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WiMAX Based on IEEE 802.16 Standard- A Survey

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Abstract

The IEEE 802.16 standard, commonly known as Worldwide Interoperability for Microwave Access (WiMAX) is that the latest technology that has promised to offer broadband wireless access over long distance. This standard was designed to support the bandwidth demanding applications with quality of service (QoS) and a solution to broadband wireless access (BWA) commonly called as (WiMAX), may be a recent wireless broadband standard that has promised high bandwidth over long-range transmission. In this survey we provide an overview of the state-of-the-art mobile WIMAX technology, its development, and (QoS) provisioning

Keywords: QoS, wireless card

Introduction

IEEE 802.16 or WiMAX networks are receiving a good deal of attention in both industry and research.

A network consists of individual wireless cards, like shown in Figure 1 that acts either as a Base Station (BS) or as a Subscriber Station (SS). Resource allocation is performed within the MAC under the control of the Driver.

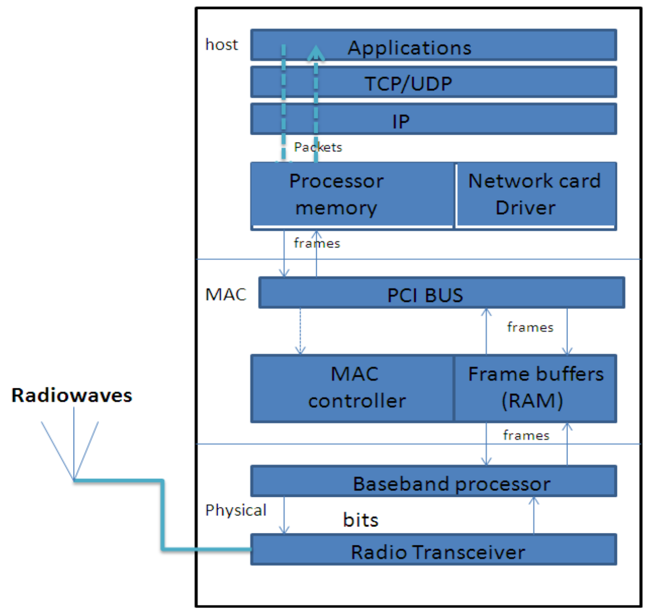

Fig. 1: Design of Wireless Card

The host interface communicates with the MAC controller and most of the time on to memory using Direct Memory Access (DMA). That is, the host writes packets to a specific memory wherever the controller, using a specific scheduling algorithm, reads them and sends them. QoS within the MAC-based bandwidth reservation scheme or Scheduler of IEEE 802.16, cannot be decoupled from the QoS routing protocols, and plays a major role in the deciding routing performance. With the Scheduler we perceive not solely the scheduling algorithm however conjointly the buffer management needed to confirm ensures the QoS related to a particular Traffic Class (TC).

Overview of the IEEE 802.16 Standard

This standard is designed for point-to-point (PTP) and point-to-multipoint (PTM) topologies however principally deployed for point to multipoint topologies. It also support mesh topologies. In PTM a base station (BS) services several subscriber stations (SS) that are mounted outdoors. IEEE 802.16 has three major versions; 802.16-2001, 802.16-2004 and IEEE 802.16-2005 as follows.

IEEE 802.16-2001:

IEEE 802.16-2001 addresses fixed line of sight connections and operate within the accredited frequency varies between 10 GHz and 66 GHz. At this high frequency range there are more available bandwidth and reduced risk of interference and contains a most coverage of 5km.

IEEE 802.16-2004 (802.16d):

Designed to control in lower frequency range; 2-11 GHz that Support Non-line of sight (NLOS) operation. This standard operates in each licensed

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frequency range (3.5 GHz) and unlicensed (5.8 GHz). It ranges of up to 50km and data rates of up to 75Mbps. So it is the foremost supported version of the quality by vendors.

IEEE 802.16-2005(802.16e):

This standard support mobility and can standardize networking between fastened base stations and mobile devices and would change high-speed signal handoffs necessary for communications with users moving at transport speeds that are below 100km/h and operates within the frequency range between 2-6 GHz. It will give a symmetric (up and down) bit rates of 70Mbps.

WIMAX versus Wi-Fi (IEEE 802.16 versus 802.11)

1. WiMAX was designed to exchange the last-mile wired-broadband access networks.

2. At the Physical layer, WiMAX channel sizes ranges from 1.75 MHz to 20 MHz

3. The MAC layer in WiMAX has been designed to scale from one to up 100s users at intervals one RF channel.
4. In WiMAX, the base station assigns a QoS class to every connection.
5. WiMAX supports many transport technologies, such as ATM, IPv4, and IPv6 which are not supported by Wi-Fi.
6. WiMAX has the flexibility to support longer range transmission from 2 to 40 kilometers.

Wi-Fi:

1. Wi-Fi was created for providing services into LAN networks.
2. Wi-Fi based products require at least 20 MHz for each channel.
3. Wi-Fi uses the CSMA/CA (Carrier Sense Multiple Access with Collision Avoidance) which is not an efficient protocol.
4. QoS was not considered early stage of its implementation.
5. It had been designed for low power consumption that limits the coverage to many meters.

Basic Functionality of MAC Layer in WiMAX

The Worldwide Interoperability for Microwave Access (WiMAX), based on IEEE 802.16 standard is meant to facilitate services with high transmission rates for data and multimedia system applications in metropolitan areas. The physical (PHY) and medium access control (MAC) layers of WiMAX are laid out in the IEEE 802.16 standard. Several advanced communication technologies like Orthogonal Frequency-Division Multiple Access (OFDMA) and multiple-input and multiple-output (MIMO) are embraced in the standards. Supported by these modern technologies, WiMAX is in a position to produce giant service coverage, high data rates and QoS secured services.

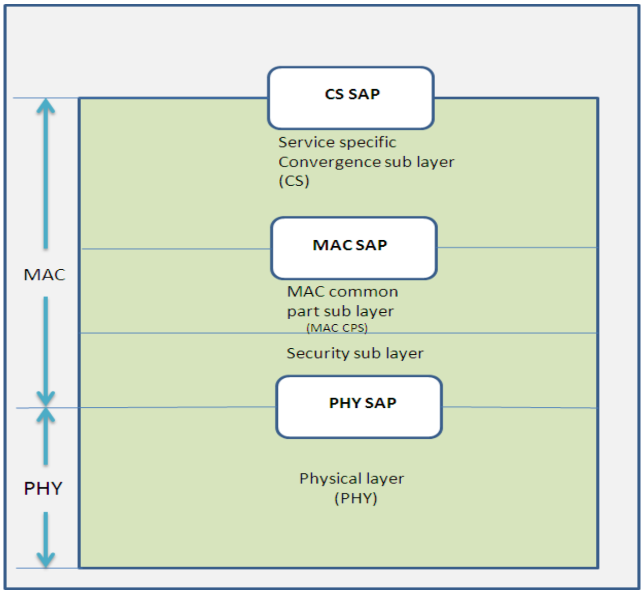

Figure1. IEEE 802.16 reference model

In the above Figure1 presents the reference model in IEEE 802.16. The MAC layer consists of three sub layers as follows:

(i) Service-specific convergence sub layer (CS): The main aim of CS is to transform or map external information from the higher layers into acceptable MAC service data units (SDUs) for the MAC CPS. This includes classification of external data with the proper MAC service flow identifier (SFID) and connection identifier (CID). An SDU is that the basic information unit exchanged between two adjacent protocol layers.

(ii) MAC common part sub layer (MAC CPS): The MAC CPS provides the core practically for system access, allocation of bandwidth, and connection establishment and maintenance. This sub layer conjointly handles the QoS aspect of data transmission.

(iii) Security sub layer: This layer provides like authentication, secure key exchange, and encryption. For the PHY layer, the quality supports multiple PHY specifications, every handling a particular frequency vary. IEEE 802.16d MAC provides two modes of operation: point-to-multipoint (PMP) and multipoint-to-multipoint (mesh).

POINT-TO-MULTIPOINT

The PMP operational mode fits a typical fixed access situation, wherever multiple service subscribers are served by a centralized service provider. In PMP mode uplink transmissions from a subscriber station (SS) to a base station (BS) occur in separate timeframes. In the downlink sub frame, the BS can transmit a burst of MAC protocol data units (PDUs). Downlink and uplink sub frames are duplexed either using frequency-division duplex (FDD) or time-division duplex (TDD).

MULTIPOINT-TO-MULTIPOINT

In mesh mode nodes are organized in an ad hoc fashion. In contrast to PMP mode, there are not any expressly separate downlink and uplink sub frames in mesh mode. Every station is in a position to establish direct communication to a variety of other stations in the system. Mesh mode has coordinated and uncoordinated distributed scheduling. Both have adopted a three-way handshake mechanism. MSH_DSCH is the scheduling message in IEEE 802.16 standards, specifically: An availabilities request is formed at the side of MSH_DSCH that indicates potential slots for replies and therefore the actual schedule. So major difference between coordinated and uncoordinated distributed scheduling are that in coordinated scheduling, the MSH-DSCH message are scheduled within the control sub frame in a collision- free manner, whereas in the uncoordinated case MSH-DSCH messages could collide.

Quality of Service

QoS provisioning is one in every of the essential options in IEEE 802.16. However, there are differences in the standard specifications, specifically, in IEEE 802.16-2004 and IEEE 802.16e. There are two QoS problems together with *service flow and bandwidth grant services*. First, a service flow is outlined as a unidirectional flow of MAC SDUs on a connection associated with specific QoS parameters like latency, jitter, and throughput. These QoS parameters are used for transmission and scheduling. Service flows are generally known by SSs and BSs supported their SFID. There are three basic types of service flows:

(i) **Provisioned service flows:** A provisioned service flow is outlines within the system with an SFID; however it did not have any traffic presence. It should be waiting to be activated for usage.

(ii) **Admitted service flows:** An admitted service flow undergoes the method of activation. In response to an external request for a selected service flow, the BS/SS can check for on the market resources supported the QoS parameters to see if it will support the request. If there are sufficient resources, the service flow is going to be deemed admitted. The resources assigned to present service flow should be used by alternative services.

(iii) **Active service flows:** Service flows are going to be active once all checks are completed and therefore the resources are allocated. Packets can flow through the connection allocated to the service flow. The use of service flows is that the main mechanism used in QoS provisioning. Packets traversing the MAC sub layer are related to service flows as identified by the CID when QoS is required. Second, Bandwidth grant services define bandwidth allocation based on the QoS parameters related to a connection. In downlink transmissions a BS has decent information to perform scheduling, however in uplink transmissions a BS performs the scheduling of various service transmissions based on information gathered from SSs. For proper allocation of bandwidth, four services are defined to support different types of data flows:

• Unsolicited grant service (UGS)
• Real-time polling service (rtPS)
• Non-real-time polling service (nrtPS)
• Best effort (BE)

Applications of IEEE 802.16

1. It provides a wireless alternative to cable, DSL and T1/E1 for last mile access especially in areas where wire broadband access are absent and provides residential 'wireless DSL' for broadband Internet at home.
2. Serves as E1/T1 replacements for little and medium size businesses.
3. It is used as wireless backhaul for Wi-Fi hotspot and cellular companies.
4. Operators/carriers will use it as a backup backbone.
5. It is utilized in disaster recovery scenes wherever the wired networks have broken down.

Literature Survey

Xiaofeng Bai et al. [1] proposed a new distributed QoS control scheme that guarantees specific service parameter settings for both uplink and downlink connections. By specifying a selected set of service parameters, the media access control (MAC) mechanisms defined within the standard are capable of giving service guarantees on the connection basis. This scheme specifies detailed operations performed at the base station and each subscriber station. IEEE 802.16 Wireless MAN system contains one central Base Station (BS) and one or more Subscriber Stations (SSs) in one architectural cell. The BS is responsible for communicating with each SS and regulating its behavior. Two operation modes are defined in the standard, i.e.,

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point-to-multipoint (PMP) and mesh modes, along with different physical layer specifications. The physical layer operation is frame primarily based and supports each Time Division Duplex (TDD) and Frequency Division Duplex (FDD) configurations. A transmission frame is outlined as a fixed time during which each the downlink and uplink transmission complete one round. A frame consists of two sub frames, i.e., downlink and uplink, designated for BS-to-SS and SS-to-BS transmissions, respectively. The downlink sub frame begins with information for synchronization and a frame control section that defines the transmission burst profile, together with modulation and coding schemes also as relevant timing information, for each SS. Following the frame control section is that the downlink information destined to individual SSs. The downlink data is grouped into several transmission bursts using TDM technique. These transmission bursts are differentiated by their applied Downlink Interval Usage Code (DIUC) that represents a particular set of modulation and coding scheme for transmission. The uplink sub frame follows downlink sub frame. Uplink data transmission is organized in TDMA fashion where the uplink bursts are differentiated by the sending SSs. Every scheduled SS transmits into the uplink during its granted window using burst profile related to the Uplink Interval Usage Code (UIUC) that was informed in the frame control section. During this methodology As Sing-Carrier Scheduling Algorithm SCSA scheme guarantees service parameters for each uplink and downlink connection and minimizes signaling overhead within the data control plane.

Kamal Gakhar et al. [2] discusses a mechanism for dynamic resource management and its relevance for traffic in IEEE 802.16 broadband wireless network that minimizes the number of bandwidth being actually provisioned for committed bandwidth traffic while keeping the cost of MAC signaling to a minimum. In general, this technique changes the amount of reserved resources between a small numbers of values depending on the actual number of active connections while limiting the number of transitions by imposing hysteresis behavior. In this method two policies for resource reservation are identified there are as follows: First, represents the mechanisms wherever resources are reserved in an exceedingly semi-permanent or permanent manner referred as permanent virtual circuit (PVC). Second, family comprises of the procedures in which resources are reserved on demand also known as switched virtual circuit (SVC). Specifically, it’s not necessary to update the resource reservation whenever a traffic flow is activated or terminated. A Markov Chain model yields two performance parameters: the reserved bandwidth and the transition rate. A new parameter, noted θ, has been introduced in addition to the performance parameters mentioned to minimize the global cost of the system.

Min Cao et al. [3] developed a stochastic model for the distributed scheduler of the mesh mode. Wherever all nodes are organized in an ad hoc fashion and use a pseudo-random function to calculate their transmission time based on the scheduling information of the two-hop neighbors. In this mode, the nodes are organized in an ad-hoc fashion. All stations are peers and every node will act as routers to relay packets for its neighbors. In typical installations, there still be certain nodes that provide the BS function of connecting the mesh network to backhaul links. However, there is no need to have direct link from SS to the BS of the mesh network. A node will opt for the links with the most effective quality to transmit data; and with an intelligent routing protocol, the traffic can be routed to avoid the congested area. This methodology has two mechanisms to schedule the data transmission in mesh mode

(i) Centralized Scheduling: In centralized scheduling, the BS works like a cluster head and determines how the SS’s should share the channel in different time slots. Because all the control and data packets need to go through the BS, the scheduling procedure is simple; but the connection setup delay is long. Thus the centralized scheduling is not appropriate for occasional traffic needs.

(ii) Distributed scheduling: Here each node competes for channel access employing a pseudo-random election algorithm based on the scheduling information of the two-hop neighbors. Data sub frames are allocated based on request-grant-confirm three-way handshaking among the nodes. Thus the distributed scheduling is more flexible and efficient on connection setup and data transmission.

Miguel Elias M et al. [4] described the state of the art in WMN metrics, taxonomy for WMN routing protocols and therefore the evolution of quality-aware metrics comes at the side of an n incremental complexity in metric computation. During this methodology routing protocols are classified in four categories: ad-hoc-based, traffic-aware, controlled-flooding, and opportunistic. All protocols aim at higher utilizing wireless medium resources however using different approaches, like mixing reactive and proactive strategies, considering tree-based approximations of the network topology, reducing control overhead or increasing medium access reliability all of those control dissemination techniques is combined with the proposed quality-aware link metrics. The first metric proposed to WMNs is that the Expected Transmission Count (ETX). ETX is the expected number of transmissions a node needs to successfully transmit a packet to a neighbor. One critical problem of wireless networks is that the quick link-quality variation. Metrics supported average values computed on a time-window interval, like ETX, may not follow the link-quality variations or could turn out preventive management overhead.

Yaling yang et al. [5] proposed distinctive characteristics of mesh networks, like static nodes and therefore the shared nature of the wireless medium, invalidate existing solutions from each wired and wireless networks and impose unique necessities on designing routing metrics for mesh networks. In an endeavor to grasp how these challenges impact routing metric design in mesh networks. First, analyze the performance of various types of routing protocols in mesh networks and performed that proactive hop-by-hop routing is that the most suitable form of routing protocol. Second, with a focus on proactive hop-by-hop routing protocols establish four fundamental requirements for designing routing metrics for mesh networks. These four requirements are: ensuring route stability, sensible performance for minimum weight paths, existing efficient algorithms to calculate minimum weight ways and ensuring loop-free routing.

Giuseppe Iazeolla et al. [6] consider an analytical framework which takes into consideration the close relationship between the CAC algorithms and the Scheduler algorithms and is applicable to every mode of operation and admission control paradigm such that by the quality. The process begins with the host interface that communicates with the MAC controller and most of the time directly to memory using Direct Memory Access (DMA). That is, the host writes packets to a specific memory wherever the controller, employing a specific scheduling algorithm, reads them and sends them. QoS in the MAC-based bandwidth reservation scheme or Scheduler of IEEE 802.16, cannot be decoupled from the QoS routing protocols, and play a significant role in the determining routing performance. During this technique it lies on the dependencies across layers and therefore the relationships between the Scheduler and CAC in 802.16 networks, and their impact on network productivity in terms of frame throughput, provider return throughput, bandwidth use and alternatively performance indices.

Conclusion

This paper presents an overview of the IEEE 802.16 MAC protocol, specifically issues associated with scheduling and QoS provisioning. It also discusses the main features of the newly standardized WiMAX, IEEE 802.16e; IEEE 802.16d has a literature survey.

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