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Performance Evaluation of Fixed and Mobile WiMAX Networks for UDP Traffic

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ABSTRACT: **WiMAX stands for Worldwide Interoperability for Microwave Access. In this paper, Performance evaluation of WiMAX is done on network simulator NS version 2.34. Various real life scenarios have been created to see how different factors such as distance, number of subscriber stations, different modulation schemes and packet size affect the performance of the WiMAX network. Simulation of performance is carried out for UDP protocol over fixed as well as mobile WiMAX. Throughput, average delay and average jitter are used as performance metrics in this study.**

Keywords: **Wireless Communication, WiMAX, Performance, throughput**

I. INTRODUCTION

WiMAX is a wireless broadband technology based on wireless metropolitan area networking (WMAN) standard developed by IEEE 802.16 group. WiMAX networks provides high data rates, last mile wireless access, point to multipoint communication, large frequency range and quality of services for various type of applications. There are two WiMAX standards, IEEE 802.16d-2004 (also known as Fixed WiMAX) and IEEE 802.16e-2005 (also known as Mobile WiMAX) Fixed WiMAX supports fixed and nomadic applications while mobile WiMAX provides support to mobile, portable, fixed and nomadic applications. WiMAX is convergence of wireless with the internet. In other words, WiMAX promises to deliver the internet throughout the globe connecting the last mile of communication services.

WiMAX provides solution to constantly increasing demands for broadband wireless applications. The bandwidth and range of WiMAX make it suitable for following potential applications: (i) providing portable broadband connectivity across cities and countries through variety of devices, (ii) providing wireless alternative to cable and digital subscriber line (DSL) for "last mile broadband access", and (iii) providing data, telecommunication (VoIP) and IPTV services (triple play).

WiMAX operates both in 10GHz-66GHz (licensed frequency band) as well as 2 Ghz-11Ghz (unlicensed frequency band) for Line of Sight (LOS) and Non-line of Sight operation respectively. The WiMAX Network technology is an evolutionary one as it uses orthogonal frequency division multiplexing which makes transmission resist to fade and minimizes multipath effect. In addition, a WiMAX network can work as a point-to-point backhaul trunk with a transmission capability of 72 Mbps at a transmission distance over 30 miles. With its technological advantages of power, throughput, transmission range and versatility, WiMAX might be a strong competitor of other technologies, such as WiFi and 3G. It is the capability of WiMAX networks in providing high bandwidth with QoS deployed over large areas which is seen as key advantage of WiMAX.

The 802.16e-2005 standard is the amendment of standard 802.16d-2004. The major difference between fixed and mobile WiMAX is that mobile variant enables a hand-off from one base station to another as the user, in one session, moves from the coverage zone of one base station to another.

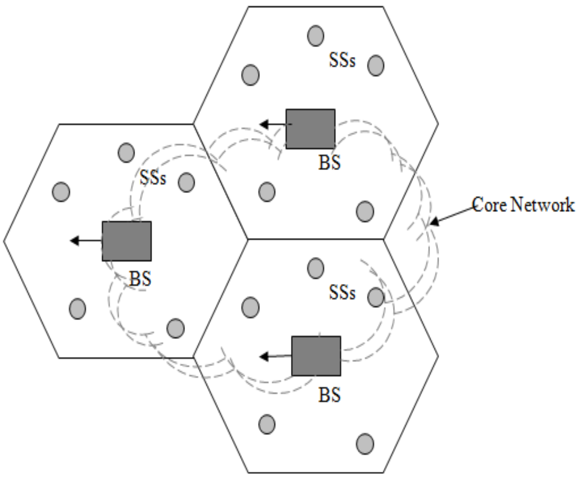

Fig. 1 Simplified network architecture and deployment topology of WiMAX

This is known as mobility management. Other important difference is that the fixed 802.16-2004 standard uses OFDM

256 technology for its PHY whereas mobile 802.16-2005 standard utilizes scalable OFDMA. Orthogonal Frequency Division Multiplexing (OFDM) breaks the wireless carrier into 256 sub-carriers. Orthogonal Frequency
Division Multiple Access (OFDMA) breaks the subcarrier into group of sub carriers known as sub channels (up to 2048 sub carriers). These and some other important differences are listed in table 1.

As the importance of WiMAX Networks has increased, quite a few research efforts have been made in different aspects. Here, we list the previous works related to the same aspects in which we have pursued our research.

TABLE I
Important differences between fixed and Mobile WIMAX

Standard	**802.16d-2004**	**802.16e-2005**
Release	June 2004	December 2005
Frequency band	2GHz-11GHz	2GHz-11GHz for fixed; 2GHz-6GHz for mobile application
MAC Architecture	Point –to-multipoint, mesh	Point –to-multipoint, mesh
Supported services	Fixed, Nomadic and Portable	Mobile, Fixed, Nomadic and Portable
Gross data rate	1Mbps-75Mbps	1Mbps-75Mbps
Coverage area	Up to 50Km maximum	2-6 km approximately
Diversity technique	SISO	MIMO:Matrix A and Matrix B
QoS classes	UGS, rtPS, nrtPS, and BE	UGS, rtPS, nrtPS, ertPS and BE
WIMAX implementation	256-OFDM as Fixed WIMAX	Scalable OFDMA as Mobile WiMAX

In [4] quality of service as provided by the WiMAX networks is analyzed. They presented the details of the quality of service architecture in WiMAX network. In their analysis, a WiMAX module developed based on network simulator ns-2 is used. Various real life scenarios like voice call, video streaming are setup in the simulation environment. Parameters that indicate quality of service such as, throughput, packet loss, average jitter and average delay are analyzed for different types of service flows as defined in WiMAX. Results indicate that better quality of service is achieved by using service flows designed for specific applications.

In [8] results of WiMAX performance study on optimal boundary per WiMAX cell under different WiMAX network models were presented. The performance metrics measured in their study inclusive of packet loss, throughput and delay. From the results, they have deduced that IEEE 802.16 networks perform differently for different network traffic, number of mobile nodes, distance from base station and mobile speed.

Research in [10] investigated the distance effects on performance degradation of mobile WiMAX. Several scenarios had been created and the mobile WiMAX topology had been tested. The data of the simulation results was gathered and the percentages of performance degradation with the effects of distance between mobile station and base station were analyzed. Based on the results obtained, the data rate degrades slightly when the distance between base station and mobile station is more than 10000 meters.

The rest of paper this organized as follows. Section II describes simulation setup. Section III contains results and discussions. The last section concludes the paper.

II. SIMULATION DETAILS

This research has used NS-2 as a simulator to simulate WiMAX network. It is a simple event driven simulation tool that has proved useful in studying the dynamic nature of communication networks.

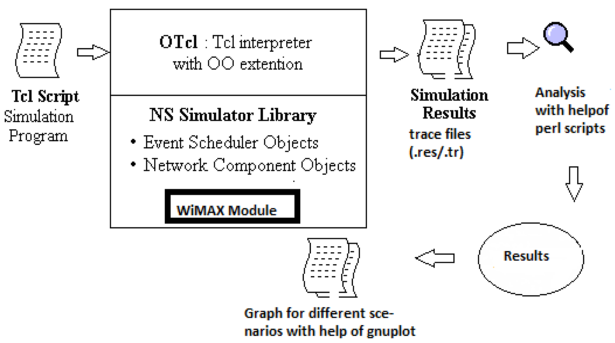

Fig. 2 Different steps in evaluation process of WiMAX on ns-2

Two WiMAX module developed by AWG, WiMAX Forum and NIST are used in our study .The WiMAX module simulate both physical (PHY) and MAC layer based on IEEE 802.16. These modules are integrated with NS-2.34. Fig. 2 shows our methodology for performance evaluation.

First TCL scripts were written to specify different scenarios, which when run on NS-2 produces trace file. Perl scripts were

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used to find the values of throughput, average delay and average jitter from these trace files. The results obtained are plotted on graph with the help of gnuplot. Values of some important parameter used in simulation are given in table II.

TABLE II
Values of some important parameter used in simulation.

Parameters	**Value**
Channel type	WirelessChannel
propagation model	OFDMA
interface type	OFDM(Fixed WiMAX) OFDMA(for Mobile WiMAX)
MAC layer protocol	Mac/802_16/BS
Link layer type	LL
Interface Queue type	Queue/DropTail/PriQueue
Antenna Model	Antenna/OmniAntenna
Maximum packet in ifq	50
Traffic pattern	UDP agent with CBR traffic
Packet size	1500 bytes
Bandwidth	10 mbps
Simulation time	300 second
cyclic prefix factor	Phy/WirelessPhy/OFDM set g_ 0.25(Fixed WiMAX) Phy/WirelessPhy/OFDMA set g_ 0.25(Mobile WiMAX)

III. Simulation Results and Discussion

Four simulation scenarios have been considered for evaluation of WiMAX networks. We analyze the effect of

(i) Number of Subscriber Station(SS),
(ii) Different Modulation schemes,
(iii) Distance between Base Station(BS) and SS, and

A. Impact of number of Subscriber Station(SS)

In this section results are presented for impact of number of subscriber stations over UDP/CBR traffic. Figure 3 to Figure 5 displays the variation of throughput, average jitter, and average delay as the number of nodes increase from 2 to 20.

Fig. 3 shows average throughput as a function of number of nodes. We observe that the throughput steadily increases as the number of nodes is increased. This is expected behavior. The reason is that as the number of nodes is increased, the number of packets being transmitted also increases. These include data packets as well as control packets that are exchanged between the SS and BS. So for two nodes, the throughput is around 486 kbps. For 20 nodes, the value reaches around 4715 kbps for mobile WIMAX. Fixed WiMAX also gives almost similar values.

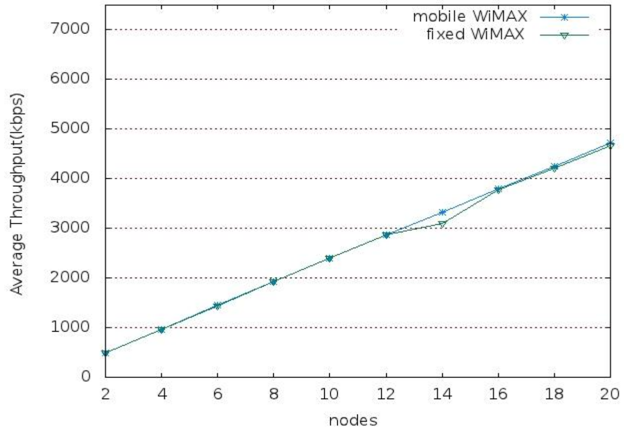

Fig. 3 Average throughput (kbps) as a function of number of nodes.

Fig. 4 shows average delay as a function of the number of subscriber stations in vicinity of base station. We observe that with an increase in the number of subscriber stations, average delay initially increases and then becomes almost constant. The reason is that the WiMAX base station provides a shared access to subscriber stations in its range, therefore, delay increases with initial increase in subscriber stations, however, when the number of subscriber stations cross a threshold, the scheduling of transmission and reception caused by creating a downlink and uplink map mitigates the increase in access delay and therefore, delay almost becomes constant. Also, we observe that the average delays in case of 802.16e are smaller as compared to 802.16d. This is due to use of Scalable OFDMA in case of 802.16e as opposed to 802.16d where classical OFDM is used.

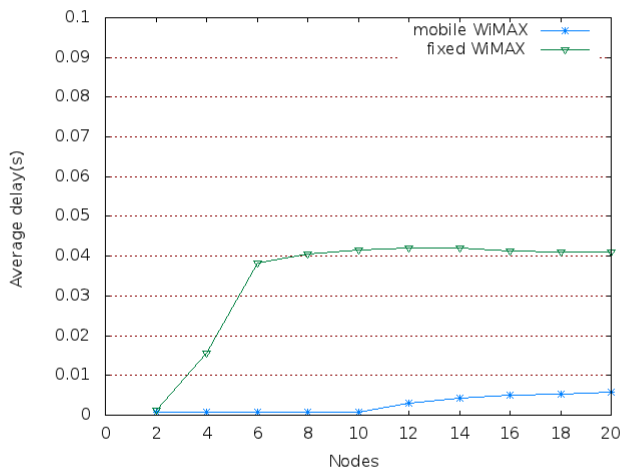

Fig. 4 Average delay(s) as a function of number of nodes.

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Fig. 5 shows average jitter as a function of the number of nodes. For mobile WIMAX, average jitter is remain constant and negligible for all practical purposes. For fixed WiMAX, there is increase in delay upto 6 nodes and then it becomes constant.

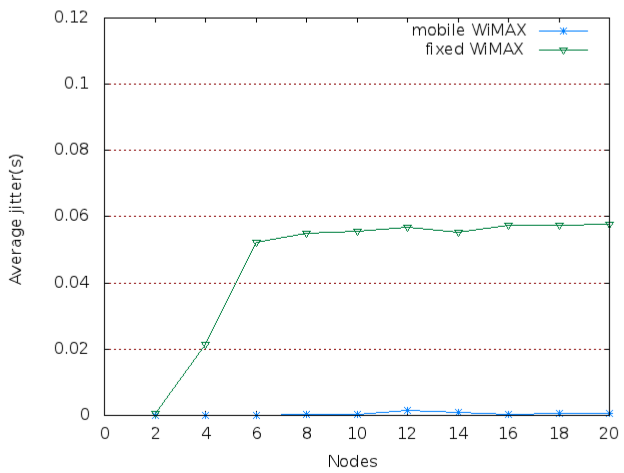

Fig. 5 Average jitter(s) as a function of number of nodes.

B. Impact of distance between BS and SS

In this section the UDP/CBR traffic is setup over fixed and mobile WiMAX. Fig. 6 to Fig. 8 displays the variation of throughput, percentage packet loss, average jitter and average delay as the distance of SS from BS varies from 1000m to 9000m.

Fig. 6 shows average throughput as a function of distance between base station and subscriber stations. We observe

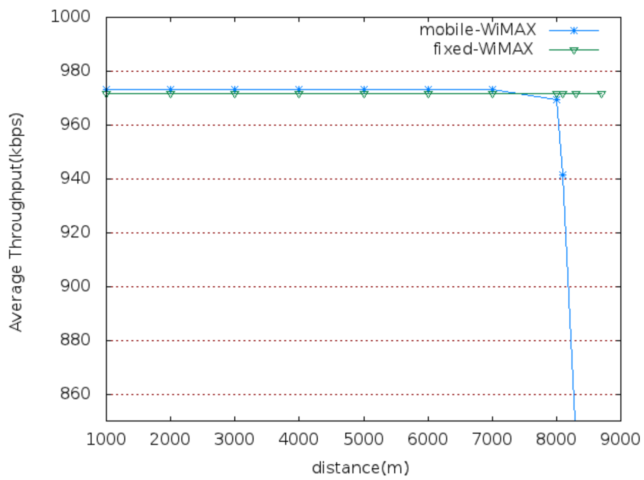

Fig. 6 Average throughput(kbps) as a function of distance between BS and SS.

that with increase in distance the throughput of both 802.16d and 802.16e remains almost constant, however, beyond a distance of 8 km, the throughput of 802.16e drops drastically. This also the reason for the fact 802.16e does not support large distances. As opposed to 802.16e, the throughput of 802.16d remains constant. We expect the throughput of 802.16d starts decreasing beyond certain range.

Fig. 7 shows the average delay as a function of distance. Average delay remains almost constant as distance is varied for both fixed and mobile WIMAX. Mobile WIMAX has lesser delay than fixed WIMAX. Fig. 8 shows the average jitter as function of distance. The average jitter does not show significant variation with distance for both fixed and mobile WiMAX. Again mobile WiMAX performs better than fixed WiMAX. The values are very low and practically insignificant.

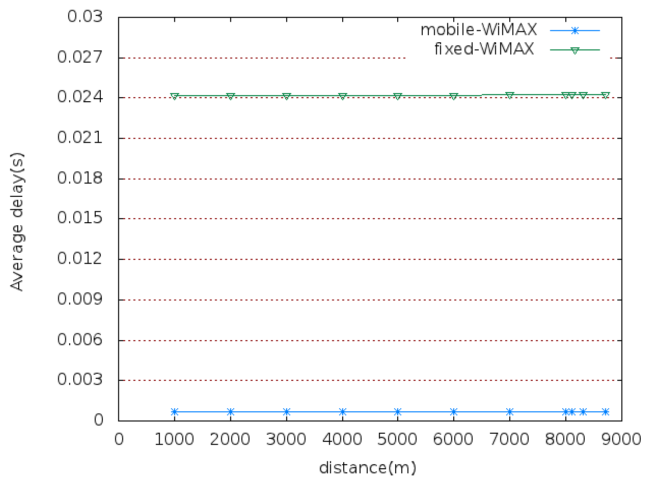

Fig. 7 Average delay(s) as a function of distance between BS and SS.

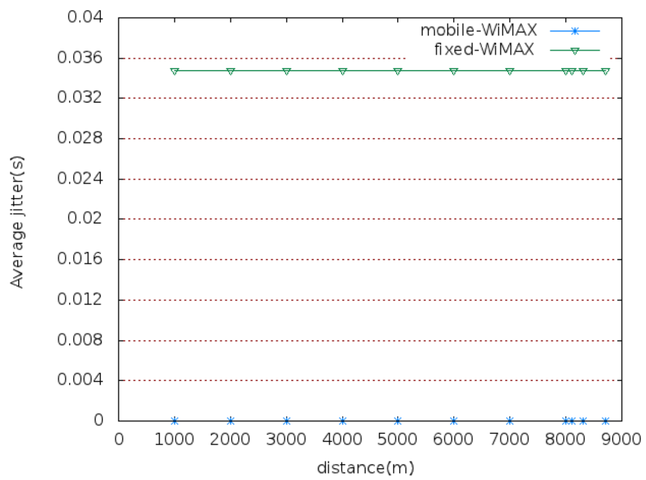

Fig. 8 Average jitter(s) as a function of distance between BS and SS.

C. Impact of different modulation schemes

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In this section, we present simulation results to evalaute an impact of different modulation schemes over UDP traffic. WiMAX supports adaptive modulation and coding, so that in conditions of good signal, a highly effcient 64 QAM coding scheme is used, whereas where the signal is poorer, a more robust BPSK coding mechanism is used. In intermediate conditions, 16 QAM and QPSK can also be employed. The current implementation of the packet scheduler for BS allows users to have different modulations.

Fig. 9 shows average throughput for different modulation and encoding schemes. We observe that the average throughput increase if one continues to move towards WiMAX base station In other words, the average throughput of 64 QAM together with encoding scheme 3/4 is larger than than that of 64 QAM with 2/3. Let Ω be the symbol denoting throughput. Then, we have

$$\Omega 64QAM\_3/4 \geq \Omega 64QAM\_2/3 \geq \Omega 16QAM\_3/4 \geq \Omega 16QAM\_1/2 \geq \Omega QPSK\_3/4 \geq \Omega QPSK\_1/2 \quad (1)$$

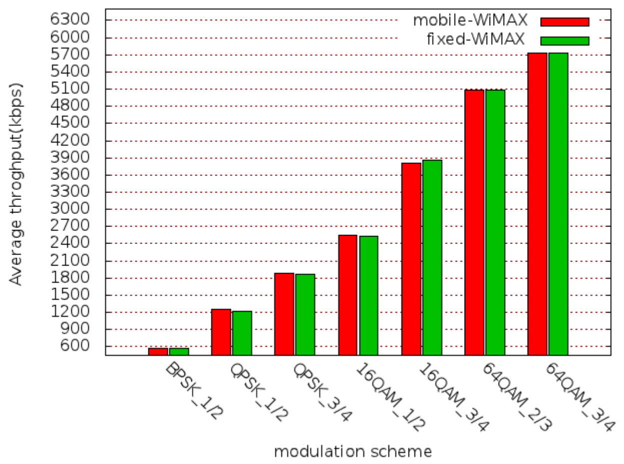

Fig. 9 Average throughput(kbps) for different modulation scheme.

Fig. 10 shows average delay for different modulation and encoding schemes. We observe that access delay for modulation technique 64 QAM together with encoding scheme 3/4 is smaller than those in case of 64 QAM together with encoding scheme 2/3. The delay incurred by modulation scheme QPSK together with encoding scheme 1/2 is much lower than modulation scheme BPSK together with encoding scheme 1/2. Let £ be the symbol denoting average delay. Then, we have,

$$£64QAM\_3/4 \leq £64QAM\_2/3 \leq £16QAM\_3/4 \leq £16QAM\_1/2 \leq £QPSK\_3/4 \leq £QPSK\_1/2 \quad (2)$$

Fig. 11 shows average jitter for different modulation scheme and encoding schemes. Though there is no specific trend observed for both 802.16d and 802.16e. however, we observe that jitter in case of 802.16e is smaller than that in case of 802.16d.

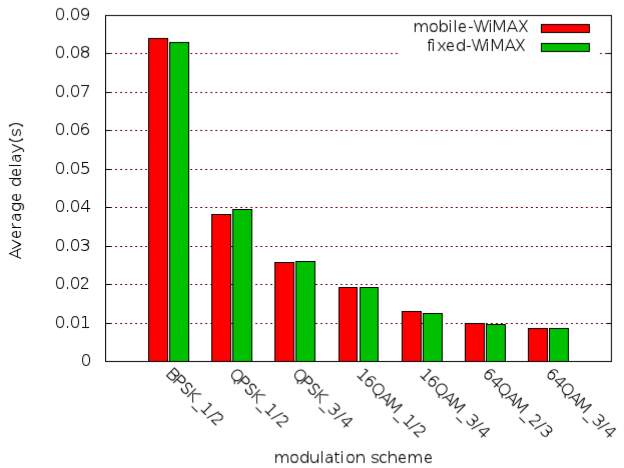

Fig. 10 Average delay(s) for different modulation scheme.

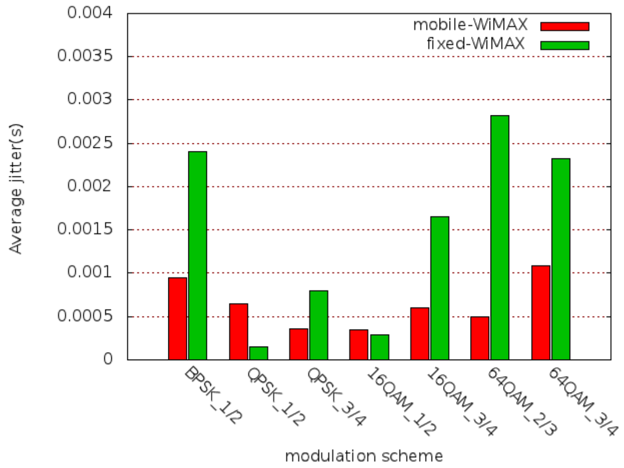

Fig. 11 Average jitter(s) for different modulation scheme.

IV. CONCLUSION

The In this paper, we presented the performance study for mobile WiMAX and fixed WiMAX using simulation tool NS-2. Result obtained from simulation shows how several performance metrics such as throughput, delay, jitter are affected by change in factors like number of nodes, modulation scheme, distance between BS and SS . From the results obtained from three scenarios, we conclude the

following.
In both fixed and mobile WiMAX, increase in the number of SS increases the throughput but also increases the average delay and average jitter values. Effect of different modulation scheme was evaluated and it is found out 64QAM is most efficient as expected and performs better than QPSK which in turn performs better than BPSK. It can also be concluded that WiMAX can provide access to large distances which is the biggest advantage of this technology when compared to Wifi. It is also found that fixed WiMAX can support up to larger distance in comparison to mobile WiMAX.
Other factors that do affect the performance of WiMAX network are antenna gain, MIMO gain, and output power of BS, TDD ratio, CPE antenna gain and receiver antenna gain of BS. Therefore, by choosing appropriate values of different factors/parameters according to channel condition and other available resources, performance of WiMAX can be optimized.

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Biography

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