CHAPTER ONE
INTRODUTION

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1.1 Preface

Worldwide Interoperability for Microwave Access (WIMAX) is wireless communication standard that is based upon IEEE 802.16. Wireless Fidelity (Wi-Fi) is a data transmission system but is based on IEEE 802.11 standard [1]. Both Wi-Fi and WIMAX are using wireless technology. They do not need a physical connection to propagate their signals. There are some differences between these two network technologies. WIMAX provides a faster and longer distance network to users than Wi-Fi. The speed of WIسMAX may reach up to 70 Mbps compared to WiFi which is only about 50 Mbps. As the development of radio technology, the speed of WiFi continues to increase in those days. The fastest speed of WiFi is using IEEE 802.11n standard, because this standard has doubled spectrum and bandwidth. The speed can be up to 300 Mbps. However, WIMAX is more expensive than WiFi on its set up expenses, because it needs outdoor facility such as base station to implement. The main difference between these two systems is the range. There is no doubt that the coverage of WIMAX is larger than WiFi. WIMAX may cover up to 50 kilometers but WiFi only covers a few feets [7]. In order to compare two different technologies fairly, some similar conditions need to be applied. In this project comparison of capabilities between WiFi and WIMAX is made in order to analyze the quality of service such as delay, jitter, package loss and interference of these two networks by having same number of users.

The comparison will be implemented by high load and high resolution video conference service application.

1.2 Problem Statement:

There are various access networks available such as WiFi and WiMAX, each with different quality of services, delay, packet loss, throughput, jitter and capacity so it is required to evaluate the performance of video conferencing service regarding parameters in various access networks.

1.3 Proposed Solution:

Applying comparative performance of WiFi and WiMAX networks by increasing the number of users, high quality of services of video conference is achieved.

1.4 Objectives:

To simulate WiMax and WiFi networks on a simulation program such as OPNET simulation modular in order to compare between the network performance in terms of the quality of service (end to end delay, jitter, throughput and packet loss) and capabilities of the two networks, considering video conference service.

1.5 Methodology:

This research has gone through multiple phases which are:

- Phase 1: general data collected about the research such as WiMAX, WiFi, video conference, their features, technologies, multiple access techniques applied in WiMAX and WiFi such as OFDM and OFDMA.
- Phase 2: Mathematical representation of performance metrics such as throughput, delay, packet loss, and jitter.
- Phase 3: OPNET simulation modular simulates the relationship between the system parameters and performance metrics such as throughput, delay, packet loss and jitter to compare the performance of WiFi/WiMAX whilst streaming a video conference.

The project includes six scenarios, three for each technology (WiMAX and WiFi). In each one the number of users is changed from one user in a cell to five users then to ten users, the application used as main traffic in this network is the video conferencing application.

- Phase 4: Results from the simulation obtained, and then the thesis is written.

1.6 Thesis layout:

The thesis consists of five chapters detailed as follows:

- **Chapter one**: presents background of WiMAX and WiFi and the primary aspects of the project.
- **Chapter two**: shows the necessary theoretical aspects of this project such as WiMAX and WiFi and the comparison of their performance while using video conference in (delay, jitter, throughput, load, and packet loss).
- **Chapter three:** presents theoretical background of the video conference application and gives the mathematical expressions used to explain the concept of quality of serve parameters (delay, jitter, throughput, load, and packet loss).
- **Chapter four:** presents the simulation process and resulting graphs for WiMAX and WiFi whilst streaming video conference.
- **Chapter five**: concludes the project and proposes some subjects that can be investigated for future work.

CHAPTER TWO

LITRATURE REVIEW

CHAPTER TWO

LITERATURE REVIEW

2.1 Overview of WiMAX:

Worldwide Interoperability for Microwave Access (WiMAX) is a standards-based technology enabling the delivery of last mile wireless broadband access as an alternative to cable and DSL. The technology is specified by the Institute of Electrical and Electronics Engineer, as the IEEE 802.16 standard [2].

Figure (2-1) is a diagram of a WiMAX network that illustrates the most typical WiMAX-based architecture, which includes a base station mounted on a building and shall be responsible for communicating on a point to multi-point basis with subscriber stations located in business offices, homes, and even automobiles. The black links represent the transmission system (fiber or microwave) and the yellow links represent wireless connection [21].

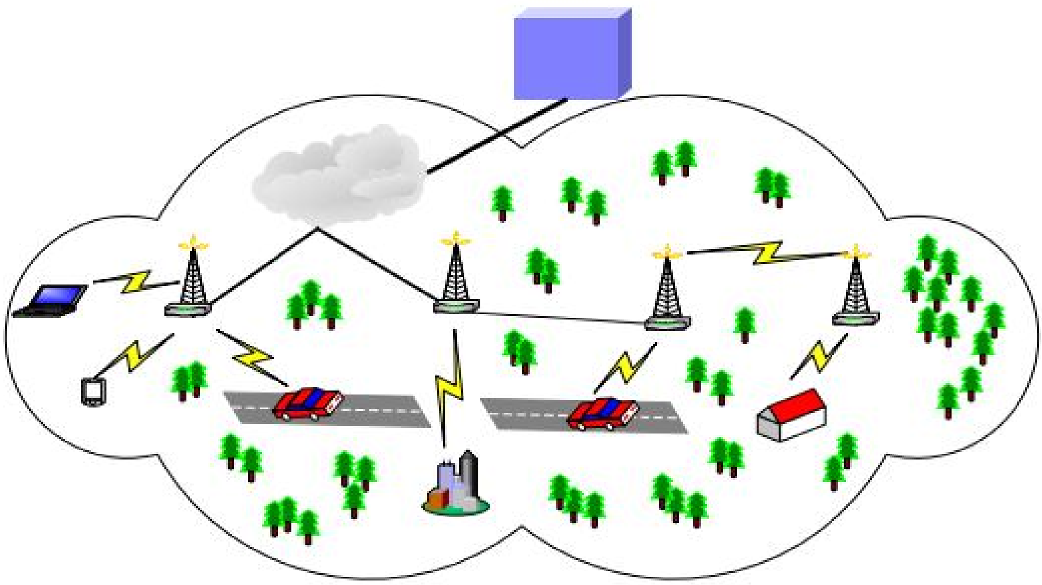

Figure (2-1) WiMAX network diagram

2.1.1Uses of WiMAX:

The bandwidth and the transmission range of WiMAX make it suitable for the following potential applications

- Providing a wireless alternative to cable and DSL for "last mile" broadband access.
- Providing data and telecommunications services.
- Providing a source of Internet connectivity as part of a business continuity plan [9].

2.2 WiMAX Specifications:

WiMAX is expected to do more for Metropolitan Area Networks (MANs) and what WiFi has done for local area networks (LANs). WiMAX is not designed to replace WiFi, but to complement it by connecting WiFi networks to each other or to the Internet through high-speed wireless links. One can therefore use WiMAX technology to extend the power and range of WiFi and cellular networks. However, in developing countries, WiMAX may become the only wireless technology because WiFi and cellular have not penetrated areas that can be reached with WiMAX technology [3].

2.2.1 WiMAX Range:

The wide range of the WiMAX technology depends on the height of the antennas, if they are installed at the suitable position from where there is no barrier between the transmitter and receiver, and then one can get better range and service from it [16].

2.2.2 WiMAX Data Rates and mobility:

The technology used for WiMAX is Orthogonal Frequency Division Multiplexing (OFDM), it is not more efficient than the technology commonly used for 3G that is Wideband Code Division Multiple Access (WCDMA). However OFDM is coupled with a high channel bandwidth, that allows greater data rates. So, on average, for an equivalent spectrum allocation, users will see similar data rates. In specific simulations, where there are few users, it is possible that WiMAX will provide a higher data rate and mobility than 3G [14], refer to Figure (2-2).

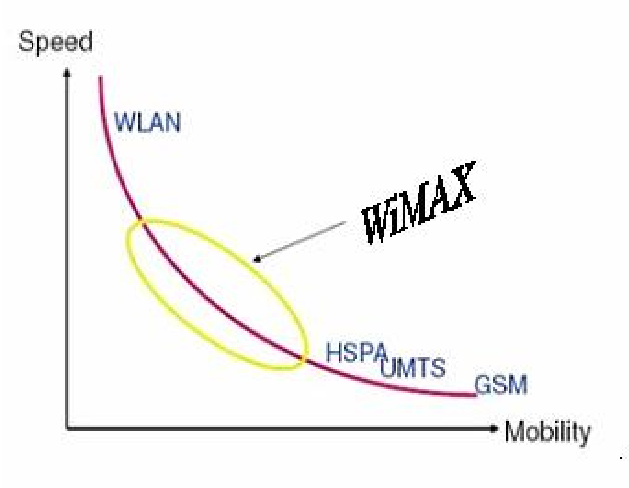

Figure (2-2) WiMAX data rates

2.2.3 WiMAX Cost:

The network costs of WiMAX are likely to be lower than for 3G because of the reduced range and hence the necessity to build more cells [10].

2.2.4 WiMAX Quality of Service (QoS):

Excellent Quality Of service management appears from variety of WiMAX features. Just as on a WiFi network.

Using the QoS features of WiMAX service providers can guarantee certain users specific bandwidth amounts by limiting the bandwidth consumption of other users [13].

2.3 WiMAX Design:

The design of the WiMAX is ideal for challenges related with earlier versions of wired and wireless access networks. At the same time the backhaul connects the WiMAX system to the network.

Normally a WiMAX network consists of two parts, a WiMAX Base Station (BS) and a WiMAX receiver also referred as Customer Premise Equipment (CPE) [21].

2.3.1 Backhaul Connection:

Backhaul is actually a connection system from the Access Point (AP) back to the provider and to the connection from the provider to the network. A backhaul can set out any technology and media provided; it connects the system to the backbone. In most of the WiMAX deployments circumstances, it is also possible to connect several base stations with one another by use of high speed backhaul microware links. This would also allow for roaming by a WiMAX subscriber from one base station coverage area to another, similar to roaming enabled by cellular phone [10].

2.3.2 A WiMAX Receiver and Base Station:

A WiMAX receiver, which is also referred as Customer Premise Equipment (CPE), may have a separate antenna or could be a stand-alone box. Access to a WiMAX base station is similar to accessing a wireless access point (AP) in a Wi-Fi network, but the coverage is more. So far one of the biggest restrictions to the widespread acceptance of WiMAX has been the cost of CPE. This is not only the cost of CPE itself, but also that of installing WiMAX base station. WiMAX base station comprises of internal devices and a WiMAX tower. A base station can normally cover the area of about 50 kilometers or 30 miles radius, but some other environmental issues bound the limits of WiMAX range to 10 km or 6 miles. Any wireless user within the coverage area would be able to access the WiMAX services Figure (2-3). The WiMAX base stations would use the media access control layer defines in the standard and would allocate uplink and downlink bandwidth to subscribers according to their requirements on real time basis [1].

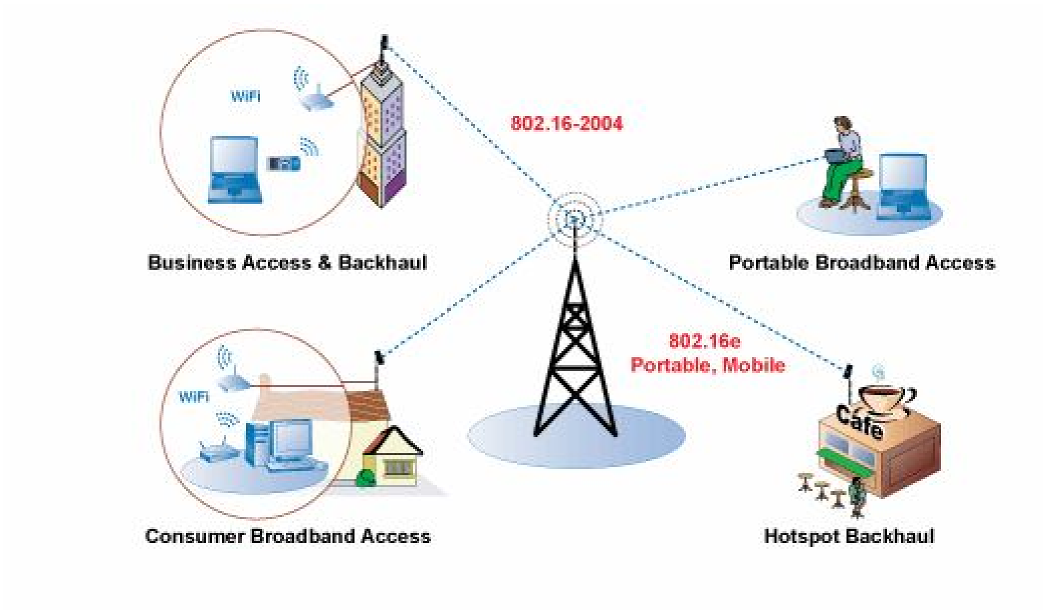

Figure (2-3): WiMAX Usage Scenarios

2.4 WiMAX Families:

The WiMAX family of standards concentrates on two types of usage models a fixed usage model and a mobile usage model. The basic element that differentiates these systems is the ground speed at which the systems are designed to manage. Based on mobility, wireless access systems are designed to operate on the move without any disruption of service; wireless access can be divided into three classes; stationary, pedestrian and vehicular.

A mobile wireless access system is one that can address the vehicular class, whereas the fixed serves the stationary and pedestrian classes. This raises a question about the nomadic wireless access system, which is referred to as a system that works as a fixed wireless access system but can change its location [4].

2.4.1 Fixed WiMAX:

Service and consumer usage of WiMAX for fixed access is expected to reflect that of fixed wire-line service, with many of the standards-based requirements being confined to the air interface. Because communications takes place via wireless links from Customer Premise Equipment (CPE) to a remote Non Line-of-sight (NLOS) base station, requirements for link security are greater than those needed for a wireless service. The security mechanisms within the IEEE 802.16 standards are sufficient for fixed access service [8].

Another challenge for the fixed access air interface is the need to set up high performance radio links capable of data rates comparable to wired broadband service, using equipment that can be self installed indoors by users, as is the case for Digital Subscriber Line (DSL) and cable modems. IEEE 802.16 standards provide advanced physical (PHY) layer techniques to achieve link margins capable of supporting high throughput in NLOS environments [8].

2.4.2 Mobile WiMAX:

The 802.16a extension, refined in January 2003, uses a lower frequency of 2 to 11GHz, enabling NLOS connections. The latest 802.16e task group is capitalizing on the new capabilities. This is provided by developing a specification to enable mobile WiMAX clients. These clients will be able to hand off between WiMAX base stations, enabling users to roam between service areas [1].

2.5 Advantages of WiMAX:

2.5.1 More flexibility and security:

Unlike WLAN, WiMAX provides a media access control (MAC) layer that uses a grant-request mechanism to authorize the exchange of data. This feature allows better exploitation of the radio resources, in particular with smart antennas, and independent management of the traffic of every user [21].

WiMAX proposes the full range of security features to ensure secured data exchange.

• terminal authentication by exchanging certificates to prevent rogue devices.

• user authentication using the Extensible Authentication Protocol (EAP).

• data encryption using the Data Encryption Standard (DES) or Advanced Encryption Standard (AES), both much more robust than the Wireless Equivalent Privacy (WEP) initially used by WLAN. Furthermore, each service is encrypted with its own security association and private keys [21].

2.5.2 WiMAX is a very Efficient Radio Solution:

WiMAX must be able to provide a reliable service over long distances to customers using indoor terminals or PC cards (like today's WLAN cards). These requirements, with limited transmit power to comply with health requirements, will limit the link budget. Sub channeling in uplink and smart antennas at the base station has to overcome these constraints. The WiMAX system relies on a new radio physical (PHY) layer and appropriate MAC layer to support all demands driven by the target applications. The PHY layer modulation is based on OFDMA, in combination with a centralized MAC layer for optimized resource allocation and support of QoS for different types of services (VoIP, real-time and non real-time services and best effort). The OFDMA PHY layer is well adapted to the NLOS propagation environment in the (2 – 11) GHz frequency range. It is inherently robust when it comes to handling the significant delay spread caused by the typical NLOS reflections. Together with adaptive modulation, which is applied to each subscriber individually according to the radio channel capability, OFDMA can provide a high spectral efficiency of about 3 - 4 bit/s/Hz. However, in contrast to single carrier modulation, the OFDMA signal has an increased peak average ratio and increased frequency accuracy requirements. Therefore, selection of appropriate power amplifiers and frequency recovery concepts are crucial. WiMAX provides flexibility in terms of channelization, carrier frequency, and duplex mode (TDD and FDD) to meet a variety of requirements for available spectrum resources and targeted services [9].

2.6. Overview of WiFi Families:

The IEEE 802.11 is an international standard describing the characteristics of a wireless local area network (WLAN). The name **Wi-Fi** (short for "Wireless Fidelity", sometimes incorrectly shortened to WiFi) corresponds to the name of the certification given by the Wi-Fi Alliance, the group which ensures compatibility between hardware devices that use the 802.11 standard. Today, due to misuse of the terms (and for marketing purposes), the name of the standard is often confused with the name of the certification. A Wi-Fi network, in reality, is a network that complies with the 802.11 standard [19].

With Wi-Fi, it is possible to create high-speed wireless local area networks, provided that the computer to be connected is not too far from the access point. In practice, Wi-Fi can be used to provide high-speed connections (11 Mbps or greater) to laptop computers, desktop computers, personal digital assistants (PDAs) and any other devices located within a radius of several dozen meters indoors (in general 20m-50m away) or within several hundred meters outdoors[19].

Wi-Fi providers are starting to blanket areas that have a high concentration of users (like train stations, airports, and hotels) with wireless networks. These access areas are called "hot spots".

- The 802.11 standard reserves the low levels of the model for a wireless connection that uses electromagnetic waves, i.e.

- The physical layer (sometimes shortened to the "PHY" layer), which offers three types of information encoding.
- The data link layer, comprised of two sub-layers Logical Link Control (or LLC) and Media Access Control (or MAC).

The physical layer defines the radio wave modulation and signaling characteristics for data transmission, while the data link layer defines the interface between the machine's bus and the physical layer, in particular an access method close to the one used in the Ethernet standard and rules for communication between the stations of the network. The 802.11 standard actually has three physical layers, which define alternative modes of transmission (Data link layer, MAC layer and Physical layer PHY) [7].

WiFi was developed by the IEEE 802.11 working group and was Initially designed to be used indoors at close range but has recently ventured into mobility. It includes the approved 802.11a, b, g, n, and p specifications. WiFi is the first high-speed wireless Technology deployed in areas such as hotspots, homes, offices, airports, etc. WiFi hotspots have become quite popular and have allowed mobile users to remain productive while on the go. WiFi, however, is limited by its range; users must remain within 300 feet (for 802.11a) or 1000 feet (for 802.11p) of a base station. The following is a diagram of a WiFi network Figure (2-4) [22].

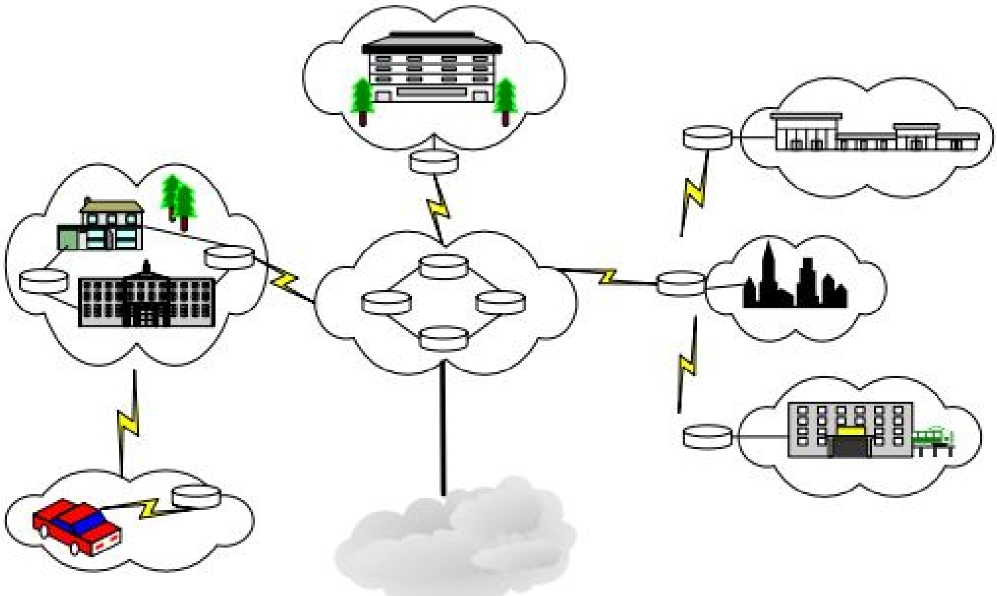

Figure (2-4) the Wifi Network typical configur

2.7 The Various Standards of WiFi:

The IEEE 802.11 standard is actually only the earliest standard, allowing (1-2) Mbps of bandwidth. Amendments have been made to the original standard in order to optimize bandwidth (these include the 802.11a, 802.11b and 802.11g standards, which are called 802.11 physical standards) or to better specify components in order to ensure improved security or compatibility [22]. Explained as:

The 802.11a standard (called WiFi 5) allows higher bandwidth (54 Mbps maximum throughput, 30 Mbps in practice). The 802.11a standard provides 8 radio channels in the 5 GHz frequency band [22].

The 802.11b standard is currently the most widely used one. It offers a maximum throughput of 11 Mbps (6 Mbps in practice) and a reach of up to 300 meters in an open environment. It uses the 2.4 GHz frequency range, with 3 radio channels available [28].

The 802.11c bridging standard is of no interest to the general public. It is only an amended version of the 802.11d standard that lets

802.11d bridge with 802.11-compatible devices (on the data link level) [28].

The 802.11d standard is a supplement to the 802.11 standard which is meant to allow international use of local 802.11 networks. It lets different device information on frequency ranges depending on what is permitted in the country where the device is from [15].

The 802.11f is a recommendation for access point vendors that allow products to be more compatible. It uses the *Inter-Access Point Roaming Protocol*, which lets a roaming user transparently switches from one access point to another while moving around, no matter what brands of access points are used on the network infrastructure. This ability is also simply called *roaming* [15].

The 802.11e standard is meant to improve the quality of service at the level of the *data link layer*. The standard's goal is to define the requirements of different packets in terms of bandwidth and transmission delay so as to allow better transmission of voice and video [5].

The 802.11g standard offers high bandwidth (54 Mbps maximum throughput, 30 Mbps in practice) on the 2.4 GHz frequency range. The 802.11g standard is backwards-compatible with the 802.11b standard, meaning that devices that support the 802.11g standard can also work with 802.11b [5].

It is also useful to note the existence of a standard called "*802.11b+*". This is a proprietary standard with improvements in data flow. However, this standard also suffers from gaps in interoperability due to not being an IEEE standard [17].

2.8. Range and data flow:

The 802.11a, 802.11b and 802.11g standards, called "physical standards" are amendments to the 802.11 standard and offer different modes of operation, which lets them, reach different data transfer speeds depending on their range [5].

The 802.11a standard has a maximum theoretical data flow of 54 Mbps, five times that of 802.11b, but at a range of only about thirty meters. The 802.11a standard relies on a technology called OFDM (*Orthogonal Frequency Division Multiplexing*). It broadcasts in the 5 GHz frequency range and uses 8 non-overlapping channels. Because of this, 802.11a devices are incompatible with 802.11b devices. However, there are devices that incorporate both 802.11a and 802.11b chips, called "dual band" devices [20].

The 802.11b standard allows for maximum data transfer speed of 11Mbps, at arrange of about 100 m indoors and up to 300 meters outdoors (or even beyond that, with directional antennas).

The 802.11g standard allows for a maximum data transfer speed of 54 Mbps at ranges comparable to those of the 802.11b standard. More than that the 802.11g standard uses the 2.4GHz frequency range with OFDM coding, this standard is compatible with 802.11b devices, with the exception of some older devices [20]. .

2.9. Comparison of WiFi and WiMAX :

Comparisons and confusion between WiMAX and Wi-Fi are frequent because both are related to wireless connectivity and Internet access.

- WiMAX is a long range system, covering many kilometers that uses licensed or unlicensed spectrum to deliver connection to a network, in most cases the Internet.

- WiFi uses unlicensed spectrum to provide access to a local network.
- WiFi is more popular in end user devices.
- WiFi runs on the Media Access Control's CSMA/CA protocol, which is connectionless and contention based, whereas WiMAX runs a connection-oriented MAC [6].
- WiMAX and WiFi have quite different quality of service (QoS) mechanisms [1].
- WiMAX uses a QoS mechanism based on connections between the base station and the user device. Each connection is based on specific scheduling algorithms.
- WiFi uses contention access - all subscriber stations that wish to pass data through a wireless access point (AP) are competing for the AP's attention on a random interrupt basis. This can cause subscriber stations distant from the AP to be repeatedly interrupted by closer stations, greatly reducing their throughput [13].
- Both 802.11 (which includes WiFi) and 802.16 (which includes WiMAX) define Peer-to-Peer (P2P) and ad hoc networks, where an end user communicates to users or servers on another Local Area Network (LAN) using its access point or base station. However, 802.11 supports also direct ad hoc or peer to peer networking between end user devices without an access point while 802.16 end user devices must be in the range of the base station [6].

Although WiFi and W1MAX are designed for different situations, they are complementary. WiMAX network operators typically provide a WiMAX Subscriber Unit which connects to the metropolitan WiMAX network and provides WiFi within the home or business for local devices (e.g., Laptops, WiFi Handsets, smart phones) for connectivity. This enables the user to place the WiMAX Subscriber Unit in the best reception area (such as a window), and still be able to use the WiMAX network from any place within their residence. The local area network inside your home or business would operate as with any other wired or wireless network. If you connect you WiMAX Subscriber Unit directly to a WiMAX enabled computer or laptop that would limit access to a single device. As an alternative for LAN, one can purchase a WiMAX modem with a built-in wireless WiFi router. Now one can connect multiple devices to create LAN. Using WiMAX could be an advantage since it is typically faster than most cable modems with download speeds between(3 — 6) Mbit/s and generally less costive than cable [17].

2.10 Orthogonal frequency-division multiplexing (OFDM):

OFDM stands for Orthogonal Frequency Division Multiplexing; it's a technology that provides the operator to beat the challenges of Non-Line-of-Sight (NLOS) transmissions in a more efficient manner. OFDM waveform put forward the advantage of functioning with the larger delay spread of the NLOS background.

With the excellent quality of OFDM functionality, time and use of a cyclic prefix and it also removes the Inter Symbol Interference (ISI) complications of adaptive equalization. Multiple narrowband orthogonal carriers are composed because of OFDM waveform, localizing selective fading to a subset of carriers that are comparatively simple to equalize [23].

A comparison between an OFDM signal and a single carrier signal, with the information being sent in parallel for OFDM and in series for single carrier are shown in Figure (2-5).

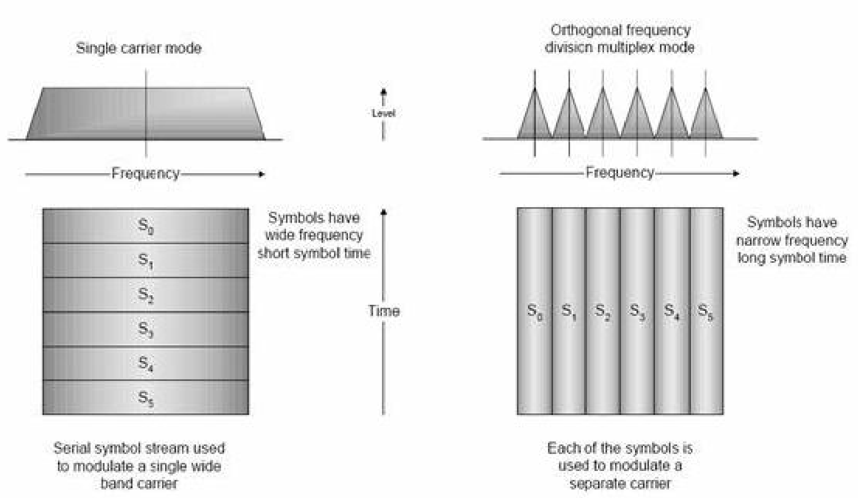

Figure (2-5): OFDM and single carrier configuration

The facility to remove delay spread, Inter Symbol Interference (ISI) and multi-path in a proficient manner allows for higher data rate throughput. It is simpler to equalize the individual OFDM carriers than to equalize the broader single carrier signal. For these entire reasons modern international standards such as those set by IEEE 802.16, have created OFDM as the ideal technology [4].

OFDM is a method of encoding digital data on multiple carrier frequencies .It has developed into a popular scheme for wide band digital communication, used in applications such as digital television and audio broadcasting, DSL Internet access, wireless networks, power line networks, and 4G mobile communications [29].

Also OFDM is a frequency-division multiplexing (FDM) scheme used as a digital multi-carrier modulation method. A large number of closely spaced orthogonal sub-carrier signals are used to carry data on several parallel data streams or channels. Each sub-carrier is modulated with a conventional modulation scheme (such as quadrature amplitude modulation or phase-shift keying) at a low symbol rate, maintaining total data rates similar to conventional *single-carrier* modulation schemes in the same bandwidth [29].

2.10.1Advantages of OFDM:

The primary advantage of OFDM over single-carrier schemes is its ability to cope with severe channel conditions (for example, attenuation of high frequencies in a long copper wire, narrowband interference and frequency-selective fading due to multipath) without complex equalization filters. Channel equalization is simplified because OFDM may be viewed as using many slowly modulated narrowband signals rather than one rapidly modulated wideband signal. The low symbol rate makes the use of a guard interval between symbols affordable, making it possible to eliminate inter symbol interference (ISI) and utilize echoes and time-spreading on analogue TV(these are visible as ghosting and blurring, respectively) to achieve a diversity gain, i.e. a signal-to-noise ratio improvement. This mechanism also facilitates the design of single frequency networks (SFNs), where several adjacent transmitters send the same signal simultaneously at the same frequency, as the signals from multiple distant transmitters may be combined constructively, rather than interfering as would typically occur in a traditional single-carrier system[2].

OFDM has high spectral efficiency as compared to other double sideband modulation schemes, spread spectrum .It can easily adapt to severe channel conditions without complex time-domain equalization.

It has robust against narrow-band co-channel interference, and has robust against inter-symbol interference (ISI) and fading caused by multipath propagation. Furthermore it is efficient in implementation using Fast Fourier Transform (FFT).As well it has low sensitivity to time synchronization errors [2].

2.10.2. Disadvantages of OFDM :

OFDM is sensitive to Doppler shift. It is as well sensitive to frequency synchronization problems. It has high peak-to-average-power ratio (PAPR), requiring linear transmitter circuitry, which suffers from poor power efficiency. It has also Loss of efficiency [12].

2.11 Related Works :

Various related efforts have been explored to compare WiMAX/ WiFi in the context of real-time and videoconference applications. Challenges for delivering videoconference over WiMAX /WiFi were discussed and analyzed: In 2012, M.Sreerama Murty, D.Veeraiah, A.Srinivas Rao, evaluated the Quality of Service (Qos) in Wi-Fi compared with WiMAX and provided the various kinds of security Mechanisms, seamless handover, location and emergency services, cooperation. Furthermore simulation results show that performance of the WiMAX is better than that of WiFi, because the entire problem of WiFi network is restricted area. But the WiMAX has no restriction to work. Both networks are reliable networks. But compared to WiFi network WiMAX technology is more secure and reliable [10].

In 2014, Mr. Nitish Meena, Dr. Nilesh parihar compared WiFi and WiMAX in a few area networks in case of heavier traffic to evaluate their performance in terms of the queuing delay, load, delay, mobility, throughput of base station, router, and subscriber station, then analyzed their effect on the performance of WiMAX in a local area network. The simulation results show that the throughput of WIMAX is higher in case of heavier traffic, WiMAX may handle heavier load compared to WiFi. , the delay in WiFi router was higher than the delay in the base station. And the WiMAX queuing delay is smaller because WiMAX provides broadband service to carry traffic load over the network Thus WiMAX is more efficient in terms of paying off more data with less queuing delay when compared to WiFi. The disadvantages are that the comparison should have been made in a wide area network [15].

In 2013, Jamil M. Hamodi and Ravindra C. Thool, investigated the performance evaluation of Video on Demand (VoD) over WiMAX networks. Its aim is to address the performance metrics of QoS for video streaming when deploying over WiMAX access technology .The streaming video content has been modeled as unicast and multicast traffics. After simulation it was clear that multicast video traffic may have yielded better performance. This work has limitations to certain assumptions like: Station transmit power, distance between base station and subscriber station, was configured as fixed not support mobility, station antenna gain, carrier operating frequency and channel bandwidth [18].

In2014, Smart. C. Lubobya, Mqhele. E. Dlodlo, Gerhard de Jager , researched the performance evaluation of WiFi networks for video surveillance applications, using three network topologies: wireless tree, star and wired tree topologies. Results show that the wireless tree outperforms the other two by 100% with a packet loss of 2.3%. Further, the wireless tree implementation had its jitter, packet end-to-end delay values within the acceptable standard limits, the wireless tree is ideal for video surveillance applications where wired connection may be unavailable such as between building, road or rail separating two areas. Such system can also be used in increasing the capacity of a backbone network. This work was limited to IEEE 802.11g standard and assumes a clear line of sight between transmitting devices [20].

In2009, M. Ergen presented a precise description of(WiFi) / (WiMAX) wireless networks and investigated how these technologies may collaborate together to form alternatives for implementing last-mile wireless broadband services. They compared in detail and analyzed them, the results provide alternative solution to the problem of information access in remote inaccessible areas where wired networks are not cost effective. Also proved that the WiMAX standard goal is not to replace Wi-Fi in its applications but rather to supplement it in order to form a wireless network web [3] .

In 2011, D.J. Reid, A. Srinivasan, and W. Almuhtadi, addressed an important performance issue when multimedia traffic is carried over WiMAX systems they focused in the effectiveness of QoS capabilities in delivering streaming multimedia such as videoconference and similar media content. The results provide a good indication on the applicability of WiMAX for multimedia applications. Measurement and analysis of performance of videoconferencing over WiMAX in terms of crucial parameters was presented [30].

CHABTER THREE

VIDEOCONFRENCING OVER WiFi/ WiMAX

CHABTER THREE

VIDEOCONFRENCING OVER Wi-Fi/ WiMAX

Videoconferencing (VC) is the application of a videoconference (also known as video conference or video teleconference) by a set of telecommunication technologies which allow two or more locations to communicate simultaneous by two-way video and audio transmissions. It has also been called 'visual collaboration' and is a type of groupware. Videoconferencing has made significant effects in business, education, medicine and media. Like all long distance communications technologies (such as phone and Internet), by reducing the need to travel, which is often carried out by planes, ships, vehicles to bring people together. This technology also contributes to reduction in carbon emissions, thereby helping to reduce global warming and pollution [9].

3.1 Technology of Videoconferencing:

The core technology used in a videoconferencing system is digital compression of audio and video streams in real time. The hardware or software that performs compression is called a codec (coder/decoder). Compression rates of up to 500:1can be achieved. The resulting digital stream of 1s and 0s is subdivided into labeled packets, which are then transmitted through a digital network of some kind (usually ISDN or IP). The use of audio modems in the transmission line allows for the use of the Plain Old Telephone System POTS, in some low-speed applications, such as video telephony, because they convert the digital pulses to/from analog waves in the audio spectrum range. [15].

3.2 Components required For a Videoconferencing system:

- Video input: video camera or webcam
- Video output: computer monitor, television or projector

- Audio input: microphones, CD/DVD player, cassette player, or any other source of audio outlet.
- Audio output: usually loudspeakers associated with the display device or telephone
- Data transfer: analog or digital telephone network, LAN or Internet
- Computer: a data processing unit that ties together the other components, does the compressing and decompressing, and initiates and maintains the data linkage via the network. [24].

3.3 Types of videoconference systems:

There are Basically Two Kinds of videoconferencing systems

1) Dedicated systems have all required components packaged into a single piece of equipment, usually a console with a high quality remote controlled video camera. These cameras can be controlled at a distance to pan left and right, tilt up and down, and zoom. They became known as PTZ cameras. The console contains all electrical interfaces, the control computer, and the software or hardware-based codec. Omni directional microphones are connected to the console, as well as a TV monitor with loudspeakers and/or a video projector. There are several types of dedicated videoconferencing devices [19].

Large group videoconferencing is non-portable, large, more expensive devices used for large rooms.

Small group videoconferencing is non-portable or portable, smaller less expensive devices used for small meeting rooms.

Individual videoconferencing are usually portable devices, meant for single users, have fixed cameras, microphones and loudspeakers integrated into the console.

2) Desktop systems are usually hardware boards add- on to normal PCs, transforming them into videoconferencing devices. A range of different cameras and microphones can be used with the board, which contains the necessary codec and transmission interfaces. [24].

3.4 Conferencing Layers

The components within a Conferencing System can be divided up into several different layers: User Interface, Conference Control, Control or Signal Plane, and Media Plane.

Videoconferencing User Interfaces (VUI) can be either graphical or voice responsive. Many industries have encountered both types of interfaces, and normally graphical interfaces are encountered on a computer. User interfaces for conferencing have a number of different uses; they can be used for scheduling, setup, and making a video call. Through the user interface the administrator is able to control the other three layers of the system [26].

Conference Control performs resource allocation, management and routing. This layer along with the User Interface creates meetings (scheduled or unscheduled) or adds and removes participants from a conference.

Control (Signaling) Plane contains the stacks that signal different endpoints to create a call and/or a conference. These signals control incoming and outgoing connections as well as session parameters.

The Media Plane controls the audio and video mixing and streaming. This layer manages Real-Time Transport Protocols (RTTP), User Datagram Packets (UDP) and Real-Time Transport Control Protocol (RTP). The RTTP and UDP normally carry information such as the payload type which is the type of codec, frame rate, video size and many others. RTCP on the other hand acts as a quality control Protocol for detecting errors during streaming [9].

3.5 Multipoint Videoconferencing:

Simultaneous videoconferencing among three or more remote points is possible by means of a Multipoint Control Unit (MCU). This is a bridge that interconnects calls from several sources (in a similar way to the audio conference call). All parties call the MCU, or the MCU can also call the parties which are going to participate, in sequence. There are MCU bridges for IP and ISDN-based videoconferencing. There are MCUs which are pure software, and others which are a combination of hardware and software. An MCU is characterized according to the number of simultaneous calls it can handle, its ability to conduct transposing of data rates and protocols, and features such as continuous presence, in which multiple parties can be seen on-screen at once. MCUs can be stand-alone hardware devices, or they can be embedded into dedicated videoconferencing units [25].

3.5.1 Logical Components of Videoconferencing:

- A single multipoint controller (MC) :

The MC controls the conferencing while it is active on the signaling plane, which is simply where the system manages conferencing creation, endpoint signaling and in-conferencing controls. This component negotiates parameters with every endpoint in the network and controls conferencing resources.

- Multipoint Processors (MP) sometimes referred to as the mixer:

The MP operates on the media plane and receives media from each endpoint. The MP generates output streams from each endpoint and redirects the information to other endpoints in the conference [19].

Some systems are capable of multipoint conferencing with no MCU, stand-alone, embedded or otherwise. These use a standards technique known as "decentralized multipoint", where each station in a multipoint call exchanges video and audio directly with the other stations with no central "manager" or other bottleneck. The advantages of this technique are that the video and audio will generally be of higher quality because they don't have to be relayed through a central point. Also, users can make ad-hoc multipoint calls without any concern for the availability or control of an MCU. This added convenience and quality comes at the expense of some increased network bandwidth, because every station must transmit to the other station directly [19].

3.6 Videoconferencing Modes:

Video conferencing systems use two operating modes as follows: Voice-Activated Switch (VAS) and Continuous Presence.

In VAS mode, the MCU switches which endpoint can be seen by the other endpoints by the levels of one’s voice. If there are four people in a conference, the only one that will be seen in the conference is the site which is talking; the location with the loudest voice will be seen by the other participants.

Continuous Presence mode, displays multiple participants at the same time. The MP in this mode takes the streams from the different endpoints and puts them all together into a single video image. In this mode, the MCU normally sends the same type of images to all participants. Typically these types of images are called “layouts” and can vary depending on the number of participants in a conference [9].

3.7 Echo Cancellation:

A fundamental feature of professional videoconferencing systems is Acoustic Echo Cancellation (AEC). Echo can be defined as the reflected source wave interference with new wave created by source. AEC is an algorithm which is able to detect when sounds or utterances reenter the audio input of the videoconferencing codec, which came from the audio output of the same system, after some time delay. If unchecked, this can lead to several problems including:

The remote party hearing their own voice coming back at them (usually significantly delayed) Strong reverberation, which makes the voice channel useless, and howling created by feedback [25].

Echo cancellation is a processor-intensive task that usually works over a narrow range of sound delays [25].

3.8 Technical and other issues for Videoconferencing:

Computer security experts have shown that poorly configured or inadequately supervised videoconferencing system can permit an easy 'virtual' entry by computer hackers and criminals into company premises and corporate boardrooms, via their own videoconferencing systems[25]. Some observers argue that three outstanding issues have prevented videoconferencing from becoming a standard form of communication, despite the ubiquity of videoconferencing-capable systems [9]. These issues are:

- Eye contact: Eye contact plays a large role in conversational turn-taking, perceived attention and intent, and other aspects of group communication. While traditional telephone conversations give no eye contact cues, many videoconferencing systems are arguably worse in that they provide an incorrect impression that the remote interlocutor is avoiding eye contact. Some telepresence systems have cameras located in the screens that reduce the amount of parallax observed by the users. This issue is also being addressed through research that generates a synthetic image with eye contact using stereo reconstruction.

- Telcordia Technologies, formerly Bell Communications Research, owns a patent for eye-to-eye videoconferencing using rear projection screens with the video camera behind it, evolved from a 1960s U.S. military system that provided videoconferencing services between the White House and various other government and military facilities. This technique eliminates the need for special cameras or image processing.
- Appearance consciousness: A second psychological problem with videoconferencing is being on camera, with the video stream possibly even being recorded. The burden of presenting an acceptable on-screen appearance is not present in audio-only communication. Early studies by Alphonse Chaplains found that the addition of video actually impaired communication, possibly because of the consciousness of being on camera.
- Signal latency: The information transport of digital signals in many steps needs time. In a telecommunicated conversation, an increased latency (time lag) larger than about 150–300 ms becomes noticeable and is soon observed as unnatural and distracting. Therefore, next to a stable large bandwidth, a small total round-trip time is another major technical requirement for the communication channel for interactive videoconferencing. The issue of eye-contact may be solved with advancing technology, and presumably the issue of appearance consciousness will fade as people become accustomed to videoconferencing [9].

3.9 Equations of Quality of service Parameters in Videoconference

The QoS is affected by jitter, throughput, packet end-to-end delay and packet loss.

3.9.1 Packet Loss:

Packet loss is essentially the number of video packets not reaching the preferred destination Mathematically, Equation (3.1) below shows the calculation of packet loss as a percentage bps [26].

$$pl = \frac{Lbps - Tp}{Lbps} \times 100$$ Equation (3.1)

Where:

pl is the packet loss percentage.

L is the average load bits per second.

Tp is the average throughput in bits per second [26].

3.9.2 End to End Delay:

Delay is defined as the time taken by the packets to reach the Receiver from the transmitter and vice versa. As a result of delay some packets lose energy in the form of noise. End to end delay could be measured as the difference in packet arrival and packet start time.

Equation (3. 2) below shows the calculation of average end to end delays in terms of seconds [27].

$$Delay = \frac{\sum(packet\ arrival\ time - packet\ start\ time)}{N}$$

Equation (3.2)

3.9.3 Packet Delay Variance (Jitter):

Jitter could be defined as the variation in delay or the variation in the time between packets arriving. The value of jitter is calculated from the end to end delay. Measuring jitter is an important way to determine the reliability of a network and the QoS offered by the network. Jitter is normally used as an indicator of consistency and stability of a network. Equation (3.3) sBelow shows how to calculate jitter in seconds [24].

$$Jitter = \frac{\sum_{i=0}^{n} square\,(Delay(i) - Avarge\ delay)}{N}$$ Equation (3.3)

3.9.4 Throughput:

It is an Important QoS Parameter. Throughput is a measure of the number of packets successfully delivered in a network. It is measured in terms of packets/second. Equation (3.4) below shows how to calculate throughput in terms of bps [24].

$$Throughput = \frac{\sum Packet\ Delivered}{\sum Packet\ Arrival - Packet\ Start\ Time}$$ Equation (3.4)

CHAPTER FOUR

SIMULATION RESULTS AND DISCUSSION

CHAPTER FOUR

SIMULATION RESULTS AND DISCUSSION

4.1 OPNET Simulation Modeler:

OPNET is a research oriented network simulation tool. It provides a comprehensive development environment for modeling and simulation of deployed wired and wireless networks. OPNET Modeler enables users to create customized models and to simulate various network scenarios. The wireless module is used to create models for wireless scenarios such as WiFi and WiMAX [10].

OPNET provides high-fidelity modeling, simulation, and Analysis of wireless networks such as the delay ,delay variation, throughput, load and packet loss .In this project the two famous wireless networks standard technologies WiFi and WiMAX are compared in different parameters for each one whilst streaming a video conference according to their reference model in order to investigate the strength of each technology regarding to capacity planning by increasing the number of users without changing any other attribute in the simulation environment. This simulation approach used the popular OPNET Modeler simulation, Release14.5.

All the results are collected according to the same simulation parameters as set from the standards of WiMAX and WiFi. The time of the simulation set in all scenarios was fixed for 10 minutes for better comparison of results.

The general environment and simulation parameters are set as constant as in all scenarios are illustrated in Table (4-1).

Table (4-1): General Environment & Simulation parameters

General Environment & Simulation parameters	
No. of cells in network	7
No. of users in each cell	1, 5, and 10
No. of simulation run sets	6
Simulation time	10 Minutes

Figure (4-1) shows the application configuration modeler. Which the video conferencing application was configured

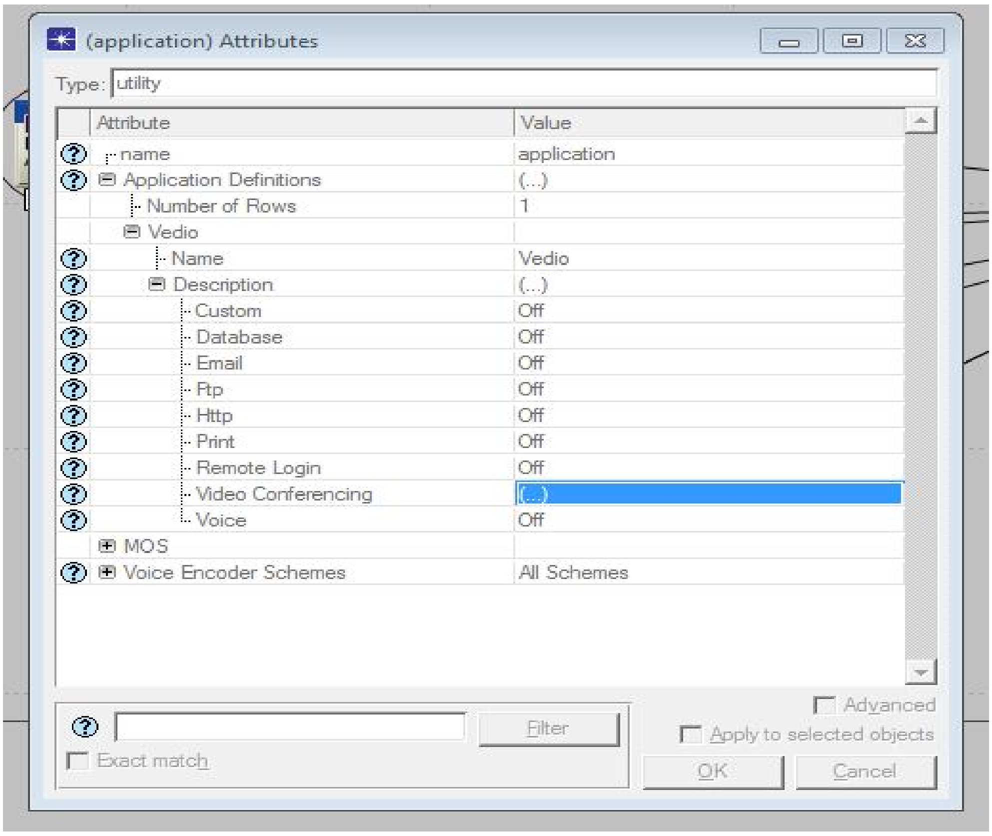

Figure (4-1): Application configuration

Figure (4-2) shows the modeler profile which is configured in OPNET to reflect the video streaming. The video clients are subsequently configured with this profile, and the video conference server is configured to support the appropriate application services.

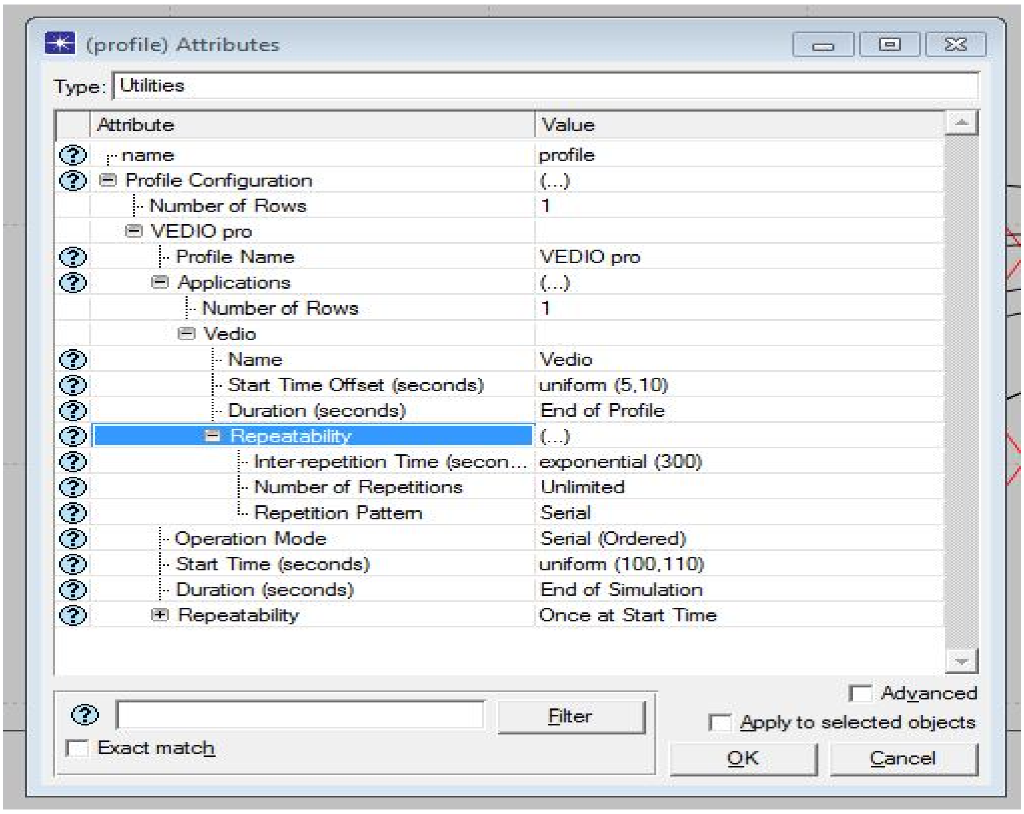

Figure (4-2): Profile configuration

The WiMax simulation parameters setups are shown in Table (4-2).

Table (4-2): WiMax simulation parameters

WiMax simulation parameters	
Physical profile	Wireless OFDMA
Base Frequency	5 GHz
Bandwidth	20 MHz
Scheduling type	Best effort
Maximum sustained traffic rate	384 Kbps
Minimum reserved traffic rate	384 Kbps
Modulation and coding scheme	64-QAM ¾
Buffer size	64 KB
SS maximum transmission power	0.5 W
BS maximum transmission power	3 W

Figure (4-3) shows the WiMAX Configuration .It was configured to support video converance. Best effort scheduling class was created for the downlink and uplink to support the real time video streaming. The scheduling was configured with 384 Kbps Maximum sustainable traffic rate, and 384 Kbps Minimum sustainable traffic rate.

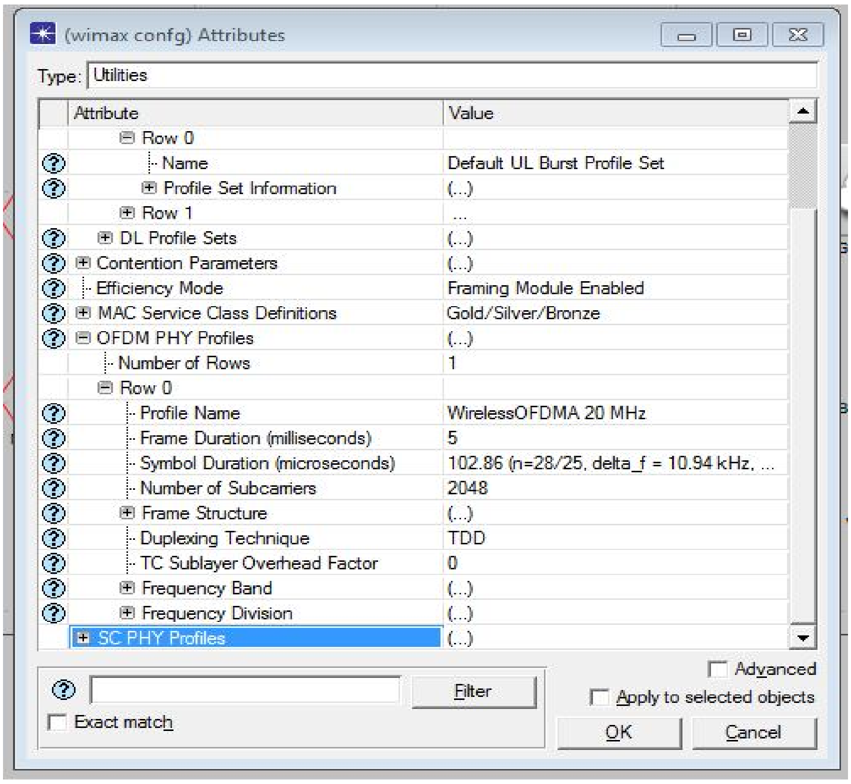

Figure (4-3): WiMAX system configuration

Figure (4-4) and Figure (4-5) shows the WiMAX base Station, and WiMAX subscriber stations configuration attribute. They 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 and downlink channel was configured with 64-QAM

Physical (PHY) layer access was configured to utilize wireless OFDMA over a 5 GHz base frequency using 20 MHz channel bandwidth. The base station transmit power was configured to 3 watts. On the other hand, the client station transmit power was configured to 0.5 watts of transmit power.

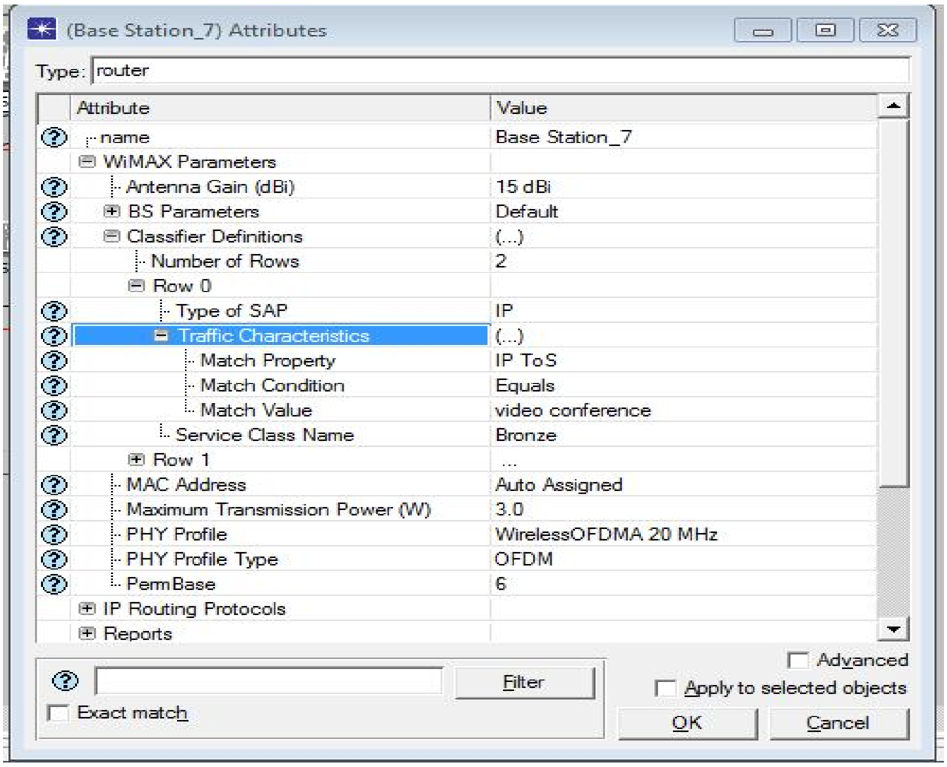

Figure (4-4): The WiMAX base station configuration

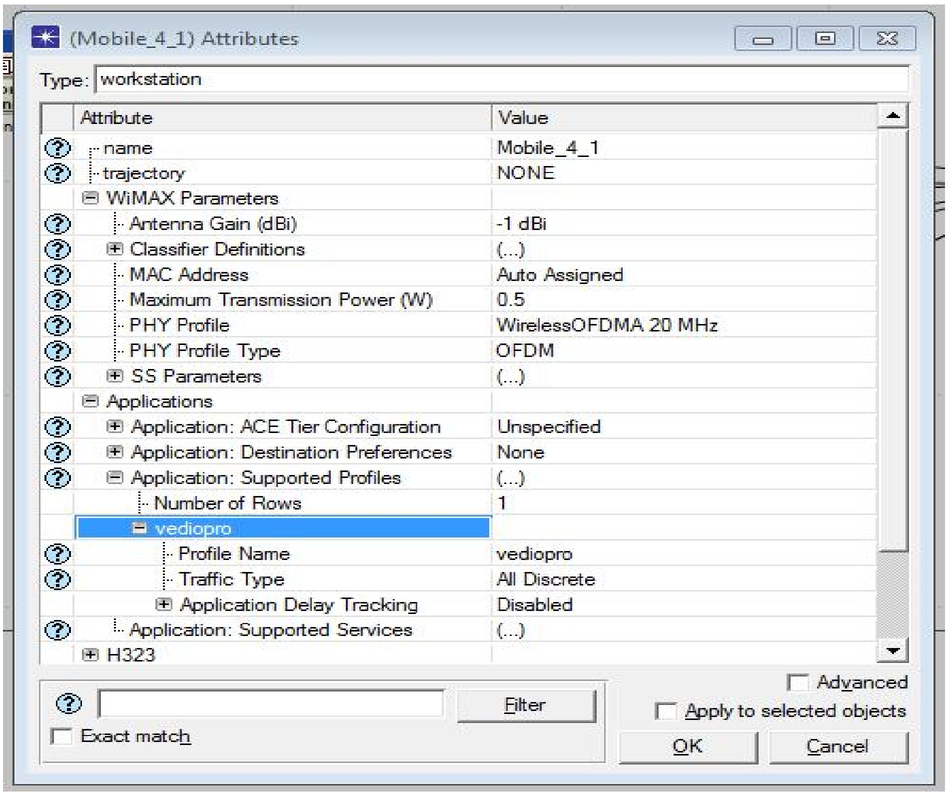

Figure (4-5): WiMAX Mobile station configuration

The WiFi simulation parameters specifying physical characteristics, data rate, buffer size and transmit powers are shown in table (4-3)

Table (4-3): WiFi simulation parameters

WiFi simulation parameters	
Physical characteristics	802.11g (extended rate)
Data Rate	54 Mbps
SS Buffer size	256 Kb
AP Buffer size	256 Kb
SS transit power	0.5 W
AP transit power	3 w

Figure(4-6)and Figure (4-7) shows the WiFi Access Point and WiFi Subscriber station 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. Physical (PHY) layer access was configured to utilize 80211g. The work station transmit power was configured to 0.5 watts. On the other hand, the access point transmit power was configured to use 3 watts of transmit power.

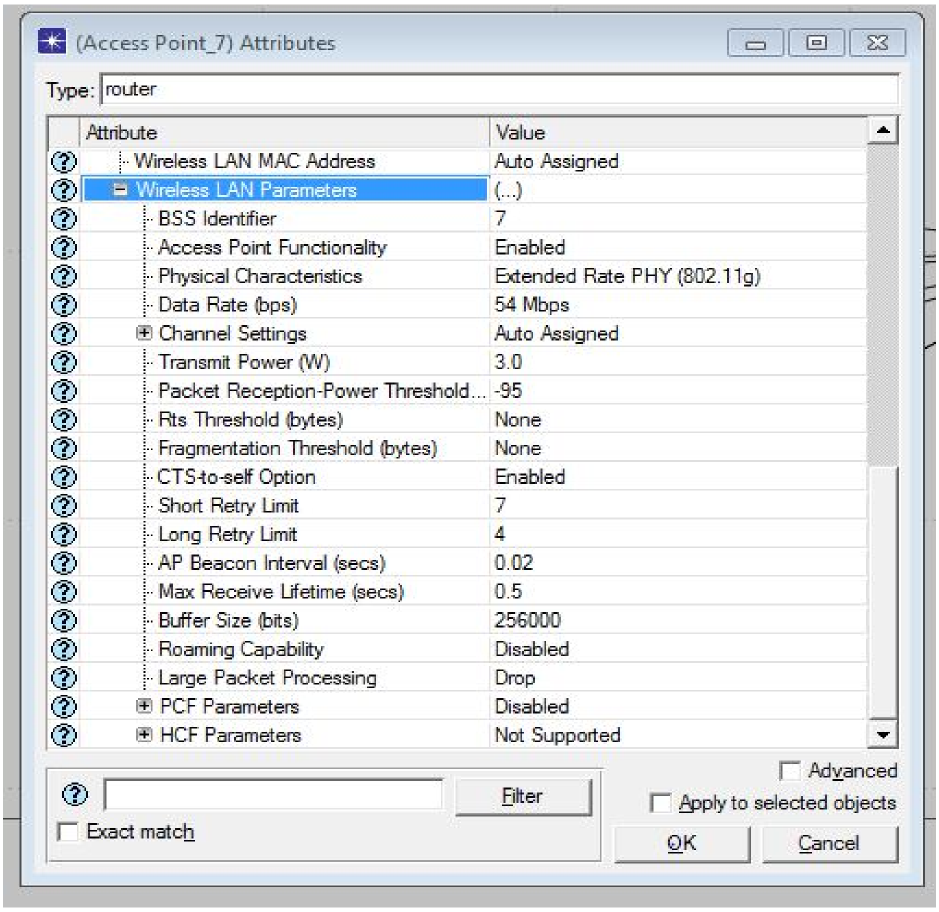

Figure (4-6): WiFi access point configuration

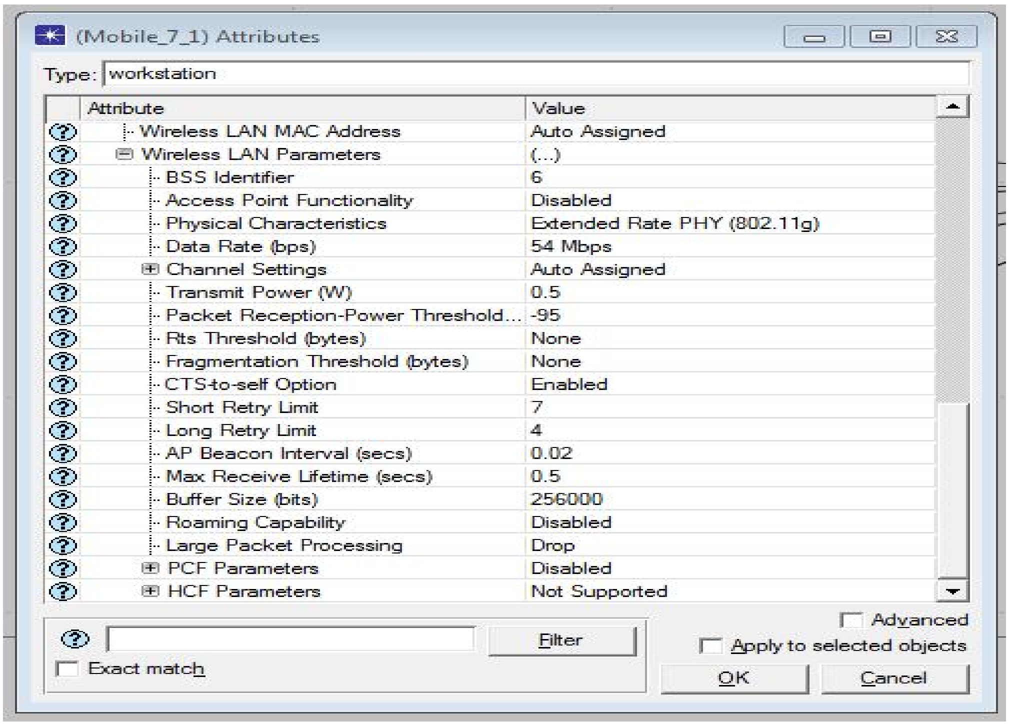

Figure (4-7): WiFi work station configuration

In table (4-4) The Server and Application (video conference) parameters showing server speed, server type, video frame internal time and video size.

Table (4-4): Server and Application (video conference) parameters

Server and Application (video conference) parameters	
Server processing speed	1 MB/sec
Type of service	Standard (64/252) priority
Video Frame interval time	10 frame/sec
Video frame size	128x120 pixels

Figure(4-8) 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 encodingrate of 10 frame/sec(fps). The video traces were scripted into video conferencing frame size as.

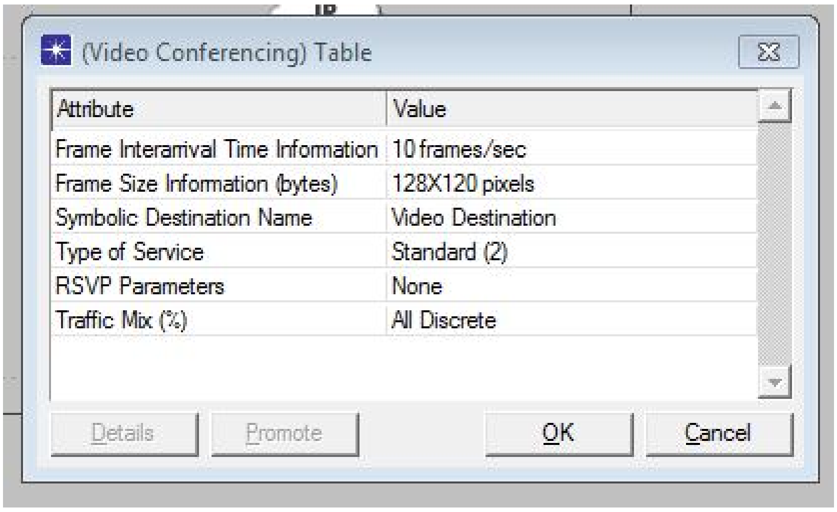

Figure (4-8): Video conference parameters

The description of models:

There are six model each model consists of a circular placement of nodes in a hexagon with one WiMAX Base Station or WiFi access point and (one or five or ten) Subscriber Stations (SS) which were 1km apart from the Base Station (BS). The BS connected to the IP backbone via a PPP link, the video server connected to the server backbone via PPP DS3 Duplex link.

WiFi Connection model

1st Scenario (one user)

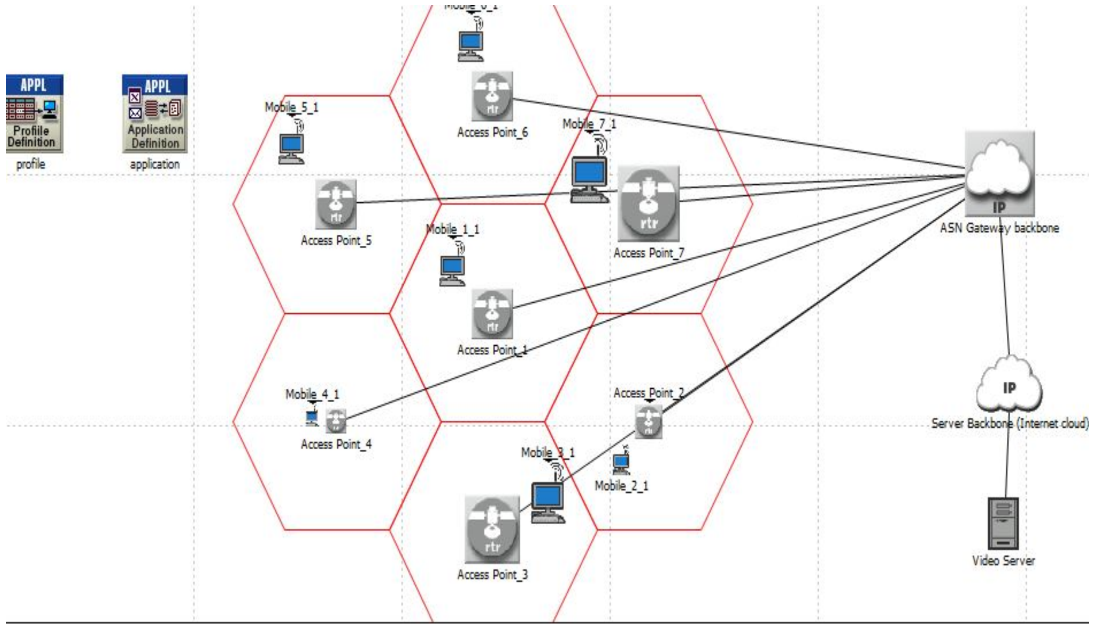

Figure (4-9): WiFi Connection model

Wimax with One user 1st Scenario

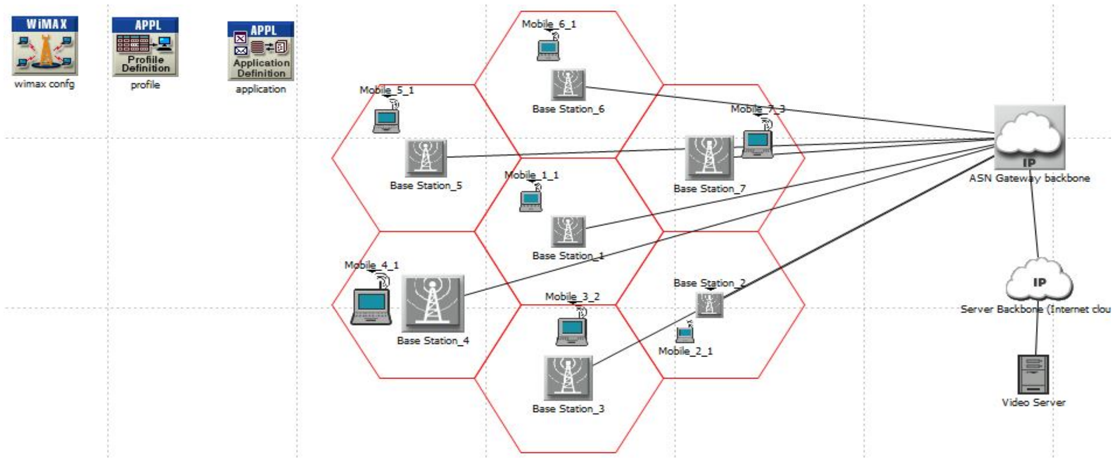

Figure (4-10): WiMAX with One user Scenario

Figure (4-11) shows the average packet delay variation for video conference for one user along simulation time for two networks: one for WiMAX and the other for WiFi. From figure (4-10) the average packet delay variation for video conference of WiMAX is higher than that of WiFi by (٩١.٧%).

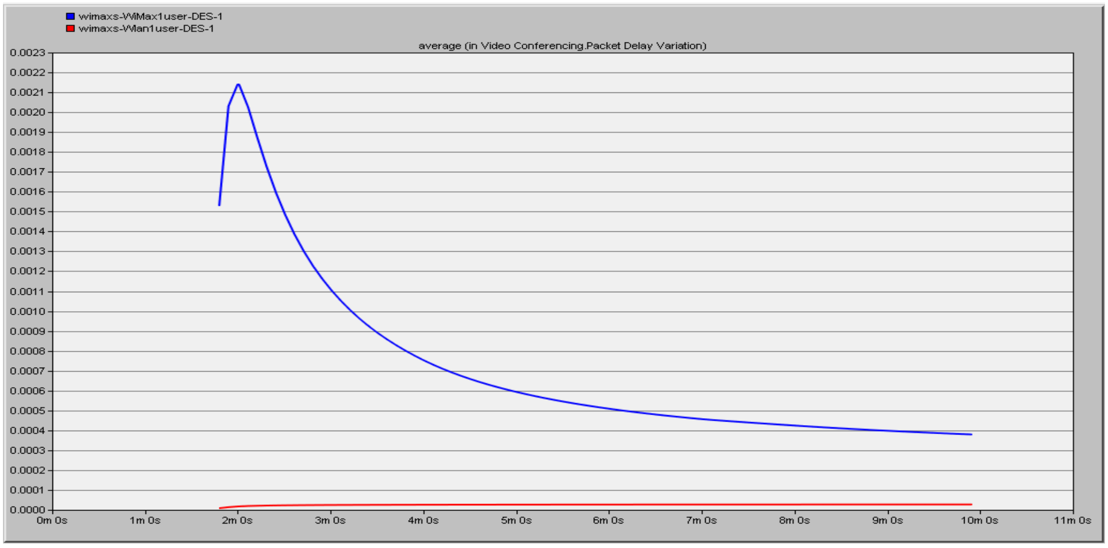

Figure (4-11): Video average packet delay variation WiMAX VS WiFi

Figure (4-12) shows the average end to end delay for video conference for one user along simulation time for two networks: one for WiMAX and the other one of WiFi. From figure (4-12) the average end to end delay for video conference of WiMAX is higher than that of WiFi by about (٩٢%).

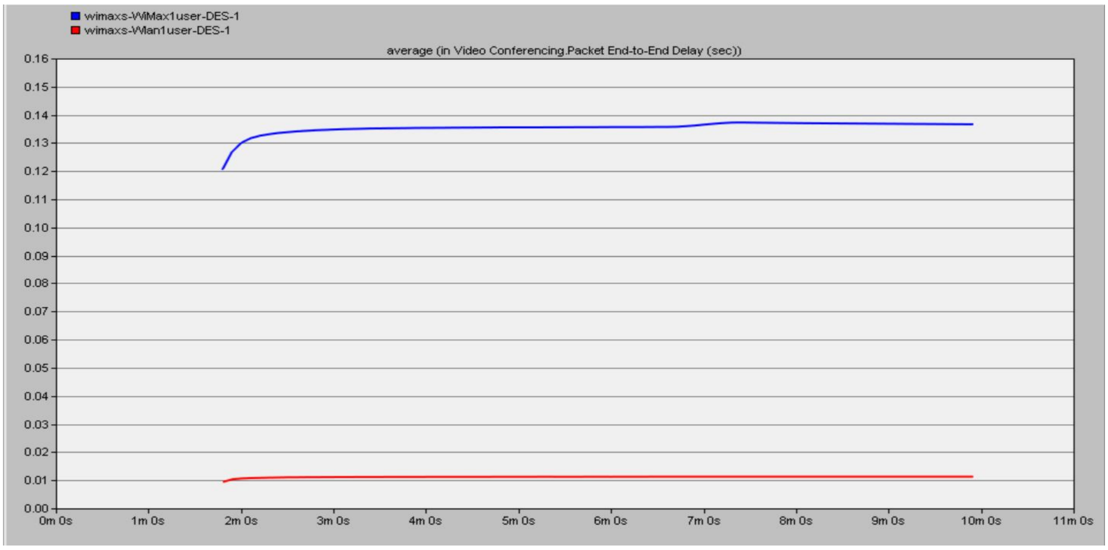

Figure (4-12): Video average end to end delay WiMAX VS WiFi

Figure (4-13) shows the traffic sent for video conference for one user along simulation time for two networks: one for WiMAX and the other For WiFi. From figure (4-13) the traffic sent for video conference of WiMAX is higher than that of WiFi by about (٤٢.١%), because the bandwidth of WiMAX is higher than the bandwidth of WiFi.

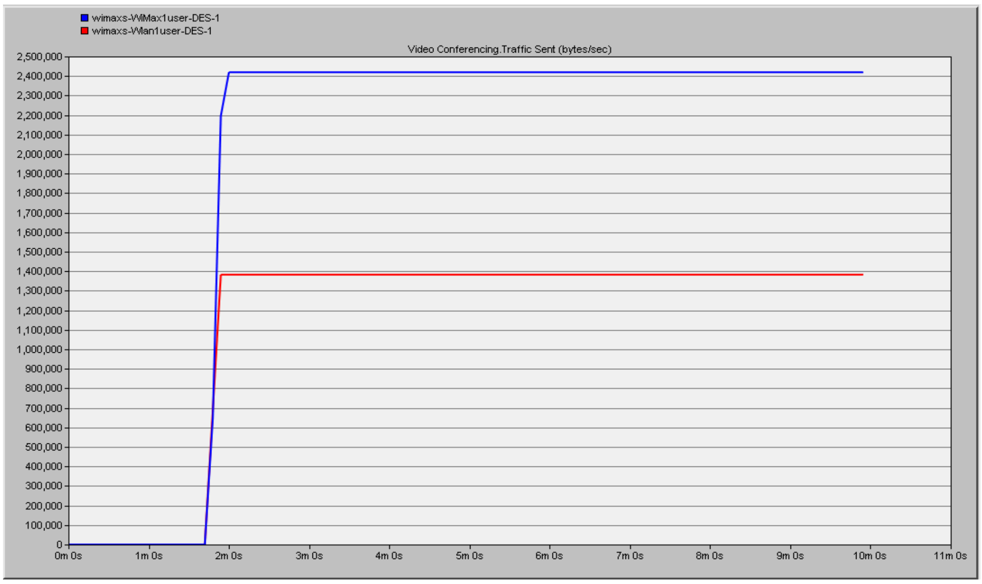

Figure (4-13): Video traffic sent WiMAX VS WiFi

Figure (4-14) shows the traffic received for video conference for one user along simulation time for two networks: one for WiMAX and the other for WiFi. From figure (4-14) the traffic received for video conference of WiMAX is about the same to that of WiFi because the delay in WiMAX is higher than that in WiFi.

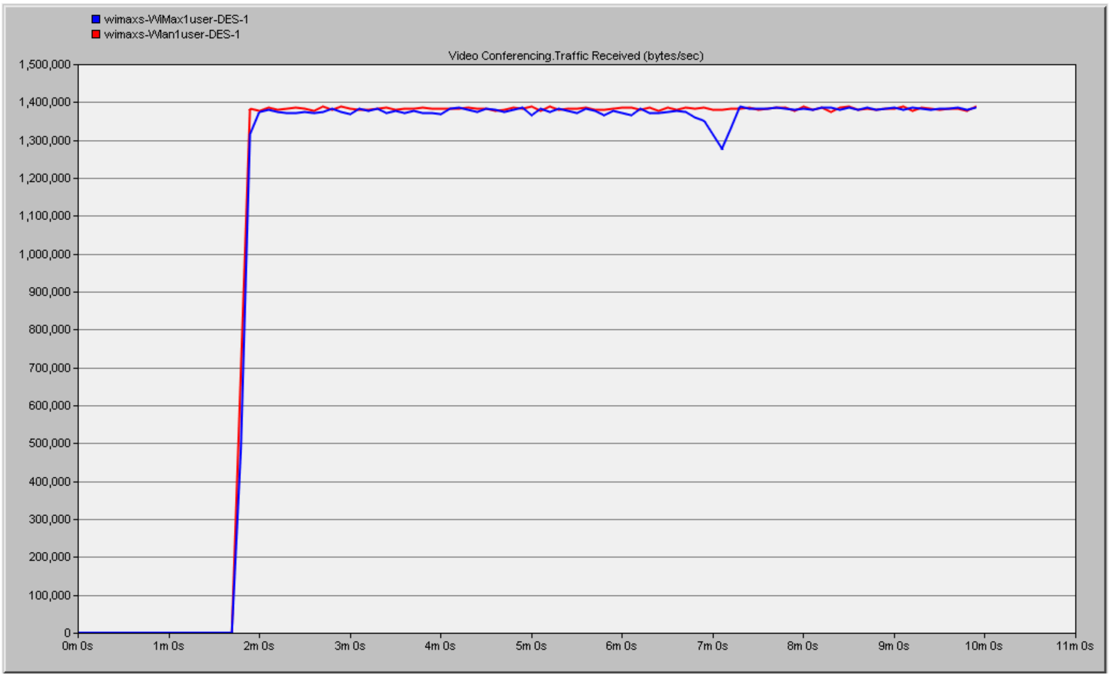

Figure (4-14): Video traffic received WiMAX VS WiFi

Figure (4-15) shows the delay in Physical layer for one user along simulation time for two networks: one for WiMAX and the other one of WiFi. From figure (4-15) the delay in physical layer of WMAX is higher than that of WiFi by about (٩٣.٥%).

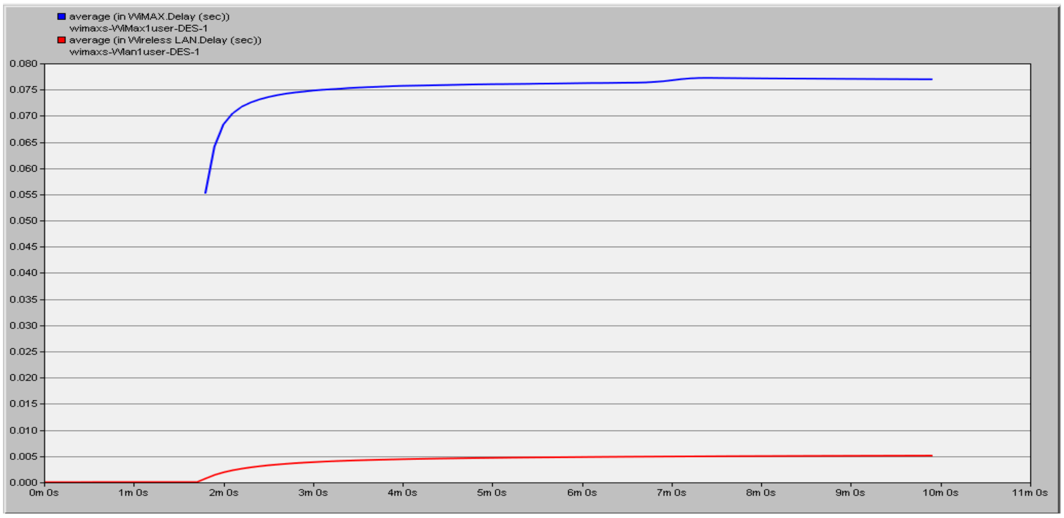

Figure (4-15): Delay in Physical layer WiMAX VS WiFi

Figure (4-16) shows the load in physical layer for one user along simulation time for two networks: one for WiMAX and the other one of WiFi. From figure (4-16) the load in physical layer of WiMAX is higher than that of WiFi by about (٦٦.٢%)

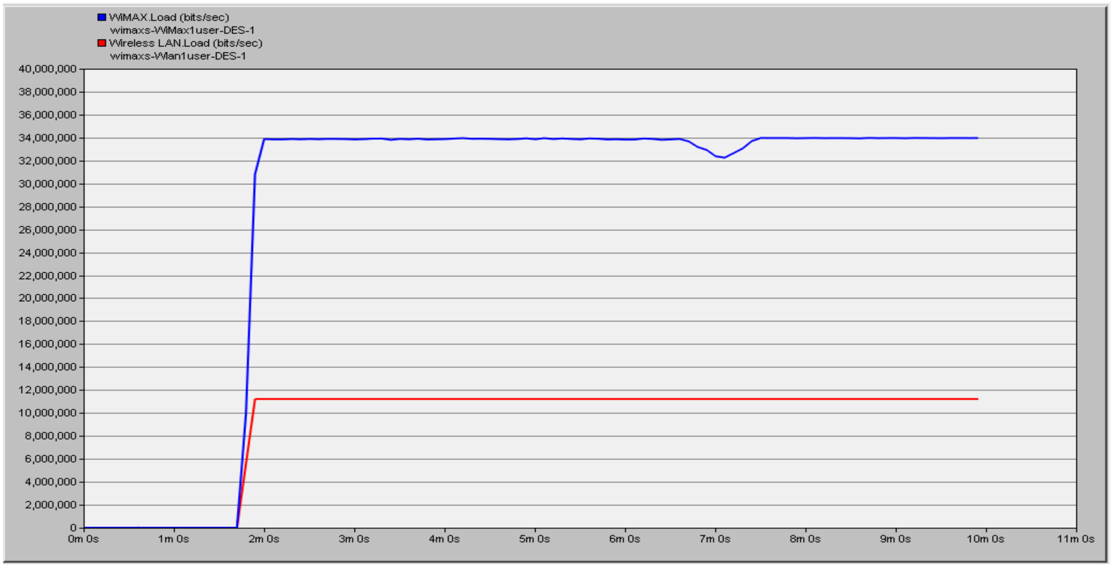

Figure (4-16): Load in Physical layer WiMAX VS WiFi

Figure (4-17) shows the throughput in physical layer for one user along simulation time for two networks: one for WiMAX and the other one of WiFi. From figure (4-17) the throughput in physical layer of WiMAX is better than that of WiFi by about (٦٣.٥%).

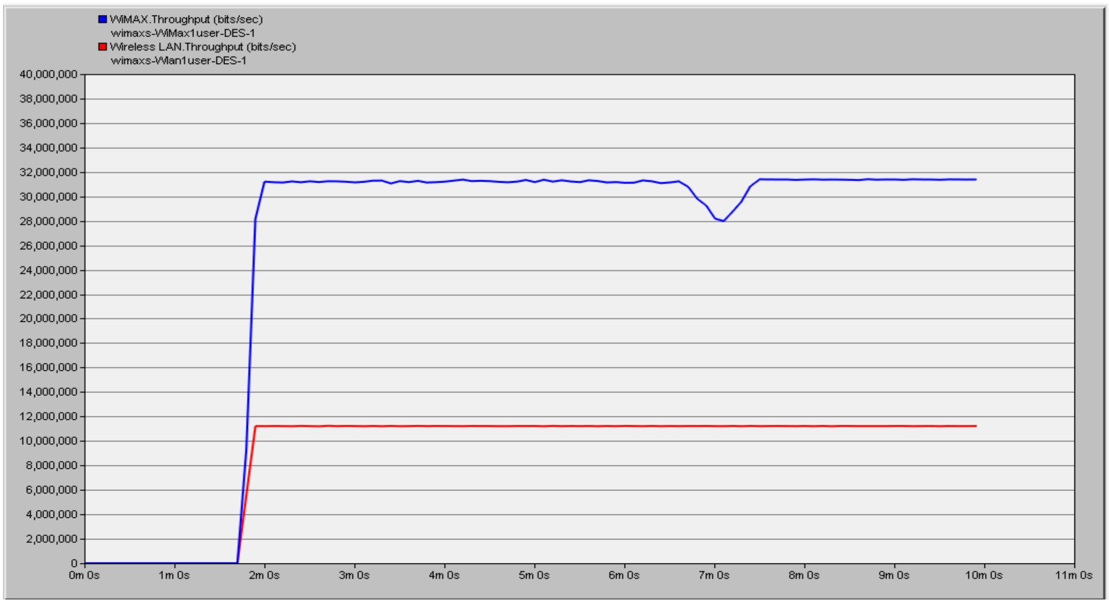

Figure (4-17): Throughput in Physical layer WiMAX VS WiFi

Wifi Connection model2nd Scenario (five users):

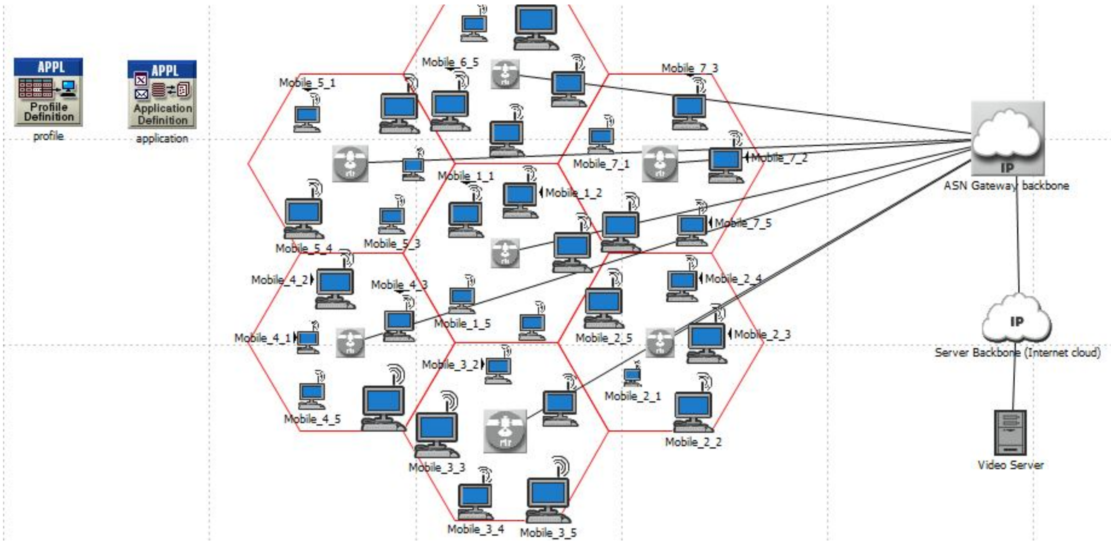

Figure (4-18): WiFi with Five users Scenario

WiMAX Connection model2nd Scenario (five users):

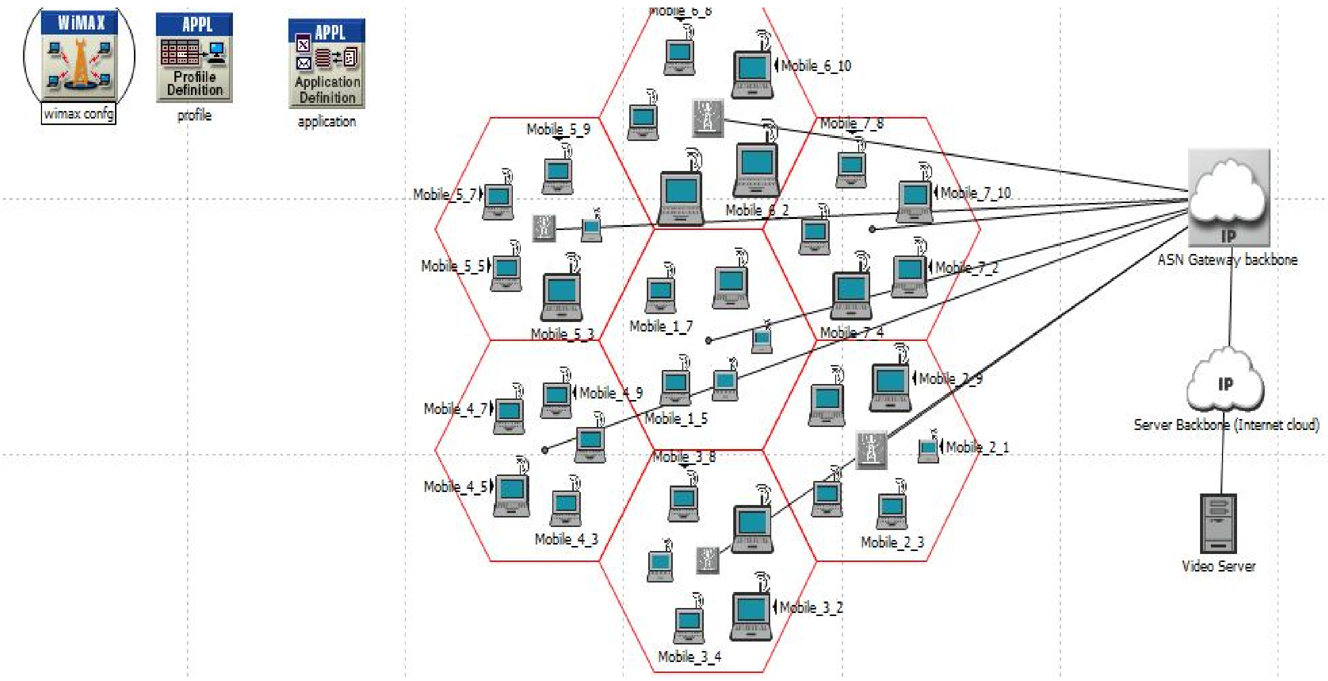

Figure (4-19): WiMAX with Five users Scenario

Figure (4-20) shows the average packet delay variation for video conference for five users along simulation time for two networks: one for WiMAX and the other one of WiFi .From (4-20) figure the average packet delay variation for video conference of WiMax is higher than that of WiFi by about (٨١.8%).

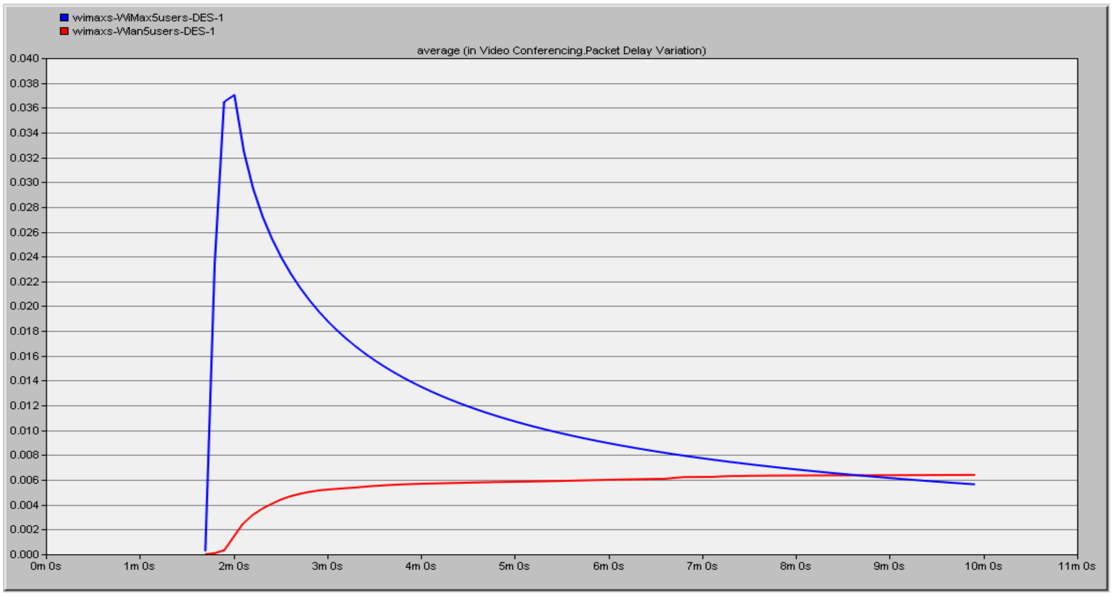

Figure (4-20): Video average packet delay variation WiMAX VS WiFi

Figure (4-21) shows the average end to end delay for video conference for five users along simulation time for two networks: one for WiMAX and the other one for WiFi. From figure (4-21) the average end to end delay for video conference of WiMAX is higher than that of WiFi by about (٨١.١%).

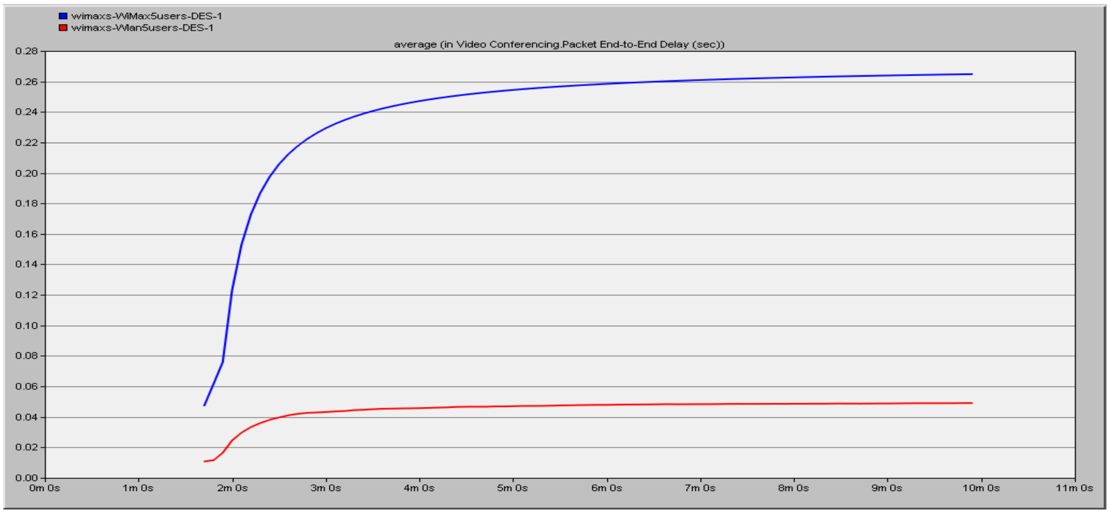

Figure (4-21): Video average end to end delay WiMAX VS WiFi

Figure (4-22) shows the traffic sent for ••video conference for five users along simulation time for two networks: one for WiMAX and the other one for WiFi. From figure (4-22) the traffic sent for video conference of WiMAX is higher than that of WiFi by about (٧١.١%), because the bandwidth of WiMAX is higher than the bandwidth of Wifi.

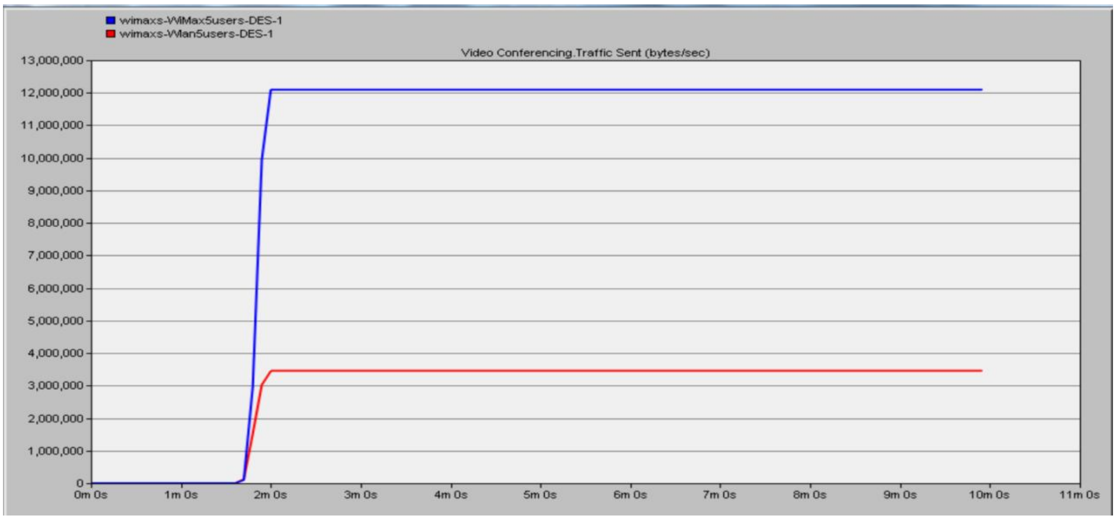

Figure (4-22): Video traffic sent WiMAX VS WiFi

Figure (4-23) shows the traffic received for video conference for ten users along simulation time for two networks: one for WiMAX and the other one of WiFi. From figure (4-23) the traffic received for video conference of WiMAX is higher than that of WiFi by about (٦٤.٨%).

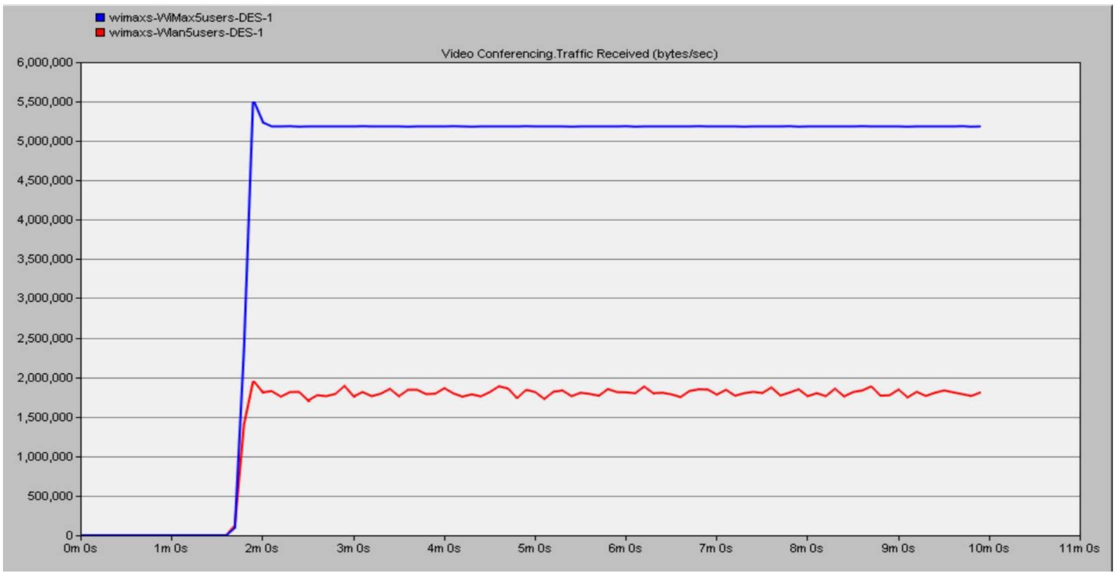

Figure (4-23): Video traffic received WiMAX VS WiFi

Figure (4-24) shows the delay in physical layer for five users along simulation time for two networks: one for WiMAX and the other for

WiFi. From figure (4-24) the delay in physical layer of WiMAX is higher than that of Wifi by about (٩٢.٦%).

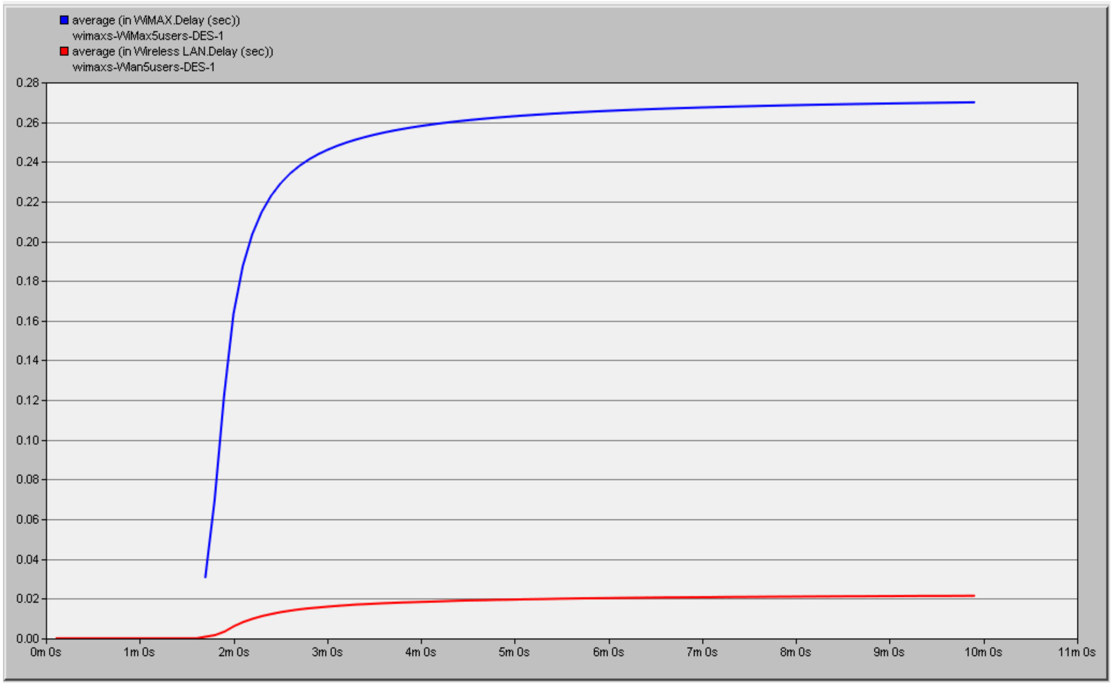

Figure (4-24): Physical layer average delay WiMax VS WiFi

Figure (4-25) shows the load in physical layer for five users along simulation time for two networks: one for WiMAX and the other one of WiFi. From figure (4-25) the load in physical layer of WiMAX is higher than that of WiFi by about (٥١.٩%).

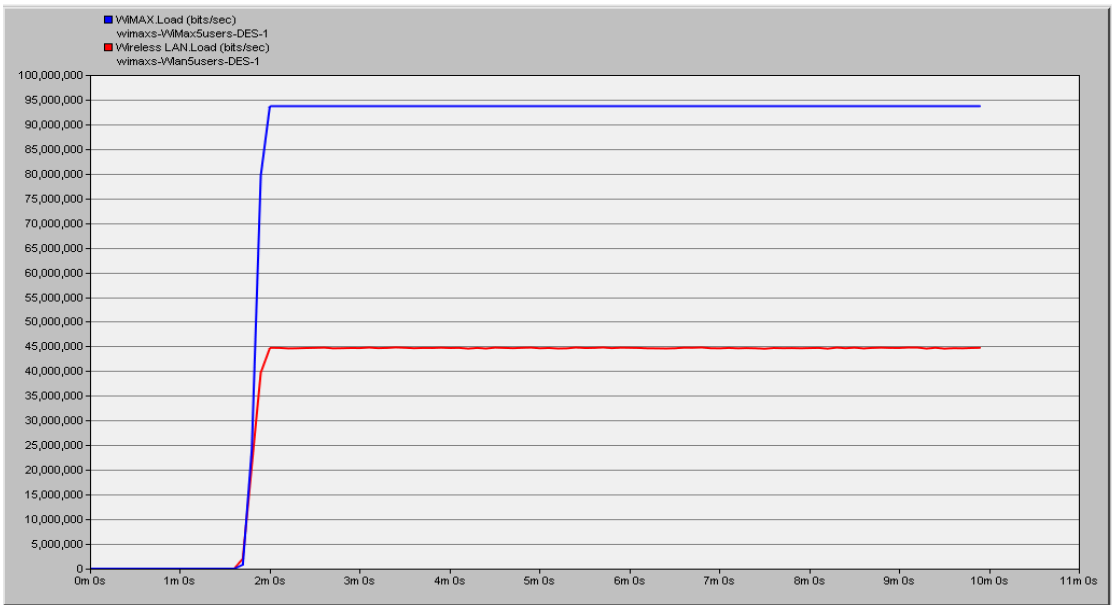

Figure (4-25): Physical layer Load WiMAX VS WiFi

Figure (4-26) shows the throughput in physical layer for five users along simulation time for two networks: one for WiMAX and the other for WiFi. From figure (4-26) the throughput in physical layer of WiMAX is better than that of WiFi by about (٤٤.٤%), this means that throughput of wimax increases as the number of users increase.

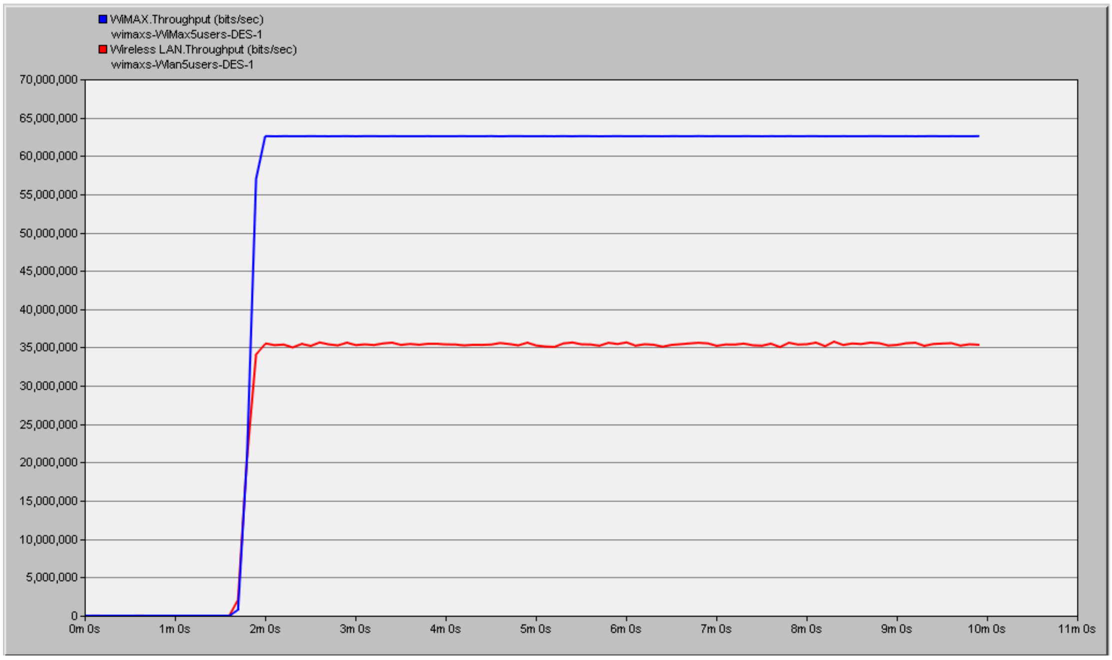

Figure (4-26): Physical layer Throughput WiMax VS WiFi

Wifi Connection model

3rd Scenario (ten users):

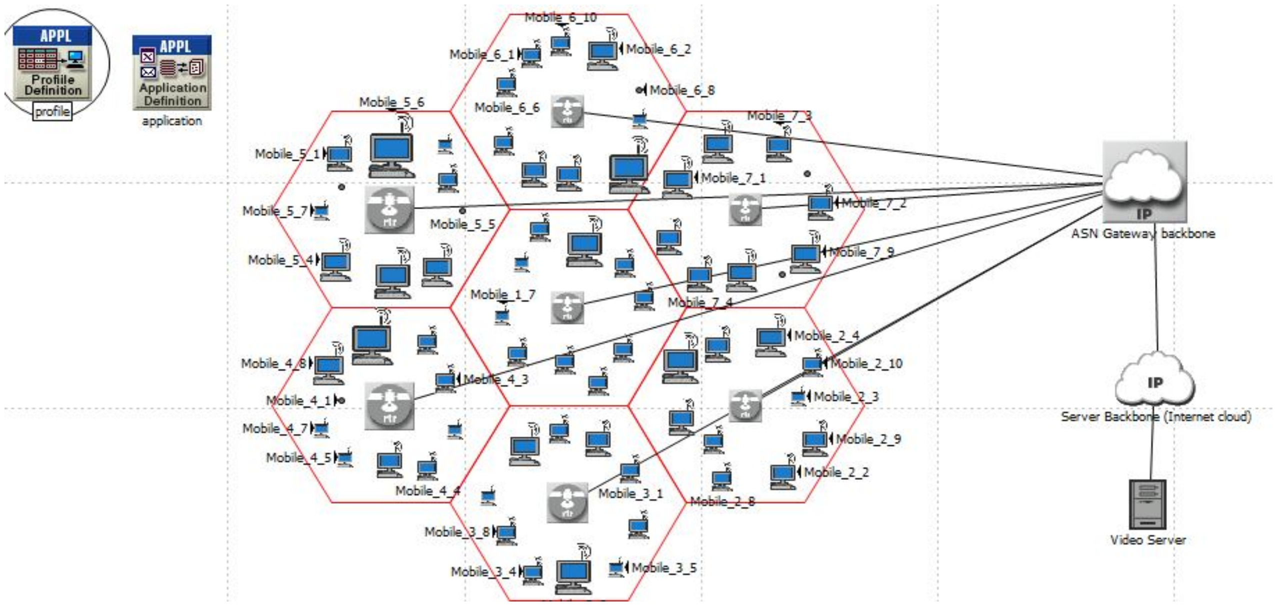

Figure (4-27): WiFi with Ten users Scenario

WiMax Connection model

3rd Scenario (ten users):

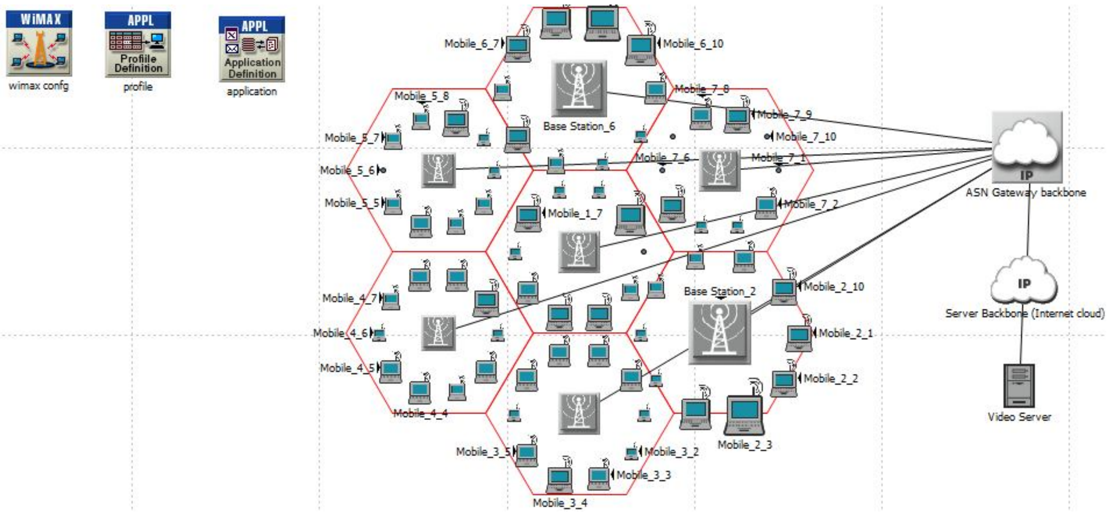

Figure (4-28): WiMax with Ten users Scenario

Figure (4-29) shows the average packet delay variation for video conference for ten users along simulation time for two networks: one for WiMAX and the other for WiFi .From figure (4-29) the average packet delay variation for video conference of WiMAX is higher than that of WiFi by about (٤٠%).

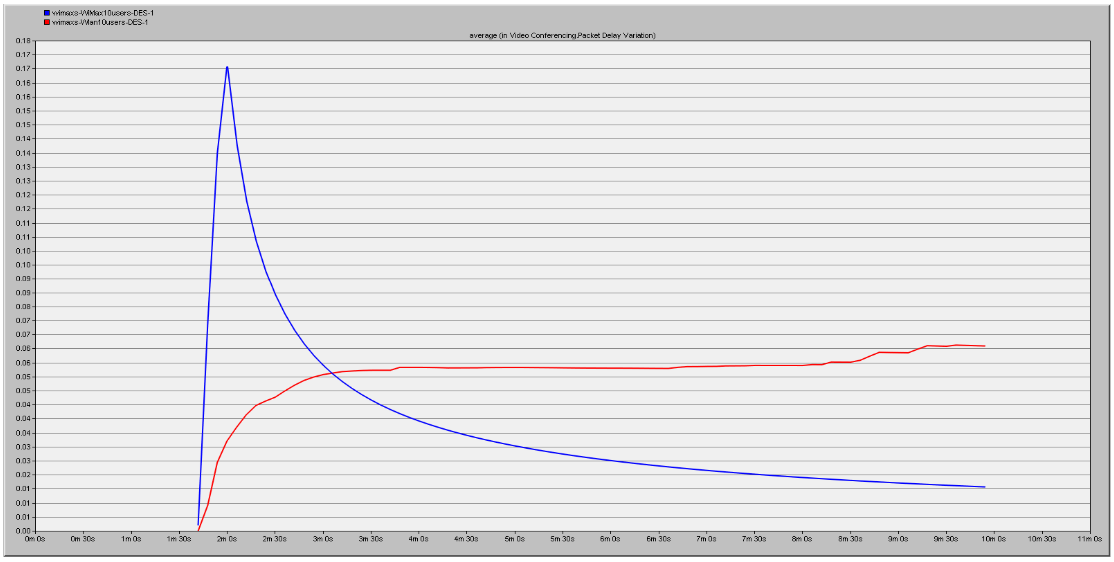

Figure (4-29): Video average packet delay variation WiMAX VS WiFi

Figure (4-30) shows the average end to end delay for video conference for ten users along simulation time for two networks: one for WiMAX and the other one of WiFi. From figure (4-30) the average end to end delay for video conference of WiMAX is higher than that of WiFi by about (٥٦.٧%).

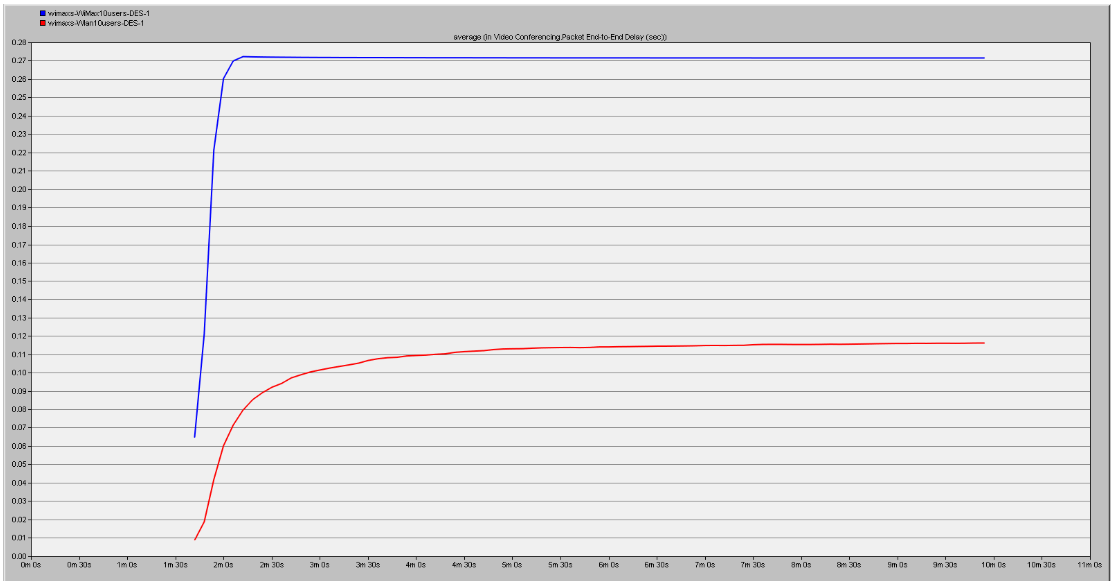

Figure (4-30): Video average end to end delay WiMax VS WiFi

Figure (4-31) shows the traffic sent for video conference for ten users along simulation time for two networks: one for WiMAX and the other one of WiFi. From figure (4-31) the traffic sent for video conference of

WiMAX is higher than that of WiFi by about (٤٢.٣%), because the bandwidth of WiMAX is higher than that of WiFi.

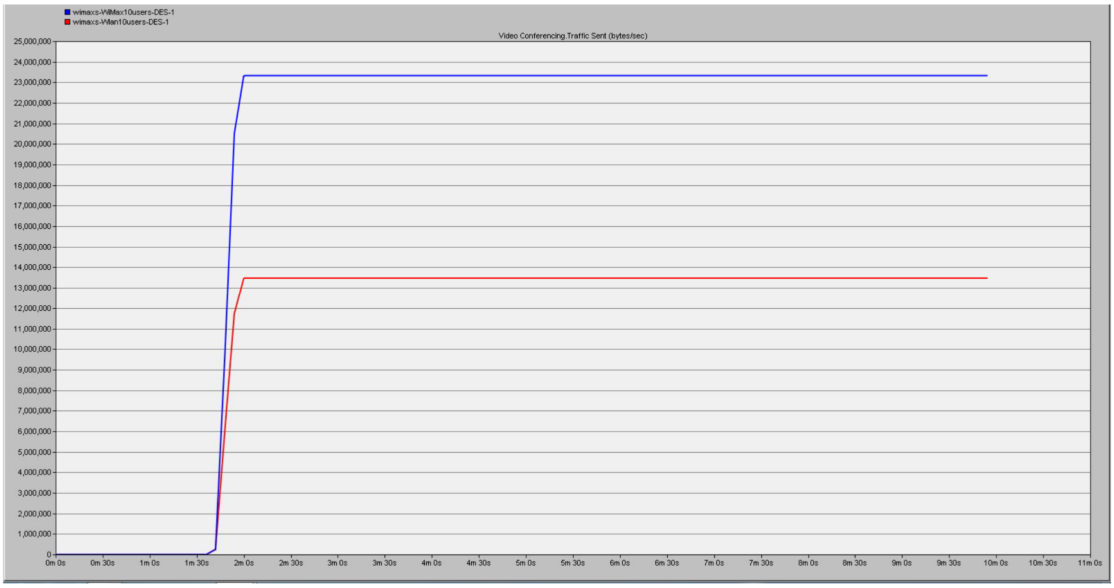

Figure (4-31): Video traffic sent WiMax VS WiFi

Figure (4-32) shows the traffic received for video conference for ten users along simulation time for two networks: one for WiMAX and the other for WiFi figure(4-32) the traffic received for video conference of WiFi is higher than that of WiMAX by about (١٨٢.٤%), this means the traffic received of WiMAX decreases when the number of users increases.

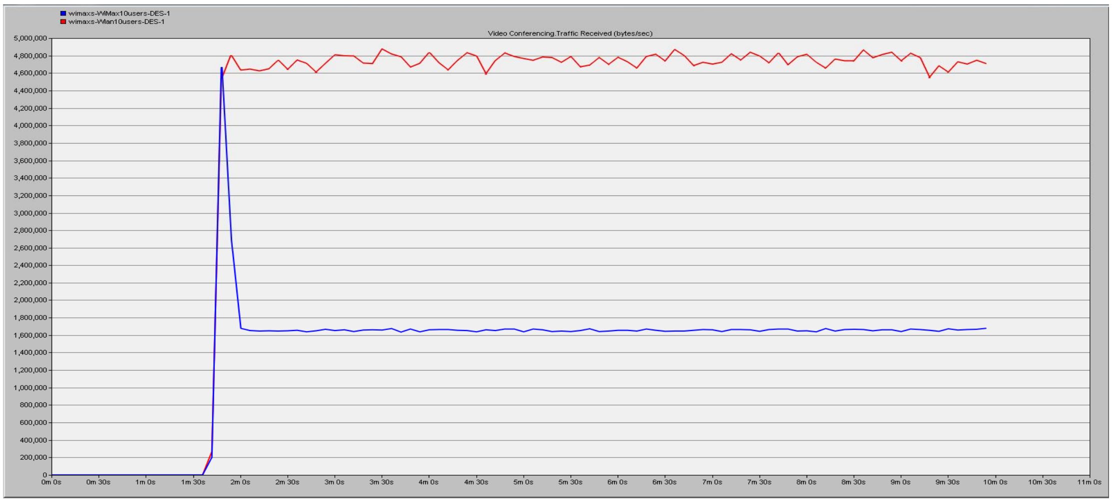

Figure (4-32): Video traffic received WiMAX VS WiFi

Figure (4-33) shows the delay in physical layer for ten users along simulation time for two networks: one for WiMAX and the other for WiFi. From figure (4-33) the delay in physical layer of WiMAX is higher than that of WiFi by about (٨٣.٣%).

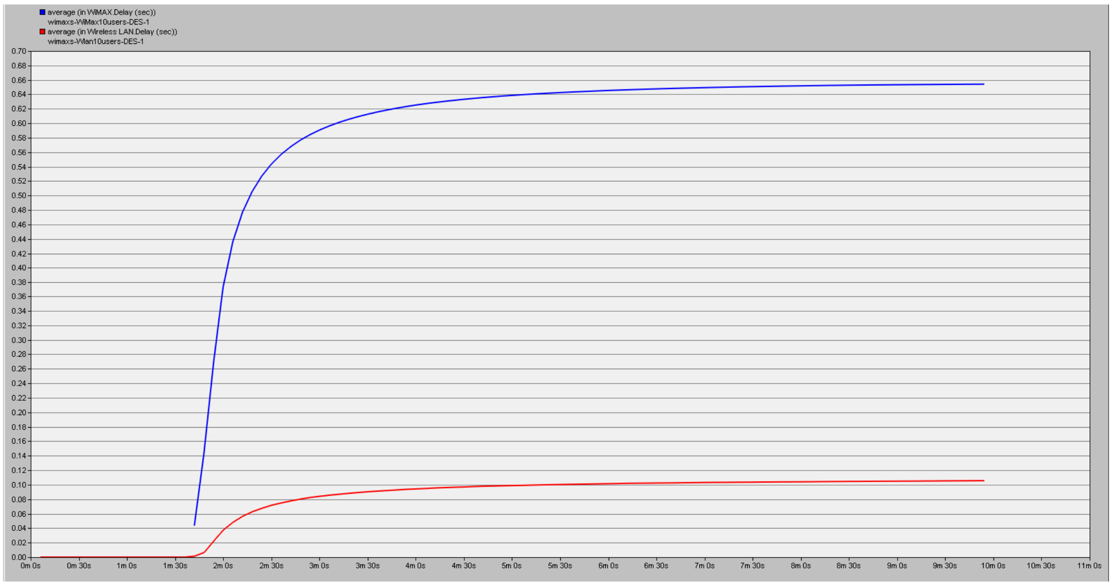

Figure (4-33): Physical layer Delay WiMax VS WiFi

Figure (4-33) shows the load in physical layer for ten users along simulation time for two networks: one for WiMax and the other for WiFi. From figure (4-33) the load in physical layer of WiMax is higher than that of WiFi by about (٢٦.٥%).

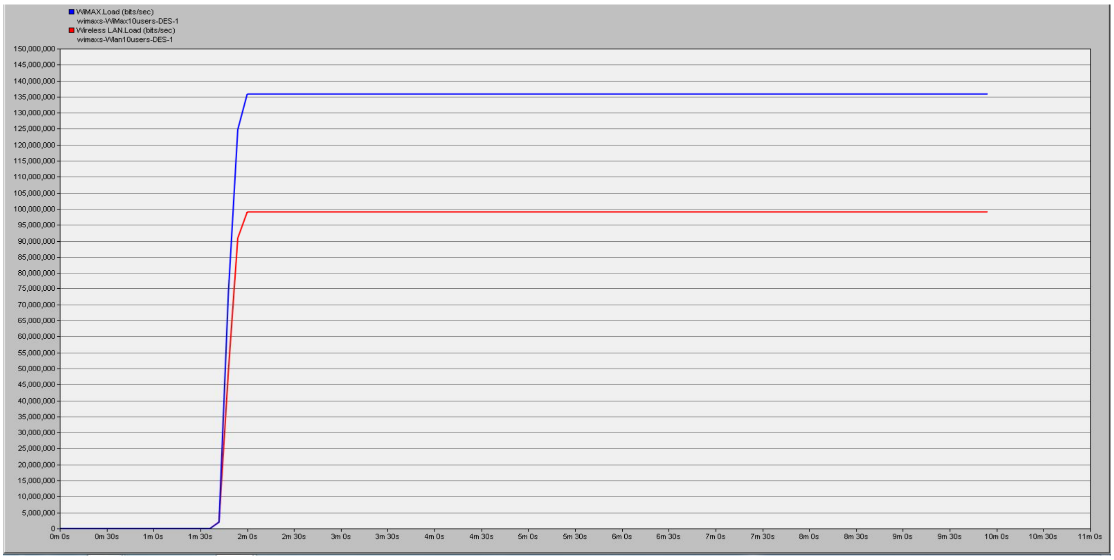

Figure (4-33): Physical layer Load WiMAX VS WiFi

Figure (4-35) shows the throughput in physical layer for ten users along simulation time for two networks: one for WiMAX and the other one of WiFi .From figure (4-35) the throughput in physical layer of WiMAX is better than that of WiFi by about (١٥.٣%).

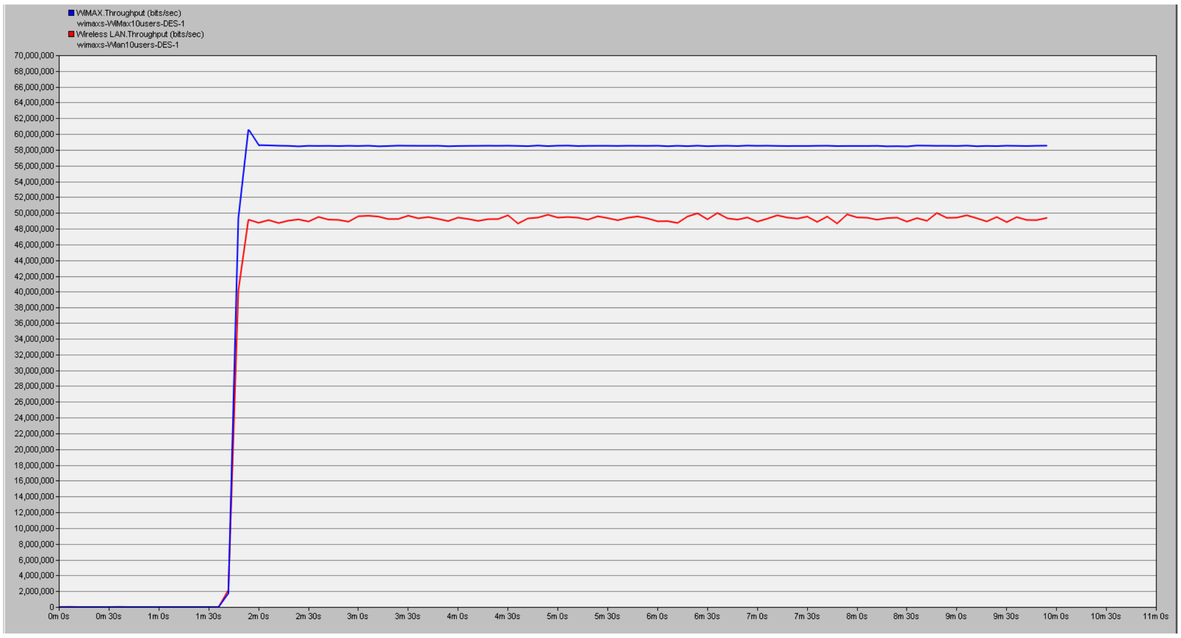

Figure (4-35): Physical layer Throughput WiMAX VS WiFi

Table (4-5): the result of simulation for all scenarios

Network	Delay	Load	Throughput	PDV	E2E Delay	Traffic Sent	Traffic Received
WiFi 1 user	0.005	11.5 Kbps	11.5 Kbps	0.0001	0.011	1.4 KB	1.4 KB
WiMax 1 user	0.077	34 Kbps	31.5 Kbps	0.0012	0.137	2.42 KB	1.4 KB
WiFi 5 users	0.02	45 Kbps	35 Kbps	0.004	0.05	3.5 KB	1.9 KB
WiMax 5 users	0.27	93.5 Kbps	63 Kbps	0.022	0.265	12.1 KB	5.4 KB
WiFi 10 users	0.11	100 Kbps	50 Kbps	0.06	0.117	13.5 KB	4.8 KB
WiMax 10 users	0.66	136 Kbps	59 Kbps	0.1	0.27	23.4 KB	1.7 KB

In WiMAX network the packet delay variation (PDV) starts with maximum values then it becomes more adapted and minimized to more reliable value when compared with WiFi PDV values. End to End delay has a constant increase according to the number of users as expected. But the only different event occurs in the third scenario when there are ten users in each cell; the video traffic received is very small when compared with five users. In five users scenario, traffic received was approximately 5.5 KB but in ten users it becomes 1.8 KB which causes 92.7% loss, this is the effect of the overload and it indicates that there was a congestion or overcrowding in the network or the network resources set in the simulation parameters aren't enough for all of these seventy users in the network this illustrate in table (4-6).

Table (4-6): The over load and video traffic loss

Network	**Physical Over load (%)**	**Video traffic loss (%)**
WiFi 1 user	0	0
WiMax 1 user	7.9 %	42.1%
WiFi 5 users	28.5 %	45.7%
WiMax 5 users	48.4%	55.4%
WiFi 10 users	100 %	64.4%
WiMax 10 users	130%	92.7%

Table (4-7) illustrates delay, load, throughput and end to end delay were increased by increasing the number of users but traffic received was decreased.

Table (4-7): Results of simulation for WiMAX VS WiFi networks

Network	**Delay**	**Load**	**Throughput**	**PDV**	**E2E Delay**	**Traffic Sent**	**Traffic Received**
WiFi VS WiMAX for 1 user	93.5%	66.2%	63.5%	91.7%	92%	42.1%	100%
WiFi VS WiMAX for 5 users	92.6%	51.9%	44.4%	81.8%	81.1%	71.1%	64.8%
WiFi VS WiMAX for 10 users	83.3%	26.5%	15.3%	40%	56.7%	42.3%	182.4%

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

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5.1 Conclusion:

This research evaluates the performance of WiMAX /WiFi networks. It was modeled by streaming a videoconference application to determine the performance of the two networks with respect to the (QoS) requirements of a high resolution videoconference application because it has significant effects in business, education, medicine and media. In addition the WiMAX and WiFi subsystems were compared with respect to their individual performance considering videoconference application.

All results show that WiMAX has advantages over WiFi in terms of throughput by about 84.7% but it has more physical layer delay when compared with WiFi by about 16.7%. This delay generates more Packet delay variation and packet end to end delay in videoconferencing traffic.

From the results of simulation it is obvious that the value of the packet delay variation in WiMAX is adapted over the time and becomes equal or even better than WiFi.

In the one user scenario ,WiFi shows better performance in terms of load and throughput relation by approximately (0%) and video traffic sent and received but in WiMAX there was 7.9% over load and 42.1% video traffic loss.

In the five users Scenario there was 28.5% overload and 45.7% traffic loss in WiFi network, while in WiMAX the overload was 48.4% and 47.1% traffic loss.

In the ten user scenario WiFi network had 100% overload and 64.4% traffic loss, while in WiMAX overload becomes 130% and 92.7% traffic loss.

To conclude it is obvious that WiMAX users who share data and quality of service, can degrade as more users are added to the network .

In this simulation WiFi shows some advantages over WiMAX but that doesn't mean it is better, because they are not compared in other terms like coverage, distance, frequency, mobility, data rate, and bandwidth

5.2 Recommendations:

After finishing this research it is recommended for further works to design a single scenario for both WiMAX and Wi-Fi technologies, and then evaluate Voice over Internet Protocol (VOIP) performance of the system. Furthermore use other simulation programs to compare the results. In addition it is recommended to increase number of clients in the scenarios to see the effects. Above all it is suggested to Use other applications.

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