Cooperative Multiple Access Encoding with States Available at One Transmitter

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Abstract

We generalize the Gel’fand-Pinsker model to encompass the setup of a memoryless multiple-access channel. According to this setup, only one of the encoders knows the state of the channel (non-causally), which is also unknown to the receiver. Two independent messages are transmitted: a common message and a message transmitted by the informed encoder. We find an explicit characterization of the capacity region of this channel. An explicit characterization of the capacity region is also provided for the same channel with causal channel state information. Further, we apply the general formula to the Gaussian case with non-causal channel state information, under an individual power constraint as well as a sum power constraint. In this case, the capacity region is achievable by a generalized writing-on-dirty-paper scheme.

I. INTRODUCTION

Communication over state-dependent channels has become a widely investigated research area. The framework of channel states available at the transmitter dates back to Shannon [1], who characterized the capacity of a state-dependent memoryless channel whose states are i.i.d. and available causally to the transmitter. In their celebrated paper [2], Gel’fand and Pinsker established a single-letter formula for the capacity of the same channel under the conceptually different setup where the transmitter observes the channel states non-causally. The main tool in proving achievability in this setup is the binning encoding principle [2]. Costa [3] applied Gel’fand Pinsker’s (GP) result to the Gaussian case, where there are two additive Gaussian noise sources, one of which, the interference, takes the role of the channel state. Costa originated the term “writing on dirty paper” which stands for an application of GP’s binning encoding scheme that adapts the transmitted signal to the channel states sequence rather than attempting to cancel it. This results in a surprising phenomenon - the operative upper bound, of a channel having no interference, can be attained, even though the channel states are not known to the receiver. It was shown in [4],[5], that this principle continues to hold even if the interference is not Gaussian. Extensions of these channel models to the multi-user case were performed by Gel’fand and Pinsker in [6] who showed that interference cancelation is also possible in the Gaussian broadcast channel, and the Gaussian Multiple Access Channel (MAC). Kim et al. [7] showed that a similar thing happens for the physically degraded Gaussian relay channel. Steinberg and Shamai [8] provided achievable rates for the broadcast channel with states

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