Chapter 8
Joint Resource Allocation and Interference Mitigation Techniques for Cooperative Wireless Networks

Rodrigo C. de Lamare
University of York, UK

Patrick Clarke
University of York, UK

ABSTRACT

This chapter presents joint interference suppression and power allocation algorithms for DS-CDMA and MIMO networks with multiple hops and amplify-and-forward and Decode-and-Forward (DF) protocols. A scheme for joint allocation of power levels across the relays and linear interference suppression is proposed. The authors also consider another strategy for joint interference suppression and relay selection that maximizes the diversity available in the system. Simulations show that the proposed cross-layer optimization algorithms obtain significant gains in capacity and performance over existing schemes.

INTRODUCTION

Multiple-antenna wireless communication systems can exploit the spatial diversity in wireless channels, mitigating the effects of fading and enhancing their performance and capacity. Due to the size and cost of mobile terminals, it is considered impractical to equip them with multiple antennas. However, spatial diversity gains can be obtained when single-antenna terminals establish a distributed antenna array via cooperation (Sendonaris, Erkip, & Aazhang, 2003; Laneman & Wornell, 2004). The use of cooperative strategies can lead to several types of gains (Dohler & Li, 2010; Pabst, et al., 2004), namely, pathloss, diversity, and multiplexing gains. Pathloss gains

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allow a significant reduction in the transmitted power for an equivalent performance, can increase the coverage (Ettefagh, Kuhn, Hammerstrom, & Wittneben, 2006) and enhance the interference suppression capability (Dohler & Li, 2010; Pabst, et al., 2004). The diversity gains improve the performance of the wireless system with respect to the probability of error because the transmission of multiple copies of the signals reduce the probability that the message will not be received correctly. The multiplexing gains (So & Liang, 2005), which correspond to the additional number of bits that the system can transmit as compared to a single-antenna link, can be obtained when a designer can use relays to form independent channels and increase the rate of communication.

Despite the many advantages in terms of gains as previously outlined, cooperative communications also entail some disadvantages such as signalling overheads (Pabst, et al., 2004), more computationally complex scheduling algorithms (Dohler & Li, 2010) and increased latency (Lu, Steenkiste, & Chen, 2007). For this reason, it is important to weigh the pros and cons of cooperative techniques prior to their adoption and consider the practical scenarios of interest (Kyritsi, et al., 2007). Motivated by their performance and diversity gains, cooperative techniques are now being considered for the next generation of mobile networks (Scaglione, Goeckel, & Laneman, 2006; Fan & Thompson, 2007; Peters, Panah, Truong, & Heath, 2009). In cooperative systems, terminals or users relay signals to each other in order to propagate redundant copies of the same signals to the destination user or terminal. To this end, the designer must resort to a cooperation protocol such as Amplify-and-Forward (AF) (Laneman & Wornell, 2004), Decode-and-Forward (DF) (Laneman & Wornell, 2004; Huang, Hong, & Kuo, 2007), and Compress-and-Forward (CF) (Kramer, Gastpar, & Gupta, 2005).

In order to obtain the benefits of cooperative techniques, designers must address a number of problems that are encountered in cooperative wireless systems. These problems include physical-layer strategies such as synchronization, interference mitigation, and parameter estimation. However, designers also have to consider a number of associated problems that belong to higher protocol layers and include the allocation of resources such as power, relays and rate. These tasks present an opportunity to perform cross-layer design and to obtain very significant gains in performance and capacity for cooperative wireless networks. This chapter is concerned with cross-layer design techniques for cooperative wireless networks and investigates the benefits of approaches that jointly mitigate interference and perform resource allocation.

In this chapter, we will consider two types of schemes, namely, Direct-Sequence Code-Division Multiple Access (DS-CDMA) (Ziemer, Peterson, & Borth, 1995; Honig & Poor, 1998) and Multi-Input Multi-Output (MIMO) (Foschini & Gans, 1998; Telatar, 1999) systems. The former is of fundamental importance in wireless ad-hoc and sensor networks (Dohler & Li, 2010), whereas the latter is one of the main ingredients of future wireless cellular networks. When implementing cooperative techniques in wireless systems, designers often consider the transmission technologies available and their suitability to certain applications. Therefore, the concept of distributed antenna arrays can be easily extended to techniques such as MIMO (Foschini & Gans, 1998; Telatar, 1999) and DS-CDMA systems (Ziemer, Peterson, & Borth, 1995; Honig & Poor, 1998).

In the context of MIMO systems, one can obtain substantial multiplexing and diversity gains (Foschini & Gans, 1998; Telatar, 1999; Zheng & Tse, 2003) with the deployment of multiple antennas at both ends of the wireless system. MIMO technology is poised to equip most of the future wireless systems and can be incorporated in conjunction with other transmission systems. There are two basic configurations which exploit the nature of the wireless channel: spatial multiplexing (de Lamare & Sampaio-Neto, 2010b)

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