Chair of the International Optical Networking Technical Committee of IEEE Communications Society (2007-2008) and the Chairman of the IFIP working group on “Photonic Networking” (2008-2009). He is currently the Chairman of the OSA Technical Group on Optical Communications (2009-2012) and the Chairman of the IEEE Photonics Society Greek Chapter (2010-2012). He was also Chairman (2010-2011) of the working group “Next generation networks” of the “Digital Greece 2020” Forum. He has been General Chair, Technical Program Chair, Subcommittee Chair, Symposium Chair or and member of the steering/organizing committees for the major conferences (e.g. OFC, ECOC, IEEE GlobeCom, IEEE ICC, ONDM, IEEE ICTON, BroadNets, etc.) in the area of telecommunications/networking (more than 100 conferences/workshops). In addition he is/was a member of the Editorial Boards of the IEEE/OSA Journal of Lightwave Technology, the IEEE/OSA Journal of Optical Communications and Networking, the IET Journal on Optoelectronics, and the International Journal on Telecommunications Management. He is a Fellow of the IET.

**Jennifer Yates** is an Executive Director of Technical Research at AT&T Labs, Research, leading Research’s Service and Network Management department. The department has an extremely strong record in both longer term Research activities and in driving Research innovations into wide-scale network deployment. Jennifer’s Research has focused on Service Quality Management in mobility networks and IP and optical networks. Jennifer was named one of MIT Technology Review’s TR100, Leading Young Innovators for 2003, was awarded the Victorian Photonic Networks Inaugural Achievement Award 2004, and received the AT&T Science and Technology medal (2007).
Eric Wong received the B. Sc. and M. Phil. degrees in electronic engineering from the Chinese University of Hong Kong, Hong Kong, in 1988 and 1990, respectively, and the Ph.D. degree in electrical and computer engineering from the University of Massachusetts, Amherst, in 1994. In 1994, he joined the City University of Hong Kong, where he is now an Associate Professor with the Department of Electronic Engineering. His current research interests include the analysis and design of telecommunications networks, optical switching and multimedia systems. He has published more than 100 journal and conference papers (most of them are in IEEE/OSA) covering areas of performance evaluation and traffic management of optical and multimedia networks. His most notable research work involved the first accurate and workable model for state-dependent dynamic routing. Since 1991, the model has been used by AT&T to design and dimension its telephone network that uses real-time network routing. He is a Senior Member of IEEE.