"Rethinking the Functional Boundaries of Integrated RF Systems Enables New Communication Paradigms for 5G: Millimeter-wave, Massive MIMO and Full-Duplex"

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Mobile data traffic in 2014 was nearly 30 times the size of the entire global Internet in 2000. Next generation wireless networks are targeting 1000x increase in capacity to meet the insatiable demand for more data. Such a tremendous increase in wireless data will require a complete rethinking of today's wireless communication systems and networks from the physical layer to the network and application layer.

My research program at Columbia University is focused on

i. transformative radio-frequency (RF) and millimeter-wave (mmWave) circuit design techniques

ii. that enable new system architectures that challenge the traditional functional boundaries (antenna/RF/analog/digital) of wireless communication systems and specifically enable advanced signal processing techniques at RF,

iii. thus enabling new wireless communication paradigms in close collaboration with communications, signal processing and network theorists.

In this talk, I will focus on recent research in CoSMIC lab in this space. I will touch upon our work on energy-efficient and high-power millimeter-wave CMOS circuits that have drawn interest for next-generation 5G cellular communications. The bulk of this talk will focus on our work on enabling full-duplex wireless communication, where transmitters and receivers operate at the same frequency at the same time, thus potentially doubling data throughput, promoting more flexible spectrum usage, and enabling solutions to several network problems. The fundamental challenge in full duplex is the tremendous transmitter self-interference at the receiver, which can be one trillion times more powerful than the desired signal and must be dealt with in all domains. This powerful self-interference is susceptible to uncertainties of the wireless channel (for instance, frequency selectivity and time variance) and the imperfections of the transceiver electronics (nonlinear distortion and phase noise to name a few), making it even harder to deal with. I will discuss several generations of fully-integrated CMOS transceiver ICs with self-interference cancellation that leverage circuit design innovations to enable advanced yet robust signal processing such as noise cancellation, distortion cancellation and wireless channel equalization in the RF and electromagnetic (i.e. antenna) domains and achieve the challenging performance required. I will also briefly touch upon our collaborative work with network theorists to determine the rate gains that are possible under various full duplex scenarios based on realistic physical layer models that we developed. Finally, I will end this talk with a brief description of our ongoing and future work on other emerging wireless communication paradigms, such as massive MIMO.