OFDMA Downlink Resource Allocation using Limited Cross-Layer Feedback

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Abstract

In this talk, we consider adaptive resource allocation for mobile OFDMA downlinks using cross-layer limited feedback. In particular, we consider the adaptation of physical-layer resources—such as subcarrier assignments, powers, and rates—using transmitter channel-state information (CSI) inferred from link-layer feedback, such as packet-level ACK/NAK. Thus, in contrast to the typical approach, which feeds back quantized channel-state through a dedicated physical-layer side-channel, we are interested in approaches that *infer* CSI from quantized *error-state* information provided "for free" by higher layers.

The use of error-state feedback, in place of channel-state feedback, adds some twists to the transmitter adaptation problem. Intuitively speaking, error-state feedback provides only "relative" information on the channel state, i.e., relative to the previously employed transmitter parameters. Thus, a given choice of resource allocation affects not only the immediate utility but also the quality of the subsequent feedback, implying a tradeoff between exploitation and exploration. In fact, the optimal resource allocation strategy is a partially observable Markov decision process (POMDP) whose complexity and memory requirements are known to grow exponentially in time. For practical reasons, we focus on suboptimal allocation strategies, and greedy schemes in particular.

Before attacking the OFDMA downlink problem, we detail the simpler single-user point-to-point problem, where resource allocation reduces to rate adaptation. For this, we propose a greedy scheme that allows a continuous (versus finite-state) Markov channel model and tracks a distributional (versus point) estimate of the SNR. Numerical experiments show that, according to several metrics (e.g., goodput, drop rate), our greedy scheme achieves performance close to POMDP upper bounds and far from the best fixed-rate scheme. We then return to the OFDMA downlink problem, where greedy resource allocation involves joint user-scheduling, power control, and rate optimization based on imperfect CSI: a mixed-integer programming problem. For this, we employ dual-optimization approach to design an algorithm with near-optimal performance and complexity that is linear in the number of users, subcarriers, and rates. We then combine this algorithm with a scheme that tracks each user/subchannel SNR distribution from previous ACK/NAKs to arrive at our OFDMA downlink solution, which—according to numerical experiments—achieves sum goodput that is close to an upper bound on the optimal POMDP scheme.

Biography

Philip Schniter received the B.S. and M.S. degrees in Electrical and Computer Engineering from the University of Illinois at Urbana-Champaign in 1992 and 1993, respectively. From 1993 to 1996 he was employed by Tektronix Inc. in Beaverton, OR as a systems engineer. In 2000, he received the Ph.D. degree in Electrical Engineering from Cornell University in Ithaca, NY. Subsequently, he joined the Department of Electrical and Computer Engineering at The Ohio State University in Columbus, OH, where he is now an Associate Professor and a member of the Information Processing Systems (IPS) Lab. Dr. Schniter's current research interests focus on signal processing and communication.