Large-scale MIMO in 5G

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by

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Multiple-input multiple-output (MIMO) techniques have been adopted in the current fourth generation (4G) wireless standards like LTE/LTE-A and WiFi (IEEE 802.11n) in order to achieve significantly higher data rates compared to previous generation of standards. Moving forward to fifth generation (5G) standards, MIMO techniques will continue to play a key role in further increasing the data rates to Gigabit range to handle high speed video traffic for a variety of emerging applications. In particular, data rate increase in standards beyond 4G is targeted to be achieved using any or combinations of the following three approaches:

- Additional spectrum (bps)
- MIMO techniques (bps/Hz)
- Dense deployments - femto cells (bps/Hz/Km).

An emerging architecture for 5G in this regard is one where the base station (BS) has tens to hundreds of antennas and the user terminals have one or two antennas. Such large-scale MIMO systems, where base stations/access points and/or user terminals employ tens to hundreds of antennas, will be the focus of this tutorial.

The motivation to consider large-scale MIMO systems is the potential to practically realize the theoretically predicted benefits of MIMO, in terms of very high spectral efficiencies/sum rates, increased reliability and power efficiency, through the exploitation of large spatial dimensions. This tutorial will address the technological challenges that need to be dealt with in implementing large-scale MIMO systems and propose solutions.

First, MIMO channel measurement campaigns using large antenna arrays and recently reported measurement results in different propagation environments and antenna configurations will be presented. Key issues related to communications on the uplink and downlink will be addressed next. Uplink communication issues include synchronization and power control, channel estimation, low complexity detection and decoding, and multi-cell operation. Downlink communication issues include low complexity precoding strategies, obtaining channel state information (CSI) for precoding, and pilot contamination problem encountered in using non-orthogonal pilot sequences for channel estimation in multi-cell scenarios. Some of the recent large-scale MIMO test beds will be discussed.

The low peak-to-average power ratio (PAPR) advantage of SC-FDMA over OFDMA has led to the adoption of SC-FDMA on the uplink in 4G wireless standards like LTE. The tutorial will highlight that SC-FDMA can be quite beneficial in large-scale multiuser MIMO downlink as well. A key advantage is that the transmit power amplifiers in the BS can be operated at more efficient operating points, making the BSs more energy efficient (more 'green'), which makes SC-FDMA a preferred choice for multiuser downlink communication in 5G. The tutorial will present SC-FDMA transmit and receive signaling architectures for multiuser communication on the downlink and present simulation results that establish the PAPR and BER performance advantage of SC-FDMA in large-scale multiuser MIMO downlink.

About the speaker: A. Chockalingam is a professor in the Department of ECE, Indian Institute of Science, Bangalore. He, along with his colleagues and students at IISc, has been an active contributor to large-scale MIMO research and development since 2008. He has several granted patents in this emerging area. He is a Fellow of the Indian National Academy of Engineering (INAE), a Fellow of the National Academy of Sciences, India (NASI), and a Fellow of the Indian National Science Academy (INSA). He is an Editor of the IEEE Transactions on Wireless Communications.