Chapter 24
The Use of Orthogonal Frequency Code Division (OFCD) Multiplexing in Wireless Mesh Network (WMN)

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ABSTRACT

In the present scenario, improvement in the data rate, network capacity, scalability, and the network throughput are some of the most serious issues in wireless mesh networks (WMN). Specifically, a major obstacle that hinders the widespread adoption of WMN is the severe limits on throughput and the network capacity. This chapter presents a discussion on the potential use of a combined orthogonal-frequency code-division (OFCD) multiple access scheme in a WMN. The OFCD is the combination of orthogonal frequency division multiplexing (OFDM) and the code division multiple access (CDMA). Since OFDM is one of the popular multi-access schemes that provide high data rates, combining the OFDM with the CDMA may yield a significant improvement in a WMN in terms of a comparatively high network throughput with the least error ration. However, these benefits demand for more sophisticated design of transmitter and receiver for WMN that can use OFCD as an underlying multiple access scheme. In order to demonstrate the potential use of OFCD scheme with the WMN, this chapter presents a new transmitter and receiver model along with a comprehensive discussion on the performance of WMN under the new OFCD multiple access scheme. The purpose of this analysis and experimental verification is to observe the performance of new transceiver with the OFCD scheme in WMN with respect to the overall network throughput, bit error rate (BER) performance, and network capacity. Moreover, in this chapter, the authors provide an analysis and comparison of different multiple access schemes such as FDMA, TDMA, CDMA, OFDM, and the new OFCD.

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INTRODUCTION

Wireless Mesh Networks (WMNs) have become a major paradigm for construing a user access network that provides high speed network access to users in the context of enterprise and community networks (Akyildiz, Wang, & Wang, 2005; Tse & Grossglauser, 2002; Xiang, Peng-Jun, Wen-Zhan, & Yanwei, 2008). From the robust and stable connectivity perspective, WMN is considered as one of the most data efficient mesh topology which is constructed by, mesh routers, clients, and gateways (Kim & Bambos, 2002; Zhang, Honglin, & Chen, 2008). In WMN, mesh routers can play the roll of gateways whereas the clients provide connectivity with the Internet. One of the main advantages of WMN is the self-healing and self-configuring nature of mesh routers. For extending the geographical area of a network, mesh routers are equipped to provide connectivity between different networking technologies such as Wi-Fi, IEEE 802.11, mobile technology and wired Ethernets (Li, Qiu, Zhang, Mahajan, Zhong, Deshpande, & Rozner, 2007; Yu, Mohapatra, & Liu, 2008).

WMN itself brings many challenging issues from physical layer to application layer. Problems like network capacity, protocols used in different layers, network management and the network security are just some of the problems to point out. Recent theoretical studies and experimental verifications (Gupta & Kumar, 2001) have shown the current WMNs are severely limited in network capacity. This is due to the fact that when all nodes communicate using a single channel in a high speed wireless LAN (e.g., IEEE 802.11a), the number of simultaneous transmissions from multiple users is limited by interference. Since WMNs are multi-hop in their nature, interference causes a serious degradation in overall network capacity when adjacent hops on the same path start interfering with the neighboring paths (Kyasanur & Vaidya, 2005).

As of now, the scalability issue in WMN has not been fully solved yet (Xiang, Peng-Jun, Wen-Zhan, & Yanwei, 2008). Most of the existing multiple access schemes which are based on CSMA/CA solve only partial problems of the overall issue for WMN (Zhou & Lai, 2005). The implementation of such schemes raises other performance issues such as minimum network capacity, low end-to-end throughput, and scalability (Lin & Rasool, 2007). Thus, how to fundamentally improve the scalability and maximize the throughput performance in WMN is an interesting research issue now days. One of the efficient solutions that can be used for not only improving the network scalability but also maximizing the end-to-end network throughput is the use of a hybrid multiple access scheme for WMN (Sundaresan & Rangarajan, 2008). For networks based on techniques other than CSMA/CA, code division multiple access (CDMA) can be applied with orthogonal frequency division multiplexing (OFDM) in WMN as an efficient multiple access scheme to overcome some of the problems mentioned above. The combination of these two multiple access schemes allow us to take advantage of both CDMA and OFDM. OFDM has become widely adopted in many next generation cellular systems such as 3GPP Long Term Evolution (LTE) and IEEE 802.16m advanced WiMAX (Chang, Tao, Zhang, & Kuo, 2009; Zhang, Honglin, & Chen, 2008).

Recently, researchers have identified two fundamental problems that degrade the throughput of WMNs (Li, Qiu, Zhang, Mahajan, Zhong, Deshpande, & Rozner, 2007). First, they identified that if we do not consider the amount of data that the nodes can transmit, the network throughput may degrade when nodes start transmitting more than what the intermediate links can support. They highlighted that this is possible due to the presence of interference (i.e., multi-access interference (MAI)) which may cause additional traffic to reduce the capacity of bottleneck links. The second problem that they