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Final Report

Performance analysis of IPTV over Fixed WiMAX

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Contents:

ABSTRACT:

IEEE specifies different modulation techniques for WiMAX; namely, BPSK, QPSK, 16 QAM and 64 QAM. This model will analyze the performance of Internet Protocol Television (IPTV) over Fixed WiMAX system considering various combinations of digital modulation. The performance will include a number of key system parameters, which will include the variation in the video coding, path-loss, scheduling service classes different rated codes in FEC channel coding. The performance study will be conducted using OPNET simulation. The performance will be studied in terms of packet lost, packet jitter delay, network throughput, and end-to-end delay. Using simulation results the performance will be measured and analyzed.

INTRODUCTION:

Worldwide Interoperability for Microwave Access (WiMAX) technology is one of the solutions of fourth-generation (4G) wireless network, which provides high data rates for IP networks that is capable of offering high Quality of Service (QoS). The high data rate and QoS assurance provided by this standard has made it commercially viable to support multimedia applications such as video telephony, video gaming, and mobile TV broadcasting. WiMAX base station (BS) can provide broadband wireless access in a range up to 30 miles (50 km) for fixed stations and 3 to 10 miles (5 to 15 km) for mobile stations with a maximum data rate of up to 70 Mbps.

The WiMAX standard product is specifically for fixed and Nomadic services. It was reviewed to address full mobility applications. Hence, Mobile WiMAX supports full mobility for nomadic and fixed systems. It addresses the following features: offers high data rates; supports fixed, nomadic and mobile applications thereby converging the Fixed and mobile networks; and has flexible network architectures; in addition to its cost-effective and easy to deploy. Moreover, it can support point to point and point to multipoint connection also support IP based architecture; and has optimized handover which support full mobility application such as Voice over Internet Protocol (VoIP). It also has the power saving mechanism, which increases the battery life of handheld devices.

Internet Protocol Television (IPTV) provides digital television services over IP for residential and business users at a lower cost. Moreover, IPTV is a system capable of receiving and displaying a video stream using Internet Protocol. Users can get IPTV services anywhere and anytime to mobile devices. IPTV services can be classified as follows by their type of content and services:

- **Video-on-Demand content:** In this IPTV service a customer is allowed to browse an online movie catalogue, to watch trailers, and to select a movie of interest. Unlike the case of live video, a customer can request or stop the video content at any time and is not bound by a particular TV schedule. The play out of the selected movie starts nearly instantaneously on the customer’s TV or PC.

- **Live content:** In this IPTV service a customer is required to access a particular channel for the content at a specific time, similar to accessing a conventional TV channel. A customer cannot request to watch the content from the beginning if he or she joins the channel late. Similar to a live satellite broadcast, live content over IPTV can be a showing of a live event or a show encoded in real-time from a remote location, such as a soccer game.
- **Managed services:** It enables video content to be offered by the phone companies who operate the IPTV business or obtained from syndicated content providers, in which the content is usually well-managed in terms of the coding and play out quality, as well as in the selection of video titles. Bandwidth for delivery and customer equipment are arranged carefully for serving the best play out performance and quality to the customers.
- **Unmanaged services:** In this service the technology of IPTV itself enables play out of any live or on demand video content from any third party over the Internet. Therefore, nothing stops a customer from accessing video content directly from any third party online such as YouTube (or Google Video), individuals, or an organization. With a wide range of choices for content selection, obviously the unmanaged services have an advantage at the expense of non-guaranteed play out quality and performance.

In wireless communication systems, there are a number of factors affect the quality of a signal received by a user equipment. These factors namely the distance between the desired user and interfering base stations, path loss exponent, log-normal shadowing, short term Rayleigh fading and noise. In order to improve system capacity, peak data rate and coverage reliability, the signal transmitted to and by a particular user is modified to account for the signal quality variation through a process commonly referred to as link adaptation. Adaptive Modulation and Coding (AMC) has become a standard approach in recent developing wireless standards, including WiMAX. However, the idea behind AMC is to dynamically adapt the modulation and coding scheme to the channel conditions so as to achieve the highest spectral efficiency at all times.

This project is geared towards investigating the performance study of IPTV (VoD) over Fixed WiMAX networks when considering different modulation and coding schemes using simulation software OPNET Modeler. This model also includes generation and integration of a streaming audio component, also provides a comparative study of performance of IPTV (VoD) over Fixed WiMAX under varying video coding and using different path-loss models and classes services under fixed types of modulation techniques in order to investigate and analyze the behavior and performance of these models. OPNET provides comprehensive development of network models including all the necessary parameters that need to be reflected in the design procedure of PHY and/or MAC layers. A series of simulation scenarios under OPNET for broadband wireless communication is developed. This project aims to establish a comparative study of performance of IPTV (VoD) over Fixed WiMAX under varying video coding and using different path-loss models and classes' services under fixed types of modulation techniques in order to investigate and analyze the behavior and performance of these models.

i. WIMAX OVERVIEW

In this Section, a brief overview of WiMAX technology is mentioned. Worldwide Interoperability for Microwave Access (WiMAX) is currently one of the hottest technologies in wireless. The Institute of Electrical and Electronics Engineers (IEEE) 802 committee has published a set of standards that define WiMAX. IEEE 802.16-2004d was published in 2004 for fixed applications; 802.16e is publicized in July 2005 for mobility. WiMAX is a standard-based wireless technology that provides high throughput broadband connections over long distance. WiMAX can be used for a number of applications, including “last mile” broadband connections, hotspots and high-speed connectivity for business customers. It provides wireless metropolitan area network (MAN) connectivity at speeds up to 70 Mbps and the WiMAX base station on the average can cover up to 5 to 10 km.

WiMAX operates in the 10–66 GHz band with line of sight (LOS) communications using the single carrier (SC) air interface. The IEEE 802.16a standard outlined non line of sight (NLOS) communications in the 2 – 11 GHz band using one of three air interfaces: SC, Orthogonal Frequency Division Multiplex (OFDM), and Orthogonal Frequency Division Multiple Access (OFDMA). OFDM and OFDMA enable carriers to increase their bandwidth and data capacity. Spacing subcarriers very closely together without interference achieve this increased efficiency because subcarriers are orthogonal to each other. Channel bandwidths range between 1.25 MHz and 20 MHz in the 2 – 11 GHz with OFDM, the number of subcarriers scales linearly with the channel bandwidth. Within a given channel bandwidth, subcarriers are allocated as: null subcarriers, data subcarriers, pilot subcarriers, and DC subcarriers. Subcarriers are then modulated using conventional digital modulation schemes with various inner code rates: Binary Phase Shift Keying (BPSK), Quadrature Phase Shift Keying (QPSK), and Quadrature Amplitude Modulation (QAM) (16-QAM, 64-QAM, and optional 256-QAM). Consequently, WiMAX data rates between 1.5 to 75 Mbps are achievable.

ii. VIDEO OVERVIEW AND COMPRESSION

This section gives a brief overview of the video content and compression technology. The video information available from video service providers is referred to as the video content. The content is structured as a sequence of video frames or images that are sent or streamed to the subscriber and displayed at a constant frame rate. Based on the differential transmission of the streaming real-time video and their buffering requirements from the network and the client server, video content is characterized by several parameters including video format, pixel color depth, coding scheme, and frame interval rate. The International Standards Organization (ISO) and the International Telecommunication Union (ITU-T) developed a numerous amount of compression technologies.

The main advantage of this code and compression technology is that it has reduced the required bandwidth for encoding content that is done by reducing the space within the frame content. The series of MPEG specifications that are in widespread use in virtually. All existing IPTV deployments have been developed by jointly between the International Telecommunication Union (ITU-T) and the International Organization for Standards/International Electro-technical Commission (ISO/IEC). The introduction of

ITU-T recommendation H.264 or also known as an advanced video codec (AVC) has become interest to deploy future IPTV and VoD.

The H.264/SVC video codec is the name for the Annex G extension of the H.264/MPEG- 4 AVC, has been found to offer improved visual quality compared to the preceding standards and proved to be suitable for dynamic bandwidth environments. Telecommunications companies focus their efforts to deploy IPTV-DVD quality video services over DSL and the Internet by using H.264 (SVC) instead of H.264/ AVC and MPEG-x.

iii. VIDEO TRAFFIC CHARACTERISTICS

This section discusses some issues that come up when have been needed to deploy video in any network. These issues are characterizing the nature of video traffic, QoE, QoS requirements, and hardware components or devices.

- **Quality of Experience (QoE)**

Quality of Experience is more important than quality of service (QoS). QoE is measured by the user's perception of the service. QoE for voice and video has traditionally been measured by Mean Opinion Score (MOS). MOS is based on the perception of the quality of conversation and picture of a sample population. The quality of real-time services for video has been benchmarked against the Mean Opinion Score (MOS) mandated by the International Telecommunication Union, and Telecommunication Standardization Sector (ITU-T) for circuit switched networks. Two standard methods used to evaluate the video quality: by calculating the PSNR between the source and the received video sequence the first method was used to assess the performance of video transmission systems, which is calculated image-wise and very similar to the well-known SNR but correlating better with the human quality perception.

- **Quality of Service (QoS)**

Quality of Service (QoS) is very important for deploying IPTV and VoD as it is a real-time service. However, QoS for deploying IPTV will be affected by packet loss, packet end-to-end delay, throughput, and jitter. Packet End-to-end delay: Small amount of delay does not directly affect the Quality of Experience (QoE) of IPTV. While the delay large than 1 second may result a much worse QoS toward end-user experience.

- **Packet loss:** Average number of packets lost compared to send a packet per second. Packet lost in the video processing layer is used for comparison purpose. There are some standard packet loss ratios given by ITU-T for classifying IPTV services. A packet loss ratio above 1% is unacceptable.
- **Jitter:** Jitter is the signed maximum difference in one-way delay of the packets over a particular time interval. Generally, it is defined as the absolute value of delay difference between selected packets.
- **Throughput:** It is the rate at which a computer or network sends or receives data. It is considered as a good measure of the channel capacity of a

communication link and connections to the Internet are usually rated in terms of how many bits they pass per second (bit/s).

RELATED WORK

There are various related efforts have explored WiMAX in the context of real-time and stored video applications. These include the challenges for QoS requirements. Challenges for delivering IPTV over WiMAX were discussed in [2]. Also, they described the transmission of IPTV services over WiMAX technology, and the impact of different parameters in WiMAX network when deploying this service. An intelligent controller was designed based on fuzzy logic to analyze QoS requirements for delivering IPTV over WiMAX. An OPNET Modeler was used to design, characterize, and compare the performance of video streaming to WiMAX and ADSL in [1], [3], [4]. Also, an intelligent controller based on fuzzy logic in [3] was used to analyze three parameters: jitter, losses and delays that affect the QoS for delivering IPTV services. The aim was to define a maximum value of link utilization among links of the network. The simulation results indicated that, ADSL exhibited behavior approached the ideal values for the performance metrics. While WiMAX demonstrated promising behavior within the bounds of the defined metrics. The work in [4] is extended work in [1] to include generation and integration of a streaming audio component, also enhanced the protocol stack to include the real time protocol (RTP) layer. Network topology was redesigned to incorporate WiMAX mobility. Also, they include characterization of WiMAX media access control (MAC) and physical (PHY) layer. Simulation scenarios used to observe the impact on the four performance metrics.

In [5] simulation used to compare the performance metrics between ADSL and WiMAX by varying the attributes of network objects such as traffic load and by customizing the physical characteristics to vary BLER, packet loss, delay, jitter, and throughput. Simulation results demonstrated considerable packet loss. ADSL exhibited considerably better performance than the WiMAX client stations. An important performance issue was addressed when multimedia traffic is carried over WiMAX systems in [6]. The main focus is to show the effectiveness of QoS capabilities in delivering streaming multimedia such as IPTV and similar media content. The results provide a good indication on the applicability of WiMAX for multimedia applications. Measured and analyzed the performance of VoIP over WiMAX in terms of crucial parameters was presented in [7]. Different parameters such as jitter, MOS value, packet end-to-end delays and packets sent and received used to measure the performance of VoIP over WiMAX with different codes G.711, G.723, and G.729 in order to find the most appropriate voice codec for VoIP over WiMAX network. The simulation results showed that VoIP performed better under the G.711 codec as compared to the G.723 and G.729 codecs. The findings also showed that VoIP applications could perform better under the exponential traffic distribution.

MAIN SECTION(s)

OPNET Simulation Model:

This section will include the description of the OPNET simulation model. The simulation was performed to evaluate the performance of VoD over the WiMAX networks. The network topology of the model is given in Figure 1.

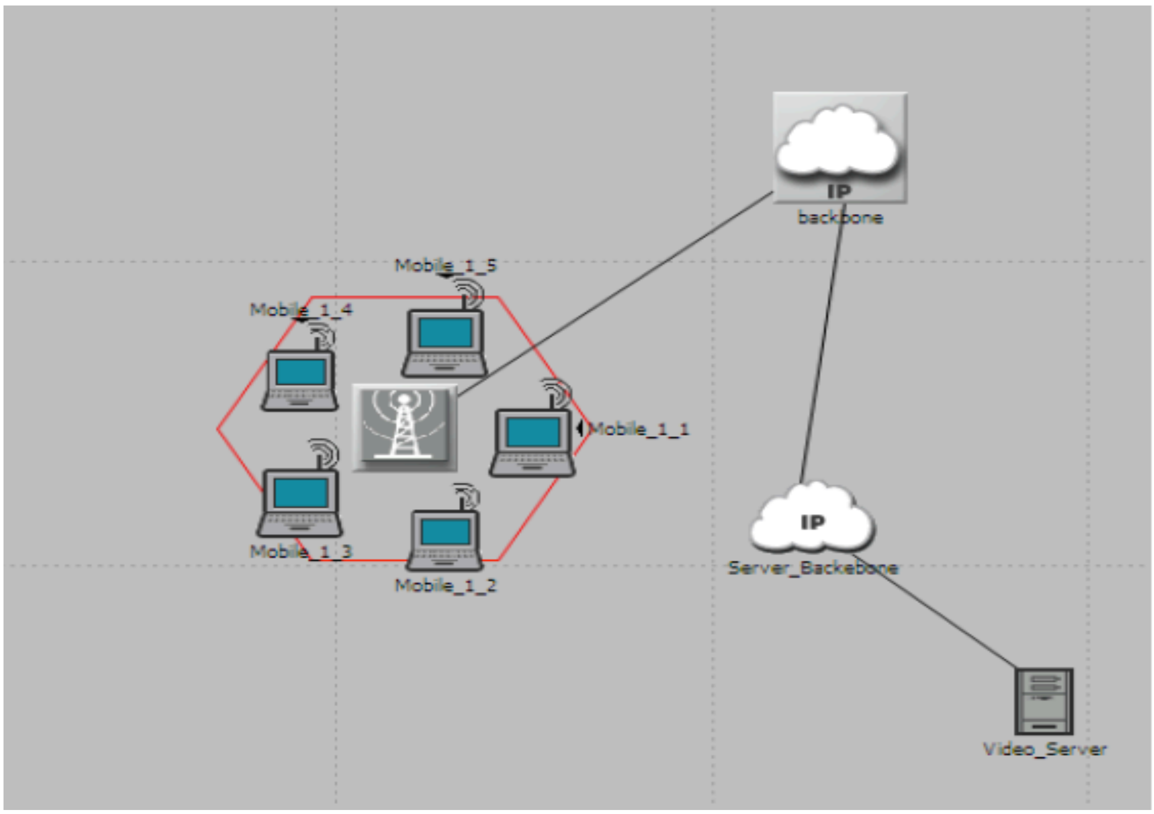

Figure 1. OPNET model of WiMAX network

The network topology of our test bed network is given in Figure 1. This model consists of a circular placement of nodes in a hexagon with one WiMAX Base Station, and five Subscriber Stations (SS), which are 1km apart from the Base Station (BS). These nodes are fixed nodes, which means no mobility is configured. The BS is connected to the IP backbone via a DS3 WAN link, the video server connected to the server backbone via ppp_sonet_oct1 link. Various scenarios have been designed in this simulation to measure the performance of some parameters such as throughput, jitter, packet loss and packet end-to-end delay as well as to meet the goal to analyze the quality of service of IPTV (VoD) over WiMAX networks.

Video streaming over wireless networks is challenging due to the high bandwidth required and the delay sensitive nature of video than most other types of application. As a result, video traces of Tokyo Olympics with different video codes were used in our simulation. These traffics were obtained from Arizona State University [14] with a

532x288 from resolution; Group of Picture (GOP) size is selected as 16 for this video for all codes, and encoded with 30 frames per seconds (fps). Table 1 shown below contains the mean and peak rates for these video codes of the Tokyo Olympics movie; all the video traces reflect only video frames.

Parameters	**H.264/AVC**	**SVC**
Frame Compression Ratio	21.7	18.01
Min Frame Size (Bytes)	17	22
Max Frame Size (Bytes)	62289	58150
Mean Frame Size (Bytes)	7004.52	8440.74
Peak Frame Rate (Bytes)	14.92	13.9
Mean Frame Rate (Bytes)	1.68	2.02
Mean Frame PSNR (dB)	46.49	47.89

Table 1. Video Codec traces characteristics [11]

Configuration:

Video Application Configuration

This section will include the configuration of the simulation model. To the best of our knowledge, the OPNET Modeler does not have built-in features to support video streaming or its deployment. In this subsection, we elaborate on our approach for emulating video streaming traffics. The parameters of the video conferencing application in modeler are: The frame inter-arrival time and the frame size. The incoming frame inter-arrival rate was configured to reflect the content encoding rate of 30 fps, and the outgoing stream inter-arrival time remains at none to create a unidirectional stream. The video traces were scripted into video conferencing frame size as shown in Figure 2.

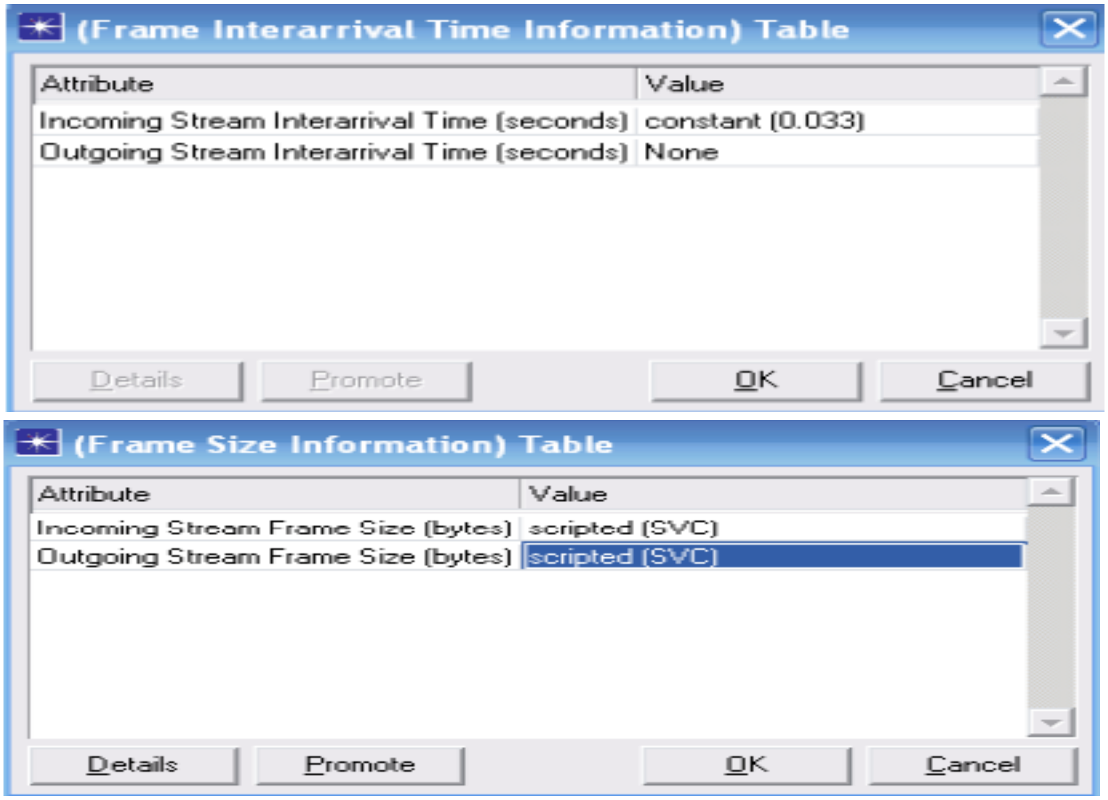

Figure 2. Application configuration of video traffic.

The modeler profile configuration is shown in Figure 3. The operation mode for this profile was configured to be simultaneous, with a starting time of 70 seconds. The video clients are subsequently configured with this profile, and the VoD server is configured to support these appropriate application services.

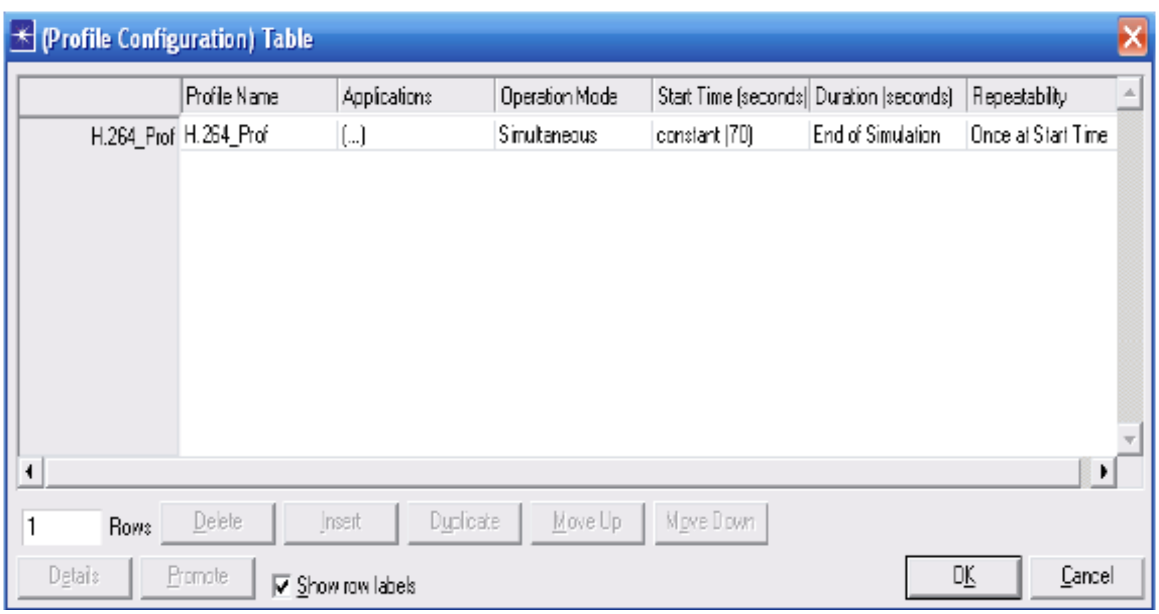

Figure 3. H.264/SVC video streaming traffic profile configuration.

WiMAX Configuration

The WiMAX model was configured to support video traffic on only fixed station, which means that it's not supporting the feature of mobility. The scheduling has been configured with 5 Mbps Maximum sustainable traffic rate, and 1 Mbps Minimum sustainable traffic rate as shown in Figure 4.

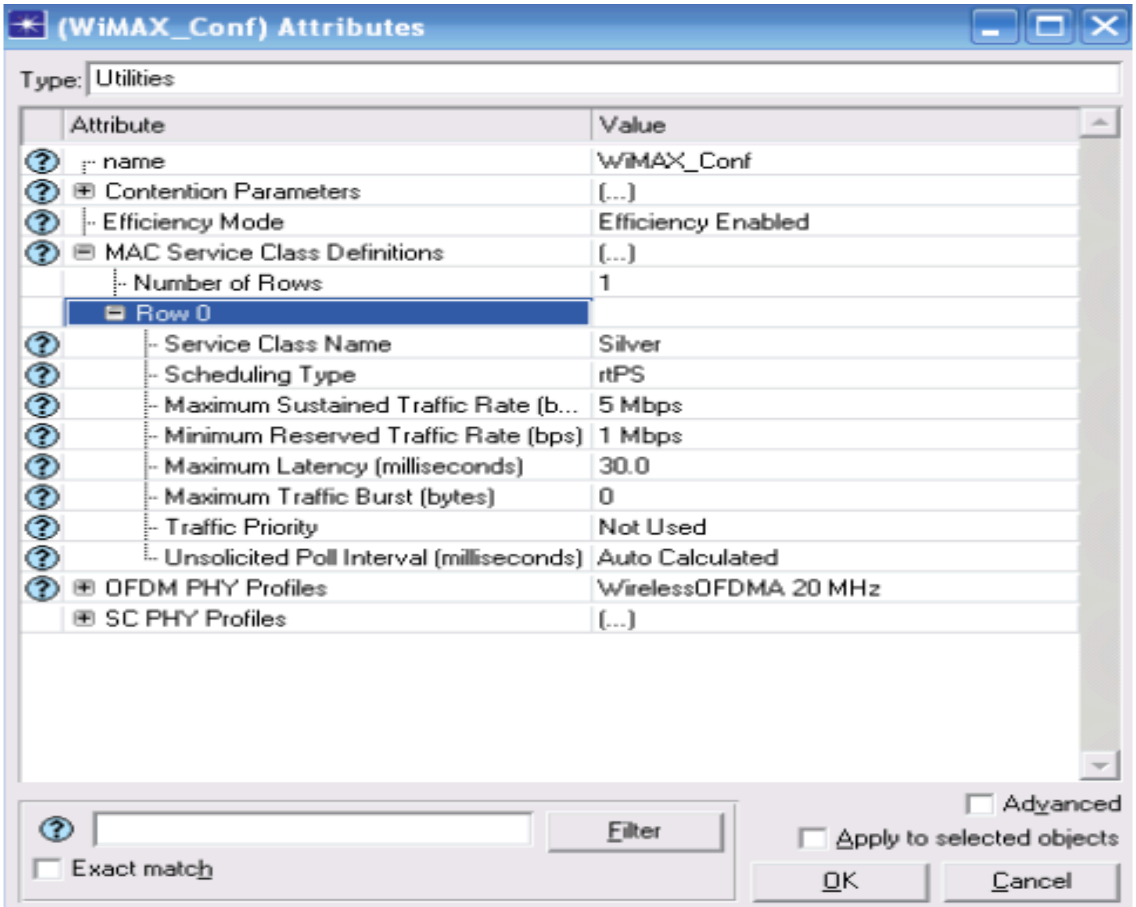

Figure 4. WiMAX configuration.

The Base Station and WiMAX Subscriber Stations were configured to map the uplink and down link service flows to a specific type of service (ToS) setting that was configured during the application node configuration. Moreover, each service flow uplink and downlink can be configured with the specific burst profile. For this study, the uplink channel was configured with 16-QAM, which is different burst profile than of downlink 64-QAM. Figure 5, and Figure 6 show Base Station, and Subscriber Stations configuration parameters.

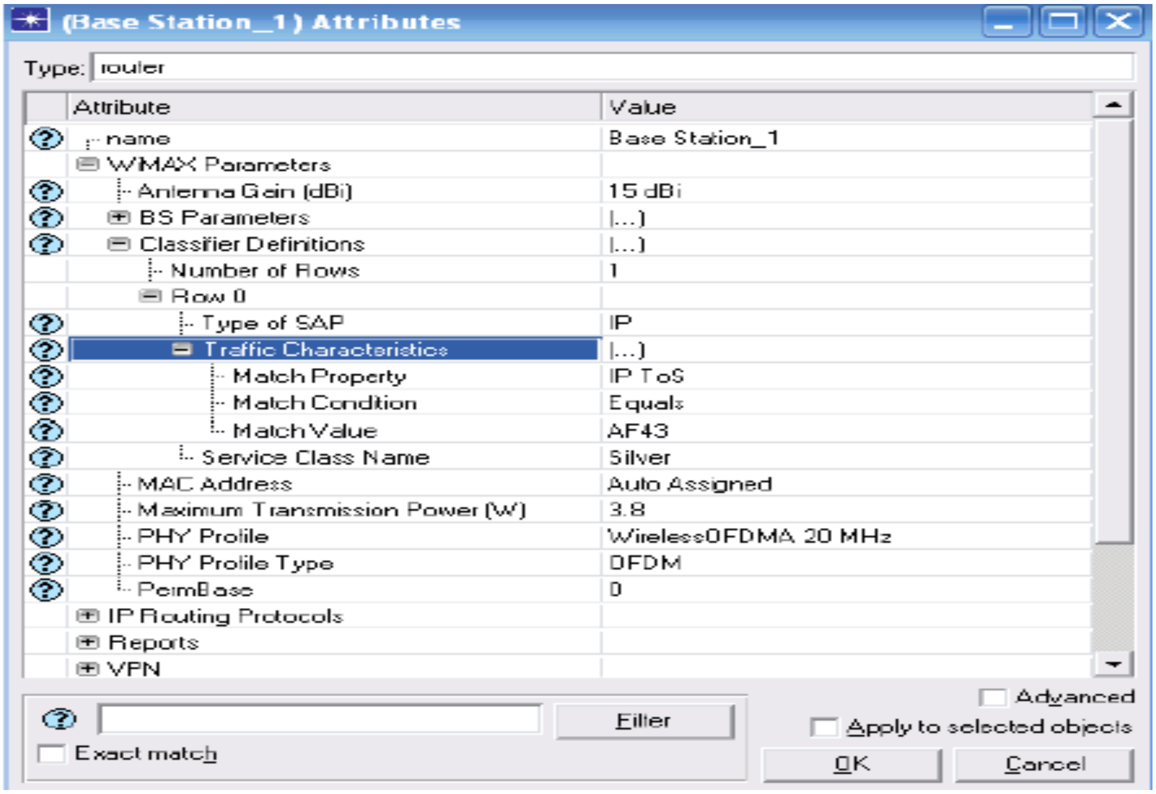

Figure 5. Base station configuration parameters.

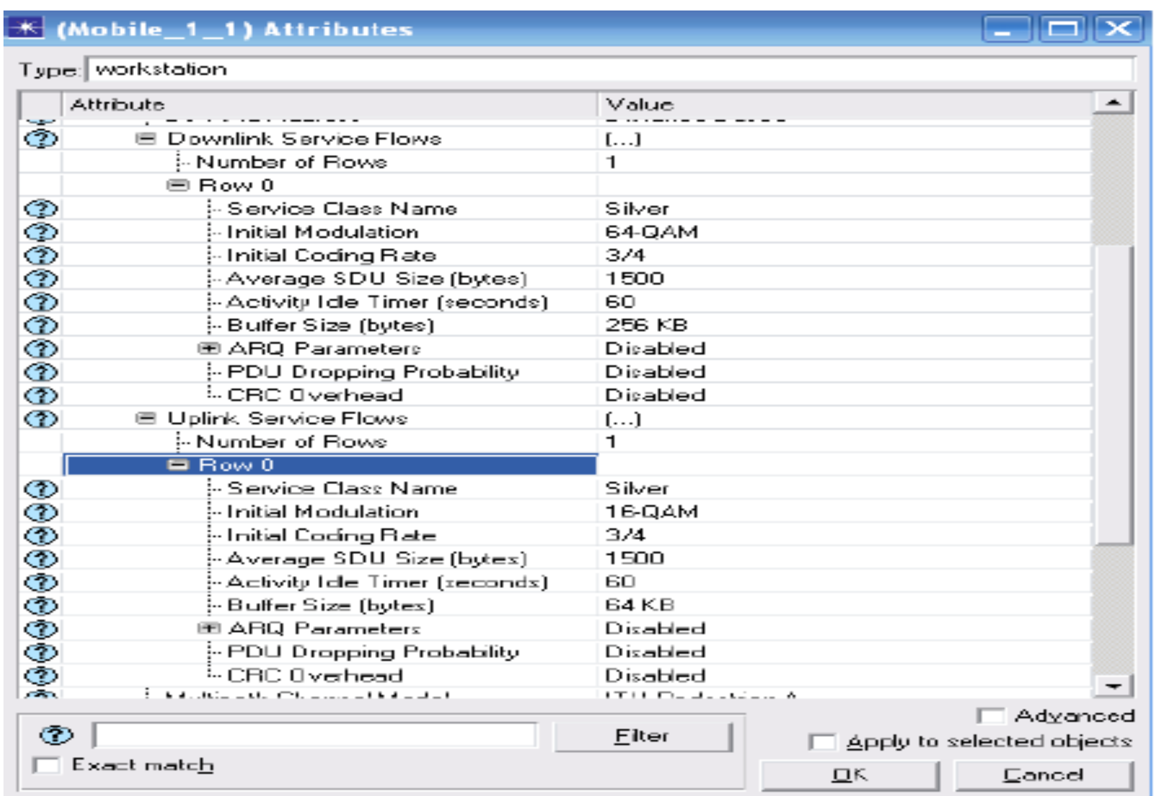

Figure 6. Subscriber station configuration parameters.

Physical (PHY) layer access was configured to utilize OFDM over a 2.5 GHz base frequency using a 5 MHz channel bandwidth that provisions 512 subcarriers allocated. The base station transmit power was configured to 35.8 dB which equals approximately 3.8 watts with 15 dBi gain antenna. On the other hand, the client station transmit power was configured to use 33 dB equivalent to about 2 watts of transmit power over the 5MHz channel bandwidth, using 14 dBi gain antennas.

RESULTS:

The simulation results will be discussed in this section. Snapshots of OPNET simulation results for deploying VoD services with different codes over WiMAX model was presented in this section. The goal of our simulation was to test the deployment, and to analysis the performance metrics IPTV (VoD) over WiMAX networks. The performance metrics of SVC codec mentioned in [11] have been used during the analysis of the derived simulation results.

Parameters	**SVC**
Throughput	1.25 Mbps
End-to-End delay	2.7 milliseconds
Jitter delay	5.6 microseconds
PSNR	47.89 dB

Table 2. Performance metrics of SVC video codec.

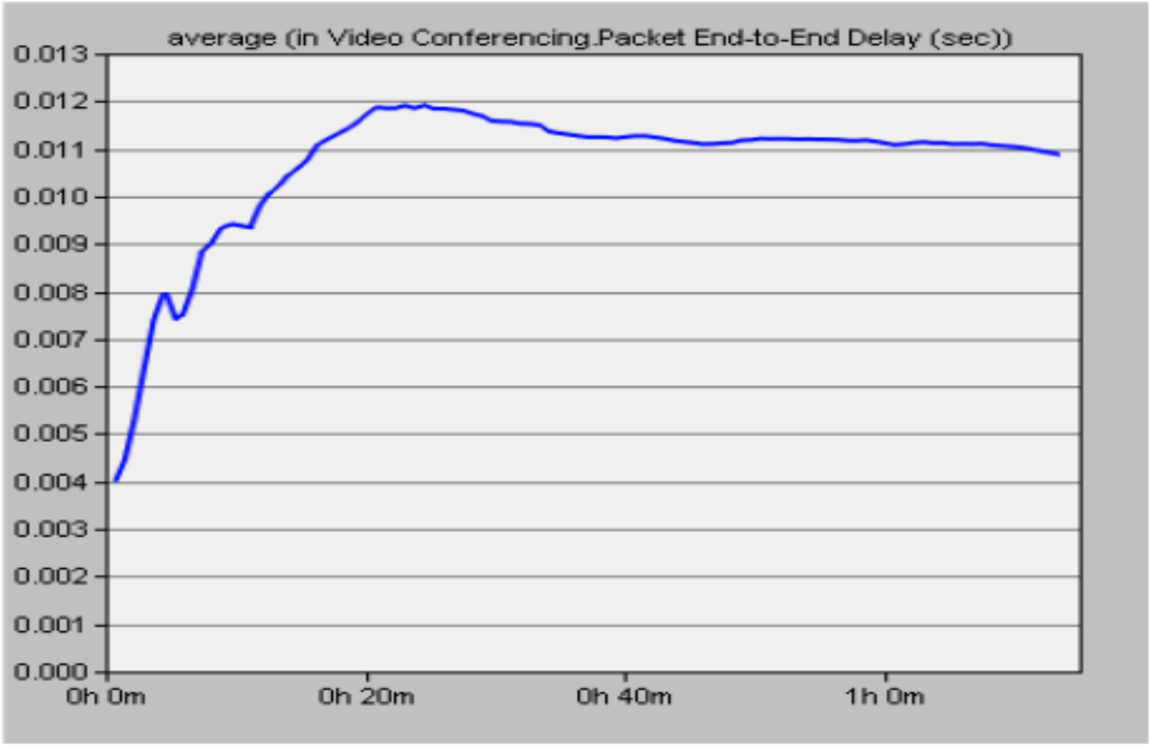

Figure 7. Average End-to-End packet delay.

The ideal jitter is less than 10ms, which is the Packet Delay Variation for the video traffic. The average jitter value for multiple users is shown in Figure 8 and it is about 60 μs.

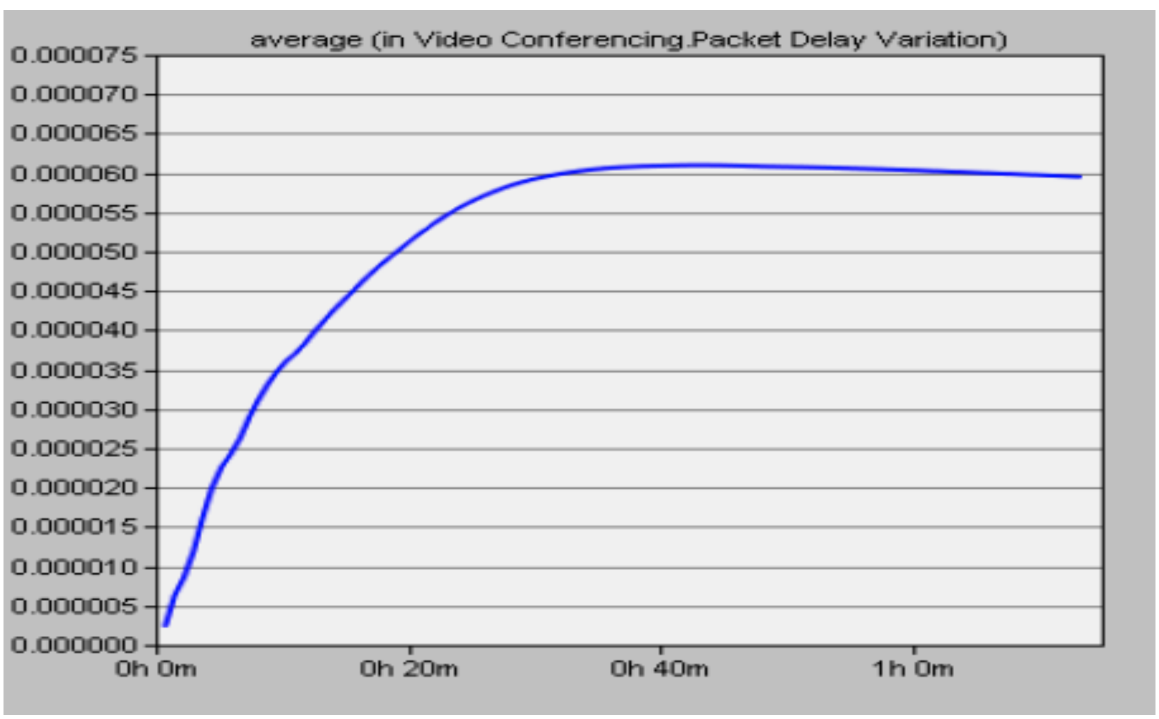

Figure 8. Jitter delay.

We can observe that the jitter value for our case is significantly less than the ideal value of 10ms, which is considered as a robust statistic. The throughput for our case in the range required of 10 kbps – 5 Mbps. The average throughput for our case is about 1.5 Mbps as shown in Figure 9.

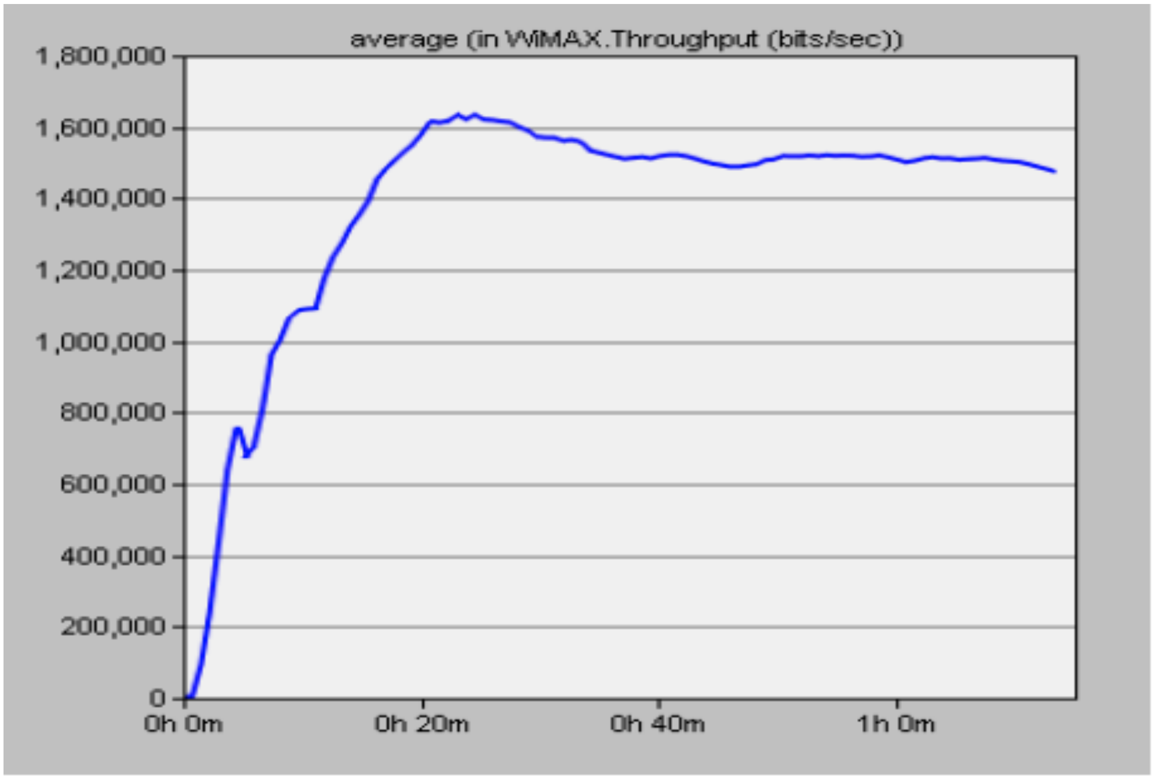

Figure 9. Average throughput.

This indicates the throughput of our video codec is as expected. The dropped packet rates by the PHY layer for the WiMAX Subscriber Station are shown in Figure 10, which exhibits a much higher loss rate.

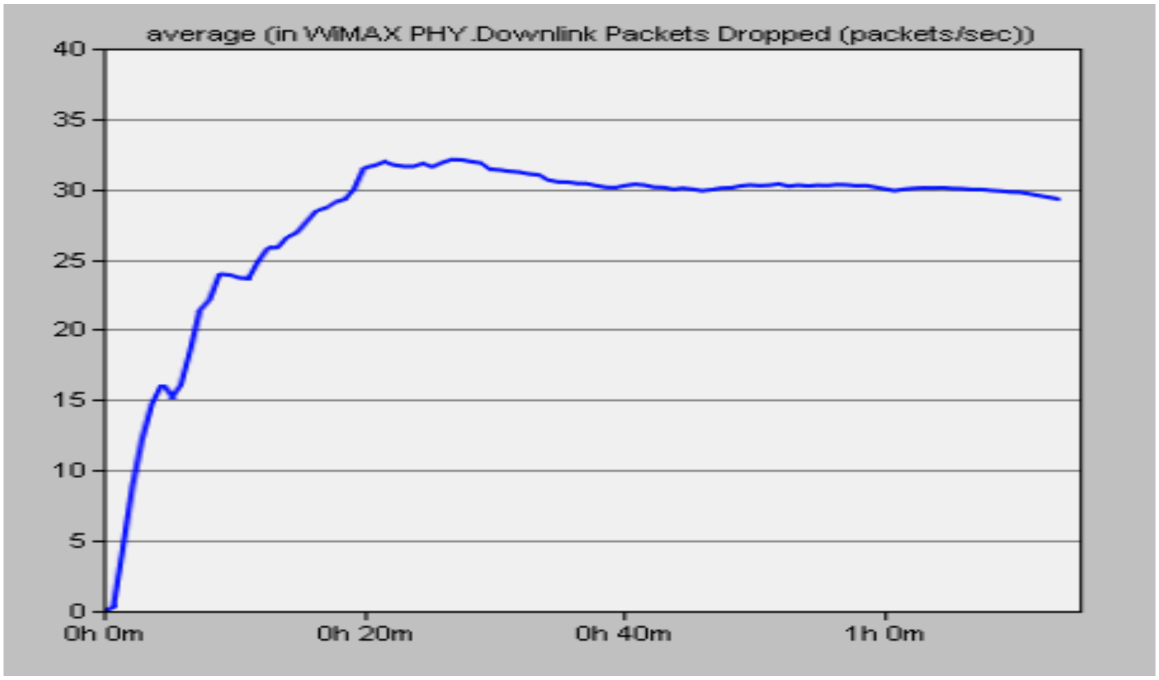

Figure 10. Dropped packet rates by PHY layer for WiMAX SS.

The downlink SNR for the Subscriber Station is shown in Figure 11.

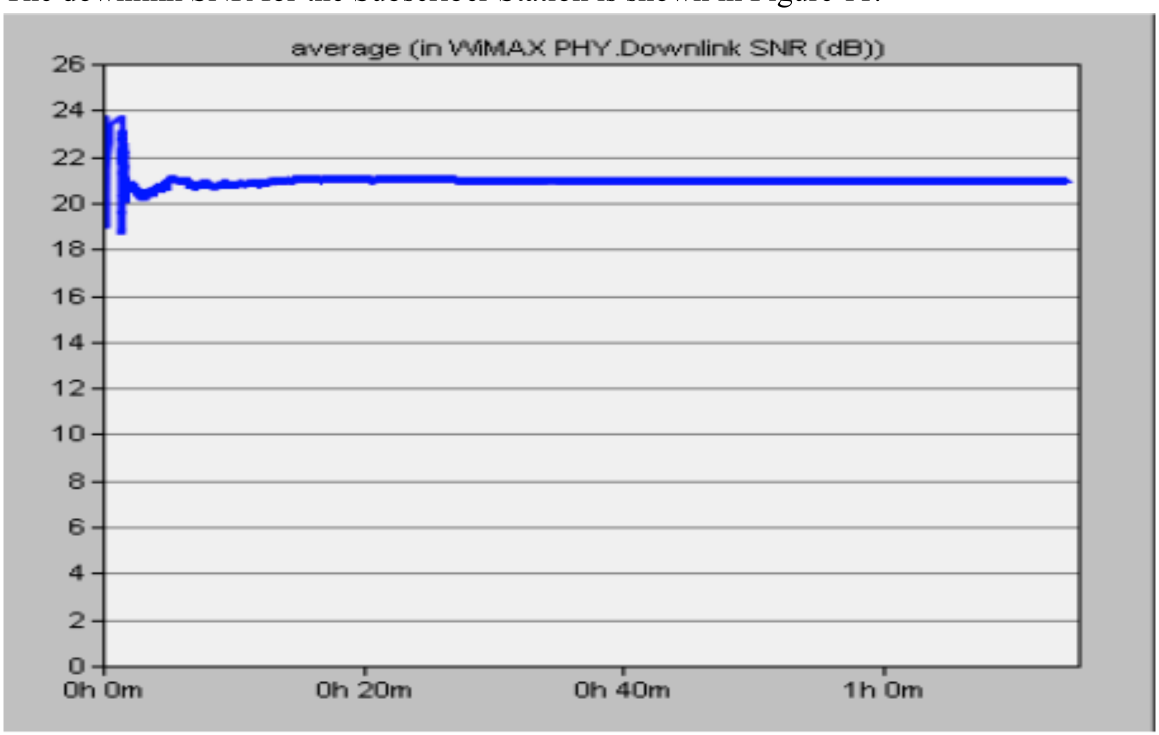

Figure 11. Downlink Signal Noise Ratio (SNR) for SS.

The subscriber station exhibits a downlink SNR that is below the necessary minimum level for 64-QAM. The low SNR for the subscriber station is a major contributor to the high packet loss rate. Quality of Experience has been measured by MOS. Mean Opinion

Score (MOS) is dependent on calculating the Peak Signal Noise Ratio (PSNR). We used the PSNR ratio from the State University [14] as in Table 2. From that result, we can see all these codes have a good MOS, and PSNR for SVC code is about 47.89, which means it has an excellent MOS. The simulation results clearly indicate that SVC provides the best quality of video in terms of MOS value, throughput, end-to-end delays and jitters. Therefore, SVC the most appropriate video codec scheme for delivering IPTV services over WiMAX network.

CONCLUSION:

This study explores the technical details and performance analysis of IPTV over WiMAX broadband access technology. Its aim is to address the performance metrics of QoS for video streaming when deploying over WiMAX access technology. The OPNET Modeler is used to design and characterize the performance parameters of Tokyo Olympics video streaming with different codes of H.264.x to WiMAX video subscribers using QoS performance metrics. The simulation results indicate that, the H.264/SVC video codec has been found to offer improved visual quality and appropriate codes for delivering video compared to the preceding standards. Furthermore, the streaming video content has been modeled as unicast traffic while multicast video traffic may have yielded better performance. This work has some limitations to certain assumptions such as the station transmit power, distance between base station and subscriber station, subscriber station was configured as fixed not support mobility, station antenna gain, carrier operating frequency and channel bandwidth.

FUTURE WORK

This model can be configured using the feature of mobility. It can be configured using other video codecs such as H264/AVC. As a future study, study the impact of mobility on video quality, and also the impact of using multicast SVC multilayer adaptation scheme on enhancing the performance of video streaming over mobile WiMAX. The work can be implemented to overcome some limitations such as the station transmit power, distance between base station and subscriber station, subscriber station was configured as fixed not support mobility, station antenna gain, carrier operating frequency and channel bandwidth.

REFERENCES

[1] W. Hurdey and L. Trajkovic, "Streaming video content over IEEE 802.16/WiMAX broadband access," *OPNETWORK 2008*, Washington, DC, Aug. 2008.

[2] A. Shehu, A. Maraj, and R. M. Mitrushi, "Analysis of QoS requirements for delivering IPTV over WiMAX technology," *International Conference on Software, Telecommunications and Computer Networks (SoftCOM)*, Sept. 2010, pp. 380-385.

[3] A. Shehu, A. Maraj, and R. M. Mitrushi, “Studying of different parameters that effect QoS in IPTV systems,” International *Conference on Telecommunications and Information (WSEAS)*, 2010.

[4] W. Hrudey and Lj. Trajkovic, "Mobile Wimax MAC and PHY layer optimization for IPTV," *Journal of Mathematical and Computer Modeling*, Elsevier, Mar. 2011, vol. 53, pp. 2119–2135.

[5] R. Gill, T. Farah, and Lj. Trajkovic, “Comparison of WiMAX and ADSL performance when streaming audio and video content,” *OPNETWORK 2011*, Washington, DC, Aug. 2011.

[6] D. J. Reid, A. Srinivasan, and W. Almuhtadi, "QoS Performance Testing of Multimedia Delivery over WiMAX Networks," First International Conference on Data Compression, Communications and Processing (CCP), 2011, pp. 271-274.

[7] [S. Alshomrani, S. Qamar, S. Jan, I. Khan and I. A. Shah, ―QoS of VoIP over WiMAX Access Networks,‖ International Journal of Computer Science and Telecommunications, April 2012, Vol. 3, Issue 4, pp. 92-98.

[8] K. Ain, M. S. R. Tarafder, S. A. Khan, and M. L. Ali, “Path Loss Compensation Technique for WiMAX Technology Based Communication System,” *International Journal of Engineering Science and Technology*, 2011, vol.3, no.9, pp.7226-7233.

[9] Uilecan, C. Zhou, and G. Atkin, “Framework for Delivering IPTV Services over WiMAX Wireless Network,” in *Proc. of IEEE EIT 2007*, Chicago, IL, May 2007, pp. 470-475.

[10] J. She, F. Hou, P. H. Ho, and L. L. Xie, “IPTV over WiMAX: Key Success Factors, Challenges, and Solutions,” *IEEE Communication Magazine,* 2007, vol.45, no.8, pp. 87- 93, 2007.

[11] J. Hamodi, and R. Thool, “Investigate the performance evaluation of IPTV over WiMAX networks,” *International Journal of Computer Networks & Communications (IJCNC)*, vol. 5, no.1, pp. 81-95, 2013.

[12] So-In Ch, Jain R, Tamimi A-K., “Scheduling in IEEE 802.16e Mobile WiMAX Networks: Key Issues and a Survey,” *IEEE Journal on selected areas in Communications*, 2009, vol. 27, no. 2, pp. 165-171.

[13] D. Niyato, E. Hossain, and J. Diamond, “IEEE802.16/ WiMAX-Based Broadband Wireless Access and its Application for Telemedicine / E-Health Services,” *IEEE Wireless Communications Magazine*, Feb. 2007, vol. 14, no. 1, pp. 72–83.

[14] (April 8, 2014) G. Auwera, P. David, and M. Reisslein, “Traffic characteristics of H.264/AVC and SVC variable bit rate video” [Online]. Available: http://trace.eas.asu.edu/h264/index.html.