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Research Article

Design and Simulation of Worldwide Interoperability for Microwave Access Computer Network for 3×3 Km Universal Sample of Building Campus

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ABSTRACT

The aim of this study to design a wireless computer network of a particular network as a large-scale company or university to improve mobility and to let the teachers and students of the university, for example, stay interacted and connected at any time in any campus location or site. Therefore, This study needed to cover the overall area of this campus with efficient wireless coverage that exceeds the university boundaries to maintain wireless signal strength. To do that, the researchers thought that it is very significant to design a Worldwide Interoperability for Microwave Access (WiMax) computer network with the most powerful and advanced hardware component capabilities to full fit teachers' and students' requirements of fast net browsing and files' download. After designing the university campus of computer network, simulation has done by OPNET 14 Modular to determine the WiMax network design parameters. The purpose of the current research is to find if the design of the campus network is efficient or not and also to determine the performance of the implemented network.

Keywords: Computer network design, data traffic, server HTTP, voice over IP, Worldwide Interoperability for Microwave Access network delay

INTRODUCTION

In this research, the Worldwide Interoperability for Microwave Access (WiMax) technology was used to implement this computer network, and the supposed coverage is of 3 km×3 km, which is very suitable for a group of campus buildings on a specific area. The researchers found a very efficient example, which needs a large number of users, and then suggested that this work would be accomplished for an example of a university, which has the nearest specification such as area, mobility, and number of subscribers. Hence, if a university teacher needs to move or change his or her position while he is still online with his service provider or wireless distribution node, it will be a very good thing. In other words, if we talk about a university campus, it is very good to let the university staff moves (walking) without cutting his internet service, and hence, mobility will be achieved. In many sectors, nowadays, when you have a WiFi distribution device such as access point, wireless router, or nanostation, you must not get too far from your wireless distributer that provides you the service. The WiFi range has a limited area with tiny differences depending on the quality of the device used. All WiFi devices have small range coverage area comparing with the WiMax ones that is due to its wave signal characteristics and specifications such as frequency range, modulation, and multiplexing. On the other hand, the WiMax has a much wider coverage area with higher data speed, making it the best wireless communication system for all the reasons above. Nowadays, every company or individual wish is to get the higher speed and larger coverage area. Therefore, the choice of replacing the existed WiFi or/and wired computer network with WiMax systems will be much better. Accordingly, the researchers started thinking to prepare a design of a new computer network depending mainly on WiMax technology instead of the old one, getting the benefit of centralized network design, which will make it easy to control the whole network, protect, and distribute this network service to the subscribers. WiMax IEEE standard called as IEEE 802.16 can support many protocols such as

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Ethernet and IP. WiMax technology is able to provide higher bandwidth and it works depending on orthogonal frequency division multiplexed access (OFDMA), while WiFi depends on carrier sense multiple access/collision detection (CSMA/CA) technology. OFDMA is able to provide higher bandwidth.

The designed computer network in this paper can serve 600 users on overall WiMax network sites and locations. The WiMax network is constructed by three cells; each cell contains WiMax station and WiMax tower to distribute the wireless service. These three WiMax stations are sufficient rigidly to cover the required network area by WiMax propagated signals ensuring the quality of internet services.

More and more advantages were achieved by simulating a network design on simulators such as GNS, packet tracer, or OPNET. Really, this software has many advanced capabilities of obtaining results corresponding to the computer network determinations. The efficiency mode of mobility and ranging enable WiMax base-station to be configured. The base station MAC address is designed as a distance based for the workstation. In addition to that in real network implementation, these deadlocks must be fixed, so this in role will add a cost, time emplaced, and more manipulation process to any project, especially, if modification made to overcome these deadlocks, the new upgraded design must be experimented again until solving these deadlocks. Simulation can overcome all these problems and cost consequences. After that, when the solution is configured, this simulation can detect, if the last solution (upgraded) is efficient or not, and if it will produce good performance or not. This process can be done repeatedly until getting the best network performance. This cannot be done in real practical case or real computer network experimentation. Laboratories can get very big benefits if this simulation software are used intensively for under- or post-graduate students.

The advantages of using WiMax instead of WiFi:

- WiMax can provide service to a larger number of users
- The coverage area will be very larger
- WiMax provides a higher speed
- The network architecture will be a little bit smaller, so end devices can be supported with WiMax wireless controller (receivers) in addition to WiFi interface cards, or CPE devices can be used to convert WiMax to WiFi which can be distributed easily to any device nowadays. These devices have two jobs or actions. CPE device job is receiving WiMax and then broadcasts a WiFi.
- Much more mobility and flexibility of movement will be provided to all users.
- WiMax efficiency is much higher than WiFi efficiency.

NETWORK CONSTRUCTION

In general, it is better to look at any computer network from the top; this is called top view. When the top view is taken, a term used by computer network engineers called topology, this network topology covers an area of 3 km×3 km that must be covered by WiMax propagated signals to provide the services to all distinct users that is located far from the center distribution towers of WiMax broadcasting tower reaching all the campus boundaries. This gives the researchers a reason to check if the network can cover these areas or not. Connecting the main computer network to the three WiMax towers creates a one backbone star topology; this backbone connected directly to the cloud that provides the IP to whole network and makes the entire users to the internet. The backbone is about high data stream cable (wired media).

THE NETWORK DESIGN

In this research, WiMax network signaling has used to insure the connection and connection establishment, there are many WiMax factors such as hardware specification, application definitions, and network configuration details; in this research, researchers will focus on main ones. For this research, the network configuration done as following, the Path loss and Multipath channel model use ITU vehicular and pedestrian mechanism has not used. ITU vehicular is a type of signal propagation over the transmission channel used. ITU vehicular is given to simulate the higher mobility speed of any workstation (mobile phone), in another word if a person who moves across the coverage area of the supposed network, while he makes a mobile (voice over IP) call and he is moving with a high speed or taking a bike. A number of cells used are three. The geographical overlay (signal coverage) of each cell is shaped as hexagon. Users' distribution over the three areas can be also like grid or circular instead of random depending on the requirements and the demands of the design. In this research, the third one is used to simulate the reality of the motion of end network nodes, and hence, all users can freely move across the suggested network area. The 600 users are distributed on these three cells, and 200 users are distributed around each of these three cells (WiMax towers). The users are managed as mobile work stations (mobile phones) in the simulation. The efficiency mode configured as mobility and ranging enable for WiMax base-station configuration. Base station MAC address is designed and configured as distance based for workstation to check the handover.

The cell radius of each one reaches 1 km. The subscribing station placement nodes are distributed in circular fashion rather than random. Base station transmission power of subscriber node transmission power is 0.5 watt, where the power transmission in which use is 50 watt in each of the base stations. A very powerful and advanced technology was used for this wireless network to maintain network speed and to increase the number of users called wireless OFDM of 20 MHz with modulation and adaptive coding of wireless system PHY physical layer with UGS scheduling; the researchers did not use etPs rtPS or ntPS services. Where UGS is a type of quality of service (QoS) and is useful for VoIP application, because UGS is very essential to this type of wireless networks.

Handover threshold hysteresis in db used was 0.4 with resource retain time of 200 ms as one of the handover parameters. Throughput was configured to 0.8 Mbps. The researchers tried many times to simulate a larger number of users, but unfortunately, the computer did not respond because too many parameters were used. They want to monitor the VoIP service to check network performance. Interactive voice was used for match value of traffic characteristics; this is one of the WiMax characteristics. Antenna gain of each base station used was 15 dBi, and SUD was 1500 byte. In the bottom of each tower, there is WiMax base station installed and configured to be able to connect with other two tower base stations. TDD

duplexing type of time division had been used, instead of frequency division duplexing. The TDD is more widely used nowadays for modern voice transmission. The base frequency configured at 5.8 GH with bandwidth equals to 20 MH. The wait time used is 1 min. The ground speed was 24 km/h to simulate the maximum movement speed of any mobile user. Antenna gain was −1 db. The maximum sustained traffic rate was of 484 k. Minimum received traffic rate was equal to 484 k. Maximum latency was equal to 30 ms. Frame duration was 5 ms. Symbol duration equaled to 100.8 ms, and the number of subcarriers was 2048. To full fit the signal transmission performance.

One cloud backbone used provides the internet service by cable connecting 3 WiMax base stations, each one of base stations is distributing the service by WiMax wireless technology. Figure 1 show that WiMax towers was configured as rectangular shape; it is an effective way to fix these towers in online. VoIP application was configured in all the computer network mobile devices as well as base station; this application has been configured in the WiMax configuration and application profile items in the simulator. WiMax configuration and application are main components in the simulator software in which it must be configured carefully. Otherwise, the whole network will not be able to work.

The network position as shown in Figures 2 and 3 shows more zoom-in on the network which is located in the Middle East in the Kurdistan rejoin of Iraq specifically in the Kurdistan rejoin capital Erbil because most researchers reside in this city.

OPNET software is one of the best and powerful computer applications that provide so many network deterministic parameters, with its tiny details in very sufficient way, which make it very easy to design and simulate and then determine the results very fast.

LITERATURE REVIEW

The researchers found many researches working on wireless networks and especially on WiMax; it is a new high interesting and beneficial technology. This technology has many extensions to other corresponding data transfer technologies. Therefore, it is getting higher and higher attention and interesting by the researchers in all over the world because it is one of the most important responsibilities and problems is how to get a higher speed data stream with higher bandwidth for longer distance to the far areas in our planet. Jaswal and Vats[1] practically examined many techniques of QoS depending on the IEEE Standard of WiMax. They made a comparison between these technologies and obtain a result of taking one of these as the best technique. They determined that a network of 25 nodes is the medium scale and the larger queuing delay obtained in the bigger network with a larger number of users. Therefore, the queuing delay is going to be lower in the smaller networks with less number of users, in addition, the PHY losses its transmission

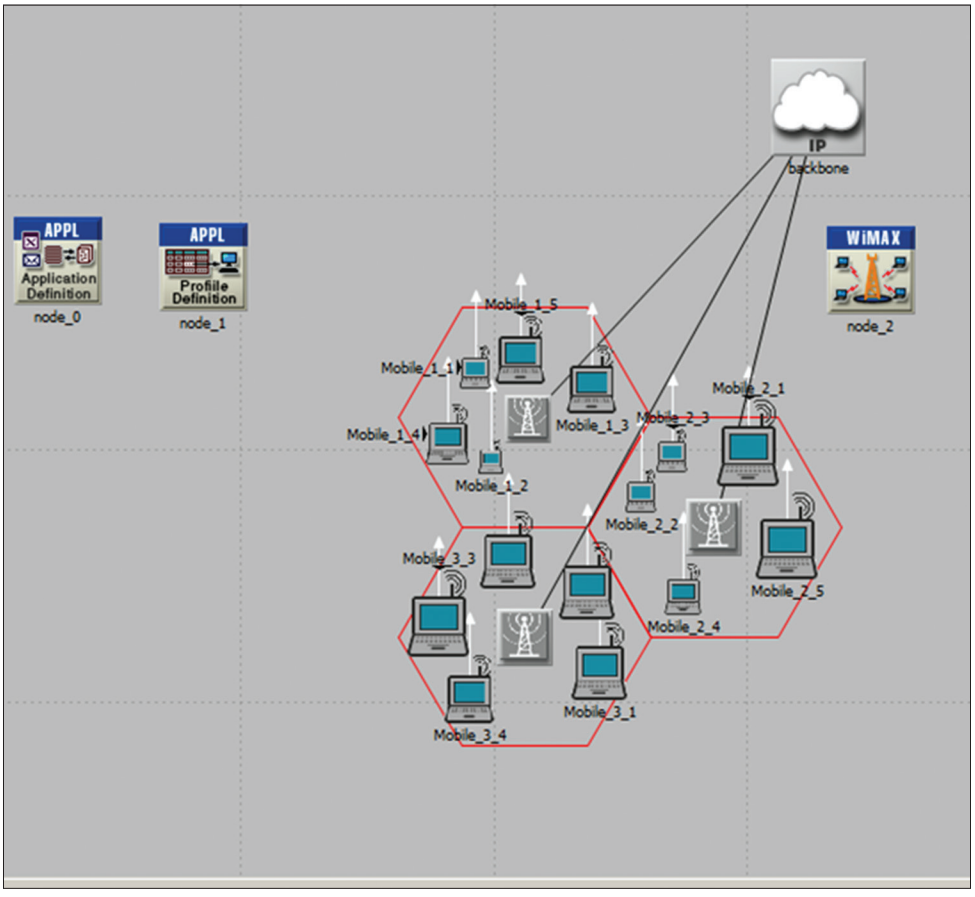

Figure 1: The network topology showing the network interconnection, constructed by three base stations on three towers, each one of them distributing the service by the coverage shaped to hexagon

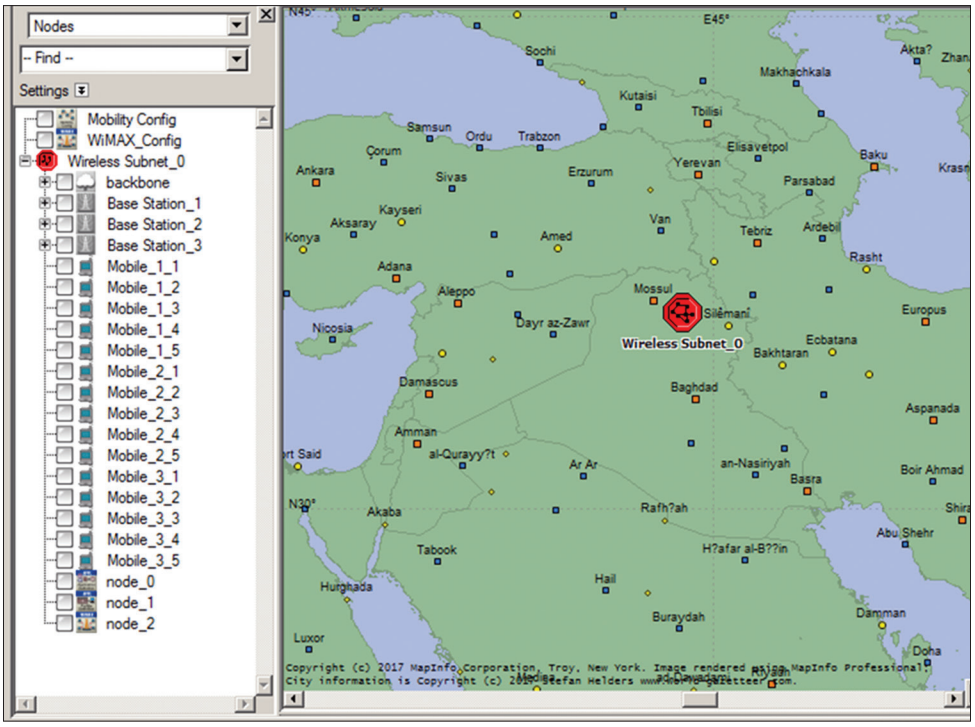

Figure 2: The network location on rejoin map

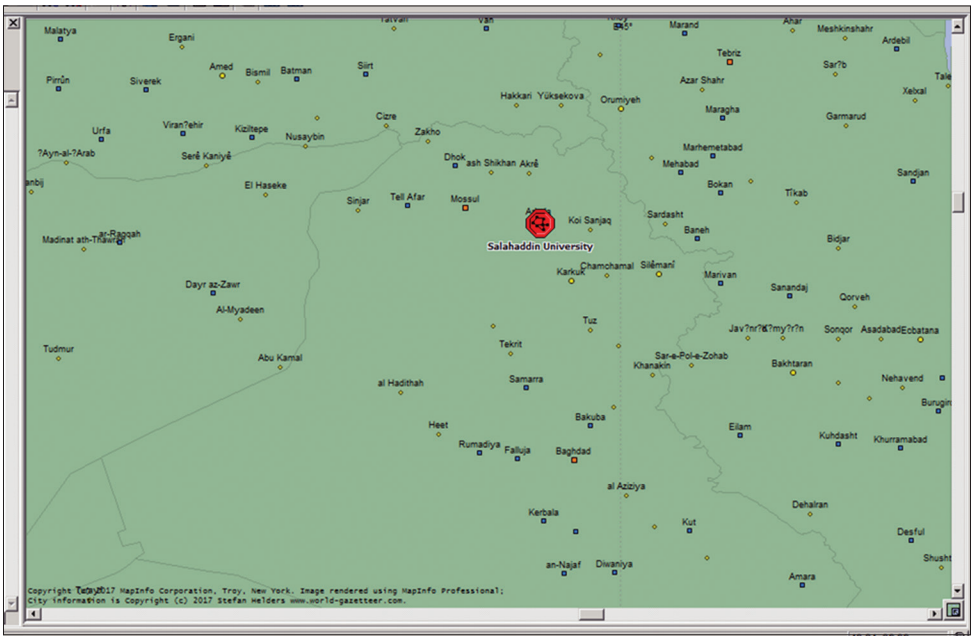

Figure 3: Zoom-in to the network location on Iraq Kurdistan region map

power with short networks distance and with less number of users. Singh *et al.*[2] studied the Bluetooth as a wireless technology and determined a new advanced data exchanging mechanism to improve bit rate and the interconnecting of this technology. Murty *et al.*[3] determined that WiMax has a higher level of security if comparison made between WiMax and WiFi in addition to the wider coverage area of wireless interconnection of the last one. Song and Issac[4] studied about the data received in addition to delay as a very important factor, which is delay. They found that WiMax is very powerful in comparison to WiFi, but it has some difficulties. WiMax needs to plan well, and it needed to improve this technology, especially considering the market demand. In addition, WiMax moved to LTE, as the market needs. Wee[5] determined by results that CSMA CA, at any connected node, such as personal computer (PC) or laptop needs to be connected to the network and transmit data. Hence, the media must be checked first to avoid any collision caused by the meeting of two frames in

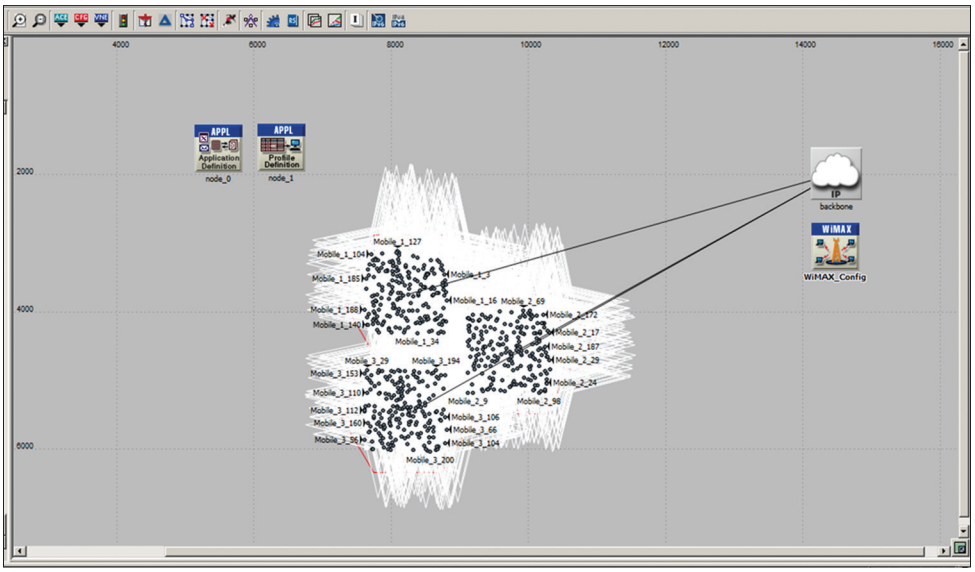

Figure 4: The network topology shows network trajectories and components for each mobile user, but it is not obvious so much because the overlapping caused by a higher number of them

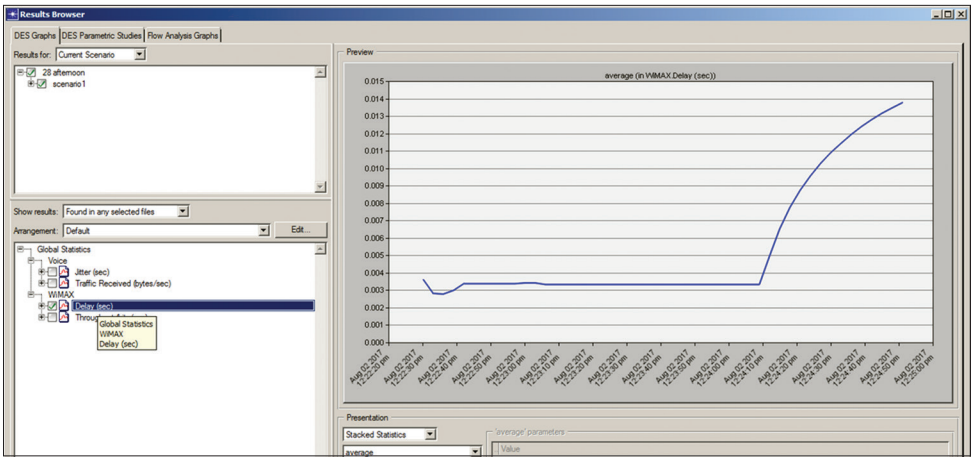

Figure 5: Network global characteristics of Worldwide Interoperability for Microwave Access delay measured in seconds which is competitively efficient with its low value

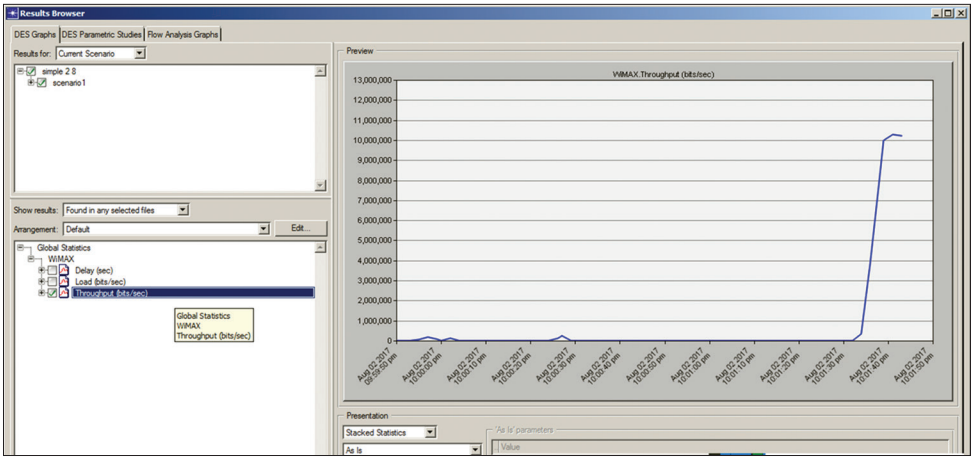

Figure 6: Network global characteristics of Worldwide Interoperability for Microwave Access (WiMax) throughput measured in bit/s, this value represents the overall throughput of the WiMax simulated network

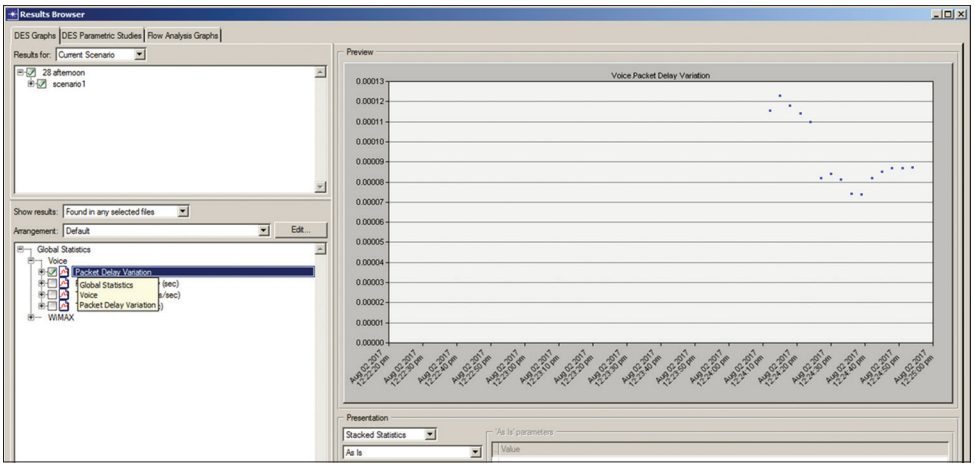

Figure 7: Network global characteristics of voice over IP delay measured in seconds after 2 min (1 m: 50 s), the network begins to work with fewer values, and this will improve the network performance

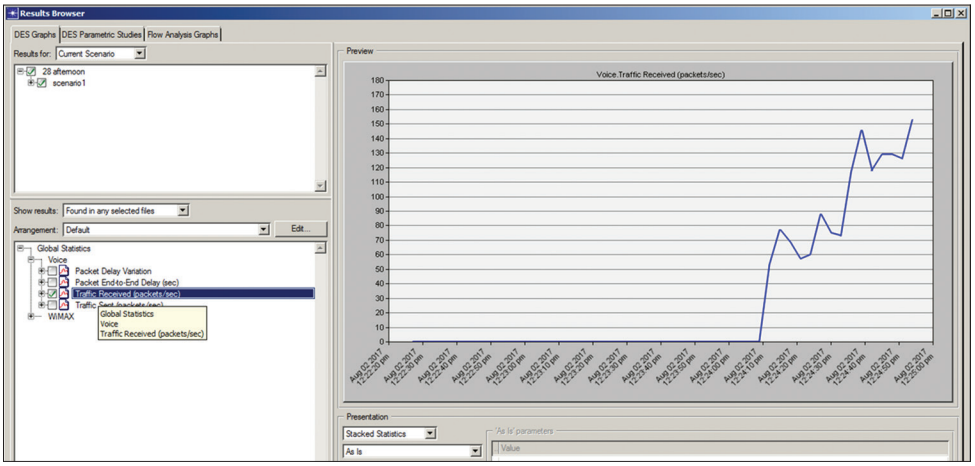

Figure 8: Network global characteristics of voice over IP traffic received measured in packet/s after 2 min, the received data start with the handover showed in this curve

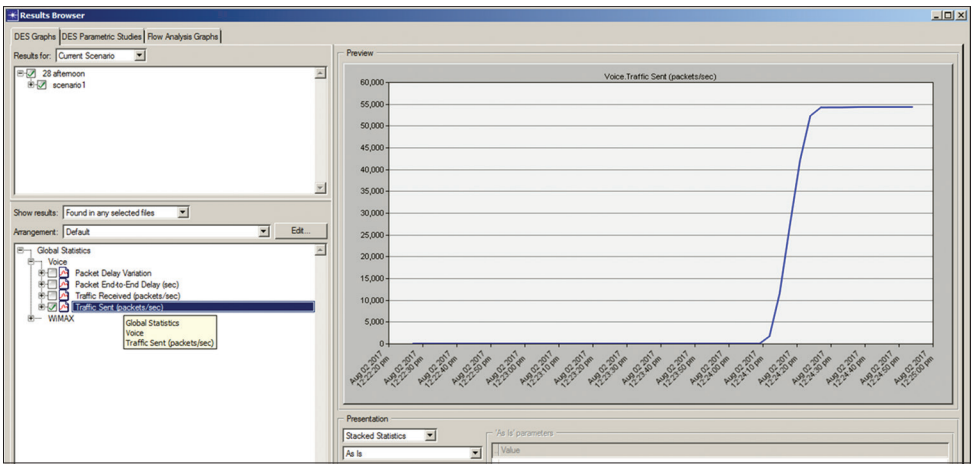

Figure 9: Network global characteristics of voice over IP traffic sent measured in packet/s, reaches 54,000 packet/s after few minutes of starting the simulation

the same time. Moreover, if the media was busy, this PC must wait for a random period and then starts transmitting again. This process continues until the media will go to be free. This means that when media is free, the PC will be able to transmit the information. The source PC transmits a request-to-send packet to the destination PC. The receiver PC will check the

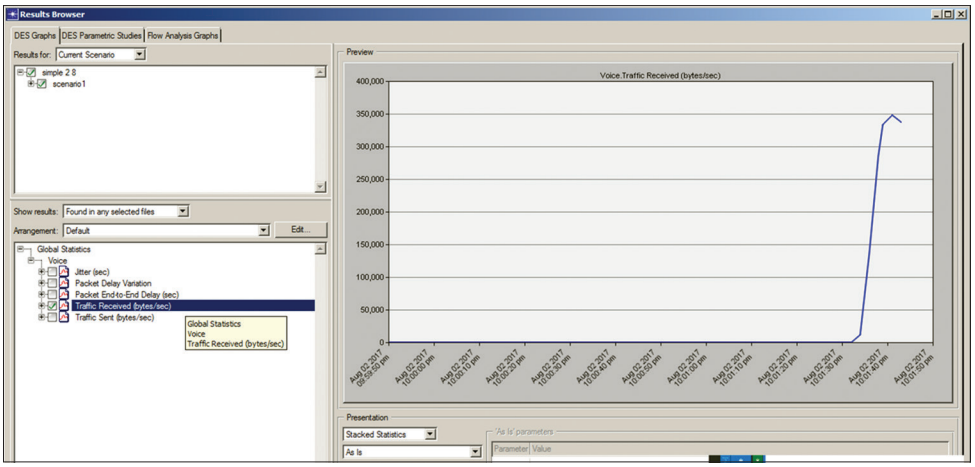

Figure 10: Network global characteristics of voice over IP traffic received measured, but this time is in packet/s

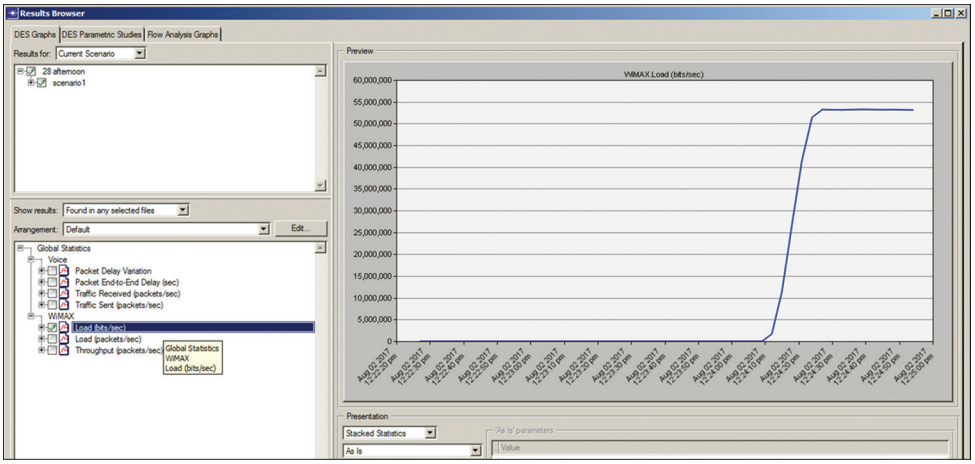

Figure 11: Network global characteristics of Worldwide Interoperability for Microwave Access (WiMax) load measured in bit/s, this load is of the Hall WiMax network reaches 53,000,000 bit/s

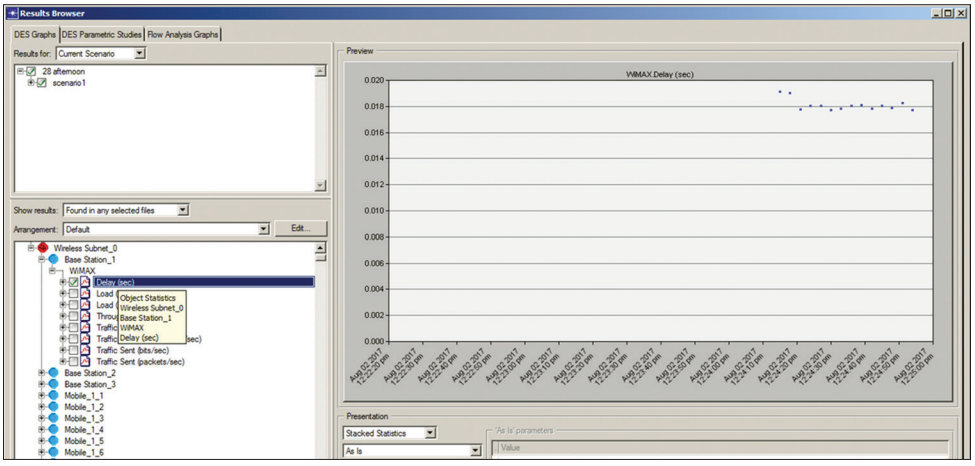

Figure 12: Network object statistics of wireless base station Worldwide Interoperability for Microwave Access (WiMax) delay measured in seconds which is much higher than the delay shown in the voice over IP application

medium and clear-to-send (CTS) packet will be generated. Therefore, only when the CTS received successfully, the source PC would be able to transmit data. Sran[6] funded that only WiMax technology can provide a low-cost network service to let the ISPs get good benefits from the service provided to the users. Joshi and Yadav[7] took an overview of WiMax wireless computer networks, especially on OFDM technology and on the first layer of open system internet working. They focused

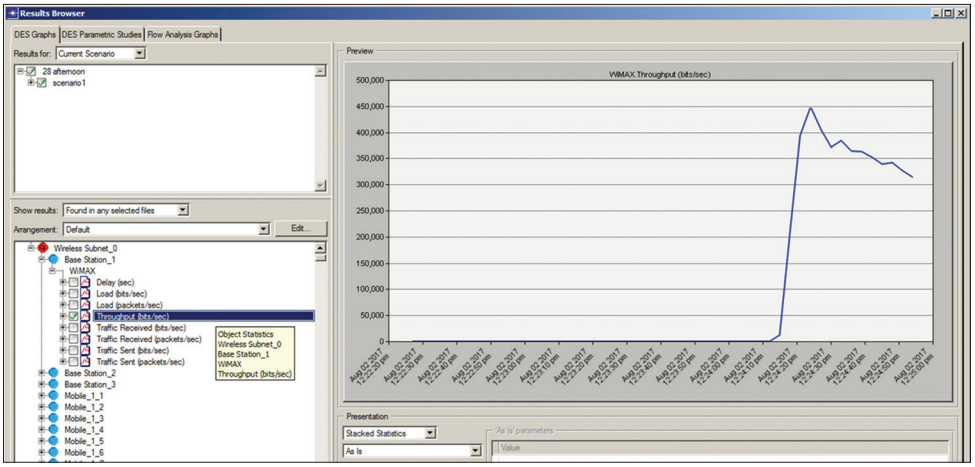

Figure 13: Network object statistics of Worldwide Interoperability for Microwave Access throughput measured in bit/s, also starts rising after a few minutes

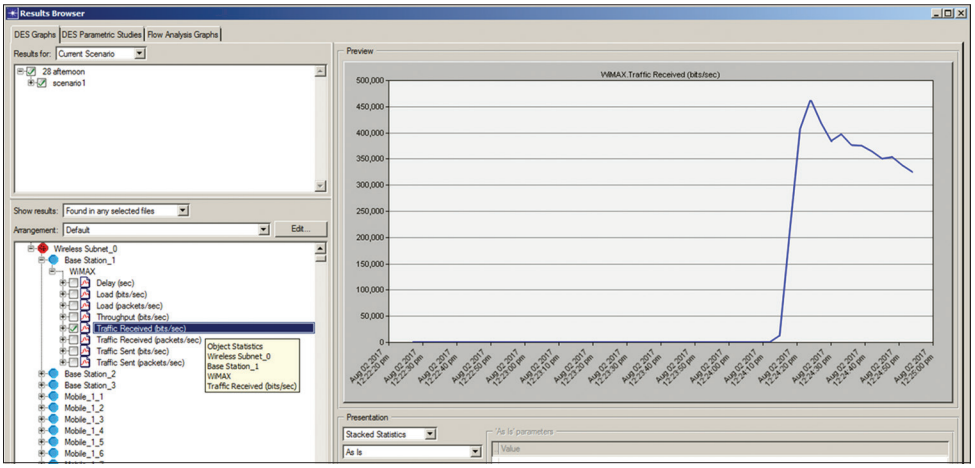

Figure 14: Network object statistics of Worldwide Interoperability for Microwave Access base station traffic received, measured in bit/s

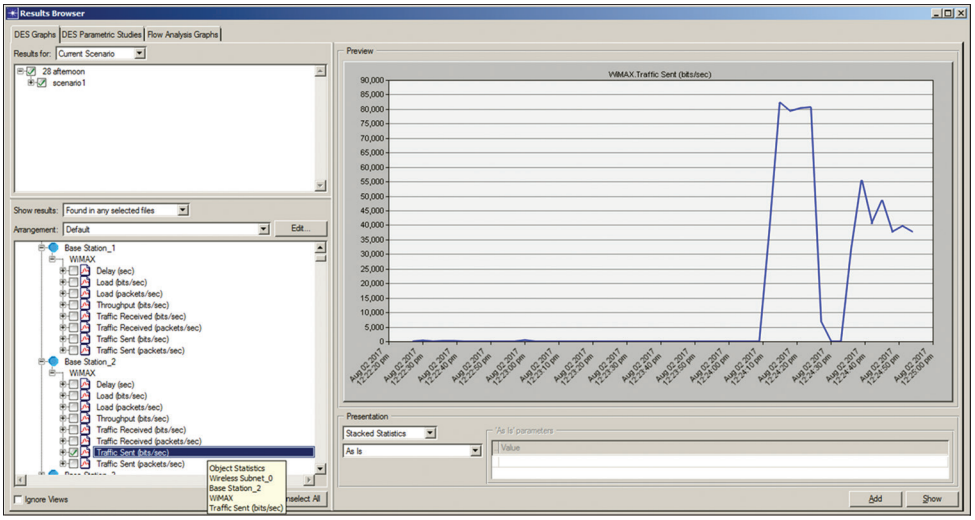

Figure 15: Network object statistics of Worldwide Interoperability for Microwave Access, base station traffic sent, measured in bit/s which handover is shown

on the security features of computer network significantly in wireless network in addition to WiMax wireless networks with maintaining the connectivity over its users. Tyagi and Garg[8] studied both WiFi IEEE and WiMax IEEE 802.16 and 802.11

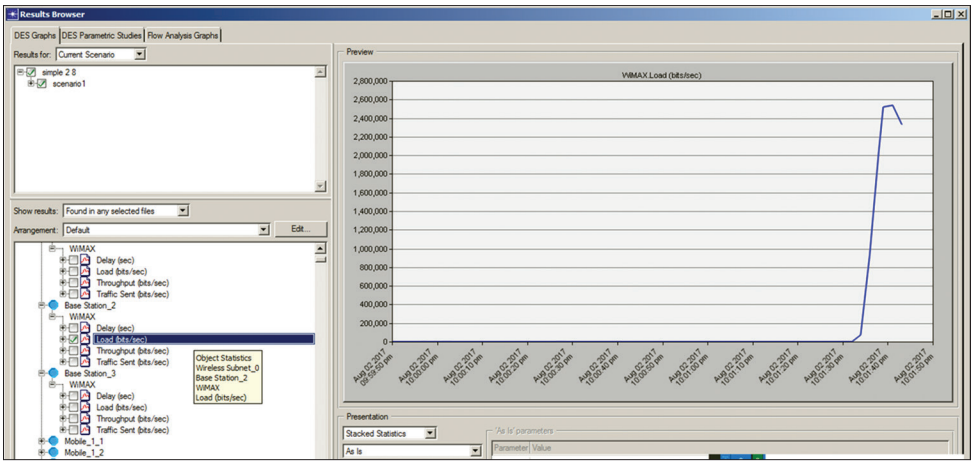

Figure 16: Network object statistics of Worldwide Interoperability for Microwave Access tower base station load, measured in bit/s

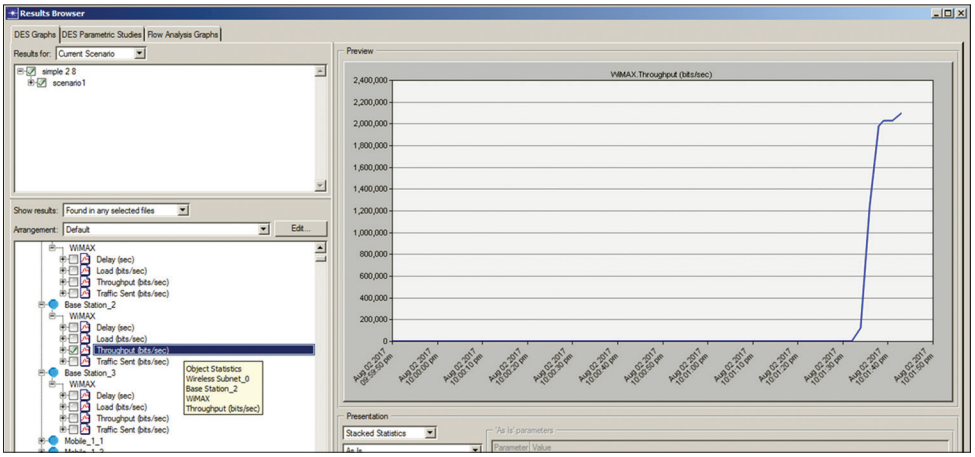

Figure 17: Network object statistics of one of the Worldwide Interoperability for Microwave Access base station throughputs, measured in bit/s

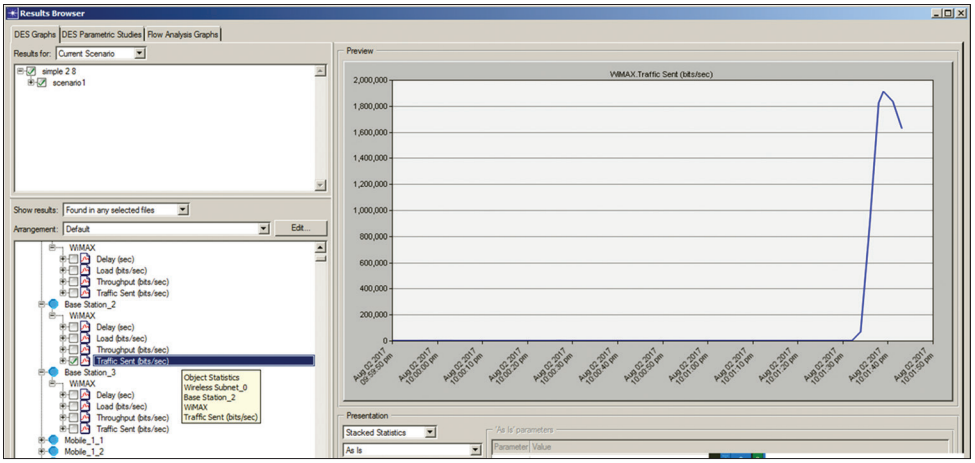

Figure 18: Network object statistics of Worldwide Interoperability for Microwave Access base station traffic sent by one of the base stations, for example, BS.2, measured in bit/s

network standards and how these two standards can be used to implement wireless computer network. Then getting benefit from the high-speed data transmission for building wireless networks. In addition, the network standards prove that WiFi could not be replaced by WiMax, but only for supporting and reshaping the wireless networks. Lastly, if the WiFi is less efficient for practical applications, VoIP are used to compare the WiMax technologies. Finally, they focused on the repeatedly interruption that happened if the near users start connecting to the source nodes, then all wireless users will challenge

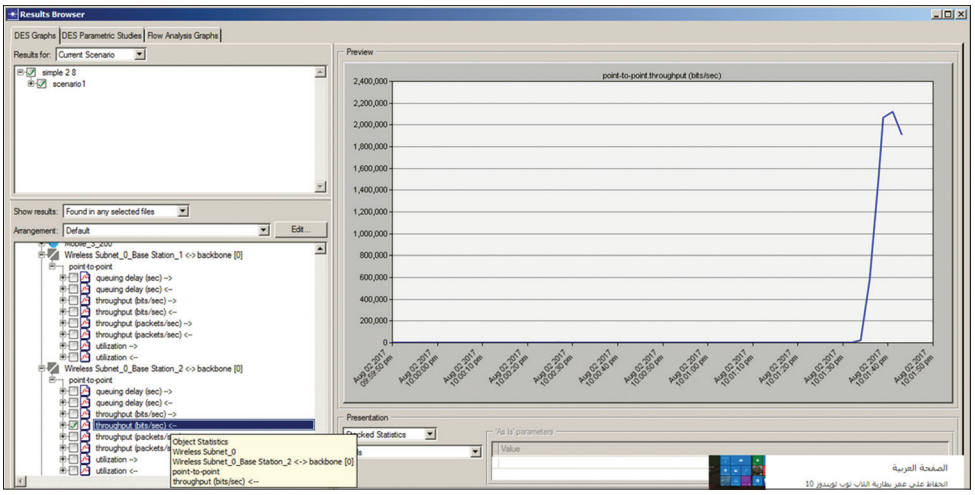

Figure 19: Network object statistics of wireless point-to-point base station throughput, measured in bit/sec

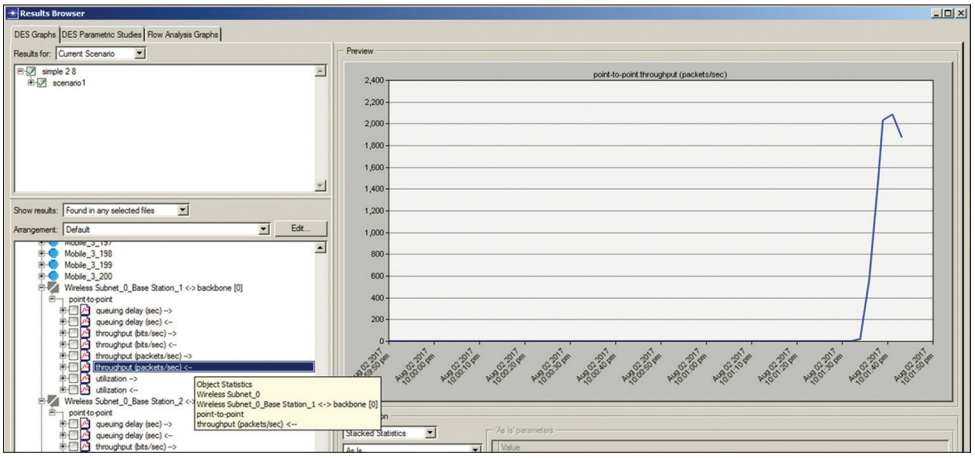

Figure 20: Network object statistics of wireless subnet point-to-point base station throughput measured in packet/s

to take connection establishment, to get the service from a access nearest point. Murty *et al*.[9] found that the WiMax has no limitation compared with WiFi, and the WiMax computer network is more reliable, secure, and higher performance. Chen[10] designed a radio frequency amplifier to modulate a variable spectrum frequency that could be managed by the administrator to get the best OFDM modulation. Thomas[11] used NS3 software to simulate and improve an OFDMA downlink mapping technology algorithm by simulating a new model for these technologies. Garg and Tyagi[12] found that the WiMax technology 802.16 is more applicable for mobile node than WiFi 802.11 and improved it with more flexibility and high performance. Rajaraman *et al*.[13] proposed a wireless antenna using photolithography technology and specific frequency response used for WiMax network and OFDM signal. The electromagnetic field radiation of WiMax was very efficient and more compact and cheap. Finally, this antenna can be used also for array applications. Ravichandiran *et al*.[14] discussed an algorithm and built it by OPNET simulator to find the results. They tried to find better throughput and QoS for a mobile WiMax subscriber. Valencia[15] used four mobile techniques of WiMax to make a comparison between them. Analyzing and monitoring of the data rate was based on the environmental conditions (variables) and the software applications. Seyedzadegan and Othman[16] did a technical overview of concept, technology, standard, and architecture for IEEE 802.16 WiMax. They proved that WiMax technology has a confrontation of many obstacles in market, while on the other hand, it has great advantages that make a very advance interconnecting technology.

CONCLUSIONS

The most important criterion that taking into account in any computer network design nowadays is smart device connectivity efficiency; this achieves by high-speed mobility supported by non-line of site signal which avoids small and even large obstacle maintaining the connection with good efficiency and bandwidth performance. The WiMax network starts operating and simulation after about 1:45 min, and this interval is compulsory to let the wireless devices achieve the connection establishment process and then soar up to its maximum value. The time delay noticed in the curves as shown in Figures 1-20 is caused by other subjects that did not mention in this paper such as fetch, receives, and acknowledgment signals to achieve IP address from DHCP server and the authentications requirements. The throughput

results show a reliable bit rate amount, which is sufficient to serve a large area with approximately 600 mobile users. The results obtained classified into two categories, global characteristics result curves and object statistics result curves. The last one showed the results of each object individually such as mobile device, base station, and server. In addition to end-to-end (device to device) or source to destination, results showed data transfer; sending data, receiving data, and time delay of multiple sections. The results show that the VoIP delay determined has a lower value than the WiMax delay. The VoIP application requires a higher speed of data transfer rate to insure a real-time system. This application has a significant problem, which gets a higher delay if we implement this application on the simulator. These results prove that WiMax delay has very low value in this network design insuring the WiMax performance by the higher data speed achieved. The researchers were choosing the vehicular to simulate the mobile motion and taking a higher speed motion.

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