

Chapter 14

MAC Protocol of WiMAX Mesh Network

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ABSTRACT

WiMAX based on IEEE std 802.16 is believed one of the important technologies of 4G. It aims to provide high-speed access over distance of several to tens kilometers. In IEEE std 802.16-2004, WiMAX defines an optional mesh mode, with which multi-hop, multi-route, self-organizing and self-healing communications can be achieved in metropolitan-level areas. This chapter presents medium access control (MAC) protocol of WiMAX mesh mode, on frame structure, network configuration, network entry, and scheduling algorithms. It also summaries the most recent progress on data slots resource scheduling and allocation algorithms. Finally, an application example of using WiMAX mesh network for high-speed and low-cost maritime communications is also presented in this chapter.

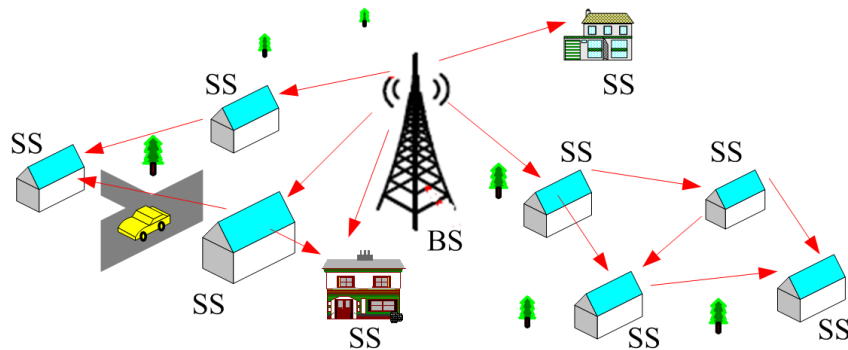
1. INTRODUCTION

A number of technologies are under development toward next generation wireless networks beyond 3G, such as WiMAX (Worldwide Interoperability for Microwave Access), UMB (Ultra Mobile Broadband), and LTE (Long Term Evolution). Among of them, WiMAX is based on IEEE 802.16 standard, and it aims to provide high-speed data access using a variety of transmission modes, from point-to-multipoint links to portable and fully mobile Internet access.

IEEE std 802.16-2004 is an important member of WiMAX standard family IEEE (802.16-2004). It specifies layers of Physical (PHY) and Media Access Control (MAC), and it superseded earlier 802.16 documents. This version of standard supports line-of-sight (LOS) connections in 10-66 GHz and non-LOS (NLOS) communication in 2-11 GHz. Two multi-carrier modulation technologies are supported, i.e., OFDM with 256 carriers and OFDMA with 2048 carriers. In 2005, an amendment to 802.16-2004 was completed and named as 802.16-2005. This newer version of standard supports combined fixed and mobile operation in

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Figure 1. Typical topology of WiMAX mesh networks



frequencies below 6 GHz, and it includes many new features such as scalable OFDMA (SOFDMA), Multiple Input Multiple Output (MIMO), Adaptive Antenna Systems (AAS), and hard and soft handoffs.

There are two operation modes defined in IEEE 802.16-2004, i.e., point-to-multipoint (PMP) and mesh. WiMAX PMP networks are based on cellular infrastructure, while WiMAX mesh network operates in a manner of multi-hop and multi-path communications. Some basic terms in WiMAX mesh network are different from that of cellular-like WiMAX PMP networks. In WiMAX mesh, a base station (BS) is a node that has direct connection to backbone services outside the network and all other nodes are called mesh subscribers (SSs). Uplink and downlink in WiMAX mesh are defined as traffic in the direction to the mesh BS and traffic away from the mesh BS, respectively. In addition, a mesh mode node is different from a PMP mode node in frame structure, procedures of synchronization, network entry, data scheduling, ranging, and power control, etc. Although WiMAX mesh mode is not included in 802.16-2005, it attracts a lot of attention due to a number of advantages and potentials for applications in a variety of scenarios.

Figure 1 shows a typical topology of WiMAX mesh networks. A WiMAX mesh SS can be connected to backbone network through mesh BS. Peer-to-peer communications among mesh

nodes is achievable through multi-hop relay. Each WiMAX mesh node is capable of playing a role of wireless router, and then the network capacity can be greatly increased. Since there is no a requirement of cellular infrastructure, it is relatively easy to deploy a WiMAX mesh network and the expensive cellular base stations can be saved, hence the cost can be relatively low. As there are multiple paths in a WiMAX mesh network, the network is robust and flexible. In cases of link failure, the network can recover by routing over redundant links. In addition to above, WiMAX mesh network has much longer connection distance (up to tens kilometers) than WiFi mesh network (up to several hundred meters) and ZigBee mesh network (up to several meters). Moreover, unlike WiFi mesh and ZigBee mesh, WiMAX mesh has a Time Division Multiplexing Access (TDMA) MAC protocol, by which easier quality-of-service (QoS) can be achieved

This chapter serves to introduce MAC protocol of WiMAX mesh mode and summarizes recent research progress on this technology (Figure 1). The frame structure, network configuration, and network entry of WiMAX mesh networks are presented in Section 2, 3, and 4, respectively. In Section 5, the three data scheduling schemes: coordinated centralized scheduling, coordinated distributed scheduling and uncoordinated distributed scheduling are introduced, as well as a number of new developments. In Section 6, a

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