Analysis of capacity and coverage region for Rayleigh fading MIMO relay channel‡

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SUMMARY

In this paper, we consider Rayleigh fading MIMO relay channel with channel state information at the receivers. First, we extend the previously obtained results for the ergodic capacity of uncorrelated and semi-correlated MIMO channels and derive closed-form expressions for the capacity bounds of MIMO relay channel. Next, we study this channel from a new point of view, maximizing coverage region for a desired transmission rate, and investigate the optimal relay location in the sense of maximizing coverage region. However, in order to overcome the mathematical complexity in desired transmission rate analysis, because of the randomness of the multiple antenna channel matrices, we evaluate this rate by using an existing exact formula and also by an approximation we find in the high signal-to-noise ratio regime. Numerical results show a perfect match between the Monte Carlo simulations and the obtained analytical closed-form expressions and also confirm the effectiveness of our approach in cooperative vehicular communication for determining optimal relay location at which the coverage region is maximum. Copyright © 2013 John Wiley & Sons, Ltd.

KEY WORDS: capacity bounds; channel state information (CSI); coverage region; optimal relay location; desired transmission rate

1. INTRODUCTION

Relay channel is the most basic structural unit for multiuser communications in wireless networks. Relaying strategy can increase channel throughput, extend coverage region, facilitate information transmission, and realize some of the gains of multiple-antenna systems by single-antenna terminals. The relay channel, since its introduction by van der Muelen [1], has been extensively studied [2–9]. In their seminal work, Cover and El Gamal [2] presented many results such as a capacity upper bound and achievability strategies for the relay channel.

Using multiple antennas can be considered as an effective technique to combat fading, which also can result in a significant increase in channel throughput. Nonetheless, the capacity gain obtained from this technique heavily depends on the amount of instantaneous channel state information (CSI) available at the receiver and transmitter [10]. The results of [2] and [11] have been extended to the MIMO relay channel [12–14]. In [12], the capacity bounds for the full-duplex MIMO relay channel with full CSI are derived, and it is shown that optimizing capacity bounds requires to solve an optimization problem with respect to per-node transmit power constraint and a scalar parameter ρ, which captures the cross correlation of the source and relay signals. For the full-duplex MIMO relay channel with only channel state information at the receivers (CSIR), the capacity bounds are also

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