QoS Analysis over WiMAX Network with Varying Modulation Schemes and Efficiency Modes

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ABSTRACT
Real time media applications such as video conferencing, Video on Demand, live video streaming have made a significant strike in business, education, medicine, media and several other fields. Video applications are delay and noise sensitive and require higher bandwidths. To accomplish this, there is an ever growing need of Quality of Services (QoS) for establishing these applications. IEEE 802.16 standard for wireless broadband, Worldwide Interoperability for Microwave Access (WiMAX) is a technology that provides QoS. In this paper a comparative analysis of video conferencing over WiMAX networks is conducted. QoS parameters like network delay, load and throughput are evaluated with respect to different modulation schemes and efficiency modes using Opnet Modeler 14.5.

General Terms
Analysis, Evaluation, comparative study, simulation

Keywords
WiMAX, video conferencing, QoS parameters, Opnet

1. INTRODUCTION
With the fast growing wireless technology, Internet access has gradually faced a tremendous change over the past decade. Multimedia applications and services are moving ahead with a great pace, where Voice-Over-IP (VOIP), video conferencing, video on demand and live video streaming are majorly required in almost all domains. Wireless multimedia applications are highly dependent upon durable and robust networks. Such applications are error and delay sensitive. These require the use of networks with high quality of service that needs higher bandwidth.

Worldwide Interoperability for Microwave Access – WiMAX, is a wireless digital communication system based on the IEEE 802.16 standard which provides broadband wireless Internet access at very high speed rates up to 70 Mbps or a data rate of about 3 Mbps over 30 miles. The data rate increases as the distance decreases.

WiMAX covers area up to 50 km and provide 30 to 40 mbps data rate. It is the replacement for DSL (Digital Subscriber Line) and cables [3]. WiMAX can support very high bandwidth solutions where large spectrum deployments (i.e. >10 MHz) are desired using existing infrastructure keeping costs down while delivering the bandwidth needed to support a full range of high-value multimedia services.

WiMAX has five essential design segments [4]:

- Base Station (BS): The BS is the hub that consistently joins wireless endorser gadgets to administrator systems. The BS keeps up communication with endorser gadgets and administers access to the administrator systems. A BS comprises of the foundation components important to empower wireless communications i.e., radio wires, handsets, and other electromagnetic wave transmitting gear.
- Subscriber Station (SS): The SS is a stationary WiMAX-proficient radio framework that communications with a base station.
- Mobile Station (MS): A MS is a SS that is planned to be utilized while as a part of movement at up to vehicular paces.
- Relay Station (RS): RSs are SSs designed to forward movement to different RSs or SSs in a multi-hop Security Zone.
- Operator Network: The administrator system envelops infrastructure network functions that give radio access and IP network administrations to WiMAX subscribers.

WiMAX is a wireless broadband solution that offers a rich set of features with a lot of flexibility in terms of deployment options and potential service offerings. The WiMAX physical layer (PHY) is based on orthogonal frequency division multiplexing - OFDM, a scheme that offers good resistance to multipath, and allows WiMAX to operate in Non Line of Sight conditions. WiMAX is capable of supporting very high peak data rates. In fact, the peak PHY data rate can be as high as 74Mbps when operating using a 20MHz wide spectrum. Under very good signal conditions, even higher peak rates may be achieved using multiple antennas and spatial multiplexing. WiMAX has a scalable physical-layer architecture that allows for the data rate to scale easily with available channel bandwidth. IEEE 802.16-2004 and IEEE 802.16e-2005 supports both time division duplexing and frequency division duplexing. TDD is favored by a majority of implementations because of its advantages: (1) flexibility in choosing uplink-to-downlink data rate ratios, (2) ability to exploit channel reciprocity, (3) ability to implement in non-paired spectrum, and (4) less complex transceiver design [2].

1.1 QoS in Video Conferencing and WiMAX
Interactive multimedia applications require large amounts of bandwidth and different means of dealing with latency and loss. There must be sufficient bandwidth in the network to meet the demands of the heavy load. Sometimes despite of these provisions, variance is seen network bandwidth. This occurs because traffic in the network is not evenly spread during all times. The amount of traffic that a device can forward is limited by the capacity of its bandwidth. When too many packets arrive at a device at the same time, the device

cannot forward all the packets immediately due to low bandwidth. This causes congestion and results in delay and loss of packets [5].

Quality of service is the guarantee of the service-level performance for a data stream from a source to destination. When a network is QoS enabled, it can smooth out the communication between multimedia, file transfer and interactive applications which immensely differ in terms of bandwidth, delay and load specifications.

To support such varying requirements, WiMAX broadly uses 5 QoS classes which are described in Table 1. WiMAX includes QoS mechanism in the architecture of MAC layer.

Table 1. WiMAX service classes

QoS Classes	Designation Defining QoS Parameters	Application Examples
Unsolicited grant services (UGS)	Maximum sustained rate Depends on delay Jitter tolerance	Voice over IP (VoIP) without silence suppression
Real-time Polling service (rtPS)	Minimum reserved rate Delay dependent Traffic priority	Streaming audio and video, MPEG (Motion Picture Experts Group) encoded
Non-real-time Polling service (nrtPS)	Minimum reserved rate Traffic priority	File Transfer Protocol (FTP) TFTP HTTP
Best-effort service (BE)	Maximum sustained rate Traffic priority	Web browsing Data transfer Email
Extended real-time Polling service (ErtPS)	Minimum reserved rate Maximum sustained rate Maximum latency tolerance Jitter tolerance Traffic priority	VoIP with silence suppression and activity detection

WiMAX employs a range of measurable performance metrics such as delay, load and throughput. In this research paper evaluation of the performance of the WiMAX network based on these metrics. Delay is the time taken for a packet to leave the source and reach the destination. Load is the amount of data (traffic) being carried by the network. Throughput refers to how much data can be transferred from one location to another in a given amount of time [3][4][7].

This research paper analyzes the WiMAX network for video conferencing and hence the network is created using the real time Polling Service – rtPS which provides minimum reserved rate, delay dependent traffic priority. rtPS is always used when dealing with streaming audio, video, MPEG encoded applications.

1.2 Modulation techniques in WiMAX

Modulation is the process of varying one or more properties of a periodic waveform, called the carrier signal, with a modulating signal that typically contains information to be transmitted.

- Quadrature Phase Shift Keying (QPSK): Quadrature Phase Shift Keying is a form of Phase Shift Keying that modulates 2 bits at once, selecting one of four possible carrier phase shifts (0, 90, 180, or 270 degrees). By using QPSK twice as much information can be sent as PSK using same bandwidth. QPSK is used for satellite transmission of MPEG2 video, cable modems, videoconferencing, cellular phone systems, and other forms of digital communication over a radio frequency carrier.
- Quadrature Amplitude Modulation (QAM): Quadrature Amplitude Modulation, a signal in which two carriers shifted in phase by 90 degrees are modulated and the resultant output consists of both amplitude and phase variations. In view of the fact that both amplitude and phase variations are present it may also be considered as a mixture of amplitude and phase modulation.

A motivation for the use of quadrature amplitude modulation comes from the fact that a straight amplitude modulated signal, i.e. double sideband even with a suppressed carrier occupies twice the bandwidth of the modulating signal.

In general the greater the number of bits transmitted per symbol, the higher the data rate is for a given bandwidth. Thus, when very high data rates are required for a given bandwidth, higher-order QAM systems, such as 16-QAM and 64-QAM, are used. 64-QAM can support up to 28 Mbps peak data transfer rates over a single 6 MHz channel. However, the higher the number of bits per symbol, the more susceptible the scheme is to inter symbol interference (ISI) and noise. Generally the signal-to-noise ratio (SNR) requirements of an environment determine the modulation method to be used in the environment. QPSK is more tolerant of interference than either 16-QAM or 64-QAM. For this reason, where signals are expected to be resistant to noise and other impairments over long transmission distances, QPSK is the normal choice [8]. Evaluation of the performance for WiMAX network using all modulating schemes for a comparative analysis.

1.3 Efficiency modes in WiMAX

One the major attributes of a WiMAX network is Efficiency Mode which defines the mode that achieves maximum productivity with minimum wasted effort or expense that the network will use to send and receive the packets within the network. WiMAX has four efficiency modes, Efficiency Enabled, Framing Module Enabled, Physical Layer Enabled and Mobility and Ranging Enabled.

When this attribute is set to "Efficiency Enabled", the simulation does not model the frame-by-frame allocations on the UL and DL (nor the physical layer effects). Instead, it schedules grants for the transmission as bandwidth requests come in and as there is availability with respect to the finite data capacity of the PHY.

The "Efficiency Enabled" option produces comparatively fewer events, thus reducing simulation time and enhancing the scalability of a WiMAX simulation.

When this attribute is set to "Framing Module Enabled", the simulation does a frame-by-frame modeling of allocations on the UL and DL. This leads to more accurate delay results. Still no physical layer effects are modeled.

When this attribute is set to "Physical Layer Enabled", the simulation accounts for physical layer effects (frame-by-frame modeling is also performed).

When this attribute is set to "Mobility and Ranging Enabled", the simulation accounts for mobility and ranging effects (physical layer effects and frame-by-frame modeling is also performed).

The attribute setting takes effect over the whole network model.

1.4 Duplexing Techniques in WiMAX

For cellular systems it is necessary that it is possible to talk or send data in both directions simultaneously, and this places a number of constraints on the schemes that maybe used to control the transmission flow.

Frequency division duplex, FDD: In FDD, two different frequencies are used simultaneously for transmission and reception of signals. Using FDD it is possible to transmit and receive signals simultaneously as the receiver is not tuned to the same frequency as the transmitter [9].

Time division duplex, TDD: In TDD, single frequency is used and a common channel between transmission and reception spacing them apart by multiplexing at the same time.

The WiMAX, 802.16 standard offers two forms of duplex transmission to separate the uplink and downlink messages. Both WiMAX TDD (time division duplex) and WiMAX FDD (frequency division duplex) are available. Each method offers its own advantages and disadvantages.

It is possible to use both FDD and TDD for WiMAX. However FDD transmissions require the use of two channels, one for the uplink and one for the downlink. This not only requires there to be a separate frequency separation between uplink and downlink, but it is normally also necessary to incorporate additional filtering to remove the transmitter frequency from the receive band. This can add additional cost into consumer items that are normally very cost sensitive [10].

Using WiMAX TDD it is possible to accommodate the asymmetry in the traffic balance. By altering the number of frames for traffic in each direction it is possible to make far more efficient use of the available spectrum. Therefore TDD can handle both symmetric and asymmetric broadband traffic and TDD therefore has higher spectral efficiency than FDD for these applications [10].

The analysis conducted in this paper includes only Time Division Duplexing as it is defined by default in WiMAX attributes.

2. PREVIOUS WORK

Analysis of performance for Video Conferencing over WiMAX using different modulation schemes has been conducted in [3]. These include the QoS parameters like delay, load, throughput, packet end-to-end delay and packet delay variation. They have created three scenarios and obtained results for video conferencing using the scheduling type as rtPS for fairer comparison.

Performance of WiMAX networks using different QoS is analyzed [9]; they have created three network models with different number of nodes and base stations. The first scenario consists of 7 base stations and 5 nodes per base station. The second scenario consists of 10 base stations and 5 nodes per base stations. Performance metrics analyzed are WIMAX Management Initial ranging activity, WIMAX Management Periodic Ranging activity, Delay (sec), Neighbor advertisements sent, throughput and load. Network load of base stations is lowest in Small network and highest in large network.

Simulation of Physical layer of WiMAX Network [10], in this firstly delay, load and Throughput is discussed. Then performance analysis of physical layer of WiMAX system for uplink/ downlink on the basis of BER and SNR is given.

Performance evaluation of QoS in WiMAX network [11], here the authors have provided examination of WiMAX based network and evaluated the performance of quality of services using the idea of IEEE 802.16 technology. Four different scenarios are created, scenario-1, three base stations with single Mobile, scenari-2, three base stations with three Mobile, scenario-3, seven cells with three mobile, scenario-4, seven cells with five mobile. Accuracy is compared for delay, throughput and data dropped.

The performance of quality of services for an IEEE 802.16 based WiMAX access network is analyzed in [12]. The quality of service related parameters i.e. jitter, throughput etc. are evaluated. A scenario is developed and the behavior of different service flows provided in the standard is analyzed for different application traffics and their significance in achieving QoS for WiMAX is realized. The simulation results provided in the paper gives a better choice of WiMAX's service classes and these are investigated in the terms of various QoS related metrics.

3. SIMULATION AND ARCHITECHTURE

Optimized Network Engineering Tool (OPNET Version-14.5), OPNET is a high level event based network level simulation tool. Simulation in OPNET operates at "packet-level". Originally this tool was built for the simulation of fixed networks. OPNET contains a huge library of accurate models of commercially available fixed network hardware and protocols.

Modeler provides high-fidelity modeling, scalable simulation, and detailed analysis of a broad range of wired and wireless networks.

OPNET is a research oriented network simulation tool which provides a development environment for modeling of deployed wired as well as wireless networks. It also provides multiple solutions for managing networks and applications e.g. network planning, research and development, network operation and performance management. OPNET 14.5 is designed for modeling communication nodes, technologies, protocols and to simulate the performance of these technologies. User can create customized models and simulate various network scenarios [8].

In this paper 7 wireless scenarios are simulated for analyzing the performance of WiMAX network for video conferencing named as QPSK1/2, QPSK3/4, 16QAM1/2, 16QAM3/4, 64QAM1/2, 64QAM2/3 and 64QAM3/4.

These contain different modulation schemes, QPSK1/2, QPSK3/4, 16QAM1/2, 16QAM3/4, 64QAM1/2, 64QAM2/3 and 64QAM3/4 respectively each for three different efficiency modes namely, Mobility and Ranging Enabled, Physical Layer Enabled and Framing Module Enabled.

The Duplexing technique is kept as Time Division Duplexing (TDD), the service class name is considered GOLD, and the scheduling type is considered rtPS for video conferencing in all the scenarios for a better comparison.

In each scenario there are seven hexagonal cells each cell of 10 km radius, each scenario has Pathloss and Multipath Model as Vehicular.

There is one Base Station (BS) and five Subscriber Stations (SS) in each cell. Therefore one scenario includes 7 Base Stations, and 35 Subscriber Stations. The BS connected to the IP backbone via ppp_adv link. There are three different nodes deployed namely, Application Definition, Profile Definition and WiMAX.

Application definition includes a name and a description table that specifies various parameters. A user profile is built using various application definitions. An application definition specifies an application with parameters. An application may have tasks and a tasks may have multiple phases. A phase can have many requests and responses. A profile describes user activity over a period of time. A profile consists of many different applications. The WiMAX node includes the WiMAX attributes.

The following figure shows the WiMAX scenario created in OPNET Modeler 14.5.

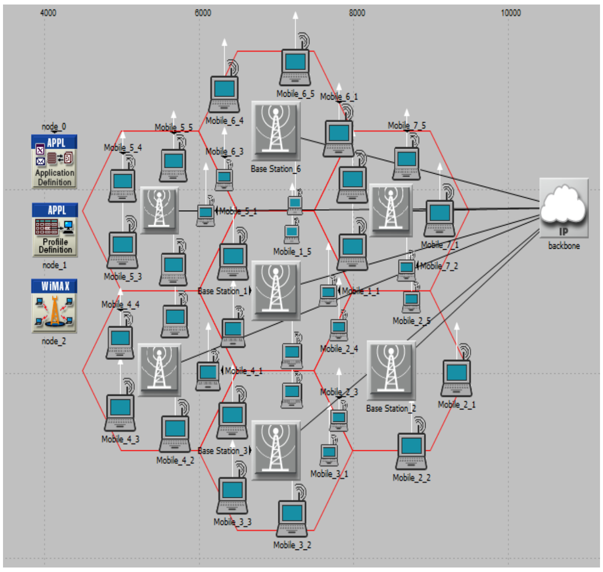

Fig 1: WiMAX scenario

The table below shows the simulation parameters used ro create the above scenario.

Table 2. Simulation parameters for Efficiency mode

Parameters	**Values**
PHY Layer	IEEE 802.16
Modulation schemes	1. QPSK1/2 2. QPSK3/4 3. 16QAM1/2 4. 16QAM3/4 5. 64QAM1/2 6. 62QAM2/3 7. 64QMA3/4
Pathloss parameter	Vehicular environment
Radius of cell	1 km
PHY profile	Wireless OFDMA 20 MHz
Efficiency mode	1. Mobility and Ranging Enabled (MRE) 2. Physical Layer Enabled (PLE) 3. Framing Module Enabled (FME)
Duplexing Technique	TDD
Service Class Name	GOLD
Scheduling Type	Real time Polling Service -rtPS

4. OBSERVATIONS AND RESULTS

The results and observations for QoS performance of video conferencing in WiMAX network is shown in this section. The simulation was run for all the 7 scenarios to conduct a comparative analysis. The delay, load and throughput of the WiMAX network for video conferencing is evaluated with respect to three efficiency modes and 7 different modulation schemes thus generating the below results.

Here parameters such as Duplexing mode to Time Division Duplexing, Service Class type as Gold are set for all the seven scenarios for a better comparison.

4.1 Delay

The delay of a network specifies how long it takes for a bit of data to travel across the network from one node or endpoint to another.

4.1.1 Delay for Mobility And Ranging Enabled (DELAY_MRE):

Firstly the results for delay in Mobility and Ranging Enabled efficiency mode is shown

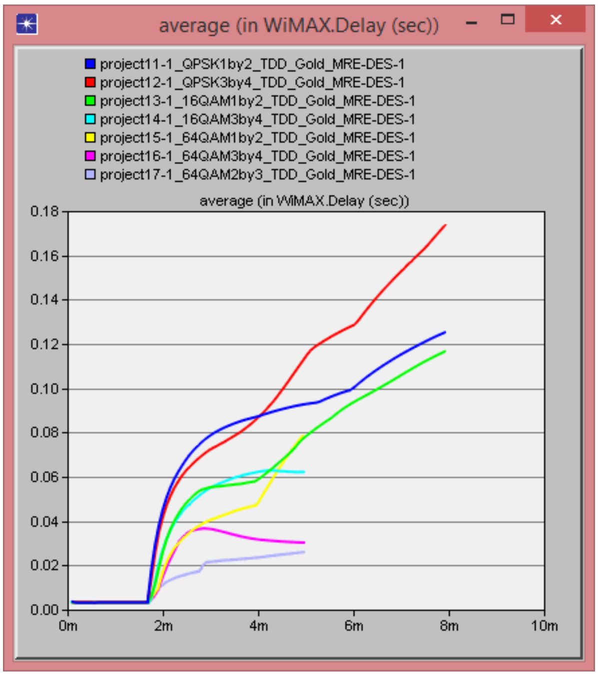

Fig 2: Average Delay_MRE

After running the simulation, the result obtained above, in Mobility and Ranging Enabled efficiency mode, can say that the delay between 0.02 and 0.04 seconds is observed for the 64-QAM2/3 modulation scheme which is lowest delay than any other modulation scheme. The delay for 64-QAM3/4 modulation scheme also gradually lowers down after a certain rise.

4.1.2 Delay for Physical Layer Enabled (DELAY_PLE):

After changing the efficiency mode to Physical Layer Enabled different results are obtained. Keeping the other WiMAX parameters same.

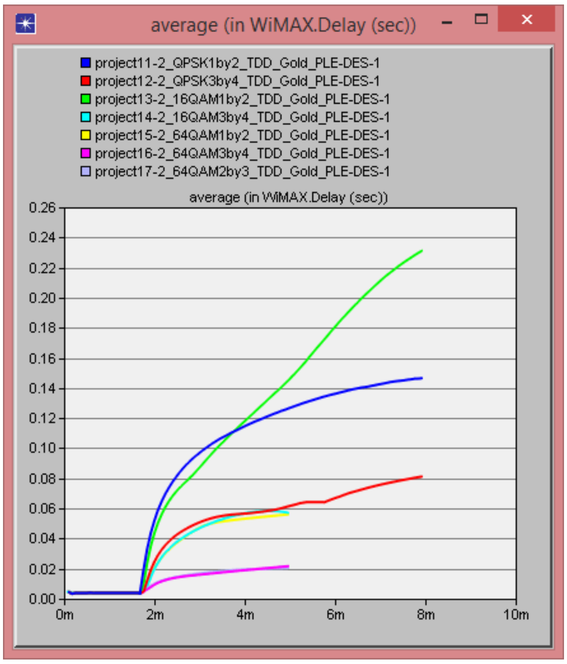

Fig 3: Average Delay_PLE

After running the simulation, the result obtained above, in Physical Layer Enabled efficiency mode is that the delay of about 0.02 seconds is observed for the 64-QAM3/4 modulation scheme which is the lowest delay than any other modulation scheme.

4.1.3 Delay for Framing Module Enabled (DELAY_FME):

Now changing the efficiency mode to Framing Module Enabled and keeping the other Wimax parameters same, below are the results obtained.

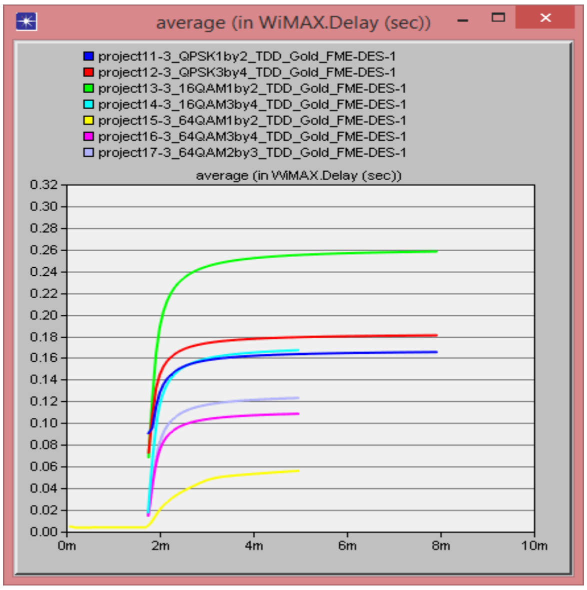

Fig 4: Average Delay_FME

After running the simulation, the result obtained above, in Framing Module Enabled efficiency mode can say that the lowest delay of about 0.06 seconds is observed for the 64-QAM1/2 modulation scheme than any other modulation scheme.

Table 3. Best Delay in all efficiency modes

DELAY FOR MRE	0.02 – 0.04 seconds	64-QAM2/3
DELAY FOR PLE	0.02 seconds	64-QAM3/4
DELAY FOR FME	0.06 seconds	64-QAM1/2

4.2 Load

Load refers to the amount of data (traffic) being carried by the network. When the network load increases it becomes essential to handle the traffic to handle the quality of service of the network.

4.2.1 Load for Mobility And Ranging Enabled (LOAD_MRE):

Firstly let's see the results for load in Mobility and Ranging Enabled efficiency mode.

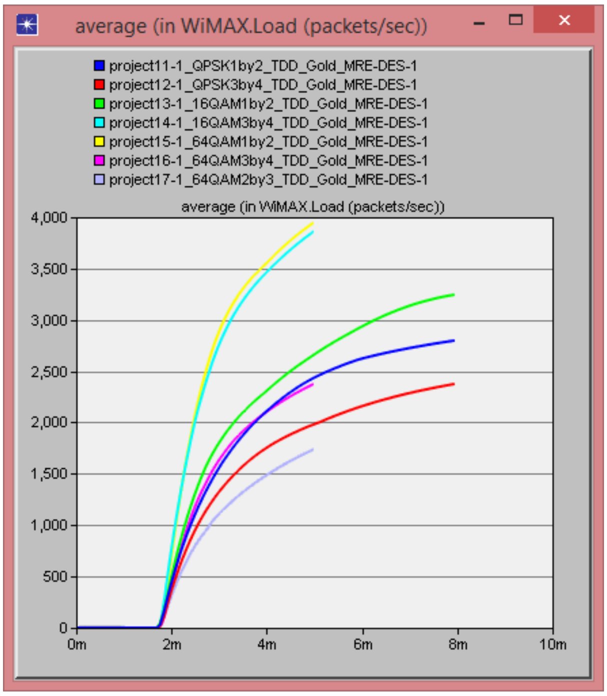

Fig 5: Average Load_MRE

After running the simulation, the result obtained above, in Mobility and Ranging Enabled efficiency mode ,the lowest load of about between 1500 and 2000 packets/seconds is observed for the 64-QAM2/3 modulation scheme than any other modulation scheme.

4.2.2 Load for Physical Layer Enabled (LOAD_PLE):

After changing the efficiency mode to Physical Layer Enabled below results are obtained, keeping other WiMAX parameters same.

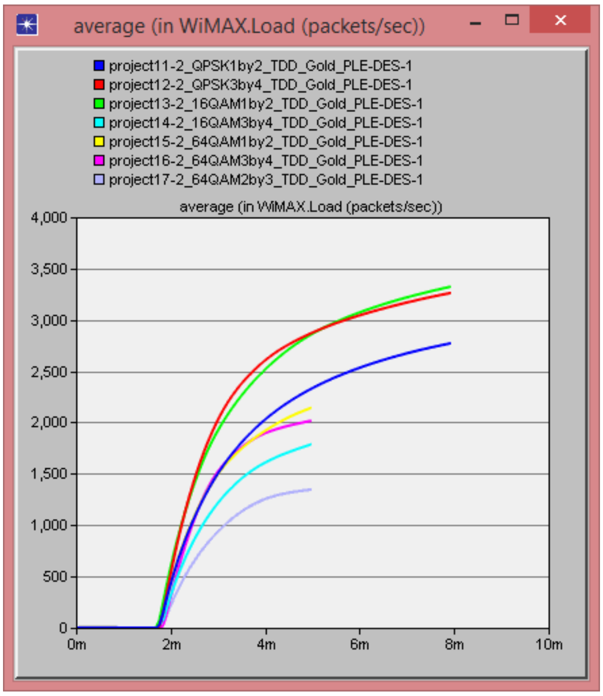

Fig 6: Average Load_PLE

After running the simulation, the result obtained above, in Physical Layer Enabled efficiency mode ,the lowest load of about between 1000 and 1500 packets/seconds is observed for the 64-QAM2/3 modulation scheme than any other modulation scheme.

4.2.3 Load for Framing Module Enabled (LOAD_FME):

After changing the efficiency mode to Framing Module Enabled below observations are noted.

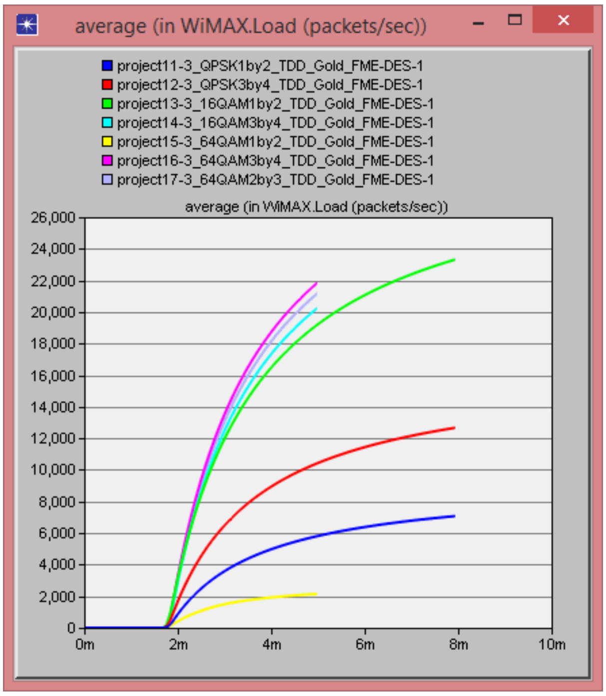

Fig 7: Average Load_FME

After running the simulation, the result obtained above, in Framing Module Enabled efficiency mode the lowest load of about 2000 packets/seconds is observed for the 64-QAM1/2 modulation scheme than any other modulation scheme.

Table 4. Best Load in all efficiency modes

LOAD FOR MRE	1500-2000 packets/seconds	64-QAM2/3
LOAD FOR PLE	1000-1500 packets/seconds	64-QAM2/3
LOAD FOR FME	2000 packets/ seconds	64-QAM1/2

4.3 Throughput

The amount of data transferred from one place to another or processed in a specified amount of time. Data transfer rates for disk drives and networks are measured in terms of throughput.

4.3.1 Thorughput for Mobility And Ranging Enabled (THROUGHPUT_MRE):

Results for throughput in Mobility and Ranging Enabled efficiency mode are shown here.

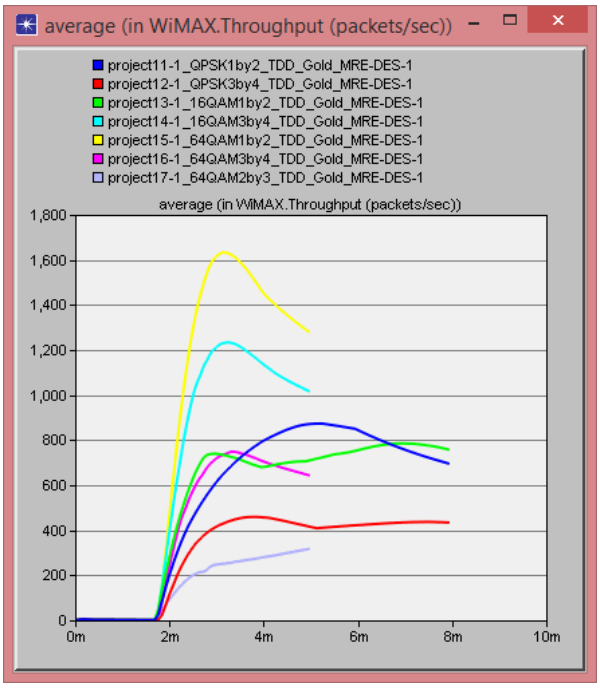

Fig 8: Average Throughput_MRE

After running the simulation, the result obtained above, in Mobility and Ranging Enabled efficiency mode, the highest throughput of about between 1600 and 1800 packets/seconds is observed for the 64-QAM1/2 modulation scheme.

4.3.2 Throughput for Physical Layer Enabled (THROUGHPUT_PLE):

After changing the efficiency mode to Physical Layer Enabled following results are obtained.

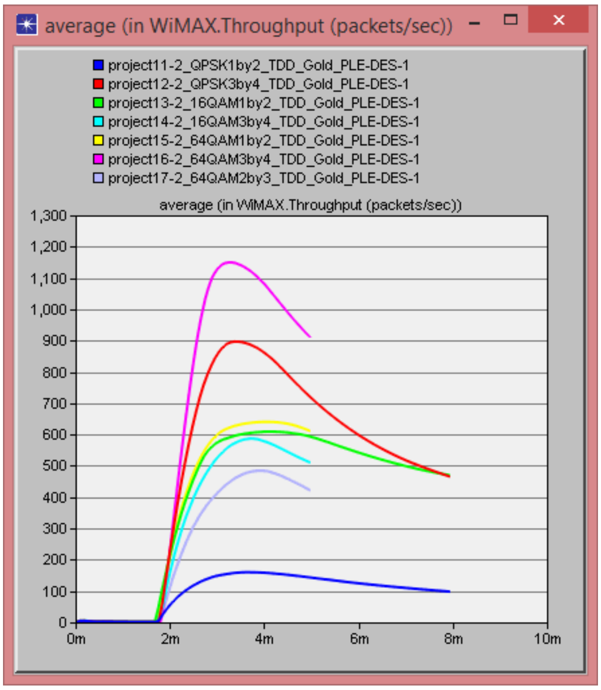

Fig 9: Average Throughput_PLE

After running the simulation, the result obtained above, in Physical Layer Enabled efficiency mode, the highest throughput of about between 1100 and 1200 packets/seconds is observed for the 64-QAM3/4 modulation scheme.

4.3.3 Throughput for Framing Module Enabled (THROUGHPUT_FME):

After changing the efficiency mode to Framing Module Enabled different results are recorded by keeping other WiMAX parameters same.

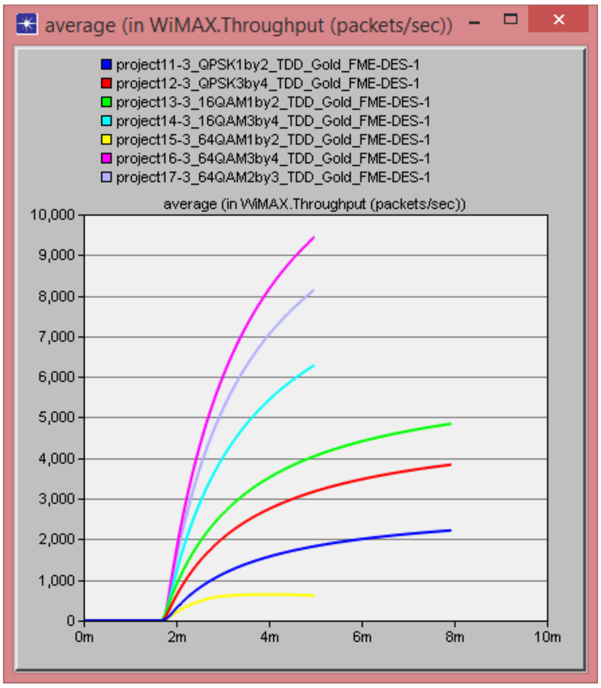

Fig 10: Average Throughput _FME

After running the simulation, the result obtained above, in Framing Module Enabled efficiency mode, the highest throughput of about between 9000 and 10000 packets/seconds is observed for the 64-QAM3/4 modulation scheme with Time Division Duplexing, Service class type as Gold.

Table 5. Best Throughput in all efficiency modes

THROUGHPUT FOR MRE	1600-1800 packets/seconds	64-QAM1/2
THROUGHPUT FOR PLE	1100-1200 packets/seconds	64-QAM3/4
THROUGHPUT FOR FME	9000-10000 packets/ seconds	64-QAM3/4

Finally the results and analysis together and state the best observed values for the scenarios created. The lowest observed value for delay, lowest observed value for load, and the highest observed value for throughput are the parameters that identify the quality of service defined network. These together will define which combination of parameters is beneficial as per the users' requirements for using WiMAX network for video conferencing.

Following table shows an overall comparative analysis of the modulation schemes and efficiency modes studied over the similar WiMAX parameters stated above.

Table 3. Best Delay in all efficiency modes

PARAMETER METRICS	**VALUES OBSERVED**	**BEST COMBINATION**
BEST DELAY (LOWEST)	0.02 seconds	64-QAM3/4_PLE
BEST LOAD (LOWEST)	1000-1500 packets/seconds	64-QAM2/3_PLE
BEST THROUGHPUT (HIGHEST)	9000-10000 packets/ seconds	64-QAM3/4_FME

From the above table it can be clearly seen the best modulation scheme is 64QAM, the best efficiency mode for delay and load is Physical Layer Enabled, however throughput obtained for Framing Module Enabled is the highest which makes it the best.

5. CONCLUSION

In this paper an analysis to evaluate the best performance metrics for video conferencing in WiMAX network is conducted. Opnet Modeler 14.5 is used as the simulation tool to generate the desired results. Several scenarios were simulated by specifying the WiMAX parameters with respect to different modulation schemes i.e. QPSK1/2, QPSK3/4, 16-QAM1/2, 16-QAM3/4, 64-QAM1/2, 64-QAM2/3 and 64-QAM3/4, and different efficiency modes namely; Mobility and Ranging Enabled (MRE), Physical Layer Enabled (PLE) and Framing Module Enabled (FME). Certain WiMAX parameters are kept similar for better results like QoS service class is rtPS, service class type is Gold, and Duplexing technique is TDD. A comparative analysis for QoS parameters delay, load and throughput was done and arrived at a conclusion that the delay is seen best when the combination of 64-QAM3/4 and PLE, load is seen best on the network when the combination of 64-QAM2/3 and PLE, and throughput is seen the best when the combination is 64-QAM3/4 and FME. Overall the performance of QAM is better in terms of all three metrics.

6. ACKNOWLEDGMENT

The Success of the work is dedicated to many who helped me during the course of this process. I sincerely thank my principal Dr. (Mrs.) C.T. Chakraborty and teaching staff of Thakur College of Science and Commerce whose support and faith have always been helpful. Collective acknowledgments to the Department of IT for providing the digital lab and their technical help.

I am very thankful to Prof. Ruchi Shah, my research guide, without whose help, guidance and motivation; I could not have proceeded and completed this project. And lastly, I would like to thank my parents for their continuous support and patience during the days of hard work and endless toil being put in for the completion of this research. It was because of the support provided by the above individualistic groups that the research paper was comprehensively completed.

7. REFERENCES

[1] Pinola, Jarno; Kostas Pentikousis (2008). "Mobile WiMAX". The Internet Protocol Journal (IPJ). Cisco.

[2] Jeffrey G. Andrews, “Fundamentals of WiMAX: Understanding Broadband Wireless Networking”,(Prentice Hall Communications Engineering and Emerging Technologies Series) Prentice Hall; 2007.

[3] Komaldeep Kaur, Vinit Grewal, “QoS Performance Analysis of Video Conferencing Over Wimax using different Modulation Schemes” International Journal of Computer Applications (0975 – 8887) Volume 146 – No.4, July 2016

[4] Nancy, Chakshu Goel, “Performance Evaluation of Different Modulation Techniques for Different Mobility Pattern by using SVC Code over Wimax” International Journal of Computer Applications (0975 – 8887) Volume 116 – No. 12, April 2015

[5] Subha Dhesikan, “Quality of Service for IP Videoconferencing Engineering White Paper”, Cisco Systems 1, June, 2001.

[6] Amritpal Kaur (2012), “Analysis of QoS for Video Conferencing and Voice Application in WiMAX Network”,” International Conference on Recent Advances and Future Trends in Information Technology (iRAFIT2012)

[7] Maha Abdullah Gumaa1, Khalid Hamid Bilal2, “Performance Evaluation of QoS Parameters in WiMAX Network” Faculty of Engineering, EL Neelain University, University of Science and Technology International Journal of Science and Research (IJSR) ISSN (Online): 2319-7064 Impact Factor (2012): 3.358

[8] OPNET Modeler [Online]. http://www.opnet.com/products/modeler/home.html.

[9] Neeru Jakhar, Ankit, Kuldeep Vats, Suman “OPNET based Performance Evaluation of WIMAX Network with WIMAX Management using Different QoS” Neeru Jakhar et al, International Journal of Computer Science and Mobile Computing, Vol.3 Issue.6, June- 2014, pg. 862-872

[10] Narendra Bagoria#1, Anita Garhwal *2, Anurag Sharma #3 , “Simulation of Physical layer of WiMAX Network using OPNET Modeller”, M.tech scholar, Department of Electronics & Communication Engineering,Jagannath University, Jaipur, Rajasthan, India, #2& 3 Assistant Professor, Department of Electronics & Communication Engineering, Sobhasaria Group of Institutions, Sikar, Rajasthan, India, International Journal of P2P Network Trends and Technology (IJPTT) - Volume3 Issue4- May 2013

[11] Ahmed Hassan M. Hassan, Elrasheed Ismail M. ZAYID, Mohammed Altayeb Awad, Ahmed Salah Mohammed, Samreen Tarig Hassan , “Performance evaluation of qos in wimax network”, Computer Applications: An International Journal (CAIJ), Vol.2, No.2, May 2015

[12] Priyanka Grover, Meenakshi Chawla, "Performance Analysis of QoS For WiMAX Using OPNET", IEEE International Conference on Computer, Communication and Control (IC4-2015).

[13] FarrukhEhtisham, Emmanouil A. Panaousis and Christos Politis, “Performance evaluation of secure video transmission over wimax”, International Journal of Computer Networks & Communications (IJCNC) Vol.3, No.6, November 2011