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Quality of service assurance in multi-antenna relay-assisted networks

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Abstract: This study concerns two-hop communication over a relay-assisted wireless network, including L point-to-point communication links and a multi-antenna relaying node. It is assumed the relay is equipped with N_r antennas and the amplify-and-forward strategy is employed at this node, considering the second-order statistics of channel coefficients are merely available at the relay. To this end, each source sends its desired signal to the relay during the first hop. Thus, the relay simultaneously receives a faded version of L transmitted signals corrupted with an additive white Gaussian noise in a vector form. Then, the relay applies a weight matrix of dimension $N_r \times N_r$ to the received vector and transmits the resulting vector to the destinations throughout the second hop. In this regard, the task of finding the best weight matrix at the relaying node under two different criteria, that is, minimising the relay's transmit power to have a minimum signal-to-interference noise ratio (SINR) at destinations and maximising the worst-case SINR for a given relay's transmit power, is investigated. Accordingly, it is demonstrated that the corresponding problems can be formulated as optimisation problems which are not convex in general. This motivated the authors to propose suboptimal solutions through using the so-called semidefinite relaxation method to translate original problems into semidefinite programming problems. Numerical results are provided, showing the superiority of the proposed methods as compared to the best known method.

1 Introduction

It is widely recognised that fading and interference are two main challenges in multiuser wireless networks, which greatly alleviate the performance of wireless communication links. This motivated researchers to propose methods to combat the aforementioned issues. The former, the impact of fading, can be tackled through the use of multiple antennas at the transmitter and/or the receiver side to initiate some virtual parallel paths between the transmitter and the receiver side, thereby increasing the diversity and/or multiplexing gains [1]. However, in some applications, due to the lack of space, the end user cannot incorporate multiple antennas. In this case, it is shown another variation of diversity, called user cooperation diversity, can be employed. The idea is to involve many users in transmission to help the transmitter to establish additional paths to the affiliated receiver, thereby increasing degrees of freedom [2–6]. On the other hand, the interference, emerging in multiuser wireless networks, is an important issue which dramatically decreases the performance of such networks, and should be given careful attention. As such, there have been some attempts to mitigate the impact of interference in multiuser wireless networks [7–9].

Relaying is another variation of cooperation diversity in which some extra nodes are incorporated to increase the spatial diversity and the received signal-to-noise ratio (SNR), thereby improving the quality of service (QoS) of communication links. In this regard, several relaying protocols have been proposed, among them, amplify-and-forward (AF) [5], compress-and-forward (CF) [10], coded-cooperation (CC) [11] and decode-and-forward (DF) [12] are extensively addressed in the literature. It is worth mentioning that there is not a single method which performs well in all channel conditions and for every network topology. In other words, depending on the channel condition and the network topology, one of the aforementioned strategies may outperform the others. Nevertheless, the AF strategy is commonly used at the relays as it possesses less complexity to the network. This is due to the fact that in AF, a scaled version of the received signal is sent to the destination, thus the relay does not need to do any further processing.

In this regard, a plethora of works are devoted to the performance evaluation of AF strategy in relay networks for different scenarios [13–28]. For instance, in [20] a two-hop communication in a point-to-point wireless channel with the aid of multiple AF relays is considered, assuming there is a direct link between the transmitter and affiliated receiver. Accordingly, when the channel state information (CSI) is perfectly available at both the destination and relay nodes, it is shown that the best precoding strategy at AF relays is transmit beamforming and similarly the best decoding strategy at the destination is maximum ratio combining.

In [21], the problem of distributed beamforming in single antenna relay-assisted wireless networks is considered. It is assumed the transmitter aims at sending information to the affiliated receiver through multiple single antenna AF