

Selected Topics in Quantum Communications

An *Ad Hoc* QCIT Workshop at ICC'2020

Organized

by

Andrea Conti, Lajos Hanzo, Soon-Xin Ng and Peter Mueller

I. 9:10 EDT - Akbar M. Sayeed: From Millimeter-Wave to Quantum Communication: A Call for Cross-Disciplinary Research and Technology Innovation

Information science and technology is experiencing an explosive growth and unprecedented changes. On the one hand are the synergistic developments in optical and wireless communication networks and the proliferation of mobile and cloud computing. These developments are spawning new applications, including the Internet of Things, augmented and virtual reality, and autonomous vehicles, and imposing progressively stringent requirements on communication networks in terms of rate, latency, reliability and security. At the same time, there is a growing sense that we are beginning to hit fundamental physical limits; e.g., the electromagnetic degrees of freedom for communication, and the density of integrated circuits for computation. On the other hand, a second information revolution is unfolding in parallel for exploiting fundamental quantum mechanical phenomena, e.g., superposition and entanglement, to manipulate information in ways that is not possible with existing classical technologies. The frontier of quantum information science and engineering promises to augment existing technologies and lead to radically new and disruptive paradigms for computing, communication and sensing. In this talk, I will highlight a few salient attributes that are shared by the emerging classical, quantum and hybrid information technologies and need to be exploited for fully harnessing their potential: i) cross-disciplinary research, ii) optical and photonic principles, techniques and technologies, iii) experimental testbed development, and iv) machine learning and artificial intelligence techniques.

Biography: Akbar M. Sayeed is a Professor of Electrical and Computer Engineering at the University of Wisconsin-Madison and leads the Wireless Communications and Sensing Laboratory. His research interests include wireless communications, channel modeling, statistical signal processing, communication and information theory, time-frequency analysis, machine learning, and applications. A current focus is the development of basic theory, system architectures, and testbeds for emerging wireless technologies, including millimeter-wave wireless and high-dimensional multi-antenna multiple input multiple output (MIMO) systems. He also led the creation of the NSF Research Coordination Network on Millimeter-Wave Wireless in October 2016. Dr. Sayeed recently served as a Program Director at the National Science Foundation (NSF) where his program portfolio covered the basic science

and engineering of sensing, processing, and communication of information in all modalities, including integrated design of hardware and algorithms for information processing systems. He was a member of the working groups of two of the 10 NSF Big Ideas: 1) Quantum Leap - an NSF-wide effort for developing new cross-disciplinary initiatives for advancing quantum information science and engineering, and 2) Harnessing the Data Revolution - an NSF-wide effort for developing new cross-disciplinary initiatives for advancing Data Science and Engineering.

II. 9:30 EDT - Dominic O'Brien: The UK Quantum Technology Hub in Computing and Simulation; programme overview and research challenges

Biography: Dominic O'Brien is a Professor of Engineering Science at Oxford and leads the optical communications group. He is the Director of the UK National Hub in Quantum Computing and Simulation

This is one of the four Quantum Technology Hubs funded as part of the UK National Quantum Technologies programme, running from 2019-2024. He was co-director for systems integration of the NQIT hub, which ran from 2014-2019, and a member of the Blackett review of quantum technologies. His research is in optical wireless communications, with a particular focus on system demonstration, with a number of world-firsts in this area. Recent demonstrations, together with industrial and academic partners, include Quantum Key Distribution free-space links between handheld devices, between UAVs and ground stations, and Terabit/s wireless links within buildings.

III. 10:00 EDT - Rob Malaney: CV-QKD From Space It Will Work!

Biography: Robert Malaney has a BSc. and Ph.D. from the University of Glasgow, Scotland, and the University of St. Andrews, Scotland, respectively. He is currently a Professor with the School of Electrical Engineering and Telecommunications at the University of New South Wales, Australia. He was previously with the California Institute of Technology, USA, the University of California, Berkeley, USA, and the University of Toronto, Canada.

IV. 10:30 EDT - Gui-Lu Long: Overcoming the lack-of-practical-quantum-memory obstacle in quantum secure direct communication: quantum-memory-free protocol using classical coding

Biography: **Gui-Lu Long** is a professor in quantum information at Tsinghua University & Beijing Academy of Quantum Information Sciences. Notably among his contributions, he proposed the quantum secure direct communication(QSDC) that transmits information directly, in sharp contrast to QKD; constructed Grover-Long algorithm for exact search and the full quantum eigensolver (FQE) for NISQ applications; and established the widely used linear combination unitaries (LCU) method for quantum algorithm designs. He published 300+ papers with 18000+ citations. He is IEEE member, fellow of IoP (UK) and APS (US). He was President of AAPPS, one of three biggest continental physical associations in the world.

V. 11 EDT - Mohsen Razavi: The prospects and challenges of long-distance quantum communications

Biography: **Prof. Mohsen Razavi** received his B.Sc. and M.Sc. degrees (with honours) in Electrical Engineering from Sharif University of Technology, Tehran, Iran, in 1998 and 2000, respectively. From August 1999 to June 2001, he was a member of research staff at Iran Telecommunications Research Centre, working on all-optical CDMA networks. He joined the Research Laboratory of Electronics, at the Massachusetts Institute of Technology (MIT), in 2001 to pursue his Ph.D. degree in Electrical Engineering and Computer Science, which he completed in 2006. He continued his work at MIT as a Post-doctoral Associate during Fall 2006, before joining the Institute for Quantum Computing at the University of Waterloo as a Post-doctoral Fellow in January 2007. In 2009, he joined the School of Electronic and Electrical Engineering at the University of Leeds, where he currently is a Professor of Quantum Communications. He is the Coordinator of the European Innovative Training Network, QCALL, which aims at providing quantum communications services to all users. Dr Razavi has authored an introductory book on quantum communications networks published as part of IOP Concise Physics series. His research interests include a variety of topics in quantum and classical optical communications, quantum cryptography, quantum optics, and quantum networks.

VI. 11:30 EDT - Julian Cheng: Quantum Discrimination

Biography: **Julian Cheng** (S96M04SM13) received the B.Eng. degree (Hons.) in electrical engineering from the University of Victoria, Victoria, BC, Canada, in 1995, the M.Sc.(Eng.) degree in mathematics and engineering from Queens University, Kingston, ON, Canada, in 1997, and the Ph.D. degree in electrical engineering from the University of Alberta, Edmonton, AB, Canada, in 2003. He was with Bell Northern Research and NORTEL Networks. He is currently a Full Professor with the School of Engineering, Faculty of Applied Science, The University of British Columbia, Kelowna, BC, Canada. His current research interests include digital communications over fading channels, statistical signal processing for wireless applications, optical wireless communications,

and 5G wireless networks. He was the Co-Chair of the 12th Canadian Workshop on Information Theory in 2011, the 28th Biennial Symposium on Communications in 2016, and the 6th EAI International Conference on Game Theory for Networks (GameNets 216). He currently serves as an Area Editor for IEEE TRANSACTIONS ON COMMUNICATIONS. He was a past Associate Editor of IEEE TRANSACTIONS ON COMMUNICATIONS, IEEE TRANSACTIONSON WIRELESS COMMUNICATIONS, IEEE COMMUNICATIONS LETTERS, and IEEE ACCESS. He served as a Guest Editor for a Special Issue of IEEE JOURNAL ON SELECTED AREAS IN COMMUNICATIONS on Optical Wireless Communications. He is also a Registered Professional Engineer with the Province of British Columbia, Canada. He currently serves as the President for the Canadian Society of Information Theory and the Secretary for the Radio Communications Technical Committee of the IEEE Communications Society