Effect of WiMAX Networks on IPTV Technology

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Abstract

The IEEE 802.16 technology (WiMAX) is a better alternative to 3G or wireless LAN networks for providing last mile connectivity by radio link due to its high data rates, low cost of deployment and large coverage area and Ease of Use. With the IEEE 802.16e−2005 mobility amendment, WiMAX promises to address the ever-increasing demand for mobile high speed wireless data in fourth-generation (4G) networks. WiMAX supports various multimedia applications like VoIP, IPTV and online gaming. Quality of Service is an essential parameter to judge performance of any Network. WiMAX market studies continue to project increased subscriber growth rates and planned carrier trials worldwide. Coupled with these increasing growth rates and higher WiMAX throughput rates, bandwidth intensive video on demand (VoD), Internet Protocol TV (IPTV), and mobile TV services are emerging in the forefront of the mobile arena. In this paper, analyzing QoS parameters through OPNET Modeler that affects on IPTV and IPTV over WiMAX such as Packet delay variation, ,Packet end to end delay, traffic sent (packets/sec) and traffic received (packet/sec) according to coverage area and number of IPTV connections. Results at the end of system simulation shows that WiMAX increase number of IPTV connections and allows making IPTV transmission anywhere.

Keywords: *Internet Protocol Television (IPTV); Worldwide Interoperability of Microwave Access (WiMAX); Physical and Media Access Control (MAC) Layers of WiMAX; OPNET Modeler 14.5*

1. Introduction

Worldwide Interoperability for Microwave Access (WiMAX) embodies the IEEE 802.16 family of standards that provide fixed and mobile broadband access in the telecommunications landscape. Initially, WiMAX was employed as a last mile broadband access solution, circumventing the significant infrastructure costs of cable and Digital Subscriber Line (DSL) deployments. Recently, Mobile WiMAX has launched WiMAX into fourth-generation (4G) mobile data networks competing for subscribers demanding unprecedented levels of personalized, media-rich services. Consequently, telecommunication carriers are experiencing heightened competitive challenges in an effort to address these evolving subscriber demands. In 2007, there were over one hundred planned carrier trials worldwide [2]. Market researchers are projecting 198% compound annual growth rate in Mobile WiMAX systems [3]. In March 2008, the WiMAX Forum published projections of 133 million subscribers by 2012 [4]. In February 2009, the WiMAX Forum was reporting just under 460 WiMAX fixed and mobile deployments worldwide while over 800 million subscribers were projected by 2010 [5]. Intel has projected that over 1.3 billion people will have access to WiMAX by 2012 [6]. IPTV, or Internet Protocol Television, delivers digital television to subscribers via the Internet Protocol. This means video data are sent across the Internet in packets of data. It can then be stored on a server and sent to computers or special set-top boxes over a broadband connection. Despite this it is not ‘‘internet television’’ in the sense that people are or will be logging on to their favorite web page to access television programmers. Rather, it is a way of delivering information over a managed network that gives consumers much greater control over their desired information and entertainment experience [7]. Internet Protocol Television (IPTV), the convergence services of television and Internet, is being rapidly developed around the world. The advent of digital technologies has changed the convergence market dramatically with the wide diffusion of the convergent services. Using the Technology Acceptance Model as a conceptual framework and method of logistic regression, this research analyzes the demand for IPTV by drawing data from 452 consumers. Individuals' responses to questions about whether they accept IPTV are collected and combined with observations of their socio-economic status and intrinsic/extrinsic factors modified from the Technology Acceptance Model. Results of logistic regression show two variables (intrinsic and extrinsic factors) that seem to explain what influences consumer behavior towards adopting IPTV. Overall, the logistic regression model explains over 50% of the variance in the IPTV adoption. The variances shed light on the multi-open platform environment that IPTV will forge. This paper is organized at the following sections (i) Review of WiMAX, (ii) IPTV, (iii) QoS Metrics and (iv) System model.

2. WiMAX overview

WiMAX network is an emerging standard for wireless access technology that provides high data rates and QoS over a wide area. Now, a brief introduction to the physical and MAC layers of the WiMAX network follows.

2.1 The physical Layer of WiMAX

WiMAX network supports several transmission modes at the physical layer, i.e. SC (Single Carrier) mode, OFDM (Orthogonal Frequency Division Multiplex) mode, and OFDMA (Orthogonal Frequency Division Multiple Access) mode. In the OFDM system, FEC coding is applied to the transmitted data stream for error resilience (i.e. more robust FEC coding provides stronger error protection). RS concatenated with CC (Convolution Code) coding is mandatory for all WiMAX network implementations. The standard optionally supports CTC and LDPC (Low-Density Parity Check) codes. Then a resulting data stream is divided into multiple parallel low rate data streams. Each low rate data stream is mapped to an individual data subcarrier and modulated using some sort of PSK (Phase Shift Keying) or QAM (Quadrature Amplitude Modulation) such as BPSK (Binary Phase Shift Keying), QPSK (Quadrature Phase Shift Keying), 16QAM, and 64QAM. In fact, modulation is the process of translating a data stream into a form suitable for transmission on the physical medium, and its performance is measured by the ability to preserve the accuracy of the encoded data.

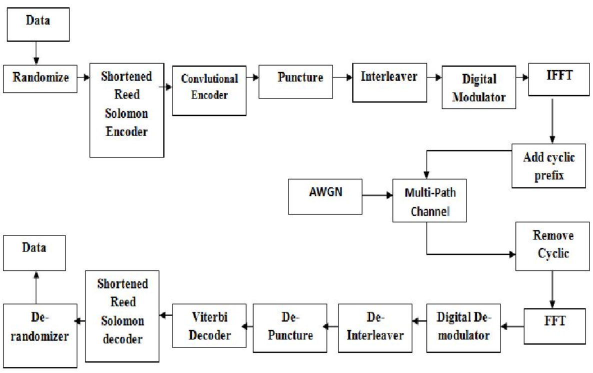

Fig. 1 WiMAX physical Layer Block Diagram.

Table.1 Representative Combinations of modulation and coding rate of the WiMAX network

Modulation	Overall coding Rate	CC code Rate
64 QAM	3/4	5/6
64 QAM	2/3	3/4
16 QAM	3/4	5/6
16 QAM	1/2	2/3
QPSK	3/4	5/6
QPSK	1/2	2/3

For each channel bandwidth, both time and frequency resources are assigned. The sampling factor n is channel size dependent Where channels that are a multiple of 1.75 MHz should use n = 8/7 and channels that are multiples of 1.25, 1.5, 2, or 2.75 MHz should use n = 28/25 [14, 15]. Consequently, the sampling factor is applied to a given channel bandwidth size to Determine the sampling frequency (Fs). The respective sample time is determined by taking the inverse of Fs. The sampling frequency f is then divided by the FFT size (NFFT) to derive the sub-carrier spacing. This concept is the underlying premise in SOFDMA systems, which scale the FFT size to the channel bandwidth in order to maintain the same fixed sub-carrier spacing across different channel sizes. In doing so, this scheme keeps the basic OFDMA symbol resource.

$$FFT{:}Y(K) = \sum_{n=0}^{N-1} X(n) W_N^{-nk} \quad ,K = 0,1,2,\dots,N-1 \qquad (1)$$

$$IFFT{:}Y(K) = \frac{1}{N}\sum_{n=0}^{N-1} X(n) W_N^{nk} \quad ,K = 0,1,2,\dots,N-1 \qquad (2)$$

2.2 The MAC Layer of WiMAX

In general, MAC, sub-layer of Data Link layer, supports addressing and channel access control mechanisms for network nodes or terminals to communicate within a network. MAC of the WiMAX network is operated in a centrally controlled manner, i.e. the resource allocation is dynamically managed by BS. Fig. 1 represents the OFDMA frame structure in TDD (Time Division Duplex) implementation. The medium is divided into continuous MAC frames in time and sub-channels. Each MAC frame is configured by DL (Downlink) and UP (Uplink) sub-frames. At the beginning of each MAC frame, the BS transmits DL Map and UL Map into the DL sub frame. These maps provide resource allocation and other control information for DL and UL sub-frames, respectively. In each frame, TTG (Tx/Rx Transmission Gap) and RTG (Rx/Tx Transmission Gap) are inserted between the DL and UL

sub-frames, which are time gaps between transmission and reception.
The minimum resource allocation unit is called a slot, which is configured by one sub-channel over one, two, or three OFDM symbols depending on the subcarrier permutation scheme. A burst is a contiguous series of slots assigned to a given subscriber and different MCS (Modulation and Coding Scheme) can be applied to it. Transmission rate on the slot is dependent on associated MCS and a tradeoff exists between link robustness and throughput. In other words, the BER (Bit Error Rate) performance which suffers from fading and shadowing in wireless channels is improved at the cost of bandwidth efficiency, as modulation becomes sparser and coding rate lower. In contrast, denser modulation and higher coding rate provide higher data rates on the slot and increase sensibility against wireless channel error. QoS is applied to transmission and scheduling of data over the PHY layer. Privacy sub layer provides authentication, secure key exchange and encryption on the MAC PDUs formed from the MAC SDUs and passes them over to the physical layer [10].

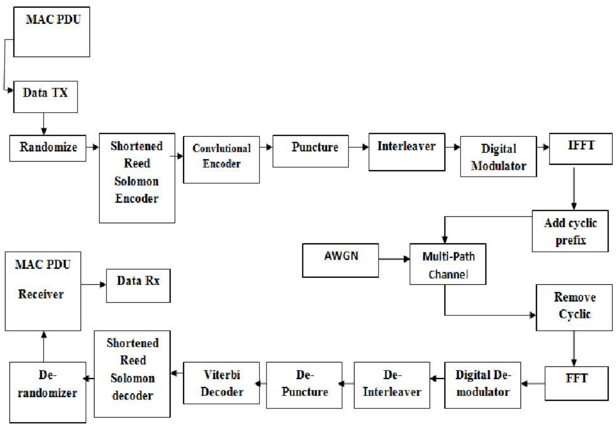

Fig. 2 WiMAX MAC Layer Block Diagram.

3. IPTV

Functional block diagram of an IPTV application is illustrated in Fig. 3. Video servers/encoders store audio/video (A/V) content which are encoded and compressed from live and pre-recorded programs. Video servers/encoders are either centralized or distributed in core networks. Fig. 4 shows the protocol stack for IPTV transmission. A/V content from the source is formatted, compressed (mostly using MPEG-2 encoding and compression standard) and is encapsulated as real time transport protocol (RTP).

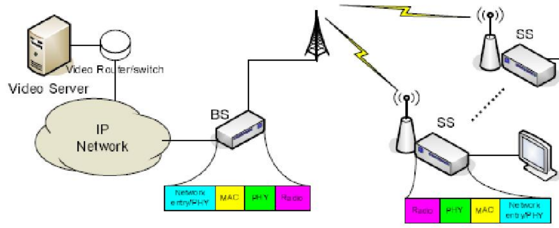

Fig.3. system Model for IPTV Applications

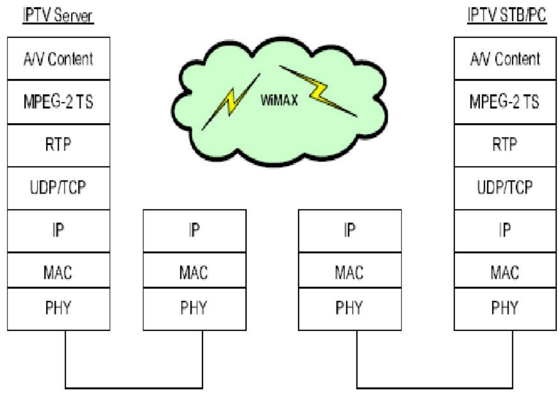

Fig.4. Protocol Stack for IPTV Transmission

The payload can be either standard definition (SDTV) or high definition (HDTV). For real time streaming video services, UDP ports can be used and for video on demand (VoD), TCP ports can be used. Broadcast, multicast or uncast services are also supported. As a result, there can be multiple packets from various sources that must be delivered to targeted users with different QoS parameters making it a challenging task. WiMAX BS MAC addresses this issue through effective scheduling of services. For this reason, it is expected that MAC scheduling and implementation will be a key differentiator amongst competitors products.

3.1 Why IPTV?

The author analyzes what delivery of TV over an IP network means, both in terms of possibilities for new services, and in terms of the impact on the network and how it has to be managed. In addition, Why IPTV? Helps you understand how introducing IPTV into the Web 2.0 world will impact the new services. It looks at the current trends in the consumer electronics industry as well as the network industry, and describes how the new technology can enhance and extend the existing business models in the TV industry, particularly in advertising; and also how it creates new possibilities, for instance, through personalization. IPTV solution provides augmented services to an existing Ethernet network without the disruption of installing new cabling or hardware for each user. To minimize support requirements, the PC client is designed to be loaded as part of a customized web page providing a simple, flexible TV solution for the PC environment. Broadcast quality live Digital TV content (satellite/terrestrial) in HD or SD is delivered to a PC or TV providing a bespoke channel line-up in accordance with a customer's requirements. Support for recording live content onto IPTV network attached Personal Video Recorder server. Enabling users to record and playback particular programmers at a time convenient to them.

3.2 IPTV Standardization

Standardization of IPTV is important and difficult; however, it is mandatory for successful deployment. There are no established standards at this stage. Lack of standardized technologies causes unnecessary investments and unavailable new services, and therefore it is feared that some businesses may be forced to use proprietary solutions [11]. Standardization of NGN has progressed in the International Telecommunication Union — Telecommunication Standardization Sector (ITU-T) that includes IPTV services [11].

3.3 IPTV Plus Mobile Approach

Although many think that "networked TV" will be the future of television, IPTV is currently dominated by Telco giants in an attempt to find a new source of cash-in. IPTV services are originally targeted to fixed terminals such as set-top boxes as shown in figure 5, however, issues on the requirements for mobility support were raised as an out-growth under the auspices of the Fixed-Mobile Convergence (FMC) trend. The outstanding activities are ATIS in the US, Open IPTV Forum, and ITU-T FG IPTV internationally. The development of Mobile IPTV specification is at an early stage. Currently, ITU-T FG IPTV is collecting requirements regarding mobility and wireless characteristics. ATIS has not shown any interest in mobility support yet. In Open IPTV Forum, mobility service entirely based on IMS (IP Multimedia Subsystem) which is a set of specification from 3GPP for delivering IP multimedia to mobile users will be forthcoming.

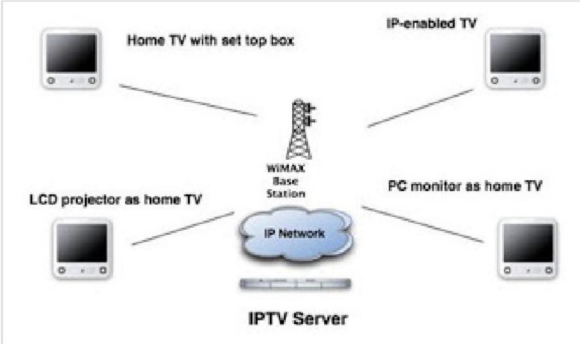

Fig.5.IPTV Server

3.4 Proposed mobile IPTV system architecture over WiMAX network

Mobile IPTV system architecture under our consideration is shown in Fig. 6. It is assumed that the head end receives IPTV channel streams from terrestrial, cable, and satellite broadcasting systems, and then transmits them to the BS of the WiMAX network in IP multicasting manner. Subscribers are connected to the BS through WiMAX-enabled devices. Thus, BS plays the role of an agent between access network and core IPTV network. The goal of the proposed system is to provide IPTV service of better quality to more subscribers. To achieve this goal, BS controls the incoming IPTV multicast streams according to the wireless link states of subscribers, and sends them through MBS zone.

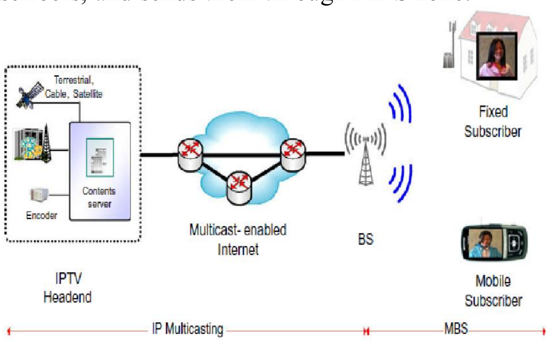

Fig.6 Mobile IPTV system architecture.

The outbound MAC then associates packets traversing the MAC interface into a service flow to be delivered over the connection [8]. The QoS parameters associated with the service flow define the transmission ordering and scheduling on the air interface. The connection-oriented QoS therefore, can provide accurate control over the air interface. Since the air interface is usually the bottleneck, the connection-oriented QoS can effectively enable the end-to-end QoS control. The service flow parameters can be dynamically managed through MAC messages to accommodate the dynamic service demand. The service flow based QoS mechanism applies to both DL and UL to provide improved QoS in both directions. Mobile WiMAX supports a wide range of data services and applications with varied QoS requirements.

3.5 Video Content Overview

In this section, we give a brief overview of video content that consists of both the audio and the visual information available from media service providers hosting VoD and IPTV services as shown in figure 7. The content originates from a wide range of sitcoms, newscasts, sporting events, and movies in real time and stored video (VoD) formats. It is structured as a sequence of video frames or images that are transmitted or ''streamed'' to the subscriber and displayed at a constant frame rate [6]. The video component is coupled (typically separately) with a multi-channel audio component that is also structured as a series of audio frames to collectively comprise the video content. Such content is inherently loss-tolerant yet delay sensitive [9], which implies that video playback on the subscriber stations, may tolerate some degree of frame loss. However, delays or variations in inter-frame reception rapidly degrade the overall video playback experience. Various video coding schemes have been engineered to reduce the raw video size by exploiting this redundancy while balancing quality. These schemes include the International Telecommunications Union (ITU) H.26x and International Standards Organization (ISO) Motion Picture Experts Group (MPEG) codec's. The audio component of the streaming video content may be viewed as a one or more audio channels encoded into a multi-channel audio stream. Channel configurations range from a single channel to 7.1 configurations consisting of left, center, right, left surround, right surround, left back, right back, and low frequency effects (LFE) channels. However, as one separately encodes additional source channels, the resulting audio stream bandwidth requirements increase. A potential compromise in IP-based video streaming systems is the down-mixing (matrixing) of multi-channel sources into conventional two-channel stereo format (known as stereo surround sound) or to only encode the two main channels.

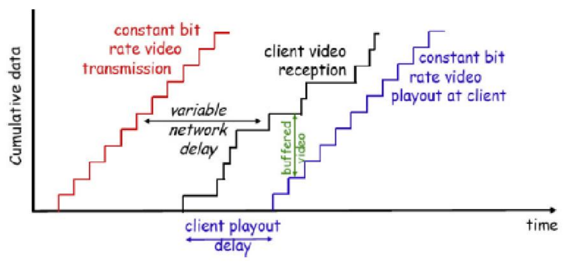

Fig.7. Buffering required at the video client station [9].

3.6 Quality of Services Metrics.

Quality of Service (QoS) is very important for deploying IPTV and VoD as it is a real-time service. In our simulations, we use the following metrics to evaluate the performance of WiMAX network in terms of end-to-end QoS for IPTV.

1) End- to- End Delay [sec]

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. The delay for one way must be less than 300ms. On the other hand, the end-to-end delay more than 500ms was considered to be unacceptable [12].

$$Delay = \sum packet\ arrival_i - packet\ start_i \qquad (3)$$

2) Packet Delay Variation [sec]

PDV defined as the variance of the packet delay, which can be, calculated from the following Eq.

$$PDV = \frac{\sum_{i=1}^{n}([t(n)' - t(n)] - \mu)^2}{n} \qquad (4)$$

Generally, jitter is defined as the absolute value of delay difference between selected packets. The jitter delay for one way must be less than 60ms on average and less than 10 ms in ideal [13].

3) Throughput [packets/sec]

Throughput is measure of number of packets successfully delivered in a network. It is measured in terms of packets/second. The rate at which a computer or network sends or receives data. It therefore is 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). The minimum end-to end transmission rate acceptable for video is between 10 kbps and 5 Mbps.

$$Throughput = \frac{\sum_i packet\ delivered}{\sum_i packet\ delivered - packet\ start\ time_i} \qquad (5)$$

3.7 Challenges of IPTV and Mobile TV.

We first describe the QoS guarantee and traffic management for IPTV services. Since admission control mechanisms are essential for IPTV services, we then present multicast admission control, admission controls for Ethernet, congestion control, WLAN (wireless IPTV), and DSL. Finally, we briefly mention security and standardization aspects, as well as communications among admission control schemes. Challenges of P2P IPTV services include providing QoS, which is difficult because the services are provided via the public Internet so that the video quality is subject to network traffic conditions. Current cellular networks cannot support high bandwidth, real-time applications such as video, whereas mobile broadcast networks support many users within a cell with downlinks only.

Wireless multicast plays an important part for mobile TV. For purposes of robustness, mobile TV is normally distributed from two or more Video content sources to multiple destinations. Most of the research about multicast does not address the problem of multiple sources and multiple destinations. Wireless multicast is similar to wired multicast in concept. However, minimizing energy consumption of mobile devices should always be considered for wireless multicast.

4. System Model

4.1 Implementation

The simulation was performed to evaluate the performance of IPTV over the WIMAX networks. We used the OPNET Modeler to facilitate the utilization of in-built models. Different scenarios are performed to study the effect of WiMAX on IPTV in comparison with IPTV itself. The model is composed of a complete WiMAX network that consists of application configuration, profile configuration, WiMAX configuration, WiMAX BS, video server and fixed WiMAX SS connected to BS. Application configuration to define high resolution video application on it. Profile configuration to define video application and deliver it to each SS. WiMAX configuration to define physical layer as an efficiency mode. WiMAX BS to distribute power to each SS and it connected directly to Video server to define our application. These data transferred through IP32_Cloud to the other Campus network as shown in figure 8.

Fig. 8 Network Topology

Eight scenarios will be discussed as shown in table 2: (i) Scenarios from 1 to 4: In the first four scenarios, both of the subscriber stations (caller and called) were being fixed power and adaptive modulations scheme and both of the subscriber stations one of them is called and the other one is considered as a caller network were being fixed at 10 km away from the base station at a different connections 1, 6, 12 and 25 connections. (ii) Scenarios from 5 to 8: In the four scenarios, both of the subscriber stations (caller and called) were being fixed power and adaptive modulations scheme, but we change the coverage area on each scenario as 10 KM, 20 KM, 30 KM and 50 KM respectively.

Table 2: state of scenarios

No. of Scenario	Data	State of scenario
Scenario1	1	IPTV connections over WiMAX
Scenario2	6	
Scenario3	12	
Scenario4	25	
Scenario5	10 Km	IPTV coverage Area over WiMAX
Scenario6	20 Km	
Scenario7	30 Km	
Scenario8	50 Km	

4.2 Simulation Results

In our simulation we makes 20 minutes to configure each scenario and taking in our considerations end to end delay ,delay variations and both of traffic sent and received (packets/sec) where we considered these parameters as a reference of quality measurements for our view of study.

4.2.1 IPTV Connections over WiMAX

Scenarios 1, 2,3and 4 are configured at a fixed modulation scheme and maximum power transmission in watt. This configuration shows a minimized value for system delay at different IPTV connections through WiMAX as follow:

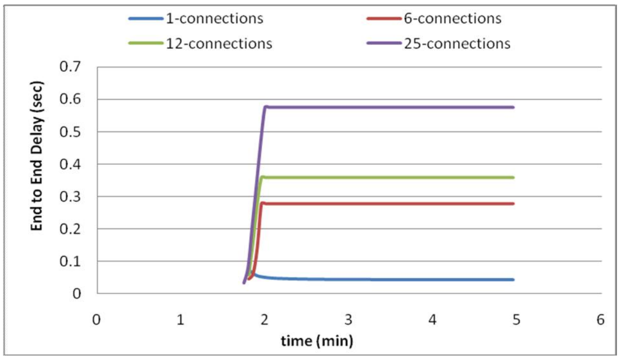

Fig.9.packet end- to -end delay (sec) [IPTV Connections over WiMAX]

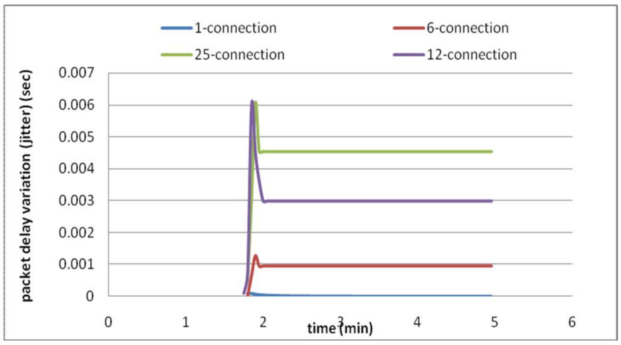

Fig.10.packet delay variation (Jitter [sec]) [IPTV Connections over WiMAX]

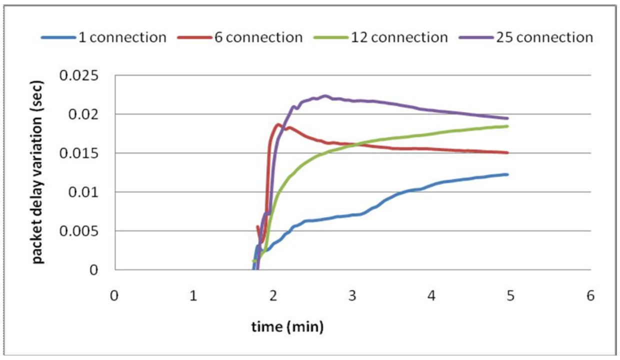

Fig.11.packet delay variation (Jitter [sec]) [IPTV Connections]

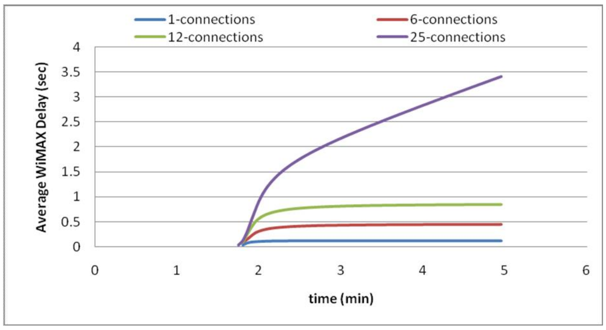

Fig.12. Average WiMAX Delay (sec)

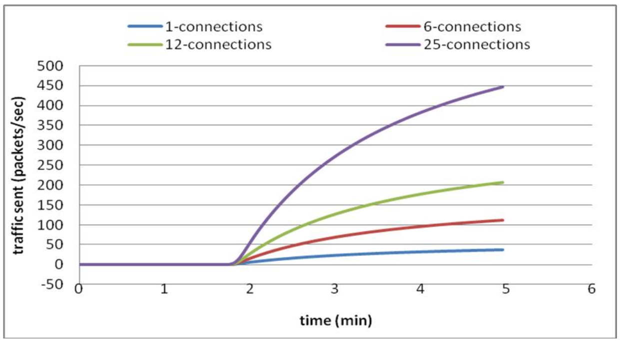

Fig.13.Traffic Sent (packets/sec)(Accumulated data) [IPTV Connections over WiMAX]

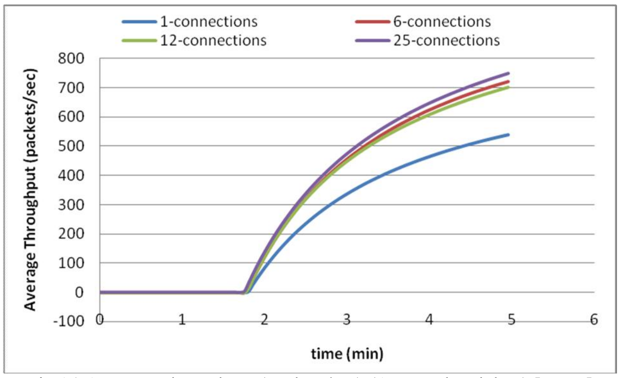

Fig.14.Average Throughput (packets/sec) (Accumulated data) [IPTV]

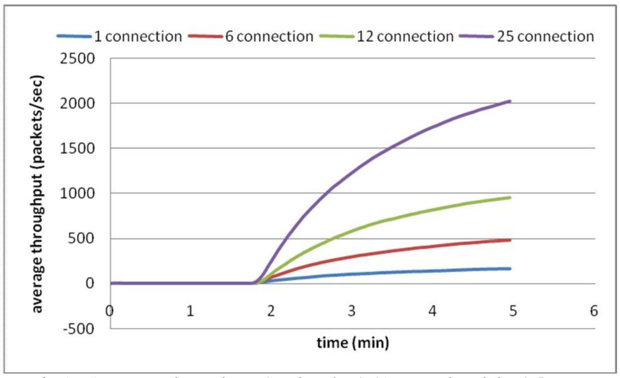

Fig.15.Average Throughput (packets/sec) (Accumulated data) [IPTV Connections over WiMAX]

4.2.2. IPTV Coverage Area over WiMAX

Scenarios 5, 6, 7 and 8 are configured at a fixed modulation scheme and maximum power transmission in watt. This configuration shows a minimized value for system delay at different IPTV coverage areas through WiMAX as follow:

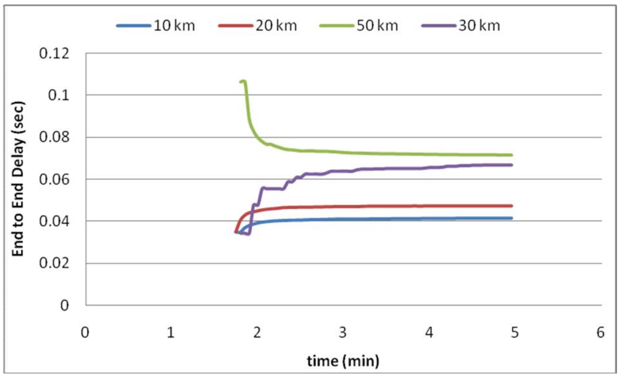

Fig.16.packet end to end delay (sec) [IPTV coverage area over WiMAX]

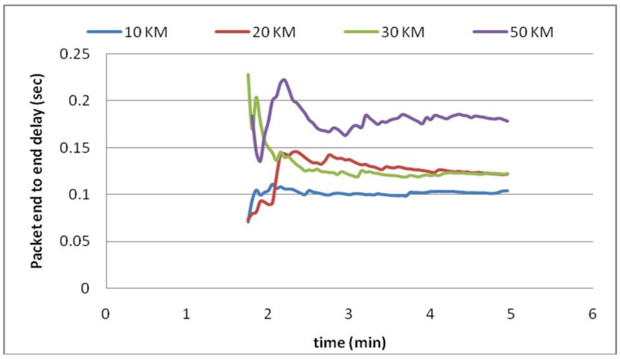

Fig.17.packet End to End Delay (sec) [IPTV]

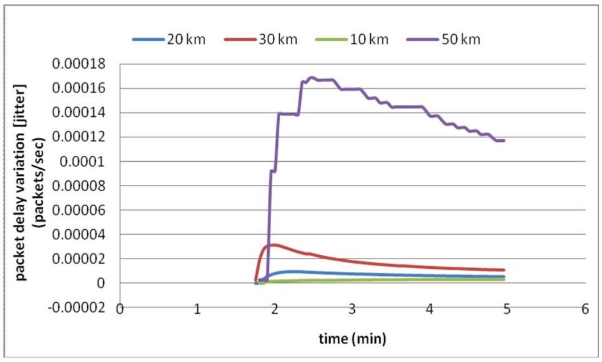

Fig.18.packet delay variation (packets/sec) [IPTV coverage area over WiMAX]

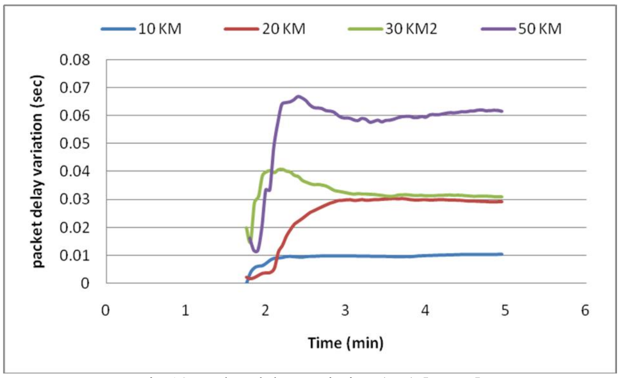

Fig.19.packet delay variation (sec) [IPTV]

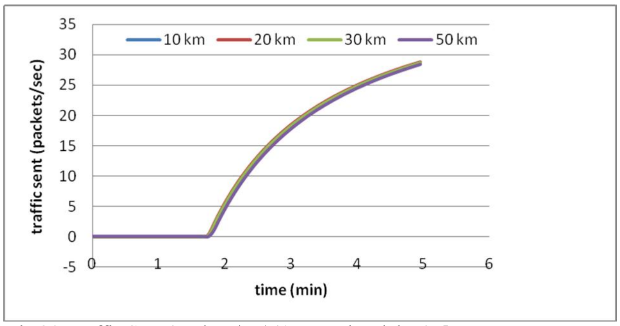

Fig.20.Traffic Sent (packets/sec)(Accumulated data) [IPTV coverage area over WiMAX]

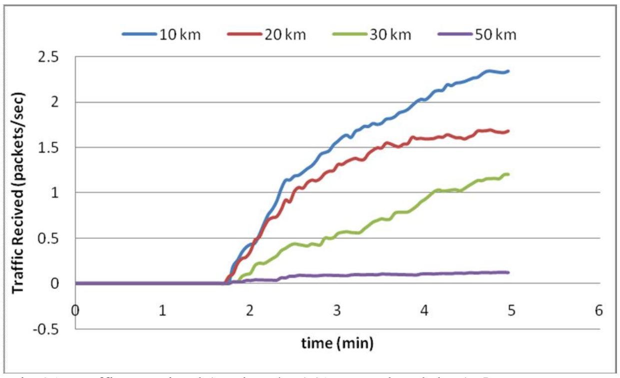

Fig.21.Traffic Received (packets/sec)(Accumulated data) [IPTV coverage area over WiMAX]

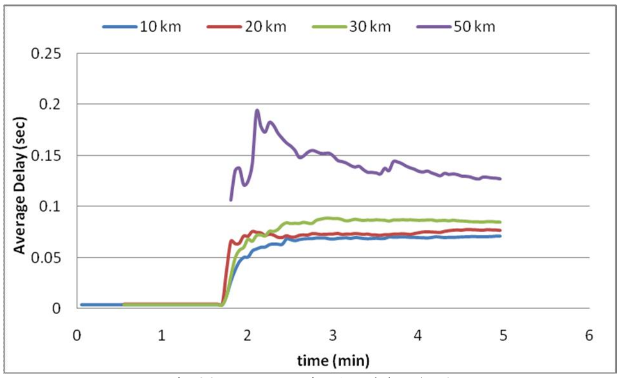

Fig.22.average WiMAX delay (sec)

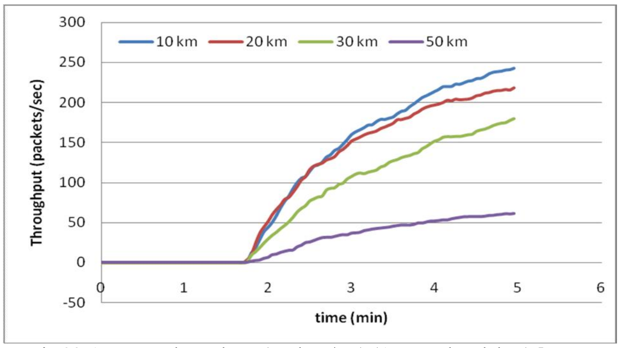

Fig.23.Average Throughput (packets/sec) (Accumulated data) [IPTV coverage area over WiMAX]

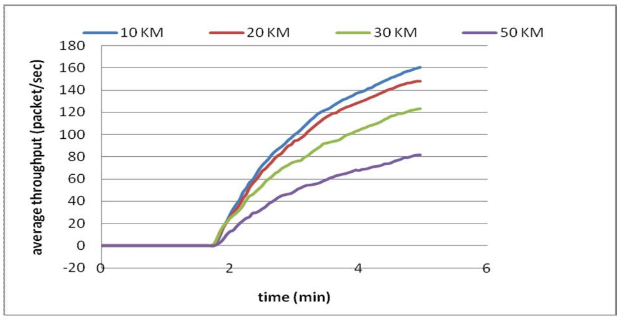

Fig.24.Average Throughput (packets/sec) (Accumulated data) [IPTV]

Table 3 Results of the overall system

State of scenario	scenarios	E2E Delay[sec]	PDV (Jitter)[sec]	Throughput [Packets/sec]
No. of IPTV Connections	1	0.05	0	2000
	6	0.25	0.001	1000
	12	0.37	0.003	500
	25	0.6	0.005	350
IPTV Coverage Area	10 km	0.04	0	250
	20 km	0.05	0.0001	220
	30 km	0.063	0.0002	198
	50 km	0.07	0.0016	56

5. Results and Discussion

As a result of the comparative study, it was found that: (i) In the four first scenarios, When number of connections are two it has the best performance at least delay in comparison with the other number of connections but when number of connections is increasing the delay is slightly high but WiMAX reduce this delay as shown in table 3. (ii) In the second four scenarios following We note that at the distance 10 km it has the best performance compared to the other distances but WiMAX reduce this delay that's meaning that WiMAX increase IPTV coverage area at small values for delay as shown in table 3. This project has successfully completed all major enhancements described. These results indicate Mobile WiMAX can deliver sufficient bandwidth while ensuring E2E packet delays and jitter meet the stringent requirements of video content streaming.

6. Conclusion

Next generation networks with multiple technologies offer different multimedia services to the user. In this study we make an extensive simulation study to evaluate the effect of WiMAX on IPTV for supporting video streaming traffic. We have analyzed several important critical parameters such as end-to-end delay, packet delay variation and throughput. Simulation results show that WiMAX allow making IPTV transmission from anywhere because it increase coverage area and also increase number of IPTV connections, so WiMAX is the is the best technology to support IPTV applications. Future work includes a suitable model for mapping QoS for IPTV over LTE networks and what LTE has add to video streaming technology?

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