International Journal of Engineering and Technical Research (IJETR)
ISSN: 2321-0869 (O) 2454-4698 (P), Volume-4, Issue-3, March 2016

Quality of Service in Wimax

Keval Bhavsar, Harsh Dave, Vipul Jethva, Dhruv Mehta

Abstract— **A quality of service framework is a fundamental component of a 4G broadband wireless network for satisfactory service delivery of evolving Internet applications to end users, and managing the network resources. Today's popular mobile Internet applications, such as voice, gaming, streaming, and social networking services, have diverse traffic characteristics and, consequently, different QoS requirements. A rather flexible QoS framework is highly desirable to be future-proof to deliver the incumbent as well as emerging mobile Internet applications. This article highlights QoS frameworks and features of OFDMA-based 4G technologies — IEEE 802.16e, IEEE 802.16m — to support various applications' QoS requirements. A few advanced QoS features such as new scheduling service (i.e., aGP), quick access, delayed bandwidth request, and priority controlled access in IEEE 802.16m are explained in detail. A brief comparison of the QoS framework of the aforementioned technologies is also provide**

Index Terms— **4G, QoS, QoS frameworks, aGP**

I. INTRODUCTION

As the number of mobile broadband subscribers and the traffic volume per subscriber are rapidly increasing, quality of service (QoS) is becoming significant as operators move from single to multiservice offerings, and emerging rich devices capable of running multimedia and gaming applications. Fourth-generation (4G) broadband wireless technologies such as IEEE 802.16e, IEEE 802.16m, and Third Generation Partnership Project (3GPP) Long Term Evolution (LTE) have been designed with different QoS frameworks and means to enable delivery of the evolving Internet applications. As the Internet evolves, Internet applications and associated traffic patterns are also evolving over time. Web 2.0 supports rich media applications such as interactive voice and video services, web audio/video streaming services, and online gaming services, with smart optimization engines at both the client and server sides [1]. QoS specifically for evolving Internet applications is a fundamental requirement to provide satisfactory service delivery to end users and also to manage network resources. In other words, today's popular Internet applications, including real-time and non-real-time traffic such as multimedia services and online gaming, have very different traffic patterns and distinct QoS requirements. The traffic patterns of these emerging Internet applications show non-periodic variable-sized packet arrivals. The traditional QoS framework is no longer efficient and/or sufficient to support these new mobile Internet applications with good or required user experience. The organization of the article is as follows. The next section reviews the key elements of the QoS framework in IEEE 802.16e. We then highlight some advanced features in IEEE 802.16m to improve performance of a WiMAX network compared to a legacy network based on IEEE 802.16e. We then explain QoS framework of the LTE wireless technology. We then provide a high-level comparison between QoS frameworks of these three 4G wireless technologies focusing on the air interface.

II. QOS IN IEEE 802.16E

The QoS framework in IEEE 802.16e is based on service flows (SFs). An SF is a logical unidirectional flow of packets between the access service network gateway (ASN-GW) and a mobile station (MS) with a particular set of QoS attributes (e.g., packet latency/jitter and throughput) identified by a connection ID [2].Based on IEEE 802.16e, packets traversing the medium access control (MAC) interface are associated with SFs according to classifier rules. Figure 1 demonstrates SFs in IEEE 802.16e. Traffic mapping to appropriate SFs is done at the ASN-GW for downlink (DL) and at the MS for uplink (UL) directions, respectively. Between the ASN-GW and the base station (BS), the QoS of the SFs is supported by backhaul transport QoS. On the air interface, a BS scheduler provides QoS for DL, and cooperation between the BS and MS schedulers provides QoS for UL. This air interface scheduler at the MAC sublayer determines how radio resources are assigned among multiple SFs based on QoS attributes. Resources assigned to an MS enable it to receive traffic over DL and transmit data over UL. Details of air interface scheduler operation are not specified by the standard; therefore, it is vendor-specific. Traffic classification and mapping from application packets onto SFs in WiMAX is done at the convergence sublayer (CS), based on

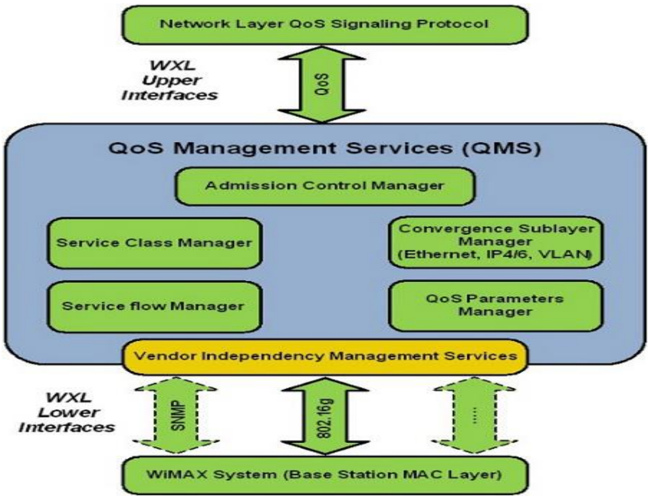


Figure 1. Service flows in the WiMAX QoS framework.

Keval Bhavsar, Electronic And Telecommuniation /Mumbai University/K J Somaiya Institute Of Engg And It.Mumbai,India,9594611923

Harsh Dave Electronic And Telecommuniation /Mumbai University/K J Somaiya Institute Of Engg And It. Mumbai,India,8451893521

Vipul Jethva Electronic And Telecommuniation /Mumbai University/K J Somaiya Institute Of Engg And It.Mumbai,India,8108919343

Dhruv Mehta Electronic And Telecommuniation /Mumbai University/K J Somaiya Institute Of Engg And It. Mumbai,India,7303604336

protocol-specific packet matching criteria like a combination of five-tuple, such as source and destination IP addresses, source and destination port address, protocol, and differentiated services codepoint (DSCP) [2]. IEEE 802.16e supports both QoS control paradigms: network-initiated, where SF creation is initiated by the BS, and terminal-initiated, where SF creation is initiated by the MS. With network-initiated, an application function (AF) inside the network can trigger messaging signals to set up SFs with appropriate QoS attributes; consequently, the client application can be left access-agnostic, and there is no need for accessspecific information in application layer signaling [2]. On the other hand, with terminal-initiated QoS control, the MS requests creation of SFs with appropriate QoS attributes; hence, the client application is aware of the specifications of the access QoS model [2]. Network-initiated SF creation is a mandatory, but terminal-initiated SF creation is an optional capability of IEEE 802.16e [2]. SFs may be created, changed, or deleted through a series of MAC management messages referred to as DSX (i.e., DSA, DSC, and DSD).

III. QOS ARCHITECTURE IN WIMAX NETWORKS

The WiMax Forum's Network Working Group [3], is responsible for developing the end-to-end network requirements, architecture, and protocols for WiMax, using IEEE 802.16e-2005 as the air interface. The network reference model envisions unified network architecture for supporting fixed, nomadic, and mobile deployments and is based on an IP service model. Figure 1.8 shows a simplified illustration of IP-based WiMax network architecture. [2] The overall network may be logically divided into three parts:

Mobile Station (MS): It is for the end user to access the mobile network. It is a portable station able to move to wide areas and perform data and voice communication. It has all the necessary user equipments such as an antenna, amplifier, transmitter, receiver and software needed to perform the wireless communication. GSM, FDMA, TDMA, CDMA and WCDMA devices etc are the examples of Mobile station. Mobile stations used by the end user to access the network

Access Service Network (ASN): It is owned by NAP, formed with one or several base stations and ASN gateways (ASNGW) which creates radio access network. It provides all the access services with full mobility and efficient scalability. Its ASN-GW controls the access in the network and coordinates between data and networking elements. ASN comprises one or more base stations and one or more ASN gateways that form the radio access network at the edge.

Connectivity Service Network (CSN): Provides IP connectivity to the Internet or other public or corporate networks. It also applies per user policy management, address management, location management between ASN, ensures QoS, roaming and security. CSN provides IP connectivity and all the IP core network functions. The architecture allows for three separate business entities: i.Network access provider (NAP), which owns and operates the ASN; ii.Network services provider (NSP), which provides IP connectivity and WiMax services to subscribers using the ASN infrastructure provided by one or more NAPs; iii.Application service provider (ASP), which can provide value-added services such as multimedia applications using IMS (IP multimedia subsystem) and corporate (virtual private networks) that run on top of IP.

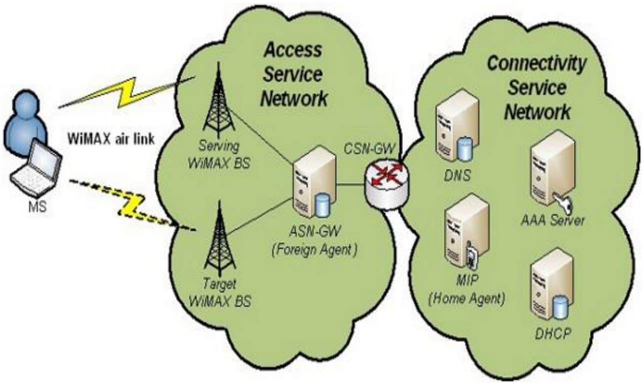


Figure 2: WiMAX architecture based on IP

The IEEE 802.16 standard supports both point-to-point (PP) and point-to-multipoint (PMP) topologies, and an optional mesh configuration. In a fixed PMP WiMAX network, a BS communicates with multiple stationary SSs, as shown in Figure 2.TheMACof a PMP WiMAX network is centrally managed by the BS, which offers connection-oriented services to individual traffic flows. Each traffic flow is uniquely identified by a connection identifier (CID), and belongs to one of the listed QoS classes, which are defined at the WiMAX MAC layer [1] to provide differentiated traffic treatment.

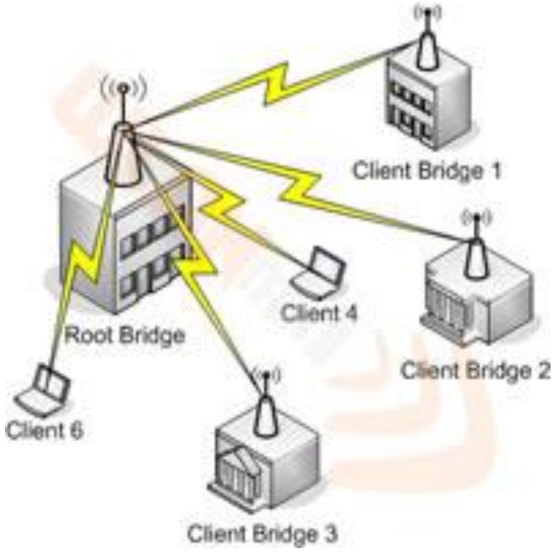


Figure 3: Point to Multipoint WiMAX Network

IV. SERVICE FLOW TYPES IN IEEE 802.16E AND ASSOCIATED PARAMETERS

IEEE 802.16e supports five SF types [2]: '

• **Unsolicited grant service (UGS)**: support real-time data streams consisting of fixed-size data packets issued at periodic intervals. Such as T1/E1 and **Voice over IP** without silence suppression

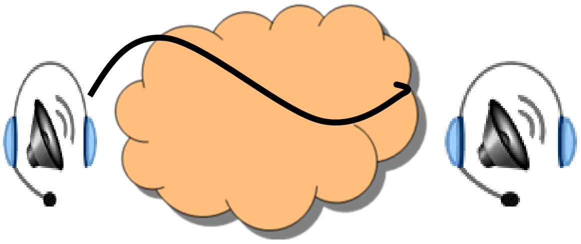


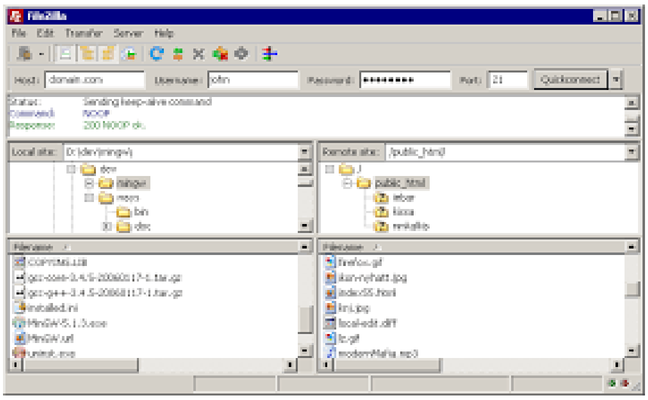
Figure 4: VoIP

• **Real-time polling service (rtPS)**: Supports real-time traffic with variable-size data packets that are issued at periodic intervals. Such as moving pictures experts group (**MPEG**) video.

Figure 5: MPEG

• **Extended rtPS (ertPS)**: Supports real-time traffic that generates variable-size data packets on a periodic basis with a sequence of active and silence intervals

• **Non-real-time polling service (nrtPS)**: Supports delay-tolerant traffic that requires a minimum reserved rate. Such as **FTP**



Host: domain.com
Username: john
Password: ********
Port: 21

Status: Sending keep-alive command
Command: NOOP
Response: 200 NOOP ok.

Local site: D:\dev\mingw\
Remote site: /public_html/

Figure 6: FTP

• **Best effort (BE) service**: support data streams for which no minimum service level is required and therefore may be handled on a space-available basis.

V. SIMULATION &RESULTS

The simulations implemented in this paper are done in a WIMAX baseband transceiver on a multi-core SDR platform. An OFDM symbol means a group of L data symbols (all the data symbols are transmitted in a parallel manner) and it lasts T seconds, where T=Ls. As the spectrum of OFDM is not band limited (sinc (f) function), linear distortion caused by multipath can cause ISI. To avoid this effect, it is important to transmit a guard interval between OFDM symbols. The duration of each guard interval (Tg) has to be longer than the delay spread (τ) of the channel to ensure that each symbol interferes only with itself. After its introduction, the duration of each symbol is T total=T+Tg. Its introduction also reduces the synchronization problems. The ratio TG/Td is very often denoted by G in WIMAX/802.16e documents. If the channel conditions are good, a lighter value of G has to be used. If the multipath effect is important and the channel is bad, a high value of G is required. For OFDM PHY layers, 802.16e defines the following values for G: 1/4, 1/8, 1/16, and 1/32. Channel coding improves the performance significantly. The next simulation was done for the AWGN channel with QPSK modulation scheme and with a different rate tail biting convolution code. The system model has been tested for PBSK QPSK, 16QAM, and64 QAM modulations with an AWGN channel having the following values for G: 1/4, 1/8, 1/16, and 1/32. The simulation results are shown in the figures and Table (1) below

TABLE (1) SNR REQUIRED TO ATTAIN BER LEVEL.

Modulation	SNR(dB) at G(cyclic prefix)				Level
	1/4	1/8	1/16	1/32	BER
BPSK1/2	0.5	1	1.5	0.2	.
QPSK1/2	3.5	3.8	4	4.1	10
QPSK3/4	5.5	6	6.1	6	10
16QAM1/2	10	9.9	10	10.1	10
16QAM3/4	11.2	12.9	12.5	13	10
64QAM2/3	17.5	16.5	16.7	17	10
64QAM3/4	18	17.5	17.6	18	10
					10

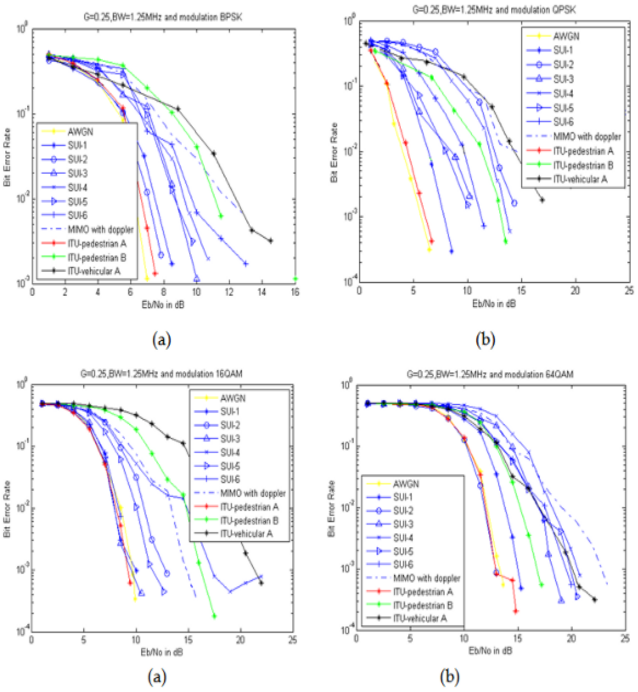


Figure 7: simulation QPSK, BPSK, QAM

VI. CONCLUSION

The paper presents a detailed design and implementation of the WiMAX simulation module for MATLAB This module includes a basic point-to-multipoint (PMP) IEEE 802.16 function, a different service flows generator, a simple bandwidth management component, and the scheduler. We also demonstrate a simulation scenario to verify the designed module. We hope that this preliminary WiMAX module can benefit academic researchers and industrial developers for early verification of designing the WiMAX system. The future work will focus on providing mobility functions [3] of the SS and the relay station (RS). In addition, an efficient bandwidth management algorithm and scheduler algorithm for QoS control are crucial for performance enhancement of the WiMAX system.

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