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**Water pouring, MUD, and dirty paper: the mathematics of  
wireless communications with multiple antennas**

Wireless systems of the future must support ubiquitous multimedia communications between people as well as devices. There are many research challenges associated with such systems, including limited bandwidth, random variations in the wireless channel, and battery limitations of embedded devices. Many of these challenges can be overcome with multiple antennas at the transmitters and receivers of the wireless network. In fact, the fundamental data rate limits of wireless systems increase linearly with the number of transmit and receive antennas. Moreover, the optimal transmission strategies that achieve these limits have intriguing mathematical properties. These strategies include optimal allocation of power across multiple dimensions via water pouring, and cancellation of interfering signals using either multiuser detection (MUD) or a clever coding strategy based on the principle of "writing on dirty paper". We will discuss these ideas along with a brief overview of some other mathematical challenges in the design of future wireless networks.