Improved QoS Support for WiMAX Networks: A Survey

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Abstract

Quality of Service (QoS) is considered as the backbone of any Broadband media access network of which WiMAX is not an exception. Immense work is being carried out in the academia in this area. The goal is to come up with improved QoS to support different traffics in WiMAX network. This work presents a survey of the various current states-of-the-art QoS schemes that could be utilised to realise a guaranteed QoS necessary for effective general high WiMAX access network performance. We concentrate on three approaches. The approaches include Hierarchical Scheduling Framework for QoS in WiMAX point-to-point Networks, this approach divides scheduling scheme into three different Tiers. Others are Cross-layer Optimization Framework and Resource Allocation for Improved QoS in WiMAX; and On-demand Bandwidth Allocation for WiMAX.

Keywords: WiMAX, QoS, Scheduling, Broadband, Bandwidth, Throughput.

1. Introduction

WiMAX network is a form of Broadband wireless access networks. It is becoming very popular in the world of communications and computer networks both in the industries and the academia. It has potential ability to provide Broadband wireless access and provide a better and cheaper solution for communication services when compared with the existing standards and technologies [1]. However, Quality of Service (QoS) remains one of the major factors that are hindering the design of WiMAX network to support different types of traffic [2]. We surveyed various works presented in this regard and come up with the top three approaches of improving the quality of service (QoS) to support different traffic in the WiMAX network with the best performances. These approaches are based on the IEEE 802.16 standards which defines the MAC (Media Access Control) layer of the WiMAX [1] network. Section II gives the overview of some related works that serve as the foundation technology to the approaches we surveyed. While sub-sections III, IV and V describe the state of the art approaches surveyed and presented in this work. The approaches are: Hierarchical Scheduling Framework for QoS Service in WiMAX point-to-point Networks; cross-layer optimization framework and resource allocation for improved QoS in WiMAX; and on demand bandwidth allocation for WiMAX. Lastly, Conclusions comes up in section VI.

2. Background Review

So many scheduling schemes and algorithm for fine tuning the QoS service for WiMAX network have been proposed and implemented in the past. A single layer approach was proposed in [3], while, [4] introduces hierarchical approach for QoS support in WiMAX networks. Token Bank Fair Queuing (TBFQ) was proposed by [5]. This makes use of the priority index and then tracks the normalised service that is received by the excess flows.

In a protocol UBAR (Uplink Bandwidth Allocation and Recovery), a proportional fair scheme is engaged to utilize the bandwidth efficiency [6]. Half-duplex allocation (HDA) a grant allocation algorithm, this algorithm proposed to certify a constant and feasible grant allocation while meeting up with the sufficient conditions [7]. Hence, you have on-board and adaptive bandwidth allocation scheme (ABAS) to adjust the bandwidth ratio according to the current traffic profile. In this scheme, the aggregate throughput is higher but it failed to reckon with the service flow priority and fairly. Certainly, the adoption of this scheme will trigger the starvation service flow [3]. However, the proposed pre-emptive deficit priority fair priority queue (PDFPQ) aimed to optimize the QoS requirement of real-time polling service (nrPS) flow category reduces the delay time and enhance the throughput at the same time. Then, the proposal of highest urgency first (HUF) algorithm emerged, a modulation aware, while meeting up with the latency, guarantees service differentiation and fairness. The three approaches (schemes) presented in this survey based on the IEEE 802.16 standards which defines the MAC layer of the WiMAX access network aimed at supporting different real-time traffic (audio/video) in the WiMAX network with the best performances are discussed in-depth in the following sub-sections.

3. Hierarchical Scheduling Framework for QOS Service in WiMAX Point-to-Point Networks

Scheduling algorithm is important in the provisioning of guaranteed quality of service parameters such as delay, packet loss rate and throughput. In this subsection, Hierarchical scheduling framework for improving the QoS (Quality of Service) in WiMAX point-to-point is x-rayed. In this approach, three-tier QoS service architecture and scheduling schemes are used to provide the needed support for the improvement of QoS supports in WiMAX networks with point-to-point topology [8]. The main techniques here is that, the QoS provisioning is dynamically distributed to three tiers and each of the tiers is independently implemented in a separate BS (Base Station) and SS (subscriber Station). It is expected of this approach to improve the performance of WiMAX point-to-point network in terms of QoS such as packet delay, packet loss rate and throughput [8]. This approach is deployed with real-time and non-real-time integration of traffic.

3.1 *The Structure of WiMAX PMP (Point-to-point) Network and workability.*

This approach provides an architecture which make up for the missing protocols in the QoS architecture specified in the IEEE 802.16d standard, thereby providing the required enhancement and improvement in the performance metrics such as delay, bandwidth, packet drop rate and throughput of the WiMAX access network.

4. Cross-Layer Optimization Framework and Resource Allocation for Improved QOS in WiMAX

The requirements of delivering end-to-end quality of service (QoS) in this new age of computing especially in wireless networking such as WiMAX (the first generation of 4G broadband access wireless technology with an enhanced in-built quality of service provision) considering the limited network resources available involve the use of spectrum more efficiently. To achieve the requirements of high spectral efficiency and QoS provision in mobile radio setting entails the compliance of several layers in the WiMAX network system which in turn calls for effective optimization scheme that is cross-layer adaptive [11]. According to [10], to attain the QoS requirement of service guarantee such as minimum data rate, reliability, jitter-controlled, low latency, and user fairness of next generation wireless network systems, proper and efficient designing of cross-layer optimised wireless network is a necessity. In this section, cross-layer framework for WiMAX networks is proposed to optimise the network performances along with sustaining the end-to-end QoS of individual users. Reference [10] maintained that cross-layer design approaches are very vital for efficiently making the most of the limited radio resources with QoS delivering in the 4G wireless network systems such as WiMAX. In other words, better system performance (QoS requirements) in terms of minimum data rate and low latency can be achieved through information exchanges across different protocol layers which the conventional layered architecture cannot provide.

Resource allocation and scheduling remain crucial concern since efficient use of the scarce network resources is highly needed to achieve the sole aim of high level of cross-layer optimisation for QoS in next generation wireless network. According to [12], resource allocation is associated with medium access control (MAC) and is a cross-layer design issue that is applied in MAC by means of information exchange with other layers. Proper and efficient cross-layer resource allocation remains a challenge that must be considered and addressed as the wireless channel conditions and user requirements of QoS may not be constant, hence the need for constant updating of network add-on parameters. Cross-layer design based on the order in which QoS optimisation is carried out can be classified in four (4) categories as discussed below:

- *Top-down technique* – in this approach, higher protocols improve their parameters together with the strategies in use at the immediately following lower layer. According to [10], most current systems has employed this cross-layer solution during which the MAC parameters and strategies are dictated by the application, while the MAC selects the most advantageous PHY layer modulation and coding scheme.
- *Bottom-up technique* – in bottom-up technique, lower-layer protocols attempt to shield the higher-layers from losses and bandwidth variations. This cross-layer solution is not the best when it comes to multimedia transmission owing to the unnecessary performance (throughput) reductions and delays experienced during the transmission.

- *MAC centric technique* – here, the application layer forwards its traffic details and requirements to the MAC which in turn comes to a decision as to which application layer packets should be transmitted and the particular QoS level the packets should be transmitted. The MAC as well chooses the PHY layer parameters and strategies [13] depending on the available channel information.
- *Integrated technique* – in integrated approach, all feasible strategies and their corresponding parameters are tried so as to choose the most appropriate composite strategy that will lead to the best quality or optimal performance (throughput). In order words, strategies are determined jointly; but this is rather difficult if not impractical as a result of the associated complexity involved. With reference to [10] and [13], this complex cross-layer optimisation problem could be resolved in an integrated manner through the application of learning and classification techniques, which yield the most optimum but complex design.

The MAC centric cross-layer optimisation which is comparatively easier as well as simple to implement, and presents the most suitable approach to solving our problem of using cross-layer framework for WiMAX networks for the system performance optimisation in addition to maintaining the end-to-end QoS of individual users. MAC centric cross-layer conceptual framework for resource allocation optimisation is as depicted in figure 1 below. It is made of source, wireless channel, Application Layer, MAC and PHY layers. Application layer accesses the source through the source characteristics Dynamics.

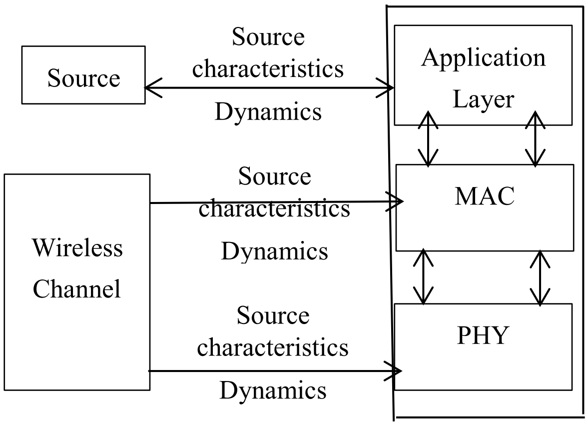

Figure 1: Dynamics of Cross-layer Design [10]

5. On-demand Bandwidth Allocation for WiMAX.

This technique is proposed to tackle the problem of bandwidth allocation in IEEE 802.16e-2005 standard based WiMAX accessed network, by using a mechanism which allocates the bandwidth on demand.

However, it is important to note that the IEEE 802.16e-2005 is an additional expansion of WiMAX standard. IEEE 802.16e-2004 and further expansion of WiMAX in the frequency range up to 6GHz with the goal of accommodating mobile application and roaming [14]. The size of carriers can vary over a wide range relative to the permutation zones and Fast Fourier Transform (FFT) base (128, 512, 1024, and 2048). The frame control header (FCH) content has been shortened and modified for Fast Fourier Transform (FFT) size 128. This adjustment introduces new feature and attribute to the standard necessary to support mobility.

WiMAX key technology can use both OFDMA and OFDM modulation scheme to sufficiently enable Multi-path access in non-line-of –sight situations (NLOS), it thus, selects appropriate bandwidth at 1.25—20Mhz based on the frequency resources and service flow demand [14]. WiMAX Physical layer Switch to TDD mode, to select proportion frame for uplink and down link direction, based on the service demand. In order to provide efficient channel access control mechanism, the MAC layer is defined by IEEE 802.16e-2005 protocol to control mechanism mainly includes service, access control past convergence ranging link scheduling and optional automatic retransmission mechanism. Brief description of the model design is presented under the following headings.

5.1 Bandwidth Allocation Requirement

- *Ranging*: WiMAX ranging process includes 4 types of ranging as shown in the table 1 below.

Code	Function
Initial ranging code	Establish connection between BS & CS
Period ranging code	BS and SS keep contact
HO ranging code	Establish connection between SS and new BS
BR ranging code	SS send to BS for bandwidth allocation

Table 1: WiMAX Ranging process

- *Service flow Management of WiMAX System*: IEEE 802.16e standard based WiMAX access network define five (5) types of service flow as following, Unsolicited Grant Service (UGS), Extended real time polling service (ertPS), Real time polling service (rtPS) non-real time polling service (nrtPS) and Best effort (BE) [14].
- *QoS parameters Class*: This is a parameter group which describe the service flow such as Maximum delay, tolerant jitter, and minimum reserved traffic rate etc. it has 3 levels of class, preparative QoS parameters Class, admitted QoS parameters Class and Activated QoS parameters class.

5.2 Brief Description of the Approach

Two new modules are introduced in SS. They are service flow Management (SFM) module and UL Bandwidth Management (ULBM) module respectively. The terminal is not responsible for sending the bandwidth request message based on every service flow connection, rather the UBLM will compute the total amount bandwidth of all of the service flow necessary and then forward the bandwidth request message to BS. After receiving the granted UL bandwidth by SS from BS, the SS will then distribute the UL bandwidth according to the different service flow QoS demand and requirement [15]. The SFM handles the dynamic service flow management. It sends DAS/DCS/DSD request message to ULBBM and the ULBM will feedback a response message to SFM according to the UL bandwidth size. Eventually, the UL scheduler will schedule the activated service flow, and the scheduler will adjust the AMC state dynamically according to the granted UL bandwidth size and HRGQ.

6. Conclusions

We have presented a survey of three improved approaches to QoS service for enhancing the performance of scheduling scheme in IEEE 802.16e-2005 standard based WiMAX accessed networks to support different traffics, both non-real-time and real-time applications. Each of these three approaches focuses on a major network add-on performance entities of QoS, (Delay, throughput and bandwidth utilization) for different applications. By way of careful investigation, the three approaches, it can be seen that each of them tremendously improve and enhance the performance and the QoS service support in WiMAX access networks. Hence, the application of these presented approaches will provide Performance add-on parameters that suggest optimum QoS namely throughput, packet delay variation, WiMAX network delay, packet end-to-end delay and jitter Although more work is needed to be done to fully harness and extract the potentials in WiMAX access networks for possible replacement to circuit-switched communication technology like Public Switched Telephone Networks (PSTN).

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