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Comprehensive Performance Analysis for IEEE 802.11 and IEEE 802.16: A Case in Egypt

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Abstract— Broadband wireless access networks are firmly considered to meet the developing requirements for level networks capacity and coverage of remote and rural areas in a most cost-effective manner. Recently, many problems related to distance and location almost have been solved through changing the communication way. Thus ongoing research efforts dedicated in this paper targets a technical analysis of different services enhancing last-mile wireless broadband. Group of technical differences between Wi-Fi wireless technologies (IEEE 802.11n) with mobile WiMAX technology (IEEE 802.16e), through the transmission of all types of multimedia content using mobility and over large coverage areas with a new technology will be illustrated. Moreover, numerous difficulties in remote distance applications are worked out and are completely solved. The extensive simulation results showed that by using WiMAX, there would be a great improvement in overall network performance under conditions of mobility, higher coverage and beneath fading effects as compared with Wi-Fi.

Index Terms— Wireless Fidelity, Wi-Fi, Worldwide Interoperability for Microwave Access, WiMAX, Quality of Service, QoS.

1 Introduction

Communication technology is developing and many are increasingly implemented, although, they are incompatible with each other [1]. Nowadays, Wireless networks are extremely prevalent. Wireless Local Area Network (WLAN), which uses the IEEE 802.11 standard, and WiMAX, which uses the IEEE 802.16 standard will be the target and will be explored [2].

Subscribers are more demanding to roaming capabilities crosswise over various networking technologies. In this context, Wi-Fi and WiMAX, provide due service progression with QoS requirement and feasible security features. Worldwide Interoperability for Microwave Access (Wi-MAX) is a Wireless Metropolitan Access Network (WMAN). It is used generically to describe wireless systems in light of IEEE 802.16 [3]. Recently, WiMAX technology has met the user's demand for broadband wireless access since its ability to provide higher speed connection, with a greater coverage alongside with the quality service are assured [4].

Although WiMAX is remarked as a wireless broadband access technology that is coming into existence in a very strong and competitive way. The advancement possibilities of its market are still considered obscure. Hybrid networks, as a kind of a completeness, must be added to cell-based or IP packet-based services to completely show the distinctive features of the coverage of the wide network. It means making a wireless cohabitation of Wireless Local Area Network and Wi-MAX for devices on various technology segments to be connected and enabled to be mutually communicating [2].

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This paper, presents the Wi-Fi and WiMAX systems in details, with a comparison between their own characteristics as well. Next, utilizing the OPNET simulation software, with also an evaluation of the wireless concurrence arrangement in multimedia such as voice, video, HTTP, and FTP with output, many graphs are illustrated and discussed to give a vision for the future of Wi-MAX linked to Wi-Fi.

2 Overview of Wi-Fi and Wi-MAX

2.1 Wi-Fi

Wi-Fi is a technology of short-range wireless transmission with the association with IEEE 802 standard with OSI model shown in figure 1. Wi-Fi encompasses an interconnection between personal computers, hand-held devices (such as PDA, smartphone etc.) as well as another connecting systems. Its power path can help in holding and serving effectively [2].

Recently, hotspots provide access points, which have a coverage space of about twenty meters indoors and even a larger space outdoors. This is often achieved by victimization of multiple interfering access points [5]. Nowadays, several specifications utilized under the title of 802.11a, 802.11b, 802.11g, 802.11n, and 802.11ac. In this context, IEEE presented a pack of specification and standards under the title 802.11 for Wi-Fi, which clarifies the structure of the comparatively short-range radio signal for Wi-Fi service [6], [7].

1) IEEE 802.11: Two variations are utilized on the initial 802.11 wireless standard. Both suggested 1 or 2Mbps transitional rapidity and the same radio frequency of 2.4GHz. The difference between them was how data pass along the transmission media. One utilized FHSS, and the other utilized DSSS as shown in (figure 1) on the physical layer. The original 802.11 standards are broadly too slow for modern networking needs and are not prevailed now anymore [8].

2) IEEE 802.11a: Here we find an almost complete difference in terms of speed. 802.11a presented speeds of up to 54Mbps in the 5GHz band but incompatible with 802.11b, 802.11g and 802.11n. The most commonly communication exactly occur at 6Mbps, 12Mbps, or 24Mbps [9].

3) IEEE 802.11b: The 802.11b standard offers a maximum speed of 11Mbps and is compatible with 802.11g. Designing devices aims to be in reverse congruent with each other, utilizing a 2.4GHz RF range [10].

4) IEEE 802.11g: 802.11g suggested a transmission over distance of 150 feet and speeds up to 54Mbps however it is 11Mbps of the 802.11b standard. As 802.11b, 802.11g operates in the 2.4GHz range that is compatible with it [11].

5) IEEE 802.11n: Today, 802.11n is the most popular wireless standard. 802.11n standard increases throughput in both the 2.4GHz and the 5GHz frequency range. The baseline goal was to achieve speeds of 100Mbps, however given the right conditions, it is evaluated that the 802.11n speeds can achieve a staggering 600Mbps. In practical, 802.11n speeds are lower than the announced theoretical values [9], [11].

6) IEEE 802.11ac: The list of most modern patterns of the wireless standards in the Network plus objectives are 802.11ac, which turned into an approved standard in January of 2014 and is considered as an extension of 802.11n. Any device utilizing this standard must support all the imposed modes of both 802.11n and 802.11a. The objective of the standard is 500Mbps with one link and 1Gbps with multiple links. It has bolster for up to 8 MIMO streams and increased strong channel linking. 802.11ac is a 5 GHz-only technology [12].

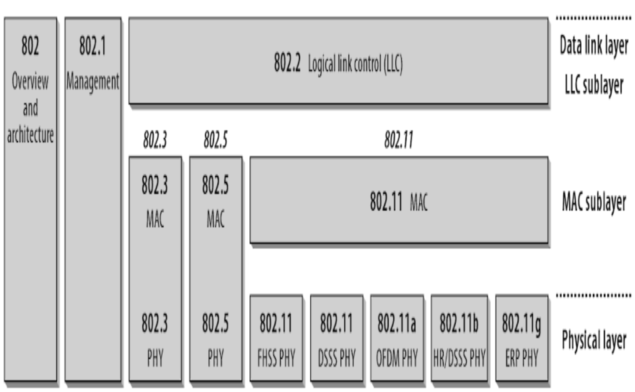

Fig. 1: IEEE 802 Family and its Relation to the OSI Model

Table1:
Characteristics of the 802.11 Standards [12]

IEEE Standard	Freq. GHz	Data Rate	Distance Range	Transmis-sion Tech-nique
802.11	2.4	Up to 2Mbps	6 m	DSSS/FHSS
802.11a	5	Up to 54Mbps	20 m	OFDM
802.11b	2.4	Up to 11Mbps	45 m	DSSS
802.11g	2.4	Up to 54Mbps	45 m	DSSS/OFDM
802.11n	2.4/5	Up to 600Mbps	50+ m	OFDM
802.11ac	5	Up to 1Gbps	35+ m	OFDM

As shown in table 1, 802.11a standard was released and it allows bandwidth of 20 MHz, data rate from 6Mbps to 54Mbps and provides OFDM modulation. Moreover, 802.11b standard was released and it allows bandwidth of 22 MHz, data rate up to 11Mbps and provides DSSS modulation. 802.11g standard was released and it allows bandwidth of 20 MHz, data rate from 6Mbps to 54Mbps and provides OFDM, DSSS modulation. In 802.11n standard was released and it allows bandwidth of 40 MHz, data rate up to 150Mbps and provides OFDM modulation. 802.11ac standard was released and it allows bandwidth up to 160MHz, data rate up to 1 Gbps and provides OFDM modulation [13].

2.2 WiMAX

World Interoperability for Microwave Access (WiMAX) is considered a foundation ideally based on worldwide interoperability including ETSI HIPERMAN, IEEE 802.16d for fixed, and 802.16e for mobile, high-speed data. WiMAX is a carrier-class technology that covers wider distance, high-speed and low cost wireless broadband as compared with Wi-Fi. The main goal is to create a cost-effective technology providing high transmission capacity to deliver broadband over large and/or far areas. It is treated to provide high-quality voice, data, and video services [14].

WiMAX utilizes point-to-multipoint (P2MP) architecture. Additionally, it consolidates the nature of Wi-Fi with the mobility of cellular devices, thus, it conveys individual versatile broadband that moves with the user everywhere. Many customers, seeking each channel at varying speeds, like DSL, Cable or a T1 connection. Recent promises are to give an extent of 30 miles as the other option to wired broadband like cable and DSL. Thus, it is intended to furnish the clients with a broadband that provides quality exceptional multimedia services [15].

Wi-Fi and WiMAX technologies can conjoin in a work field. Such conjunction would harvest a non-permanent settlement of whether or not the technologies are competitive with each other. In this context, a spine network and connections to Wi-Fi, WiMAX, and wireless cellular networks can assured (Figure 2). WiMAX has been regarded as a potential competitor with other multiple wireless broadband access technologies like 3G and Wi-Fi. However, to prove that WiMAX is the backhaul method in Wi-Fi Mesh Topology, both technologies must be used as complementary for each other [16].

A WiMAX base-station is somehow mediated to have some similarities with the cellular tower, except having the power that enables it to cover almost an area of 3.000 square miles. It is remarked that a WiMAX receiver could be handled as an independent tower or a PCMCIA card embedded into the user's laptops. Thus, if it could be achieved, such enormous coverage may resolve the potential problems of handoffs related to 802.11 [16].

TABLE 2:
CHARACTERISTICS OF THE 802.16 STANDARDS [16]

	802.16	802.16a	802.16e	802.16j
Freq.(GHz)	10-66	2-11	2-16	10-16
Channel Conditions	Line of Sight Only	Non-Line of Sight Only	Non- Line of Sight Only	LOS NLOS
Bit Rate (Mbps)	32-134	Up to 75	Up to 15	Up to 120
Modulation	QPSK 16QAM 64QAM	OFDM256 OFDMA2048 QPSK 16QAM 64QAM	OFDM256 OFDMA2048 QPSK 16QAM 64QAM	BPSK QPSK 16QAM 64QAM OFDMA OFDM
Channel Bandwidth	20, 25 and 28 MHz	Scalable 1.5 : 20 MHz	Scalable 1.5 : 20 MHz	25 or 28 MHz

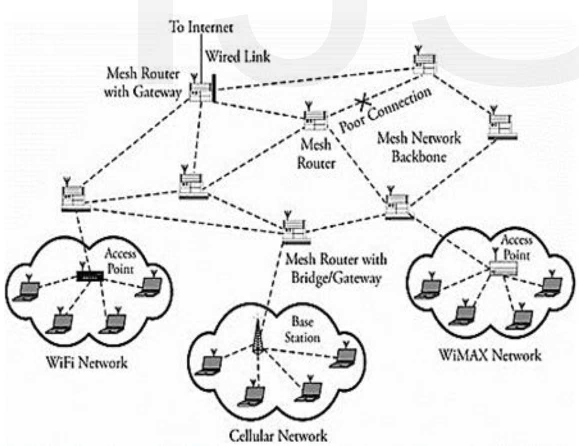

Fig.2: Overview of a Backbone Mesh Network and Connections to Wi-Fi, WiMAX, and Wireless Cellular Networks [16]

3 NETWORK SCENARIOS

Quality of Service (QoS) is measured by ITU recommendations based on parameters as (jitter, delay, packet loss and MOS); all parameters have controlled to enhance QoS by using OPNET simulator. The following metrics used to evaluate the performance of WiMAX with respect to Wi-Fi network with parameters presented in table 3 by: Sending all types of multimedia such as (Voice, Video, HTTP and FTP); under fading effects (Path loss, Multipath and Shadowing); as well as Sending and Receiving with increasing coverage of network and by using mobility.

Over Wi-Fi network by increasing coverage (50,75 and 100m) as shown in (figure 3) using two access points, one router, four multimedia servers (voice, video, HTTP and FTP) and Mobile user with ten minutes' time of simulation.

On the other hand, over WiMAX network by increasing coverage (10, 30 and 45km) as shown in (figure 4) using four WiMAX-base stations, one router, four multimedia servers (voice, video, HTTP and FTP) and a Mobile user with ten minutes' time of simulation.

Table 3:
Network Design Parameter

WiMAX Physical Profile	Wireless OFDMA 20MHz
Bandwidth	20MHz
FFT	512
Duplexing Technique	TDD
Efficiency Mode	Mobility Enabled
WiMAX Service Class	ertPS
BS Transmission Power	10W
SS Transmission Power	0.5W
Modulation & coding	16 QAM 3/4
Multipath Channel Model	ITU Vehicular B
Application	Voice Video HTTP "heavy browsing" FTP
Voice codec	G.711
Path loss Channel Model	Vehicular
Shadowing Deviation	10

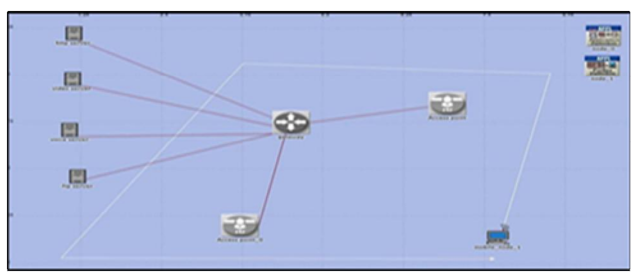

Fig. 3: Wi-Fi Network

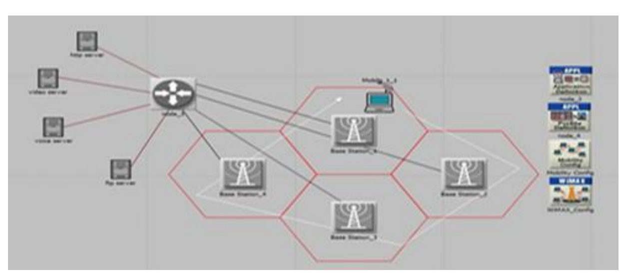

Fig. 4: WiMAX Network

4 SIMULATION RESULTS

4.1. Wi-Fi Network Results

4.1.1. Voice results:

In figure 5, it is exhibited that end-to-end delay will be increased up to 9 sec by using 100m coverage, while end-to-end delay is equal 0.125sec and 1.1sec for 50m and 75m (figure 5-a). On the other hand, the MOS will decrease by increasing the distance equal 3.080688, 3.080448 and 3.079935 for 50m, 75m and 100m respectively (figure 5-b). While, the traffic sent is 26062.76 (bytes/sec) over three networks 50m, 75m and 100m respectively (figure 5-c), and traffic received over coverage were equal 15000, 13000 and 2000 (bytes/sec) for 50m, 75m and 100m respectively (figure 5-d).

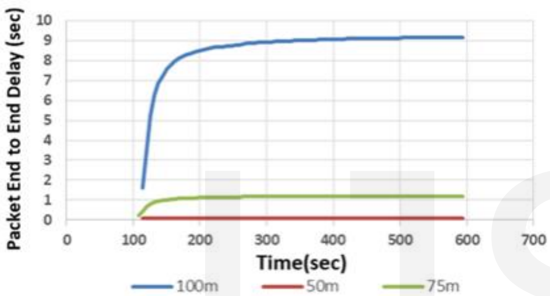

Fig. 5 (a)

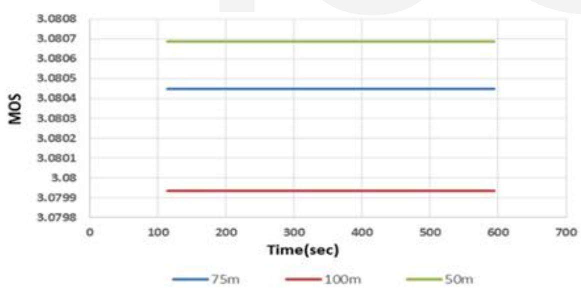

Fig. 5 (b)

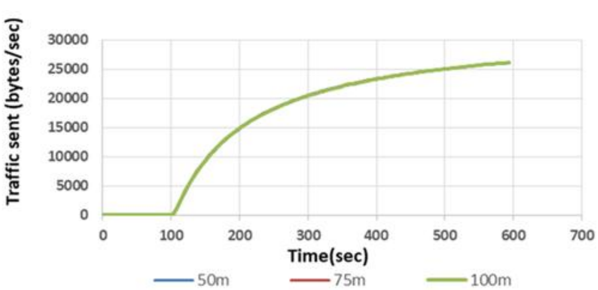

Fig. 5 (c)

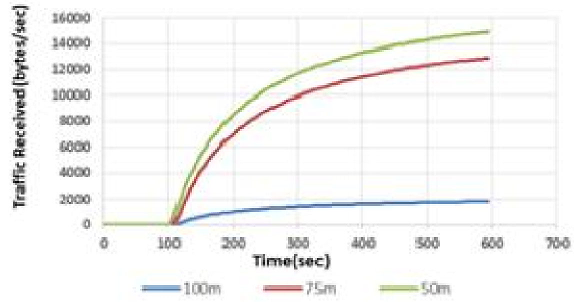

Fig. 5 (d)

Fig. 5: Wi-Fi Results (a) Voice End- to- End Delay (b) Voice MOS (c) Voice Traffic Sent (Bytes/sec) (d) Voice Traffic Received (Bytes/sec)

4.1.2. Video result:

In relation to Video, it was found that delay variation will be increased up to 3.41E-11 sec by using 100m coverage, while, it is equal 2.5E-11sec and 5E-12 sec for 75m and 50m respectively (figure 6-a). In addition, the traffic sent is 1271957 (bytes/sec) over networks 50m, 75m and 100m respectively (figure 6-b), and traffic received over different coverages 50m, 75m and 100m is 851881.6, 846950.4 and 8303001 (Bytes/sec) respectively, and there is an extremely immense misfortune in traffic received over coverage 50m, 75m and 100m (figure 6-c).

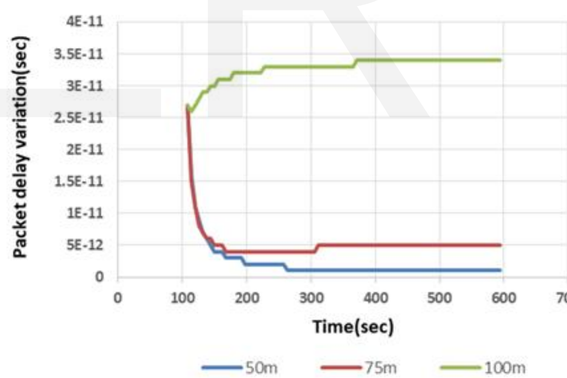

Fig. 6 (a)

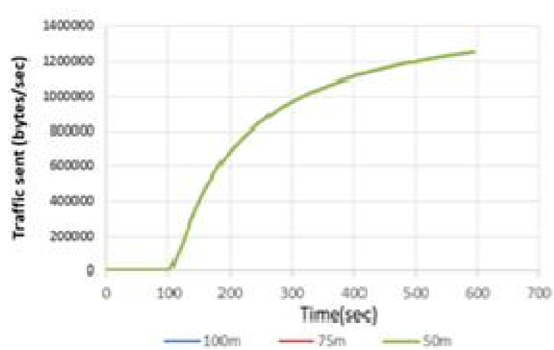

Fig. 6 (b)

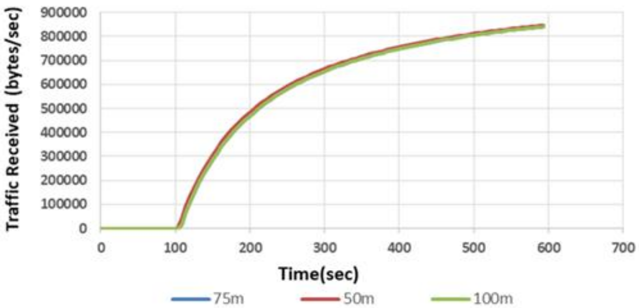

Fig. 6 (c)

Fig. 6: Wi-Fi results (a) Video Delay variation (sec) (b) Video Traffic Sent (Bytes/sec) (c) Video Traffic Received (Bytes/sec)

4.1.3. HTTP results:

The simulation of HTTP confesses that object response time will increase up to 0.057539 sec at distance 100m, 0.003368, 0.00624912 over 50m and 75m respectively (figure 7-a), and the page response time will increase by increasing the distance equal 0.0104, 0.0106sec and 0.115sec for 50m, 75m and 100m respectively (figure 7-b). Moreover, traffic sent is 6500 (bytes / sec) over networks 50m, 75m and 100m respectively (figure 7-c), while, there was found a major misfortune in traffic received over 100m and 75m compared with traffic received over coverage 50m (figure 7-d).

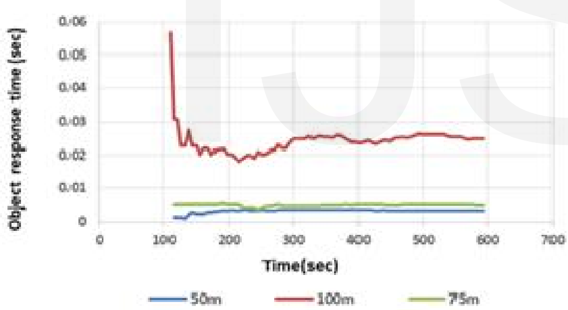

Fig. 7 (a)

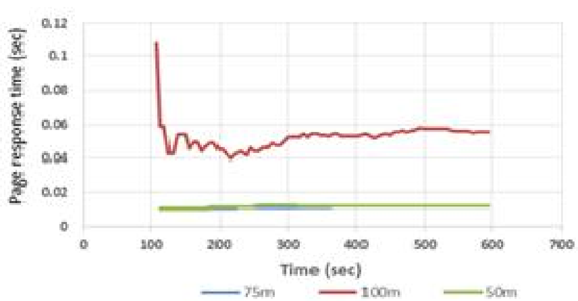

Fig. 7 (b)

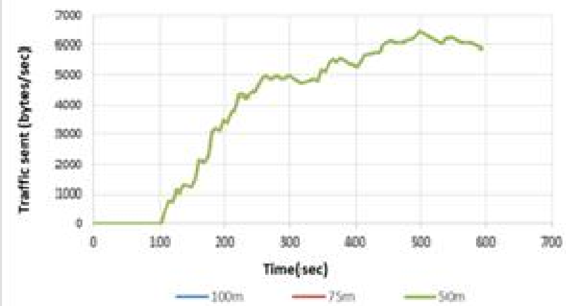

Fig. 7 (c)

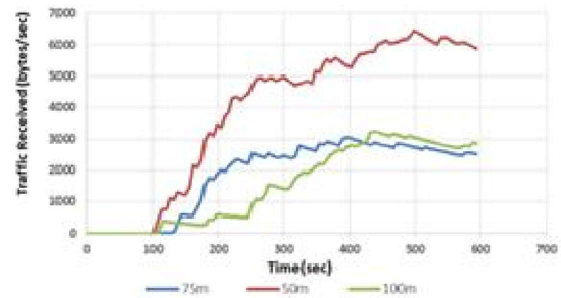

Fig. 7 (d)

Fig. 7: Wi-Fi results (a) HTTP Object Response Time (sec) (b) HTTP Page Response Time (sec) (c) HTTP Traffic Sent (Bytes/sec) (d) HTTP Traffic Received (Bytes/sec)

4.1.4. FTP results:

In relation to FTP, the simulation revealed that the traffic sent is 550 (bytes / sec) over networks 50m, 75m and 100m respectively (figure 8-a), however, unfortunately there is a big loss in traffic received over 100m and 75m compared with traffic received over coverage 50m (figure 8-b).

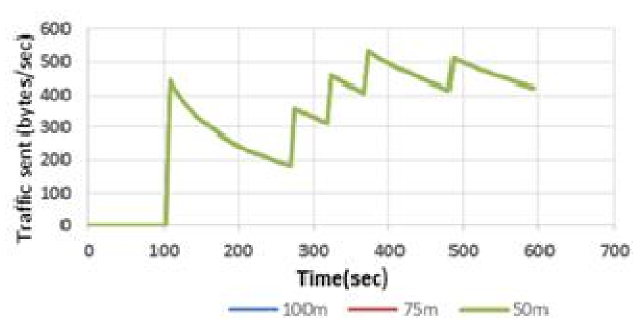

Fig. 8 (a)

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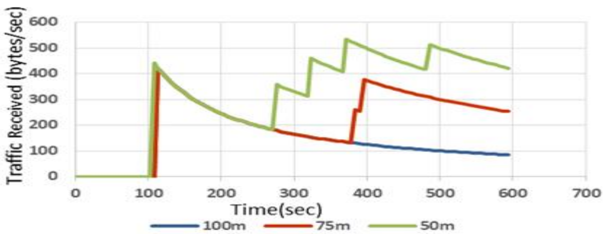

Fig. 8 (b)

Fig. 8: Wi-Fi Results (a) FTP Traffic Sent (Bytes/Sec) (b) FTP Traffic Received (Bytes/Sec)

4.2. WiMAX Network Results

4.2.1. Voice results:

Referring to WiMAX network simulation results, figure (9) shows the voice results. It was revealed that end-to-end delay will be increased up to 0.002sec by using 45km coverage, while it was equal 0.00052sec and 0.001sec for 10km and 30km respectively (figure 9-a). On the other hand, the MOS will decrease by increasing the distance equal 3.69378 and 3.69348 for 10km and 30km respectively, while there is lowest value of MOS equal 3.693 for 45km (figure 9-b). Adding to this (figure 9-c) depicts that traffic sent is 2500 (bytes/sec) over networks 10km, 30km and 45km respectively, while the traffic received is 2000, 1650 and 1550 (Bytes/sec) over distances 10km, 30km and 45km (figure 9-d). Moreover, the same figure showed that there are misfortunes in traffic received yet not as large as with traffic received over Wi-Fi network.

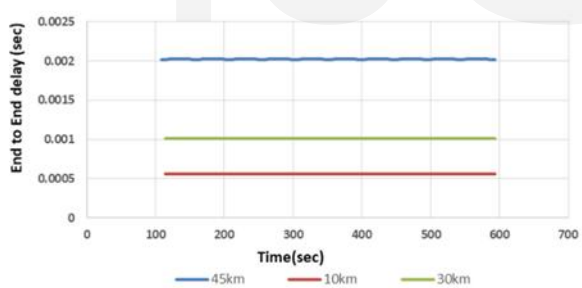

Fig. 9 (a)

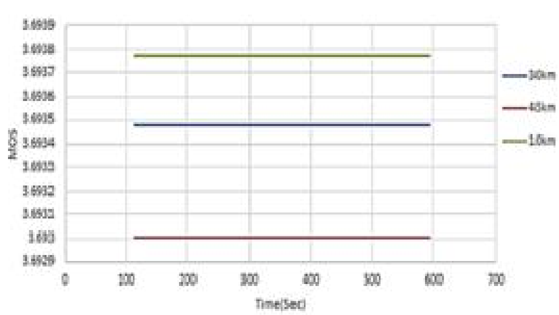

Fig. 9 (b)

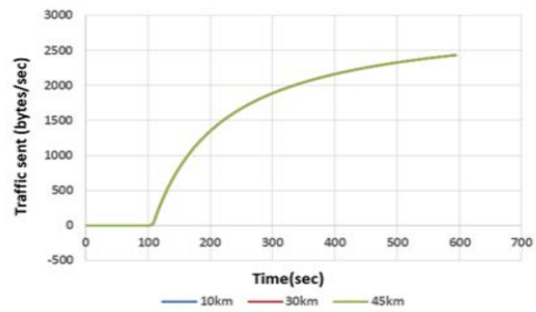

Fig. 9 (c)

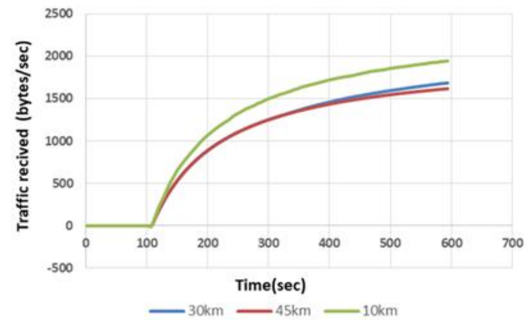

Fig. 9 (d)

Fig. 9: WiMAX Results (a) Voice End- to-End Delay (Sec) (b) Voice MOS (c) Voice Traffic Sent (Bytes/Sec) (d) Voice Traffic Received (Bytes/Sec)

4.2.2. Video results:

For video simulation results, it was exhibited that delay variation will be increased up to 2.1E-10 sec by using 45km coverage, on the other hand it is equal 1.85E-11 sec and 4.37E-11sec over 10km and 30km respectively (figure 10-a), the traffic sent is 850 (Kbytes/sec) over networks 10km, 30km and 45km respectively (figure 10-b). However, there are no losses in traffic received as compared with traffic sent over distances 10km, 30km and the network is very stable at 45km (figure 10-c).

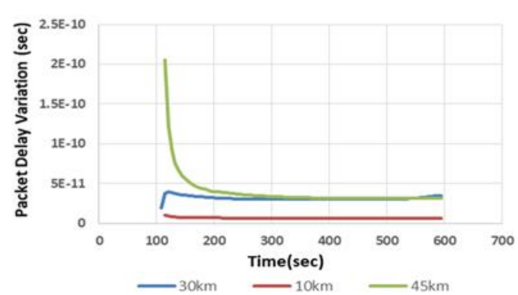

Fig. 10 (a)

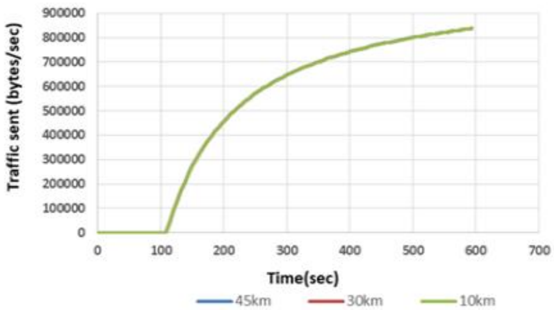

Fig. 10 (b)

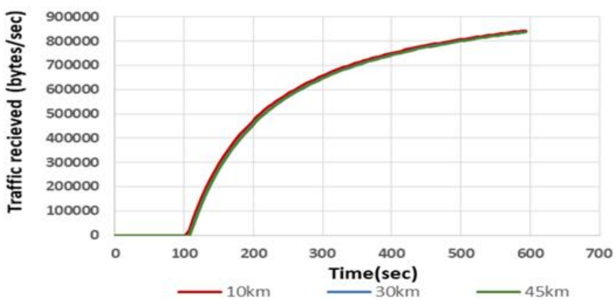

Fig. 10 (c)

Fig. 10: WiMAX Results (a) Video Delay Variation (Sec) (b) Video Traffic Sent (Bytes/Sec) (c) Video Traffic Received (Kbytes/Sec)

4.2.3. HTTP results:

For the HTTP, the simulation illustrated that the object response time will increase up to the highest value at 45km 0.00605sec while the increment will be 0.00598sec and 0.00555sec over 30km and 10km respectively (figure 11-a). The page response time will increase up to the highest value at 45km 0.01128sec, on the other hand 0.01097sec and 0.01081 sec over 30km and 10km respectively (figure 11-b). The traffic sent is 3750 (bytes/sec) over networks 10km, 30km and 45km respectively (figure 11-c). While the sending and receiving of the WiMAX network is very stable for all http traffic over various network distance 10km, 30km and 45km (figure 11-d).

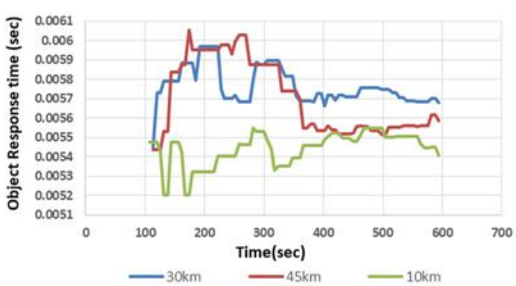

Fig. 11 (a)

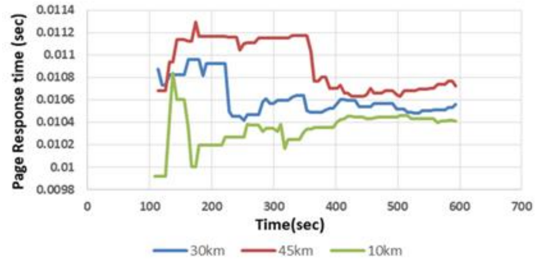

Fig. 11 (b)

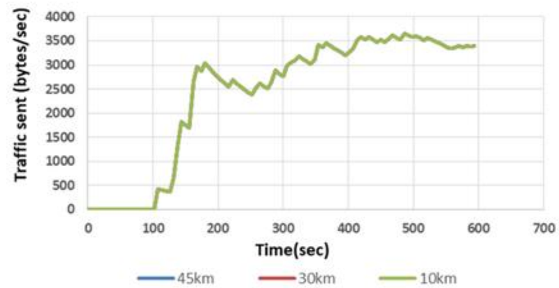

Fig. 11 (c)

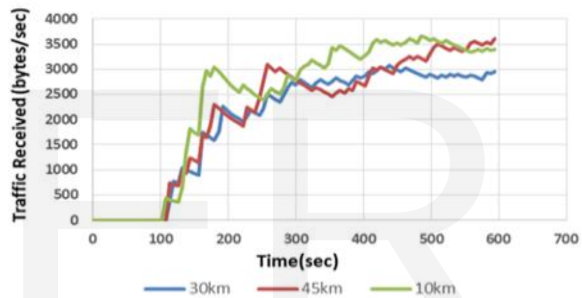

Fig. 11 (d)

Fig. 11: WiMAX Results (a) HTTP Object Response Time (Sec) (b) HTTP Page Response Time (Sec) (c) HTTP Traffic Sent (Bytes/Sec) (d) HTTP Traffic Received (Bytes/Sec)

4.2.4. FTP results:

As regards the FTP, WiMAX simulation Divulges that traffic sent is 720 (bytes/sec) over networks 10km, 30km and 45km respectively (figure 12-a). However, unfortunately, there is a big loss in traffic received over 45km and 30km as compared with traffic received over coverage 10km. Yet, this loss is small compared with Wi-Fi (figure 12-b).

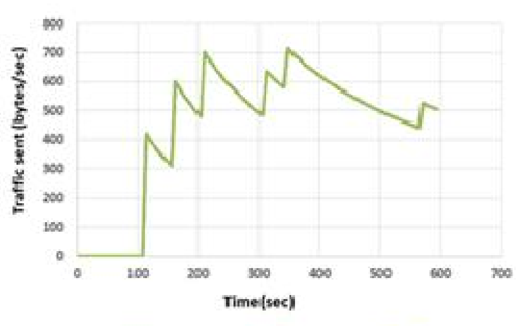

Fig. 12 (a)

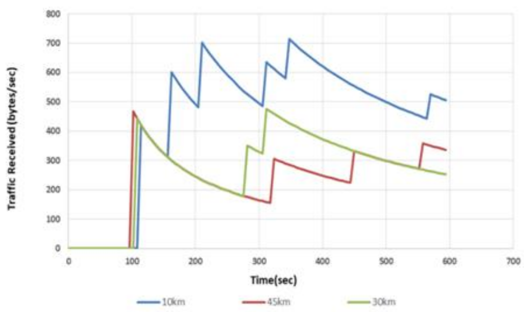

Fig. 12 (b)

Fig. 12: WiMAX Results (a) FTP Traffic Sent (Bytes/Sec) (b) FTP Traffic Received (Bytes/Sec)

5 CONCLUSION

From the previously illustrated simulation results, it can be concluded that by using Wi-Fi technology, there is a high adverse loss in traffic received by increasing coverage and by using the feature of mobility and under fading effects (Pathloss, Multipath and Shadowing). These losses affected on the overall traffic. On the other hand, by using WiMAX technology, Network is extremely steady under previously mentioned conditions, and the traffic received is with higher quality as compared with Wi-Fi. Accordingly, WiMAX networks could solve most of the highly significant problems that challenge streaming multimedia under contingencies of Mobility, Higher coverage area and under fading effects.

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