Challenges to WiMAX QoS Scheduling and its Mitigation Schemes – A Review

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***Abstract*—For realization of future high performance integrated networks, broadband distribution and access networks and to meet the increasing demand of multimedia services with a guaranteed quality of service, WiMAX becomes out as the most promising technology with flexibility and mobility of wireless networks. WiMAX has great impact in field of 4th generation networks with introduction of VoIP applications giving advantage to utilize existing infrastructure in the form of internet connection having several QoS scheduling algorithms such as UGS, Best Effort, rtPS, nrtPS and ertPS. In this paper, we review the different challenges that limit the QoS capabilities of VoIP-WiMAX communication networks and different mitigation techniques to combat with these challenges to realize high performance WiMAX using scheduling algorithms.**

Keywords: WiMAX, VoIP, QoS, QoS Scheduling, OFDM

I. INTRODUCTION

The increasing demand for larger capacity and higher transmission speeds to accommodate for data-intensive multimedia in conjunction with real-time applications, the wireless networks have experienced an explosive growth in last few years [1–2]. WiMAX stand for Worldwide Inter-portability for Microwave Access can be a communication technology for easily delivering high-speed data rates to large geographical areas using orthogonal frequency division multiplexing (OFDM) from Base Station (BS) to Subscriber Station (SS) which mitigates noise, multipath and interference effects, what exactly are primary challenges of wireless communication [3–4]. The WiMAX network is a combination of subscriber station (SS) and base station (BS). Here the packets are transferred from source node to destination node after following various scheduling, modulation technique and routing technique. In compliance with IEEE 802.16 the maximum range of WiMAX network is 50 km from the BS, where the responsibility of the base station for providing the air interface to the master station with supplementary functions that may be part of the BS are micro mobility management functions, radio resource management, handoff triggering, traffic classification, tunnel establishment, QoS policy enforcement, key management, DHCP proxy, multicast group management and session management. The receiver and antenna could be a small box or Personal Computer Memory Card International Association (PCMCIA) card or a laptop as shown in Fig. 1 [5–6].

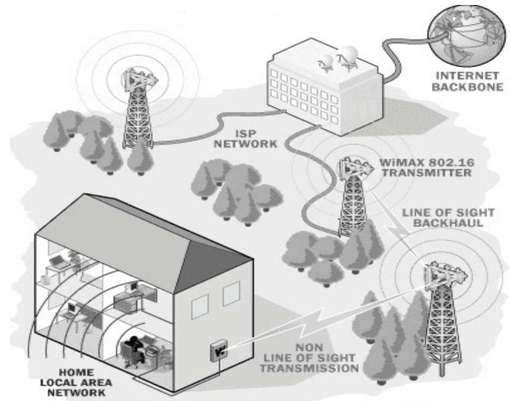

Fig. 1 WiMAX Network Architecture

With the introduction of 4G technology in WiMAX offering a metropolitan area network service that can use one or more base station and each base station provide the service to the users up to 50 km radius for spreading broadband wireless data over spacious geographic area. WiMAX offers high-speed, flexible, inexpensive and last mile services with performance similar to those of wire line infrastructures T1, DSL, cable modem based connections, optical fiber or copperware with a number of QoS needs. WiMAX provides wide area coverage and quality of service capabilities for applications ranging from real-time delay-sensitive Voice-over-Internet Protocol (VoIP) to real-time streaming video and non-real-time downloads, ensuring that subscribers obtain the performance they expect for all types of communications with a bandwidth support of upto 10 MHz [7–8]. Based on **IEEE 802.16 standard,** WiMAX provides upto 30 miles broadband access to mobile users having a telecommunication etiquette offering full access to mobile internet across cities and countries with a wide range of devices. WiMAX technology is offering very high speed **broadband access** to mobile internet. Generally 10MHz with the TDD scheme provides 3:1 up and down link ratio. The architecture of **WiMAX technology** based on **MAC layer** which is a connection oriented layer. Through MAC layer a use can perform a variety of functions such as various type of application including multimedia and voice can be used. It also supports best efforts for data traffic as bit, real time, traffic flaws etc. The aim to design WiMAX technology is to facilitate large number of user with a variety of connection per terminal [9–10].

This paper is divided into three sections. Some introductory application and characteristic areas of WiMAX technology are presented in Section 1followed by Section 2 that presents the previous research work on different QoS scheduling schemes of WiMAX technology, challenges and their mitigation schemes and finally, the conclusion is reported in Section 3.

II. Challenges and Mitigation Methods in WiMAX QoS Scheduling

With the rollout of the third generation cellular networks, the aim is already set towards the next generation. Future generation networks will be characterized by variable and high data rates, QoS services and seamless mobility both within a network and among different networks. The rapid growth of wireless communications is mainly attributed to their ease of installation in comparison to fixed networks [11–13]. QoS more barely refers to meeting certain necessity typically, packet delivery ratio, packet error rate, jitter, SNR (Upstream/Downstream) and delay associated with a given application and various demonstrations has been provided [14–16]. WiMAX networks must support a diversity of applications, such as video, voice, multimedia and data and each of these has different traffic patterns and QoS necessity and allows a better QoS handling [17]. QoS in WiMAX broadly divided in two parts, User-Centric in which the collective effect and services information performances work out how much user satisfaction is within the service and Network-Centric QoS and Network-Centric QoS comprises the systems that provide network managers and chance to manage this combination of bandwidth, delay, variances in delay (jitter) and packet reduction in the network to capable of deliver a network service [18]. In MANET, due to frequent variations in mobility of nodes in terms of speed, direction and rate, the structure of the network varies dynamically and unpredictably over time and causes route failures, which effects its QoS [19–20]. Whereas, in WiMAX the QoS is granted on the basis of type of application and service under consideration. For example, an user sending an email needs no real-time data stream like another user having a Voice over IP (VoIP) application. To provide the service parameters respectively, the traffic management is necessary. There are four main service classes named as UGS, rtPS, nrtPS, BE but there is a fifth type QoS service class which is added in 802.16e standard, named as extended real-time Polling Service (ertPS). Within all these scheduling resources are allocated to manage and satisfy the QoS of higher priority services [21–22]. Table 1 broadly classifies various service classes defined in WiMAX and its applications.

TABLE I QoS CLASSES IN WiMAX [14]

Service Classes	Description	Applications
Unsolicited Grant service (UGS)	For constant Bit rate and delay dependent applications	VoIP
Real Time Polling Service (rtPS)	For variable rate and delay dependent applications	Streaming audio, video
Extended Real time Service (ertPS)	For variable rate and delay dependent applications	VOIP and Silence Suppression
Non real time polling service (nrtPS)	Variable and non real time applications	FTP
Best Effort (BE)	Best effor	Email, Web Traffic

III. Impact of QoS Scheduling and its Mitigation

IEEE 802.16 has five QoS classes which Unsolicited Grant Service (UGS) is design to support real time service flow which generates the fixed size data packet periodically. In this algorithms BS assign fixed size grant to the subscriber station. The grants assign are basically of two type i.e. grant size and grant period. When voice session is initialized then these values are conciliated. These grants are sufficient for sending data packets. UGC service minimize the MAC overhead and uplink access delay which are caused when SS make request to the BS for bandwidth request to send the voice data packets, but UGS assign fixed size grant for sending voice data packets but voice user do not always have voice data packet to send because they have period of silence and it cause a waste of uplink resources. Real time polling service (rtPS) is designed to support real time services, which generally generates variable size data packets periodically. BS assign uplink resources to the SS when voice session is initialized then these values are conciliated. In this algorithm the SS request the BS for bandwidth of suitable size grant so that the rtPS can transport data more efficiently as compare to UGS algorithms. Because the SS always made a request for Bandwidth to the BS which in turn can cause more MAC overhead and uplink access delay as compare to UGS algorithms [23–24]. Extended Real Time Polling Services (ertPS) algorithm is proposed in order to remove the shortcomings of both UGS and rtPS algorithms. The UGS approach allows BS to assign fixed size grants to voice users which leads to wastage of uplink resources during the silent period when voice users do not have any data to send. Meanwhile rtPS although meant for variable size data packets consumes much of the time in polling process and also account for MAC overhead. So ertPS is designed for applications with variable size data packets because it does not have much MAC overhead and access delay. Thus the approach will be suitable for real-time applications like VOIP [25–26].

In ertPS algorithm whenever voice users have to increase their bandwidth users inform their BS by sending Bandwidth Request Header while setting BR (Bandwidth Request) bits to 1 in order to distinguish them from general BR bits. In this case, BS assigns uplink resources according to the requested size until user requests for another change in bandwidth. Whereas if users want to decrease the bandwidth users inform their BS by sending Grant Management sub-header while setting PBR (Piggyback Request) bits to 1 in order to distinguish them from general PBR bits. Again, BS assigns uplink resources according to the requested size until user requests for another change in bandwidth [27–28]. The ertPS only follows the request made by users periodically to assign the uplink resources, thus the rate drops to half the original rate and again it remains the same till voice user requested yet another decrement in the requested bandwidth and so on. Thus ertPS proves to be a better approach than UGS and RTPS for dealing with data transfer in real-time services more efficiently and it does not include any overheads also [29–30]. The non real time polling service (nrtPS) approach allows BS to assign variable size grants to the voice users on regular basis. This service basically supports those applications which require high throughput like FTP (File transfer Protocol) but can bear delay. In this algorithm the BS station assign uplink resources to the SS station same as rtPS algorithms but the resources are provided at the longer intervals. This will ensure that during the network congestions the SS station receives the request opportunities [31–34]. Best Effort (BE) service approach is used to support with the purpose of data stream where no minimum service level is required and it is provide efficient service to best effort traffic. These flows served by contention slots [35].

IV. CONCLUSION

A comprehensive review of research in the area of WiMAX QoS scheduling and challenges that exist within WiMAX performance and strategies to mitigate these various impairments to enhance the overall link performance is presented in this work. The main focus of this work is to put attention towards the realization of future high performance WiMAX networks, integrated with mobile broadband distribution and access networks by reviewing the past few year efforts in the area of impairments associated with WiMAX links and its mitigation techniques.

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