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Multi-Layer Broadcasting over a Block Fading MIMO Channel

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***Abstract*—This paper introduces extensions for the broadcast approach for a multi-input multi-output (MIMO) block fading channel, with receiver only channel state information (CSI). Previous works have not been able to fully characterize the fundamental MIMO broadcasting upper bound. As it seems that analytical solution for this problem is quite difficult to achieve, we consider here sub-optimal schemes, for which achievable rates may be computed. In particular, finite level coding over a MIMO channel instead of continuous layering is analyzed, the expressions derived for decoding probability regions allow numerical computation of finite level coding upper bounds. Noticing that the gains of two level coding over a MIMO channel are rather small, we consider sub-optimal techniques, which are more straightforward to implement. Among these techniques is the multiple-access channel (MAC) approach with single level coded streams, which is similar in concept to V-BLAST. Closed form expressions for probabilities of decoding regions here are derived, allowing numerical evaluation. We further consider multi-access permutation codes (MAPC). A Hadamard transform is compared with a suggested diagonal permutation code, which are shown to have similar performance, while diagonal permutation has lower implementation complexity. For all approaches, we derive information theoretic upper bounds of achievable rates.**

***Index Terms*—MIMO, MISO, MAC, broadcasting, code layering, permutation codes, MAPC.**

outage capacity [1], [2, see references therein]. The achievable rate of the described setting is $R_{1,avg} = \Pr(R_1 \leq I_k) \cdot R_1$.

However, the outage capacity is not the fundamental upper bound of achievable rates for the block fading channels (with receiver only CSI). Consider the following transmission scheme. Let the transmitter perform multi-layer coding. A practical example is super-position coding. Let the receiver decode as many layers as possible, and return a feedback to the transmitter indicating which layers were successfully decoded. Then, the transmitter reschedules only the undecoded layers for retransmission. This basically describes the essence of the broadcast approach [3],[4]. Clearly with only one layer the maximal achievable rate is the outage capacity, and with an unlimited number of layers the fundamental broadcasting upper bound can be obtained. Cover in his original paper [5] suggested broadcasting for the compound channel, where for every realization of the compound channel parameter a different set of users may reliably decode the transmission. The fading channels without transmitter CSI may be viewed as a compound channel with the instantaneous fading realization as the parameter of the compound channel.

In [4], the broadcast approach was fully analyzed for the single-input single-output (SISO) channel. That is, optimal