Standard–Based Wireless Mesh Networks

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INTRODUCTION

As various wireless networks evolve into the next-generation fixed broadband wireless access (BWA) systems, the wireless mesh network (WMN), expected as a promising technology, is still being standardized in IEEE 802.16 and commercialized in the World interoperability for Microwave Access (WiMAX) forum at present. In fixed BWA systems, the objective of applying mesh-typed topology is to build self-organized networks in the places where wired infrastructure is not pre-existing or not worthy to be deployed. The term "mesh-typed" here can also be described as "relay-based" or "multi-hopping," which means that the connection from a particular mesh subscriber station (mesh SS) to the mesh base station (mesh BS) is via one or more successive wireless links. Multi-hop wireless networking has traditionally led to significant research in the context of ad hoc or peer-to-peer networks. However, the fundamental goal of relaying augmented networks like WMNs is to provide wide-bandwidth coverage and high-data-rate throughput, while the defining goal of conventional ad hoc networks is to accomplish communications without any pre-existing infrastructure in a short time.

The mesh concept applying in WMAN systems has the relay-based and multi-hopping features. Since communications could take place through relay nodes, link distance could become much shorter, frequency and spatial reuse could become much more efficient, and interference could also become much lower. Thus WMNs could provide non-line-of-sight (NLOS) connectivity with high-data-rate capacity to extend the coverage range of existing point-to-multipoint (PMP) wireless networks, such as cellular mobile networks.

Figure 1 depicts a possible scenario where WMNs can be deployed to provide broadband access to the IPv6 backbone network. In WMNs, each mesh SS operates as not only a host but also a wireless router, which forwards transferring traffic within the network as well as traffic that goes out to other networks. The network is dynamically self-organizing and self-configuring, with both mesh BS and mesh SS automatically establishing and maintaining routes among themselves. All the nodes can use the distributed scheduling to ensure collision-free transmissions within their two-hop neighborhood, or use the centralized scheduling to complete functions in a more centralized manner through conveying much of the control work to the mesh BS; the combination of these two control mechanisms is termed as hybrid-controlling. Mesh BS is connected with WiMAX PMP BS through first tire wireless backhaul, and then WiMAX PMP BS is connected with the IPv6 backbone network through second tire wireless or wired backhaul.

In the centralized scheduling mode of WMNs, all traffic is restricted to be either in the direction of the mesh BS or away from the mesh BS. However, in the distributed scheduling mode, the transmissions are communicated between arbitrary pairs of nodes. Hence, an ad hoc network, described in Figure 1, could be considered as a type of uncoordinated distributed WMN.

Wireless sensor networks (WSNs) differ from the WMNs in that they contain hundreds or thousands of sensor nodes to allow for sensing over large geographical regions and these sensor nodes have much more limited computation capabilities, sensing capabilities, storage space, battery power, and transmission range. Even so, these sensors have the basic ability to communicate either among themselves or directly with an external BS, making WSN similar to both centralized and distributed WMN.

This article introduces a functional architecture supporting the wireless mesh networks for the IEEE 802.16 standard. Three essential techniques—collision avoiding, packet scheduling, and wireless routing—are intensively presented. Based on the mesh extension of the IEEE 802.16 medium access control (MAC) layer protocol and the relay-based characteristic of WMNs, the algorithms concerning those three essential techniques are briefly reviewed. The suitable algorithms for collision avoiding and packet scheduling mechanisms are analyzed. Meanwhile, the wireless routing algorithm for the proposal architecture is discussed. The future research work is presented and the research problems are focused.

Figure 1. WMN internetworking architecture

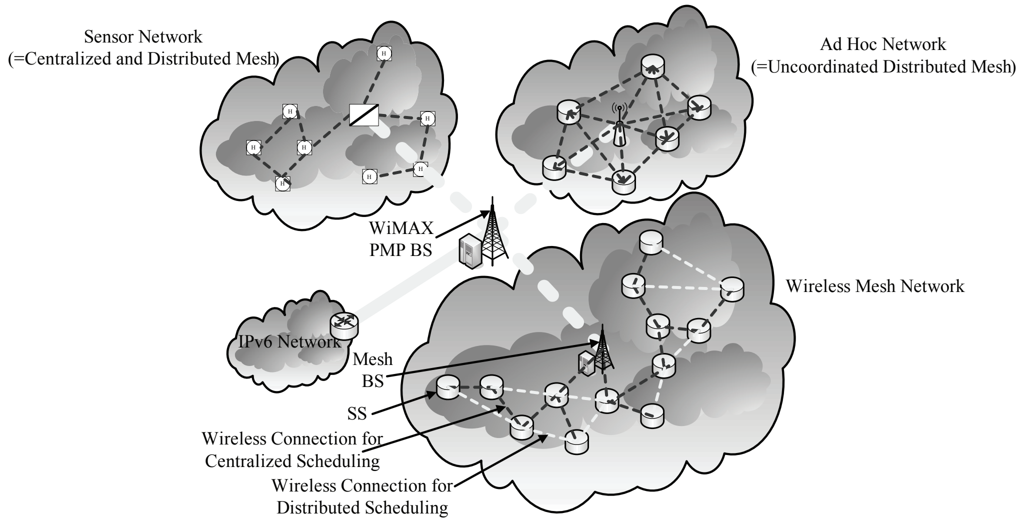
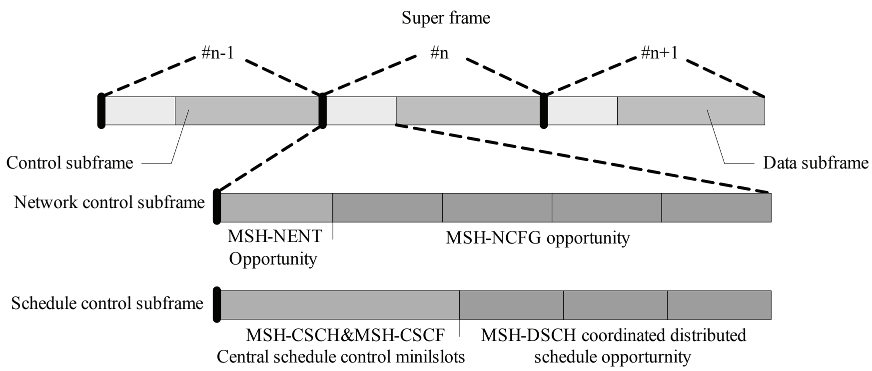


Figure 2. Frame structure for IEEE 802.16 mesh mode



SYSTEM BLOCK

IEEE 802.16 mesh mode is an optional extension of the IEEE 802.16 MAC layer as an alternative or a complement to the conventional PMP architecture in the fixed BWA systems. The physical layer of it supports OFDM modulation, particularly as presented in the IEEE 802.16 standard with both the licensed frequencies and the license-exempt frequencies operating below 11G Hz. In this physical environment with long wavelength, requirements of line-of-sight (LOS) are not necessary and impacts of multi-path may be significant.

IEEE 802.16 mesh mode provides a novel method for new nodes to enter the network with the help of a full functionality member (sponsor node) in the network and has three kinds of scheduling modes including centralized scheduling, coordinated distributed scheduling, and uncoordinated distributed scheduling for efficient transmission of the data packets as well as control messages. The mesh frame structure defined in IEEE 802.16 mesh mode, which has no difference between uplink and downlink, is demonstrated in Figure 2.

We refer to the frame containing the network control subframe as the "network frame" and similarly term the frame including the schedule control subframe as the "schedule frame" for short. One network frame and several schedule frames constitute a super frame. In the network control subframe, the first opportunity with seven OFDM symbols is for NENT (network entry) message transmission in which a new node sends an entry request or entry acknowledgement. The symbols remaining are for NCFG (network configuration) message transmission in which the network configurations are advertised. In the schedule subframe every seven symbols