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Department of Electrical and Computer Engineering

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Title: ***«Optical Networking based on Spatial Division Multiplexing»***

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Abstract:
The traffic carried by core optical networks as well as the per-channel interface rates required by IP routers are growing at a remarkable pace year-over-year. This trend is due to the widespread deployment of fixed and wireless broadband networks as well as huge growth of video-based traffic supported via internet and social media applications. Optical transmission and switching advancements have so far satisfied this huge traffic growth by delivering the content over the network infrastructure in a cost and energy efficient manner utilizing to the maximum extend the capabilities of optoelectronic and photonic subsystems and the available bandwidth of deployed optical fibers. However, we are approaching fast fundamental spectral efficiency limits of single-mode fibers and the scientific and industrial telecommunications community foresees that the growth capabilities of conventional WDM networks operating on a fixed frequency grid are quite limited.
To address such limitations, over the last couple of years a large number of significant innovations that are able to offer a capacity increase practically by a factor of around 10-20 (compared to legacy WDM systems at 10 Gb/s on a 50-GHz spacing) have emerged. Initial efforts targeted innovative modulation/coding techniques, novel switching subsystems and routing algorithms supporting flexible frequency allocations, in an effort to increase the spectral density/utilization in the optical network, leading eventually to the definition of spectrally flexible/elastic optical networks utilizing optical super-channels together with spectrally flexible/elastic multiplexing schemes (e.g. OFDM and Nyquist WDM), and advanced modulation formats which enable the dynamic and adaptive allocation of end-to-end demands with variable connection characteristics (e.g. requested data rates). However, while the spectrally flexible/elastic optical networking approaches can optimize network resources through increased spectral utilization, it has limited growth potential due to the nonlinear Shannon limit imposed on the transport capacity of single-mode optical fiber within the limited gain bandwidth of optical amplifiers.
Initially, multi-band amplification technologies (e.g., C+L+S-band amplifiers) may yield temporary relief, but the only evident long-term solution to extend the capacity of optical communication systems relies on the use of some form of “Spatial Division Multiplexing” (SDM). The simplest way to achieve spatial multiplexing is to deploy multiple systems in parallel. However, by simply increasing the number of systems, the cost and power consumption also increases linearly. In order to limit the increase in cost and power consumption, component sharing and integration have to be introduced. To this extent, significant research efforts have focused on the development and performance evaluation of few-mode fibers (FMF) and multi-core fibers (MCF), which can be seen as ‘integrated fiber’ media, for space division multiplexed (SDM) systems. For such systems, the use of spatial super-channels, which are groups of same-wavelength sub-channels that are transmitted on separate spatial modes but routed together in the network, are being investigated by several research groups and projects across the globe. The development of relevant flexible optical switches is an active research field and there are several solutions available today able to perform the switching of super-channels with variable bandwidth characteristics at a fine granularity, while they could provide support for all-optical grooming enabling the aggregation and distribution of traffic directly at the optical layer.

In addition, significant efforts are being made on the development of the proper control plane framework to orchestrate the operation of such spectrally and spatially flexible networks in order to bring out their full-potential (i.e. besides capacity increase to support also other capabilities like network virtualization).
This seminar aims to provide a comprehensive overview of the state-of-the-art for “Optical networking based on Spatial Division Multiplexing”, with respect to enabling technologies and network design/operational issues. There are specific challenges that scientists need to address with respect to the implementation of ROADMs and OXCs that will perform the switching actions in such networks and new constraints that need to be considered in the routing decisions. In our seminar we will attempt to provide a holistic view of the state-of-the-art achievements by research groups across the globe investigating the relevant topics, as well as the current research challenges and opportunities in this emerging scientific area.

Biography:

Ioannis Tomkos (B.Sc., M.Sc. Ph.D.), has been with AIT since September 2002. In the past he was Adjunct Professor at Carnegie-Mellon University, USA (2002-2010), Senior Scientist at Corning Inc., USA (1999-2002) and Research Fellow at University of Athens, Athens, Greece (1995-1999). Since 2013 he is also an Adjunct Professor at University of Arizona College of Optical Sciences and at University of Cyprus. He has a long history as inceptor, initiator and leader of major R&D projects (i.e. over 25 EU or industry funded projects; including 6 currently active). Together with his colleagues and students he has authored over 550 peer-reviewed archival scientific articles, including about 150 journal/magazine/book publications and 400 conference/workshop proceedings papers. His work has attracted about 5000 citations to date. Dr. Tomkos has served as Chairman of the International Optical Networking Technical Committee of IEEE Communications Society (2007-2008), Chairman of the International IFIP working group on “Photonic Networking” (2008-2009), Chairman of the International OSA Technical Group on Optical Communications (2009-2012) and Chairman of the IEEE Photonics Society Greek Chapter (2010-2014). In addition he is a member of the Editorial Boards of the IEEE/OSA Journal of Lightwave Technology (Deputy Editor), the IEEE/OSA Journal of Optical Communications and Networking, the IET Journal on Optoelectronics, and the Springer Photonic Network Communications. Among many other guest editorials for special issues, he is the Chief Editor for a 2012 special issue on “The evolution of Optical Networking” for the prestigious “Proceedings of IEEE”. Dr. Tomkos was elected in 2007 as Distinguished Lecturer of the IEEE Communications Society for the topic of optical networking. He was elected Fellow of the IET (2010) and Fellow of OSA (2012) for “outstanding scientific contributions to the field of transparent optical networking”.