

Chapter 7

Resource Allocation and QoS Provisioning for Wireless Relay Networks

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ABSTRACT

This chapter reviews fundamental protocol engineering aspects and presents resource allocation approaches for wireless relay networks. Important cooperative diversity protocols and their typical applications in different wireless network environments are first described. Then, performance analysis and QoS provisioning issues for wireless networks using cooperative diversity are discussed. Finally, resource allocation in wireless relay networks through power allocation for both single and multi-user scenarios are presented. For the multi-user case, we consider relay power allocation under different fairness criteria with or without user minimum rate requirements. When users have minimum rate requirements, we develop a joint power allocation and admission control algorithm with low-complexity to circumvent the high complexity of the underlying problem. Numerical results are then presented, which illustrate interesting throughput and fairness tradeoff and demonstrate the efficiency of the proposed power control and admission control algorithms.

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INTRODUCTION

Emerging broadband wireless applications in most wireless networks require increasingly high throughput and more stringent quality-of-service (QoS) requirements. In this respect, multiple-antenna technologies have been recognized as important solutions for future high-speed wireless networks (Tarokh *et al*, 1998; Tarokh *et al*, 1999; Telatar, 1998). Particularly, employment of multiple antennas at transmitter and/or receiver sides can provide significant multiplexing and/or diversity gains (Zheng & Tse, 2003). The net effects of these gains are the improvements in terms of wireless link robustness (i.e., lower bit error rate (BER)) and network capacity. Unfortunately, the implementation of multiple antennas in most modern mobile devices may be challenging due to their small sizes.

Cooperative diversity has been proposed as an alternative solution where a virtual antenna array is formed by distributed wireless nodes each with one antenna. Cooperative transmission between a source node and a destination node is performed with assistance of a number of relay nodes. In particular, the source and relay nodes collaboratively transmit information to the destination node (Laneman *et al*, 2004; Laneman & Wornell, 2003; Le & Hossain, 2007; Nabar *et al*, 2004; Nosratinia *et al*, 2004; Sendonaris *et al*, 2003a, b; Zhifeng *et al*, 2006). It is intuitive that in order to make cooperative transmission efficient or even possible, the source node has to carefully choose one or several “good” relays and first forward its data to those relays. Then, the source and relays can coordinate their transmissions in such a way that maximum multiplexing/diversity gains can be achieved at the destination node.

Although cooperative diversity is simple in concept, there are many technical issues to be resolved for practical implementation. First, protocol design for cooperative diversity is one of the important research focuses (Azarian *et al*, 2008; Laneman *et al*, 2004; Laneman & Wornell,

2003; Sendonaris *et al*, 2003a, b). Second, it is worth noting that most practical cooperative diversity protocols have two phases: in the first phase, the source node broadcasts its message to assisting relays; in the second phase, the relays collaboratively transmit the received information to the destination. Therefore, cooperative transmission may not be always beneficial or even necessary because direct transmission from the source to the destination node may already be successful. Adaptive cooperative protocols, where nodes cooperate only when necessary and/or they cooperate using incremental transmissions, usually have significantly better performance than “straight-forward” protocols (Azarian *et al*, 2008; Dai & Letaief, 2008; Le *et al*, 2007; Le & Hossain, 2008a; Zhao & Valenti, 2005). In addition, emerging technology such as network coding can be employed to design cooperative protocols (Koetter & Medard, 2003; Li *et al*, 2003; Xiao *et al*, 2007). Finally, other important issues such as relay selection, synchronization among relays’ transmissions need to be considered for practical implementation (Beres & Adve, 2008; Bletsas *et al*, 2006; Le & Hossain, 2008b; Lin *et al*, 2006; Ng & Yu, 2007; Tannious & Nosratinia, 2008; Zhao *et al*, 2007).

While most existing works on cooperative diversity in the literature focus on design and performance analysis of cooperative protocols, resource allocation for wireless relay networks receives less attention. However, resource allocation also has significant impacts on system performance (Gunduz & Erkip, 2007; Li *et al*, 2007; Liang *et al*, 2007; Luo *et al*, 2007; Madsen & Zhang, 2005; Yao *et al*, 2005). In fact, assisting relays usually have limited radio resources (e.g., bandwidth and power) and they are shared by several source-destination pairs. Therefore, a smart radio resource allocation for wireless relay networks guarantees both fair access to available relays and good overall network throughput performance. In addition, by using a proper relay selection strategy where each source-destination pair only selects

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