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Section TE (Telecommunications)
INVITED LECTURE:

Quantum Error Correction: Introduction and Latest Developments in Quantum LDPC Codes

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Abstract:
The fundamental concept of the mathematical theory of information laid down by Shannon is that of error-correcting codes. Error correction codes play a vital role in ensuring the integrity of data in systems exposed to noise or errors. Classical error correcting codes were crucial to the success of modern communications and data storage systems (from the Internet to mobile, satellite and deep-space communications, and from disk to flash memory storage) and found applications in other areas, such as pattern recognition, group testing, cryptography, or fault-tolerant (FT) computing. Likewise, quantum error correction (QEC) codes at the heart of all quantum information processing, from FT quantum computing to reconciliation in quantum key distribution, quantum sensing, and reliable optical communications. However, unlike classical coding theory which is a mature and established discipline, quantum codes are still a subject of extensive research. The importance of QEC is that it is the only presently known gateway to reap the benefits of computational quantum algorithms, but a robust and scalable QEC has not been yet demonstrated experimentally. Arguably, QEC is the only technology still lacking to realize a vision of useful large-scale quantum computation, and its development is pursued by many research groups in academia, national labs, and industry. One of the most promising solutions is based on quantum low-density parity check (QLDPC) codes, which are the only known class of quantum codes in the stabilizer family with asymptotically nonzero rates and that support fault-tolerant operation using noisy quantum gates. This talk will start with a tutorial on quantum information, noise, and quantum stabilizer codes, and then will proceed to an overview of the research in QLDPC codes. It is prepared for classical communications theory researchers, and no background in quantum mechanics or error correction is required.

Short Bio:

Dr. Bane Vasic is a Professor of Electrical and Computer Engineering and Mathematics at the University of Arizona and a Director of the Error Correction Laboratory. He is an inventor of the soft error-event decoding algorithm for intersymbol interference channels with correlated noise, and the key architect of a detector/decoder for Bell Labs data storage read channel chips which were regarded as the best in the industry. His pioneering work on structured low-density parity check (LDPC) error-correcting codes based on combinatorial designs has enabled low-complexity iterative decoder implementations. Structured LDPC codes are today adopted in a number of communications standards and data storage systems. Dr. Vasic's work on codes on graphs, trapping sets, and error floor of iterative decoding algorithms has led to decoders for the binary symmetric channel with the best error-floor performance known today. Dr. Vasic is a PI on a Department of Energy multi-university $115M project led by Fermi National Laboratory to establish a Center for Superconducting Materials and Systems. He is a co-PI of the $52M NSF Center for Quantum Network hosted at the University of Arizona. He is also funded by NASA-Jet Propulsion Laboratory through the Strategic University Partnership Program for the development of quantum codes and error correction algorithms for NASA space missions and is a PI on seven research grants funded by the National Science Foundation. He is the founder of Codelucida, a company developing advanced error correction solutions for communications and data storage. Codelucida is a Xilinx Partner providing LDPC Codec IP cores for flash memory controllers. He is an IEEE Fellow, Fulbright Scholar, da Vinci Fellow, and a past Chair of the IEEE Data Storage Technical Committee. He was born in Bela Palanka, and fluent in Prizrensko-timočki dijalekt.

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