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QoS Analysis of VOIP Traffic over WiMAX

Saira Banu[1] , K.M.Mehata[2]

[1]*Department of Computer Science & Engineering, B.S.Abdur Rahman University,*

2Department of Computer Science & Engineering, B.S.Abdur Rahman University

Abstract *- The Voice-Over Internet Protocol (VoIP) technology allows the voice information and the video traffic to pass over the IP network using the existing infrastructure. WiMAX (Worldwide interoperability for micro wave access technology) is a technology based on IEEE 802.16 standard, which provides broadband service for fixed and mobile users over long distances at high speed. Modulation and coding is one of the features of PHY layer which is used to load the data in the uplink and downlink during transmission. The existing system selects the MCS based on the channel quality.Modulation and coding scheme can also be selected based on the type of traffic used. This paper focuses on the physical layer design aspect namely modulation and coding scheme(MCS) for the VOIP traffic over WiMAX. The simulation is done for fixed WiMAX environment. Throughput and packet delay is taken as the main parameter for evaluating the performance of WiMAX. This paper focuses on selecting appropriate Modulation and encoding scheme over the WiMAX network for the voice and video application.*

Keywords *– VOIP, WiMAX, Throughput, UGS, MCS.*

I. INTRODUCTION

The Digital Subscriber Line or the cable modem based connections are the ways to access the broadband internet services before the evolution of IEEE 802.16. This wired infrastructure is costlier for deploying in the rural areas. WiMAX is the recent alternate technology to establish broadband wireless communication.

There are two types of WiMAX standards, Fixed and Mobile WiMAX. IEEE 802.16d-2004 (also known as Fixed WiMAX) and IEEE 802.16e-2005 (also known as Mobile WiMAX) Fixed WiMAX provides support to fixed and nomadic applications while mobile WiMAX supports to mobile, portable, fixed and nomadic applications. Fixed WiMAX uses 2 to 11GHZ frequencies and provides transmission to stationary devices. Mobile WiMAX use 2 to 6 GHZ frequency band and allows people to communicate while walking or riding in cars.

The Orthogonal Frequency Division Multiple Access technique is used for transferring large amount of digital data over the radio wave. The orthogonal frequency division multiplexing divides the high bit rate data stream into several low bit rate streams and allocates a separate carrier for each stream. VOIP is used to transfer the voice packets in the existing internet infrastructure. Modulation is mapping the data bits to the (I,Q) values, where I represents In-phase and Q represents the quadrature. Phase shift keying encodes information only in phase where as Quadrature amplitude modulation encodes information in both amplitude and phase. Quadrature Phase Shift Keying (QPSK) allows the signal to carry twice the information as ordinary PSK using the same bandwidth.

Quadrature Amplitude Modulation or QAM used for modulating data signals onto a carrier used for radio communications. The number before QAM (for example 16QAM) refers directly to the number of decision points in the constellation. These numbers will always a power of two. (EG. 2^6=64QAM) .The coding rate indicates the amount of data stream actually used to transmit usable data. The different convolutional coding rates that can be used are expressed in fraction as rate 1/2 , rate 3/4 , rate 2/3 and rate 5/6.Modulation and coding technique provides the primary link between the user and the wireless channel. The performance of the system and the use of resources changes in accordance with the selected modulation and coding technique which is shown in figure 1.

This paper is broadly divided into eight sections. A brief introduction about the WiMAX (IEEE 802.16) and the use of OFDMA is discussed in the first section. Published research papers related to this field are discussed in the second section. The third section deals with the architecture and the service class of WiMAX. The parameters used for analyzing the QoS of Voice and Video are introduced in the fourth section. The different modulation and coding schemes available in the MAC layer and its user are explained in the fifth section. The simulator and the simulation models are discussed in the sixth section. The seventh section analyze the result and the graph. The eighth Section concludes the paper with the conclusion.

II. LITERATURE REVIEW

Many related works were published on analyzing different Quality of Service parameters using WiMAX service classes. M.A. Mohamed, F.W. Zaki and A.M. Elfeki in [2], evaluated the performance of different VoIP codecs in WiMAX network with respect to network performance parameters such as MOS (Mean Opinion Score), packet end-to-end delay, jitter and packet delay variation. D. Joshi, S. Jangale in [1] analyzed the performance of different VOIP codec over the best effect service flow using the WiMAX network. The parameters used are throughput, average delay and average jitter. Vikram and Gupta [3] analyse the QoS parameters like jitter, throughput, delay, PDR (Packet delivery Ratio) and PLR (Packet Loss Ratio) in WiMAX network using UGS service class.. Authors in [4] evaluated the performance of WiMAX system under different combination of digital communication and different communication channels. The focuses on FEC coding schemes and noise levels.

Author in [5], analyzed the performance of coded OFDM based WiMAX system with different fading conditions . Performance study of Mobile TV over mobile WiMAX is conducted with different types of Adaptive Modulation and Coding is done in [6].Mr.SivaKumar Reddy and Ms.Lakshmi in [7] proposes the method for modulation and coding selection based on the threshold given . In this paper the QoS of voice and video in WiMAX are analyzed with the various modulation and coding scheme using the OPNET simulator. Network throughput and MOS are the parameters considered for comparing.

III. VOIP over WiMAX

Voice over Internet Protocol technology has a major impact on the telecommunications industry. VoIP technology provides advantages for both the user and client, by allowing calls to be made more cheaply, as well as enabling data, voice and video to be carried over the same network efficiently. The VoIP technology has caused a major impact in telecommunications providers.The most widely used VoIP Codec is G711, although there are a variety of others are available with varying data rates and providing different levels of voice quality.

The standards of VOIP are as follows:

- H.323: ITU-T standard for packet based multimedia communication.
- H.255.0 : Standard for registration, admission, call signalling and control
- H.245: Standard for terminal capability exchange and control of logical channel.
- H.323: Offers specifications for call control, channel setup, codecs for the transmission of Real Time video and voice over the networks where the QoS and the guaranteed services are not available.

The various parameters used for measuring the quality of voice and video in WiMAX are jitter, end to end delay and throughput. The definition of the parameters is given below.

- **Jitter:** Jitter is the variation in time between packets arriving, caused by network congestion, timing drift or route changes.
- **End to End delay**: End to end delay is the time taken for a packet to be transmitted across a network from source to destination.
- **Throughput:** The total number of packets/bits delivered to the end user in a network is called throughput. It is measured in terms of packets per second or bits per second.

IV. WiMAX Network Architecture

WiMAX is an IEEE standard for high layer protocols like TCP/IP, Voice Over Internet Protocol and Session Initiation Protocol. WiMAX offers air link interoperability. WiMAX technology is a telecommunications technology that offers transmission of wireless data via a number of transmission methods; such as portable or fully mobile Internet access via point to multipoint links. Wimax supports packet switched and urban, rural radio propagation. The Wimax architecture consists of three logical entities: BS, ASN and CSN.

- **Base Station (BS):** The functionality of base station is supervision, handoff prompting, and classification of traffic, DHCP, Keys session and multicast group management.

- **Access Service Network (ASN):** used to describe and expedient way to explain combination of functional Entities and equivalent significance flows connected with the access service. The ASN gateway supports Connection and mobility management across cell cities and manages traffic flows.

- **Connectivity Service Networks (CSN):** This entity offers IP services for connectivity to the WiMAX Clients. The CSN takes care of IP address, roaming, management of locations etc.

Fig.1 Adaptive MCS selection

Wimax operates in infrastructure mode. It consists of base station which sends data to clients, receivers' requests and forwards to the network provider. It can provide various levels of QoS in teams of queuing, scheduling, control signaling mechanisms, classification and routing**.** Figure 1 shows the WiMAX network architecture.

The connection classifier in the subscriber station map the incoming packet to the appropriate connection based on the set of criteria. The admission control mechanism in the base station is used to admit or reject the service based on the available bandwidth. The scheduler is used to allocate the resource for the effective utilization.

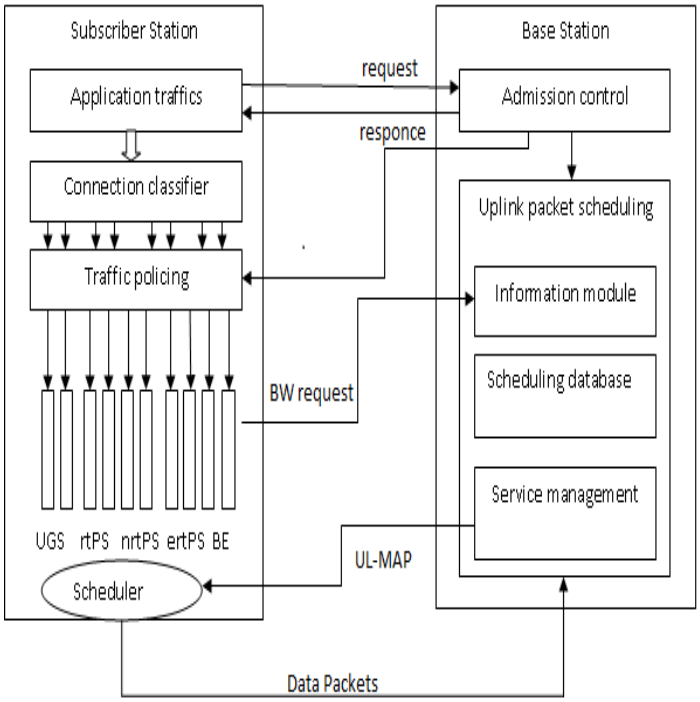


Fig.2. WiMAX network architecture

V. MODULATION AND CODING

WiMAX uses the OFDMA system to support Voice traffic. Whenever the Voice and video traffic arrives at the base station (BS) it needs to be scheduled on the uplink and downlink. The frequency, transmit power; time of transmission, mode of transmission, the identification of mobile station are need to be specified during each allocation. This control information is compressed and coded using the Modulation and Coding Scheme (MCS).Thus the resources are allocated when the user is in active mode and reallocated when the user is in silent mode. This allocation and reallocation is done for every 1.25 second. The MCS used for data transmission and reception varies according to the channel variation. The amount of allocated resources depends on MCS.

WiMAX supports a variety of modulation and coding schemes and allows for the scheme to change on a burst-by-burst basis per link, depending on channel conditions. The channel quality feedback indicator helps the mobile to provide the feedback to the base station about the downlink channel quality base station. For the uplink, the base station can estimate the channel quality, based on the received signal quality. The modulation and coding scheme is set at the subscriber station i.e. the mobile station for both uplink and downlink channel as shown in the figure 2. The subscriber station parameters and the procedure for selecting the modulation and coding in the OPNET 14.5 simulator are shown in figure 3.

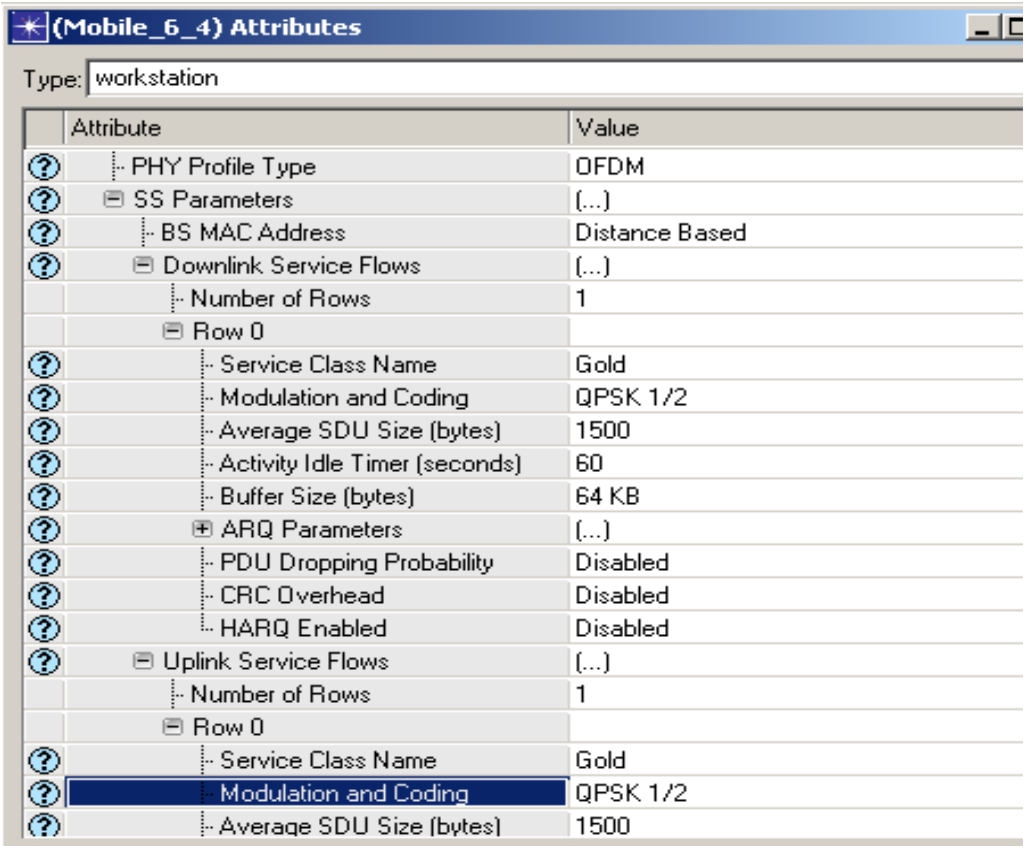


Fig. 3. ***Subscriber station Parameter***

Following is a list of the various modulation and encoding schemes supported by WiMAX.

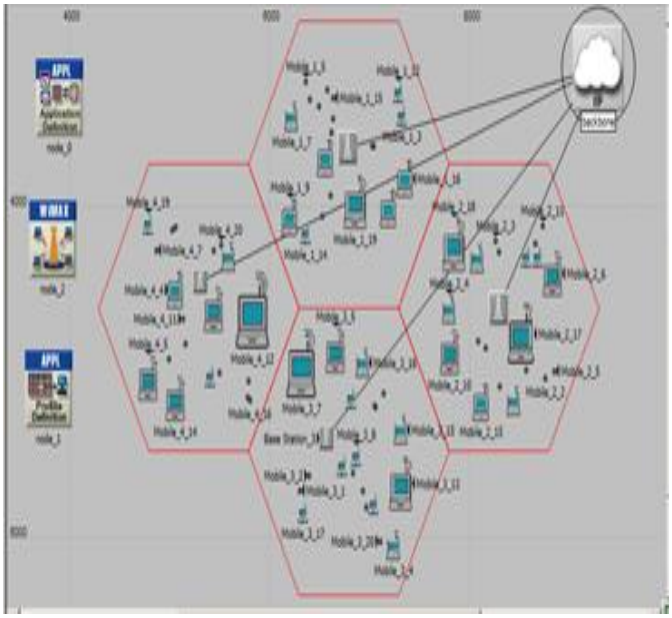
Table. 1 Various Modulation and coding schemes

	Downlink	**Uplink**
Modulation	BPSK, QPSK, 16 QAM, 64 QAM; BPSK optional for OFDMA-PHY	BPSK, QPSK, 16 QAM; 64 QAM optional
Encoding	**Mandatory:** convolutional codes at rate 1/2, 2/3, 3/4, 5/6 **Optional:** convolutional turbo codes at rate 1/2, 2/3, 3/4, 5/6; repetition codes at rate 1/2, 1/3, 1/6, LDPC, RS-Codes for OFDM-PHY	**Mandatory:** convolutional codes at rate 1/2, 2/3, 3/4, 5/6 **Optional:** convolutional turbo codes at rate 1/2, 2/3, 3/4, 5/6; repetition codes at rate 1/2, 1/3, 1/6, LDPC

VI. SIMULATION SCENARIO

This research work is done on a wireless network with four base stations and twenty subscriber stations (fixed node).The topology consist of geographical overlay of four cells ,each with radius 3km and 2 subscriber stations, which is shown in scenario 1. The nodes are placed in a random manner. Main considerations made in our simulation while deploying wireless network are technology and topology.

Technology: WiMAX technology with subscriber node transmission power 0.5 w and base station transmission power 0.5w.
Topology: The simulated topology consists of 4 hexagonal cells with cell radius of 3km.Number of subscriber stations per cell is 20.Base stations are modeled with wimax_3section_bs_atm2_ethernet2_slip4_wlan_router. The subscriber stations are modeled with wimax_ss_wkstn.



Scenario 1. Wimax Network with 4 cells and 20 subscriber stations

This topology is designed for VOIP application that is both voice and video application.The configuration used in the above simulated scenario is profile config, application config and wimax config.
Application Configuration: This specifies the various application used in the project. The various application names are web browsing, FTP, databases, HTTP, remote login, voice and video conferencing. In the above simulation we have taken the voice and video conferencing.
Profile Configuration: It is used to create the traffic pattern for the application defined in the application config.
Wimax Configuration: It is used to store profiles of physical and service classes which can be referenced by all wimax nodes in the network.

Table 2.Simulation Parameter

Parameter	Value
Network interface type	Phy/Wireless Phy/OFDMA
Propagation model type	Propagation and OFDMA
Medium Access Control type	Mac/802_16/Base Station
Routing protocol	NOAH
Antenna model	Omni Antenna
Link layer type	Logical Link layer
Frame size (msec)	5 (msec)
Duplex scheme	TDD
Packet Rate	4 packet/second
Modulation and Coding Scheme Technique	QPSK 16
Simulation time	30 minutes

VII. SIMULATION RESULT

In this section, the throughput of WiMax is computed using various modulations and encoding scheme for the voice and video application. Unsolicited grant service is set as the service class for the VOIP application. The performance of the network is considered high if the throughput is high. The throughput achieved for the VOIP (both voice and video) application when simulated with various Modulation scheme is discussed in the following section.

A. Voice Application

The graph in figure 4 shows the throughput of the WiMax network for the different Modulation and Coding scheme like QPSK ½, QPSK ¾, 16 QAM 1/2, 16 QAM2 3/4, 64 QAM1/2, 64 QAM2/3,64 QAM ¾, QPSK ½ repetition 2, QPSK ¾ repetition 2 , QPSK ½ repetition 4, QPSK3/4 repetition 4, QPSK ½ repetition 6, QPSK ¾ repetition 6.The comparison graph simulated in Opnet 14.5 is shown in the figure 4. The deployed WiMax network produces maximum throughput with the modulation scheme QPSK 1/2 for the voice application.

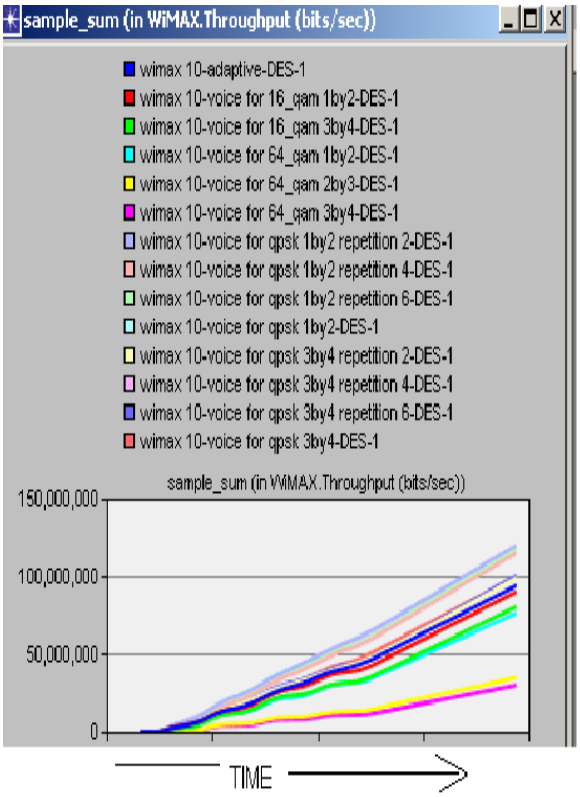


Fig.4. Throughput comparison for voice app.

The maximum throughput obtained in each MCS is shown in the figure 4.The graph shows that MCS QPSK 1/2 yields the maximum throughput when compared with the other entire Modulation and coding scheme. The information regarding the average delay is shown in the figure 5. The average delay for the MCS QPSK ½ is also less, which in turn increases the QoS of the voice.

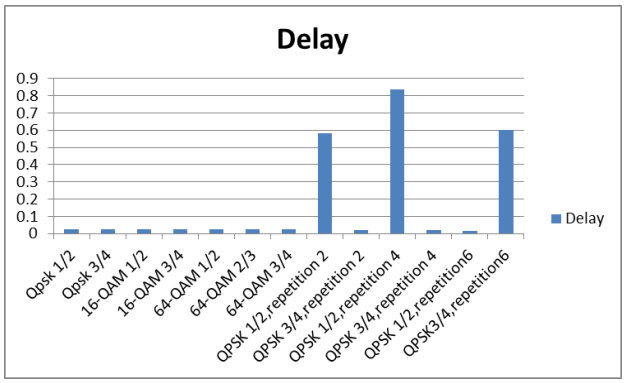


Fig.5. Average delay for different modulation schemes for voice

A. Video Application

The results of the simulation for the video application in the WiMAX network using different MCS are discussed in this section. The graph in figure 6 shows the throughput of the WiMAX network for the different Modulation and Coding scheme like QPSK ½, QPSK ¾, 16 QAM 1/2, 16 QAM2 3/4, 64 QAM1/2, 64 QAM2/3,64 QAM ¾, QPSK ½ repetition 2, QPSK ¾ repetition 2 , QPSK ½ repetition 4, QPSK3/4 repetition 4, QPSK ½ repetition 6, QPSK ¾ repetition 6. The comparison graph simulated in OPNET14.5 is shown in the figure 5. The maximum bits delivered for each MCS is analyzed and shown using the table 5. The MCS QPSK 1/2 delivers more bits than all the other MCS. This is shown clearly in the 3D bar graph in the figure 7.

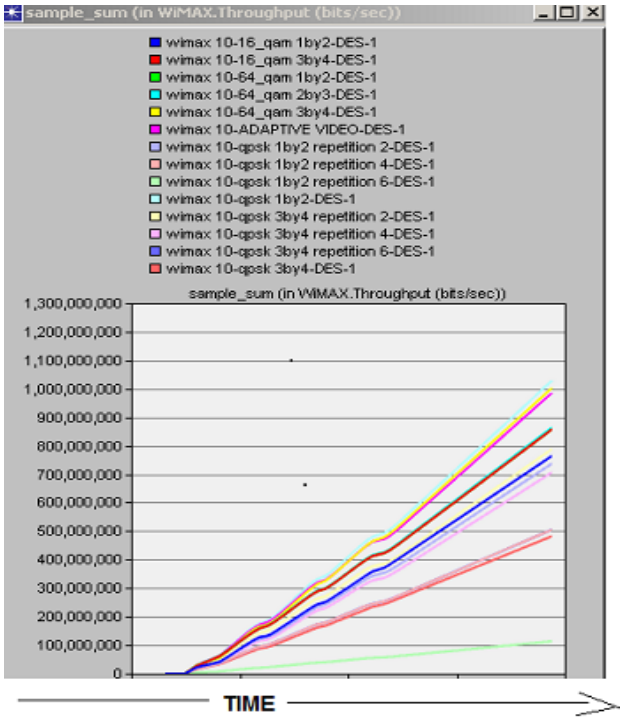


Fig.6. Throughput comparison for Video application

The values in the table 3 shows the video data, in bits delivered in the network using different MCS. The MCS Qpsk½ delivers 12724900 bits of video data, per second for the simulated WiMAX network. The performance of the network is high in the MCS Qpsk ½. The performance of the network for the video application is high for the modulation and coding scheme Qpsk ½.

Table 3: Summary of throughput obtained for video app

Modulation and coding scheme	Throughput
Qpsk ½	1.27E+07
Qpsk ¾	5.59E+06
16-QAM ½	9.24E+06
16-QAM ¾	1.03E+07
64-QAM ½	1.03E+07
64-QAM 2/3	1.24E+07
64-QAM ¾	9.08E+06
QPSK 1/2,repetition 2	9.57E+06
QPSK 3/4,repetition 2	5.94E+06
QPSK 1/2,repetition 4	8.78E+06
QPSK 3/4,repetition 4	1.33E+06
QPSK 1/2,repetition6	1.04E+07
QPSK3/4,repetition6	5.94E+06

The next option of MCS for the video application is 64 QAM 2/3. The throughput of the network is very low when Qpsk ¾ repetition 4 is selected as the modulation and coding scheme for the simulated WiMAX network.

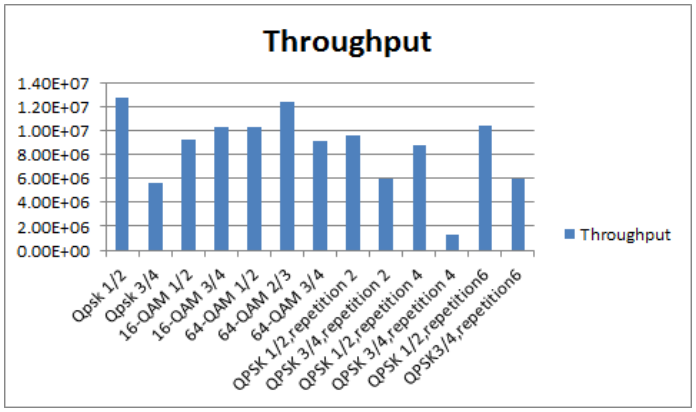


Fig.7. Different MCS and their throughput for the Video App

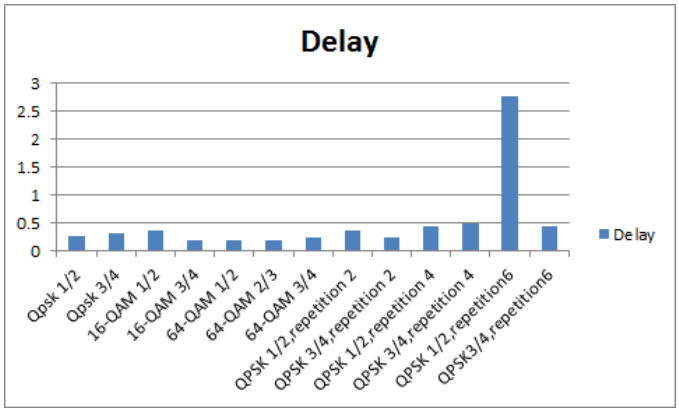


Fig.8. Different MCS and their average delay for the Video Application

The average delay is minimum for the modulation scheme QPSK ½ as shown in the figure 8.The throughput is high for

QPSK ½ and the delay is also comparately low for this modulation. so the QPSK ½ is considered as the best scheme for video application in WiMAX environment.

VIII. CONCLUSION

The simulation was done to evaluate the performance of VOIP over the WiMAX networks. The parameters used to evaluate the performance of the network are throughput and average delay. Modulation and coding scheme are used to load the data into the uplink and downlink during transmission. Thirteen modulation and coding scheme namely Qpsk ½, Qpsk ¾, 16 QAM ½, 16 QAM ¾, 64 QAM ½ ,64 QAM 2/3, 64 QAM ¾, Qpsk ½ repetition 2, Qpsk ¾ repetition 2, Qpsk ½ repetition 4 , Qpsk ½ repetition 6 are simulated in the Wimax network and their throughputs and delay are taken for comparison. The research findings show that the Voice and video application can perform better under the modulation QPSK with the encoding rate of 2/3.In this paper same MCS has been selected for the uplink and downlink. This paper work can be extended by using different combination of MCS in the uplink and downlink channel. In this paper the simulation is done for the UGS service class. The work can be extended by taking the other service classes. The simulation results indicate that the better choice of Modulation and coding scheme have significant impact on the performance of the network.

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