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FAST BREAKING PAPERS - 2009

April 2009

PDF

Taesang Yoo talks with *ScienceWatch.com* and answers a few questions about this month's Fast Breaking Paper in the field of Computer Science.

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Article Title: Multi-antenna downlink channels with limited feedback and user selection

Authors: Yoo, T;Jindal, N;Goldsmith, A

Journal: IEEE J SEL AREA COMMUN
Volume: 25
Issue: 7
Page: 1478-1491
Year: SEP 2007

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SW: Why do you think your paper is highly cited?

Our paper has both theoretical and practical significance. In the communications and information theory community, multiple-input multiple-output (MIMO) systems and multiuser diversity have been among major research topics which have drawn lots of attention and been extensively developed during the past decade. Those are two among several key concepts that will enable higher data rates and/or reliability in the near future for wireless communication systems.

From the theoretical side, information theorists have successfully characterized performance limits of multiuser MIMO channels. In particular, they have shown that the sum capacity of the channel grows in proportion to the number of antennas (multiplexing gain) and double-logarithmically in the number of users (multiuser diversity gain).

Our paper lays the foundation for bringing these theoretical results into practice by showing that the full multiplexing and multiuser diversity gains can still be realized under practical constraints, i.e., with partial channel knowledge at the transmitter due to limited feedback of channel state information.

"To our knowledge, ours was the first paper to address and successfully analyze the sum-capacity of large-user MIMO channels

Our paper points out the importance of channel quality feedback in the form of "Signal to Interference-plus-Noise Ratio" (SINR), and goes on to derive the tradeoffs between such quantities as the number of feedback bits, the number of users in the system, and the "Signal-to-Noise Ratio" (SNR). The results in our paper open the door for subsequent research in the area of multiuser MIMO techniques, facilitating the adoption of multiuser MIMO technologies into, among others, the upcoming 4th-generation cellular systems.

SW: Does it describe a new discovery, methodology, or synthesis of knowledge?

with limited feedback."

To our knowledge, ours was the first paper to address and successfully analyze the sum-capacity of large-user MIMO channels with limited feedback. Our paper put together such previous discoveries as MIMO broadcast channel capacity, multiuser diversity, and limited feedback MIMO systems, into a unified mathematical framework.

SW: Would you summarize the significance of your paper in layman's terms?

Over the past several decades, researchers have learned that by deploying multiple antennas at both the transmitter and receiver sides, we can greatly increase the achievable data rate over the wireless link. Furthermore, by appropriately grouping and serving multiple users in a single time/frequency resource, we can further increase the data rate. These gains are significant in the sense that they come free of additional spectrum and battery power, which are the two fundamental factors that limit the achievable data rate on any given wireless link.

However, the biggest hurdle, in our view, in bringing this theoretical result into practice is the limited availability of channel information at the transmitter. Our paper attacks this problem and shows that given sufficient number of users in the system; nearly all the gains promised by the theory can in fact be achieved by employing the right feedback and scheduling methods.

SW: How did you become involved in this research, and were there any problems along the way?

My research at Stanford has focused on multiuser MIMO systems and information theory. Having some industry background, I have also been interested in bringing some of the information theoretic results into somewhat more practical settings.

Our paper is built on two previous works of ours; one is a previous work by Prof. Andrea Goldsmith of the Department of Electrical Engineering at Stanford University and me on zero-forcing beamforming in large-user MIMO broadcast channels, and the other is on the subject of "MIMO broadcast channels with limited feedback" by Prof. Nihar Jindal of the University of Minnesota. I had a hunch that my conjecture in the paper was correct, but the hardest part was to actually prove it by coming up with the right combination of algorithms and mathematical tools.

SW: Where do you see your research leading in the future?

I am interested in continued research on this very topic, as well as related areas such as network MIMO and relay networks.

SW: Do you foresee any social or political implications for your research?

I believe our paper is one big step forward toward implementing multiuser MIMO technologies, which will enable faster wireless connection and better user experience.

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KEYWORDS: MIMO; QUANTIZED FEEDBACK; LIMITED FEEDBACK; ZERO-FORCING BEAMFORMING; MULTIUSER DIVERSITY; BROADCAST CHANNEL; SCHEDULING; SEMI-ORTHOGONAL USER SELECTION; RANDOM BEAMFORMING.

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