Extension of the Coverage Region of Multiple Access Channels by Using a Relay

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Abstract—From practical and theoretical viewpoints, performance analysis of communication systems by using information-theoretic results is important. In this paper, based on our previous work on Multiple Access Channel (MAC) and Multiple Access Relay Channel (MARC), we analyze the impact of a relay on the fundamental wireless communications concept, i.e., coverage region of MARC, as a basic model for uplink communications between a base station and users with the help of a relay. This analysis includes the coverage region for the MAC as a special case. Considering rate regions for the Gaussian MARC and fading Gaussian MARC, it is proved that in a fixed transmission rate, the relay extends coverage region of the MARC. Numerical illustrations confirm our theoretical results.

Index Terms—Multiple Access Relay Channel, Coverage region, Fixed desired transmission rates, Cellular network.

I. INTRODUCTION

In the relay channel, first introduced by Van der Meulen [1], the relay can increase transmission rate and extend coverage area. Fundamental coding strategies and the capacity for some special classes of relay channel and a more general class were studied in [2-6].

In some practical models, such as uplink mobile cellular networks, a relay can facilitate communication between mobile users and base station. This model known as Multiple-Access Relay Channel (MARC) was first introduced by Kramer in [7] and is a combination of Multiple-Access Channel (MAC) and the relay channel. MARC with common message was investigated, and its achievable regions and bounds were derived in [9, 10]. Furthermore the results of discrete memoryless MARC were extended to Gaussian in [9]. The bounds of MARC with non-causal CSI at the relay were derived in [11]. Capacity bounds of MARC in Gaussian and fading environment with full-duplex and half-duplex relay constraints via Decode and Forward (DF) and Compress and forward (CF) strategies have been derived in [8, 12]. Two special classes of Multiple-Access relay Channel which include a non-interfering finite-capacity link from relay to decoder were studied in [13]. The inner and outer bounds of the capacity region of multiple-access channel with multiple