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The Marriage of Photonics and Communication Theory for 100 Gb/s Long-Haul and Ethernet Fiber-Optic Transmissions

by

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Abstract: *In the past two decades, strides in fiber-optic communication system performance have resulted mainly from advances in electronic and photonic devices technologies. In terms of modulation, detection and equalization techniques, fiber-optic communications are in their infancy compared to wireless communications. However, unique characteristics of the fiber-optic channel limit the effectiveness of directly applying known techniques from the wireless literature. Over the next decade, cost-effective improvements in fiber-optic communication systems require an interdisciplinary approach involving optics, communication theory and signal processing techniques. I will talk about two research works under this theme:*

Part I: Recent advances in coherent detection (the use of phase and amplitude to encode/decode information) and DSP technologies enable arbitrary signal field generation, detection and processing. As a result, communication theory and signal processing techniques become practically relevant and increasingly important to the design of next generation long-haul links. As their performance is mainly limited by fiber Kerr nonlinearity, we study the characteristics of Kerr nonlinearity-induced system impairments for PSK/DPSK/QAM systems including intra-channel four-wave mixing (IFWM) and nonlinear phase noise (NLPN). We then propose appropriate signal processing techniques such as maximum-likelihood (ML) detection, exploitation of noise correlation properties as well as noise mitigation through the design of spacings and gains of optical amplifiers along the transmission link. The effect of Kerr nonlinearity on coherent WDM systems and optical OFDM will also be discussed.

Part II: Multimode fibers (MMF) are widely deployed in local- and storage-area networks. Next- generation Ethernet will operate at 100 Gb/s but achievable data rates and transmission distances are limited by modal dispersion, which results in inter-symbol interference (ISI). The concept of Principal Modes (PM) provides unique understanding of modal dispersion in MMF. Under this framework, we propose the use of a spatial light modulator (SLM) that modifies the spatial profile of the input electric field to mitigate ISI. The amount of ISI is shown to be a convex function of the SLM settings and adaptive algorithms have been developed to compute the optimal SLM configurations. We experimentally demonstrate this technique in 10 Gb/s and 100 Gb/s transmission experiments over multi-kilometers with real world channel impairments. Results show that our technique can outperform maximum-likelihood sequence detection (MLSD) while providing scalability and power savings advantages over conventional electrical equalization techniques.

Biography: *Alan Pak Tao Lau received his B.A.Sc in Engineering Science (Electrical Option) and M.A.Sc. in Electrical and Computer Engineering from University of Toronto in 2003 and 2004 respectively. He is currently studying towards his Ph.D. degree in Electrical Engineering at Stanford University. His current research interests include signal processing techniques for coherent long-haul fiber-optic communication systems and adaptive optics for 100 Gb/s Ethernet using multi-mode fiber. He worked at NEC Labs America in Summer 2006 on receiver structures for multi-mode fiber systems. He is the recipient of the National Science and Engineering Research Council (NSERC) Postgraduate Scholarship of Canada. He serves as a reviewer for journals and international conferences including the Optics Express and International Conference on Communications (ICC).*