USING THE CONCEPT OF A MAC SCHEDULING ALGORITHM FOR WIMAX NETWORKING ARCHITECTURE

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ABSTRACT
Wimax is wireless digital communication system which is intended for wireless Metropolitan area networks. Wimax stands for worldwide interoperability for microwave access. Wimax Technology enables ubiquitous delivery of wireless broadband service for fixed and or mobile users. An IEEE 802.16 wireless system can provide broadband wireless access to subscriber stations and operate in mesh mode. The communication between a subscriber station and a base station can pass through one or more intermediate subscriber stations. The IEEE 802.16 standard provides a centralized scheduling mechanism that supports contention-free and resource-guarantee transmission services in mesh mode. This paper show how MAC scheduling architecture is emphasized for IEEE 802.16 standards.

Keywords: MAC, QoS class scheduling, IEEE 802.16, WiMax, Networks

1. INTRODUCTION

WiMAX stands for Worldwide Inter operability for Microwave Access. WiMAX is known as IEEE 802.16 wireless man standard. The IEEE 802.16 Working Group and was designed to support the bandwidth demanding applications with quality of service (QoS). Bandwidth is reserved for each application to ensure the QoS. For variable bit rate (VBR) applications, however, it is difficult for the subscriber station (SS) to predict the amount of incoming data. It is developing a standard for broadband wireless access in Metropolitan Area Networks (MAN) known as WiMAX. One of the features of the MAC layer, in this standard, is that it is designed to provide differentiated servicing for traffic with multimedia requirements. To ensure the QoS guaranteed services, the SS may reserve more bandwidth than its demand. As a result, the reserved bandwidth may not be fully utilized all the time.

Mainly IEEE 802.16 standard can be thought as of two types IEEE 802.16d which is for fixed subscriber stations and IEEE 802.16e which supports mobility. Wimax devices are created to operate the three different bands 2.5, 3.5 and 5.7 GHz. THE physical layer In WiMAX uses OFDM technology and the maximum data rate in WiMAX is 70 Mbps. Wimax is intended to give a higher coverage area of 20 miles. Wimax standard eliminate the problem of last mile problem and act as an alternative to cable and DSL technologies [13].

The IEEE WiMAX group was started in 1998 to build an air-interface standard for wireless. The first standard 802.16 was released in December 2001 and it is designed as to use the single carrier physical layer with time division multiplexing. The MAC layer in WiMAX is same as the MAC layer for wireless from the cable modem DOCSIS. WiMAX use orthogonal frequency division multiplexing (OFDM) based physical layer.

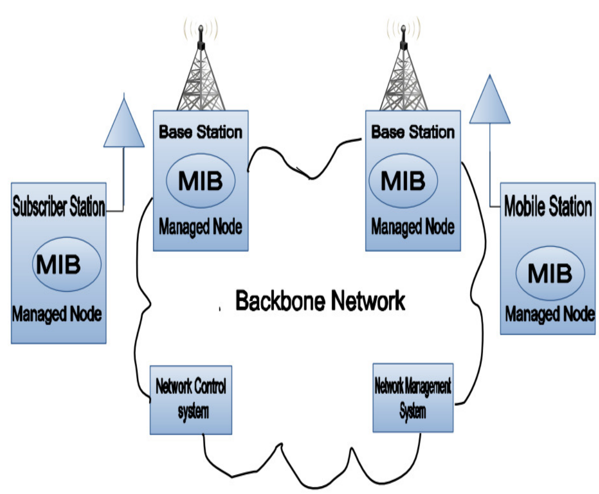

Figure 1: WiMAX Management Reference Model

2. RELATED WORKS

Despite many advantageous features of mesh configuration, when it is applied to wireless network the bandwidth is limited due to its low capacity. The wireless link quality is time and space varying, depending on the environment and interference. The existing approaches for link assessment consume substantial amount of time and thus introduce significant delay and overhead. Having a fast link assessment in WMNs is important so as to transmit a packet e□ectively. One of the traditional approaches for link assessment is to sequentially assess each link by having all nodes in the network transmit in a specific order [9] [11]. The major drawback of this approach is excessive time consumption that is proportional to the number of nodes in the network.

Another solution has been proposed in [5], where resources are scheduled in two parts: first the demands of the nodes are collected by the BS and flooded throughout the WMN. In the second part individual wireless nodes execute a collision-free schedule based on the states of their neighbours and extended neighbours. However this introduces extra tra□c in the network, thereby causing a decrease in the wireless bandwidth. The authors of [7] proposed a fair end-to-end bandwidth allocation (FEBA) algorithm to address the end to end throughput over multi-hops. The FEBA was implemented at the MAC layer of single-radio and multi-channels on WiMAX mesh nodes, which are operated in a distributed coordinated scheduling mode. FEBA negotiates bandwidth among neighbours to assign a fair share proportionally to a specified weight to each end-to-end tra□c flow. This was done by use of the fairness index. The bandwidth requesting and granting is carried out in a round-robin fashion, where the amount of service at each round is proportional to the number of incoming or outgoing flows. However, FEBA [7] does not consider multimedia tra□c, which is a prerequisite for providing quality of service.

3. NETWORK ARCHETECTURE

Since the standard only provides signaling mechanisms and no specific scheduling and admission control algorithms, some scheduling algorithms have been proposed to provide QoS (Quality of Service) for WiMAX. However, many of these solutions only address the implementation or addition of a new QoS architecture to the IEEE 802.16 standard. A scheduling algorithm decides the next packet to be served on the waiting list and is one of the mechanisms responsible for distributing bandwidth among several streams.

Regarding data traffic, it was observed that the overhead due to the physical transmission of preambles increases with the number of stations [8]. A polling-based MAC protocol is presented along with an analytical model to evaluate its performance. Due to development of closed-form analytical expressions for cases in which stations are polled at the beginning or at the end of uplink sub frames. It is not possible to know how the model may be developed for delay guarantees.

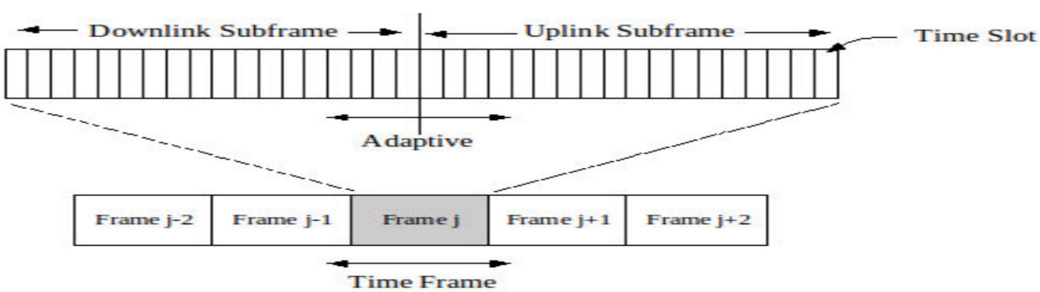

Fig. 2: IEEE 802.16 Frame Structure

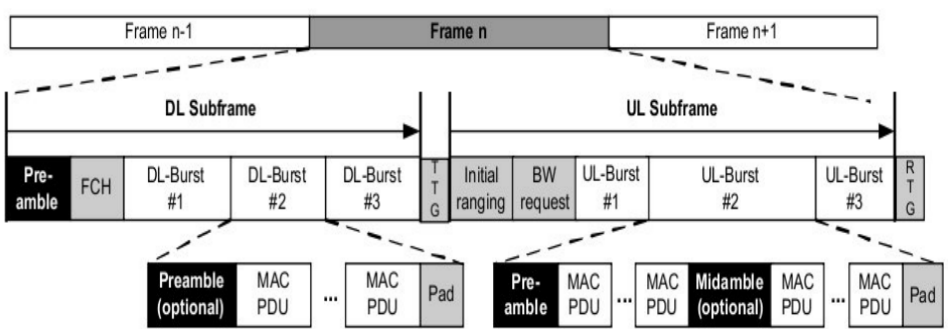

Fig. 3: OFDM Frame Structure With TDD

The Figure shows a well-established architecture for QoS in the IEEE 802.16 MAC layer. The bandwidth required by each SS for uplink data transmission, periodic bandwidth needs for UGS flows in SSs and bandwidth required for making requests for additional bandwidth. Considering the limitations exposed above, these works form the basis of a generic architecture, which can be extended and specialized. However, in these studies, the focus is in achieving QoS guarantees, with no concerns for maximizing the number of allocated users in the network.

3.1 IEEE 802.16J: An Overview

An IEEE 802.16j network consists of a Base Station (MR-BS), multiple Relay Stations (RSs) and Mobile Stations (MSs)([14]). Relay Stations can be of two types. Transparent relays serve MSs that are in range of the MR-BS and that receives control information from the MR-BS. The MS can receive signals from both the MR-BS and the relay and hence can achieve higher throughput. Non-transparent relays increase coverage area by serving MSs that cannot decode control information from the MR-BS. These relays must transmit control information at the beginning of the frame and act as the base station for the MS. IEEE 802.16j focuses on the OFDMA PHY mode of IEEE 802.16e-2005. There are five different service classes of traffic defined in the standard as shown in Table I.

TABLE I
SERVICE CLASSES IN WIMAX

Class	Application	QoS parameters
Unsolicited Grant Service (UGS)	VoIP,E1; fixed-size packets on periodic basis	max rate, latency and jitter
Real-Time Polling Service (rtPS)	Streaming audio/video	minrate, maxrate and latency
Enhanced Real-Time Polling Service (ertPS)	VoIP with activity detection	minrate,maxrate, latency and jitter
Non Real-Time Polling Service (nrtPS)	FTP	minrate and maxrate
Best Effort (BE)	Data transfer, Web	maxrate

A WiMAX network can have different modulation and code rates depending on Carrier to Interference-plus-Noise Ratio and Received Signal Strength Indication (RSSI) values at various links. Each modulation and code rate supports a different data rate. An IEEE 802.16j frame consists of a downlink sub frame followed by an uplink sub frame. We consider only uplink traffic in this article and hence discuss only the uplink sub frame. In [8], the authors mention that the IEEE 802.16j working committee has proposed a scheduling framework in the IEEE 802.16j draft in which only one node is allowed to transmit at any given time instant during the downlink sub frame. This would be a significantly simpler problem and we could easily limit the described uplink model to accommodate it.

1) Transparent relays :The uplink sub frame is divided into access zone and relay zone. Access zone is used by MSs to transmit on access links to the MR-BS and RSs. The relay zone is used by relay stations to transmit to their super ordinate RSs or MR-BS. All transparent relays must operate in centralized scheduling mode, relying on the MR-BS to allocate its resources.

2) Nontransparent relays: The uplink sub frame is divided into access zone and relay zone. This presents some challenges in a multihop scenario. For example, in Figure 4 when there are two relays (NT-RS1 and NT-RS2) between MR-BS and MS2. In this case, in the relay zone NT-RS2 transmits to NT-RS1 and NT-RS1 transmits to MR-BS. Thus NT-RS1 has to transmit and receive at the same time. There are two ways of solving this problem. One is to include multiple relay zones in a frame and relays can alternately transmit and receive in the different zones. The other approach is to group frames together into a multi-frame and coordinates a repeating pattern in which relays are receiving or transmitting in each relay zone.

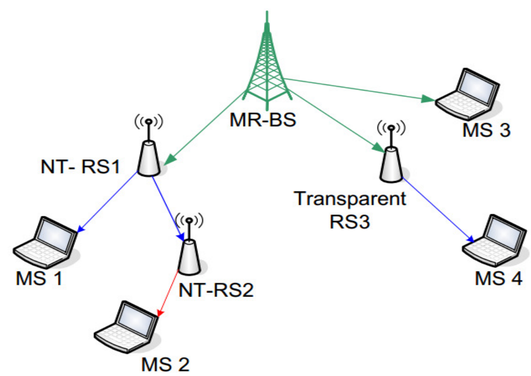

Figure 4. IEEE 802.16j Network

4. PROPOSED SCHEDULING ALGORITHM

A single hop (node) Wi-MAX provides high flexibility to attain quality of service in terms of data throughput, achieving the same in multi hop Wi-MAX is challenging. One of the major problem is dealing with the ability of IEEE 802.16 MAC to manage traffic generated (scheduling) by multimedia application or multimedia streaming from transmission of the neighboring Wi-MAX node.(i.e. rural environments).

4.1 Proposed MAC Scheduling Architecture

The IEEE 802.16 standard categorizes the uplink sub-frame into three parts namely coverage ranging period, bandwidth contention period and data uplink. We can say that Bandwidth Contention (BWC) mode [1][2]. We can also say that there are two situations:

1. BWC (Bandwidth Contention): Bandwidth contention is available. 2. NBWC (No Bandwidth Contention): In this mode no bandwidth contention is available & the uplink sub frame is divided in to two parts coverage ranging period & data uplink period. As mentioned in [3] that flow isolation is also necessary at the router (BS is a router also) in the case of unresponsive flows. Our proposed scheduling architecture broadly contains five parts– WFQ unit, BS allocation unit, SS uplink unit, BS downlink unit, and Classifier unit. WFQ unit has been used two times in our architecture. One copy of WFQ unit is insides the BS

allocation unit and the other outside copy used for downlink scheduling.

4.1.1 WFQ unit

This unit is solely responsible for allocating the available bandwidth to different flows in ratio of their assigned weights. In the WFQ scheduling algorithm [12] is an approximation of Generalized Processor Scheduling and requires.

Weights assigned to each flow and queue length for each flow. WFQ algorithm calculates the stop time of every arriving packet and adds this packet in Generalized Processor Sharing (GPS) queue. The stop time of every packet is function of its size, weight assigned to its flow.

The stop time of the last packet in its queue Packets are de-queue from GPS queue in stop time order.
For WFQ scheduling procedure using the uplink direction, each SS has to communicate two effects

The number of packets waiting on its number of connection(s) and the sizes of the waiting packets. For UGS, nrtPS and BE flows, the SS has to send the total number of waiting packets

For rtPS flows SS has to add sizes of different packets. We can say that complete information as queue information which has to be sent to BS. WFQ scheduling algorithm in downlink direction is directly forward as the BS has all queues information and assigned weights to respective application [10].

4.1.2 SS Uplink Unit

This unit is responsible for allocating data uplink slots for connections. These slots are used by an SS to send data in the uplink direction. BS wants to know the queue information (number of coming up packets and size of each packet) of connections at each SS for WFQ scheduling. This WFQ for uplink direction is completed virtually at the BS, in fact the BS knows queue information of connections from previous frame status and it can almost simulate GPS listing and enlisting purpose. For each enlisting call, BS allocate slots to the corresponding CID (CID with which this packet is connected by Classifier module) and it is related to the enough number of slots left in uplink sub-frame [3].

In ranging process, each SS chooses its connection window, waits for that many slots then sends Ranging Request (RANG-REQ) packets to BS. Any SS will keep doing the same in each frame till it gets Ranging Response (RANG-RSP) from BS. Once any SS got RANG-RSP from BS, it sends Registration Request (REG-REQ) to BS and waits for the Registration Response (REG-RSP). Once any SS gets REG-RSP from BS, it is now ready to send connection request with specified flow type to BS [4].

In NBWC mode, these architecture does not have any bandwidth contention period, so any SS sends the request packets (ranging, registration and connection) in ranging period only, while in BWC mode the request packets (registration and connection) are sent in bandwidth contention period[6].

4.1.3 BS downlink Unit

This unit is accountable for whole downlink scheduling of packets from BS to SSs. BS uses WFQ unit for downlink scheduling of packets. When the uplink sub-frame packets ends, BS first broadcast DL-MAP and UL-MAP, then RANG-RSP packets, then REG-REP packets, then CONN-RSP packets then starts sending downlink data packets to SSs. The downlink channel is always broadcast channel. The weights for different flows in downlink direction are same as in uplink direction. The WFQ scheduling is not virtual here (as in the case of BS allocation module) because BS already has the entire waiting lengths and size of each downlink packet.

4.1.4 Classifier Unit

This unit is responsible for the association of incoming IP packets with connections. We are doing this association based on the flow-id of incoming IP address packets. Therefore each SS maintains many MAC level FIFO queues. The number of MAC level queue is same as the connections formed between this SS and BS. Equivalently each connection has its own MAC level queue maintained at SS side. Incoming packets are queued in respective MAC level queue after classification.

4.2 Working of Scheduling Algorithm

The operational scheduling algorithm is to provide rtPS service flow packets with more chance to meet their bandwidth as per requirement and decrease the delay. In fig.4.2 shows Apart from checking if the allocated bandwidth is enough for granting a request, the system has to check the QoS polling services, nominal polling jitter and reference time (the time used as a reference to calculate both the generation time and the target of the rtPS data grants) related to the rtPS service flows that are applied.

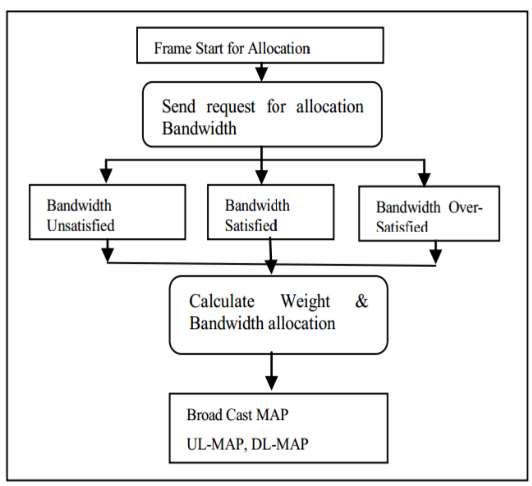

Figure 4.2 Operational Flowchart of Scheduling Algorithm

The information gathered from this monitoring is used to approximate the expected delay of each rtPS connection and the proposed scheduling algorithm, is used to calculate the target throughput & delay.

5. CONCLUSION

Quality of Service (QoS) is very important for WiMAX networks. Providing QoS in multi-hop WiMAX networks such as WiMAX mesh networks is challenging since the WiMAX mesh networks MAC is connectionless based and does not have proper support guarantees for QoS over multiple hops. As a result, multiple links can interfere with each other when they are scheduled at the same time. The scheduling function plays a crucial role in QoS support, and various algorithms have been proposed and analyzed. Thus it can be seen that downlink scheduling is easy because only involved entity is BS and it has all the required information for the same. For uplink scheduling, each SS has to send its queue information to BS. As clear in the standard, SSs can send their bandwidth request to BS either in bandwidth argument period or in a slot which is allocated to SSs in each frame or through return the connections demands with data packets. In the operational scheduling algorithm, we have broadcast MAP according to the bandwidth allocation request.

REFERENCE

[1] Claudio Cicconetti, Alessandro Erta, Luciano Lenzini, and Enzo Mingozzi, „Performance Evaluation of the IEEE 802.16 MAC for QoS Support‟, IEEE Transactions on Mobile Computing, VOL. 6, No. 1, January 2007

[2] WiMAX Forum, www.wimaxforum.org/home, news, events, white papers, links, from the group trying to make WiMAX interoperable (The download page is located at www.wimaxforum.org/news/downloads/).

[3] IEEE 802.16, IEEE Standard for Local and Metropolitan Area Networks Part 16: Air Interface for Fixed Broadband Wireless Access Systems, IEEE Std. 802.16, Oct. 2004.

[4] IEEE 802.16 Working Group on Broadband Wireless Access. http://wirelessman.org

[5] Guosong Chu, Deng Wang, and Shunliang Mei. "A QoS architecture for the MAC Protocol of IEEE 802.16 BWA System." IEEE International Conference on Communications Circuits and System and West Sino Expositions, vol.1, pp.435–439, China, 2002.

[6] Cicconetti, C., Akyildiz, I.F. and Lenzini, L. (2007) 'Bandwidth Balancing in Multi-Channel IEEE 802.16 Wireless Mesh Networks', IEEE INFOCOM, pp.2108–2116.

[7] Cicconetti, C., Akyildiz, I.F. and Lenzini, L. (2009) 'FEBA: A Bandwidth Allocation Algorithm for Service Di�erentiation in IEEE 802.16 Mesh Networks',IEEE/ACM Transactions on Networking, Vol. 17, No. 3, pp.884–897.

[8] Ephremides, A. and Truong, T.V. (1990) 'Scheduling Broadcasts in Multi-hop Radio Networks', IEEE Transactions on Communication, Vol. 38, No. 4, pp.456–460.

[9] Kim, D. and Ganz, A. (2005) 'Fair and E�cient Multihop Scheduling Algorithm for IEEE 802.16 BWA Systems', IEEE BroadNets, Vol. 2, pp.833–839.

[10] Scott Fowler and Xingjun Zhang Linköping University Post Print (2012). Ubiquitous Fair Bandwidth Allocation for Multimedia Traffic on a WiMAX Mesh Network with Multi-channels.

[11] Debalina Ghosh, Ashima Gupta, Prasant Mohapatra (2007). Adaptive Scheduling of Prioritized Traffic in IEEE 802.16j Wireless Networks Department of Computer Science, University of California, Davis, CA 95616

[12] Sk.Jahangeer basha, Ch.Prakasa rao, Prakasam Engineering College, Kandukuru Prakasam Dist, Andhrapradesh (2007). Bandwidth Optimization, Recycling In IEEE 802.16 Networks by Using Call Admission Control & Scheduler.

[13] Mamta Chauhan1*, Rajneesh Choubey, Roopali Soni (2012). Detailed WiMax Network using the Concept Scheduling. International Journal of Computer Technology and Electronics Communication. Volume 1 Issue 1 2012 www.earthjournals.org 33. ISSN 2320 – 0081

[14] P.S.Revankar ,Avinash S Kapse , Dr. W. Z. Gandhare (2010). Overview of a MAC Scheduling Algorithm for IEEE 802.16 Wireless Networks. Int

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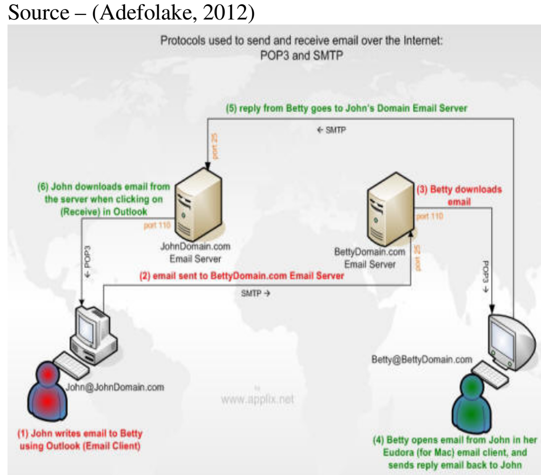

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[1] Eason, B. G. Noble, and Sneddon, K (2011) "On certain integrals of Lipschitz-Hankel type involving products of Bessel functions," Phil. Trans. Roy. Soc. London, vol. A247, pp. 529–551, April 1955. *(references)*

[2] Clerk , K and Maxwell, U (2010) A Treatise on Electricity and Magnetism, 3rd ed., vol. 2. Oxford: Clarendon, 1892, pp.68–73.

[3] Olumared, J., Kay, L., nd Bean, O. (2004) "Fine particles, thin films and exchange anisotropy," in Magnetism, vol. III, G. T. Rado and H. Suhl, Eds. New York: Academic, 1963, pp. 271–350.

[4] Jauna, E. (2003). "Title of paper if known," unpublished.

[5] Electronic Publication: Digital Object Identifiers (DOIs):
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