A Coding Theorem for the Discrete Memoryless Compound Multiple Access Channel with Common Message and Generalized Feedback

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Abstract—In this paper, we characterize an achievable rate region for the two-user discrete memoryless compound Multiple Access Channel (MAC) with common message and with generalized feedback (CMACC-GF). The achievable rate region that we provide is proved using a combination of rate splitting, Superposition Block Markov Encoding (SBME), and backward decoding. It is shown that the derived achievable rate for the CMACC-GF subsumes achievable regions for some classes of multiuser channels such as: the CMACC without feedback, CMACC with output feedback, strong interference channel with common message (SICC) and with generalized/output feedback as well as SICC without feedback.

Keywords—Backward decoding; common message; compound multiple access channel; generalized feedback; superposition block Markov encoding;

I. INTRODUCTION

The two-user discrete memoryless compound MAC in which two senders communicate with two receivers simultaneously and each of the two receivers need to decode all messages sent from both senders, was first studied by Marie et al. [1] where they characterized the capacity regions of compound MAC with common message, and of compound MAC with conferencing encoders. Simeone et al. [2] extended [1] by allowing the decoders to cooperate and studied both compound MAC with common message and conferencing decoders and compound MAC with conferencing encoders and decoders. Compound MAC with common message and with Slepian-Wolf type correlated side information was studied recently by Monemizadeh and Hodtani [3]. Feedback in network information theory has been studied for some classes of multiuser channels [4-11]. El Gamal [4] found the capacity region of degraded broadcast channels with feedback. Gaarder and Wolf [5] showed through an example that the capacity of MACs can increase with feedback. Cover and Leung [6] found an achievable rate region for the MAC with noiseless delayed feedback using list coding and lexicographical indexing. Later, King [7] studied MAC with generalized feedback where the senders receive a common channel output $Y$ that can be different from the output of the channel $Y$ received by the decoder. Carleial [8] extended [7] to the case where senders receive different feedback signals $Y_1$ and $Y_2$. Willems [9] found another achievable rate region for the MAC with different generalized feedback signals using superposition block Markov encoding and backward decoding which was much simpler to deal with than that of Carleial [8]. Tuninetti [10] found an achievable rate region for interference channel with generalized feedback. Mirmohseni et al. [11] studied interference channel with causal and non-causal generalized feedback provided at the cognitive transmitter.

In this paper, we find an achievable rate region for the discrete memoryless compound MAC with common message and different generalized feedback signals $Y_3$ and $Y_4$ given to encoders 1 and 2, respectively, using a combination of regular superposition block Markov encoding, rate splitting, and backward decoding. We also show that the proposed achievable rate for the CMACC-GF subsumes achievable regions for some classes of multiuser channels such as: the CMACC without feedback, CMACC with output feedback, strong interference channel with common message (SICC) and with generalized/output feedback as well as SICC without feedback. The rest of the paper is organized as follows. In section II, definitions and channel model are provided. Section III is devoted to the main result of the paper. In Section IV, we discuss some corollaries of the main result.

II. DEFINITIONS AND CHANNEL MODEL

Definition 1: A two-user discrete memoryless compound MAC with common message and with generalized feedback characterized by $(X_1, X_2, Y_1, Y_2, Y_3, Y_4, P(Y_1, Y_2, Y_3, Y_4|X_1, X_2))$, consists of two finite channel input alphabets $X_1, X_2$, four finite channel output alphabets $Y_1, Y_2, Y_3, Y_4$ and a transition probability distribution $P(Y_1, Y_2, Y_3, Y_4|X_1, X_2)$ with $y_1$ and $y_2$ being the outputs of the channel available at the decoders 1 and 2, respectively, and $y_3$ and $y_4$ being the channel outputs fed back to the first and second transmitters, respectively, as depicted in Fig. 1.

The channel is memoryless in the sense that