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# Comparison of LTE (Long Term Evolution) and WiMax on fixed and mobile networks for TCP, UDP traffics using NS2 Simulator.

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***Abstract*— WiMAX stands for Worldwide Interoperability for Microwave Access. In this paper, Performance evaluation of WiMAX and LTE (Long term Evolution) is done on network simulator NS version 2.34. Both are subjected to Real life scenarios to see how different factors viz. distance, number of subscriber stations, different modulation schemes and packet size affect the performances of WiMax and LTE. Simulation is carried out for UDP protocol over fixed as well as mobile networks. Throughput, average delay and average jitter are used as performance metrics in this study.**

***Keywords*— Wireless Communication, WiMax, LTE, Performance, throughput.**

## I. Introduction

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"
(iii) providing data, telecommunication (VoIP) and IPTV services (triple play).

One of the technologies that can lay the foundation for the next generation (*fourth generation* [4G]) of mobile broadband networks is popularly known as "WiMAX." WiMAX, *Worldwide Interoperability for Microwave Access*, is designed to deliver wireless broadband bitrates, with *Quality of Service* (QoS) guarantees for different traffic classes, robust security, and mobility.

The article provides an overview of mobile WiMAX, which is based on the wireless local and *Metropolitan-Area Network* (MAN) standards IEEE 802.16-2004 and 802.16e-2005 as well as fixed networks too for same standards. We introduce WiMAX and focus on various system profiles and briefly review the role of the WiMAX Forum.

We summarize the critical points of the WiMAX network reference model and present the salient characteristics.We address how mobile nodes enter a WiMAX network and explain the fundamentals of mobility support in WiMAX. Finally, we briefly compare WiMAX with *High-Speed Packet Access* (HSPA), another contender for 4G.

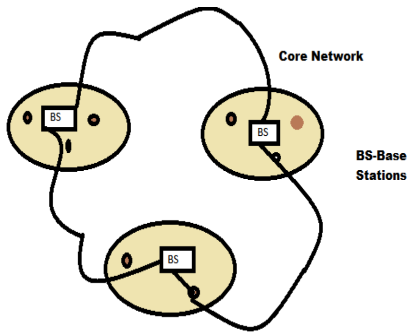


Fig. 1: WiMax Architecture

### From ***IEEE 802.16 to Mobile WiMAX***

The IEEE 802.16 standard was originally meant to specify a fixed wireless broadband access technique for point-to-point and point-to-multipoint links. During its development, however, it was decided that mobility support should also be considered.

The WiMAX defines two system profiles , called *fixed* and *mobile* system profiles, respectively. Both include mandatory and optional PHY and MAC layer features that are required from all corresponding WiMAX-certified products.An end-to-end architecture specification was deemed necessary in order to enable fast growth in manufactured quantities, market share, and interoperability. In response, the WiMAX established the *Network Working Group* (NWG) with the aim of developing an end-to-end network reference model architecture based on IP supporting both fixed and mobile WiMAX.

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

*A.* LTE(Long Term Evolution):

Long Term Evolution (LTE) technology has become the target for most of the wireless operators moving towards Fourth Generation (4G) deployments. As user demand for mobile broadband services continues to rise, LTE and its ability to cost effectively provide very fast, highly responsive mobile data services will become ever more important. For many operators, LTE represents a significant shift from legacy mobile systems as it is the first all-Internet Protocol (IP) network technology and will impact the way networks are designed, deployed, and managed. LTE uses Orthogonal Frequency Division Multiple Access (OFDMA) and advanced antenna techniques to maximize the efficient use of radio frequency spectrum with a purely Packet Switch (PS) EPC core network. In addition, the transition to IP has enabled LTE to support Quality of Service (QoS) for real time packet data services like VoIP and video conversation. The overall goal of 4G systems is to provide a converged network compatible with the Next Generation Network (NGN).

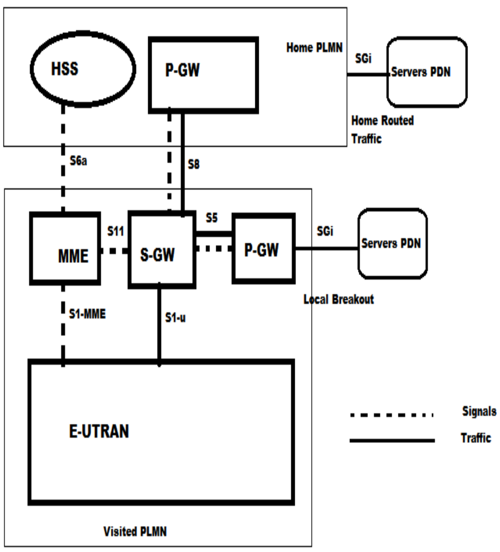


Fig. 2: LTE Basic Architecture.

LTE has a non hierarchical structure consisting of two networks viz. E-UTRAN and the EPC. It results in a flat system thereby, increasing efficiency and scalability. Furthermore, it is optimized to support real time IP based services, higher data rates and lower latency. It supports internetworking with several wireless access technologies. EPC constitutes flat all-IP systems having six nodes :The Mobility Management Entity(MME), the Serving Gateway(S-GW), the Packet Data Network Gateway(P-GW), the Home Subscriber Server(HSS), the Policy and Charging Control Fucntion(PCRF), and the evolved Packet Data Gateway(ePDG).
The Migration of GSM/UMTS to LTE is a great step because these networks are fundamentally different, and this includes the migration from circuit switch(CS) based networks to all IP-PS based Networks.
In this research paper, Simulation of LTE and WiMax is done subjected to various networks that will subsequently determine the performance of each with different network parameters and hence help deciding which is suitable over the networks for the upcoming technology.

**Simulation Details:**

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

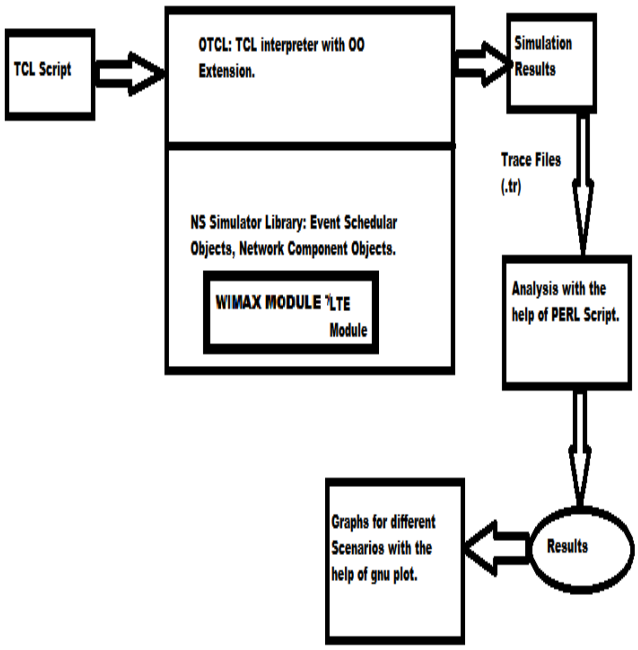


Fig. 3 Simulation Procedure.

**Simulation Procedure**

First TCL scripts were written to specify different scenarios, which when run on NS2 produces a TRACE File. Perl Scripts were written to obtain values of throughput, average delay and average jitter from these trace files. The results obtained are plotted on graph with the help of gnuplot.

**Simulation Results and Discussion for WiMax**

Four simulation scenarios have been considered for evaluation of networks. We analyze the effect of
(i) Number of Subscriber Station(SS),
(ii) Different Modulation schemes,
(iii) Distance between Base Station(BS) and SS

*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 6 displays the variation of throughput, average jitter, and average delay as the number of nodes increase from 2 to 20.

Fig. 4 shows total 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.

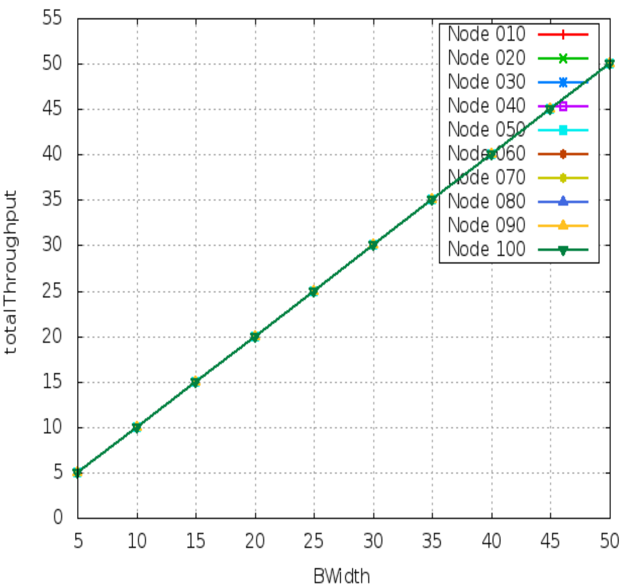


Fig 4 Total Throughput(kbps) as the number of nodes.

Fig. 5 shows average delay as a function of the number of subscriber stations in vicinity of base station. We observe that with increasing bandwidth delay subsequently decreases. As the number of nodes increase with increasing bandwidth the delay keeps reducing, this is because as the bandwidth keeps increasing the channel through which data packets need to pass becomes wider hence allows the trespassing of the data packets easily with increasing bandwidth. Along with increasing the number of nodes bandwidth also is kept increasing thereby causing the delay to reduce while the number of nodes increases.

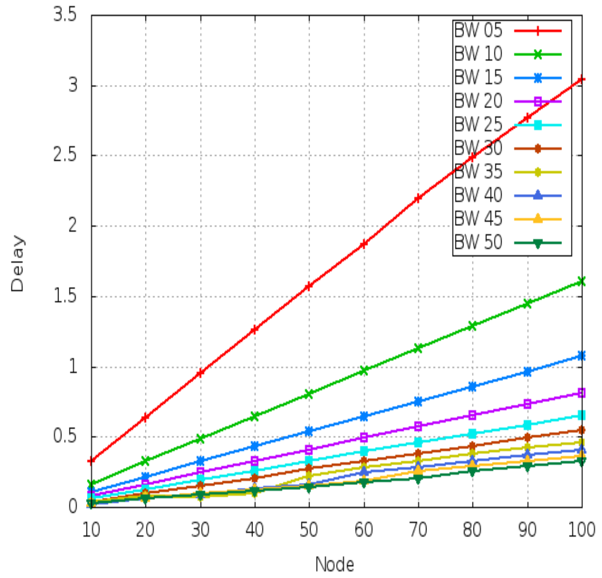


Fig 5: Average delay as the function of bandwidth.

Fig 5 shows the delay as a function of number of nodes on varying the bandwidth. For 10 nodes at 5 as bandwidth delay is more . As the bandwidth increases delay reduces. On the similar note as the number of nodes increase at bandwidth 5 delay keeps on increasing but as soon as the bandwidth is increased with increasing number of nodes delay subsequently reduces. This is because increasing bandwidth primarily allows wider scope for transmission of data packets which eventually allows large number of data packets to pass through the channel. Hence, delay in transmitting the data decreases no matter how much the number of nodes are increased. With increasing bandwidth higher number of nodes can pass through the channel.

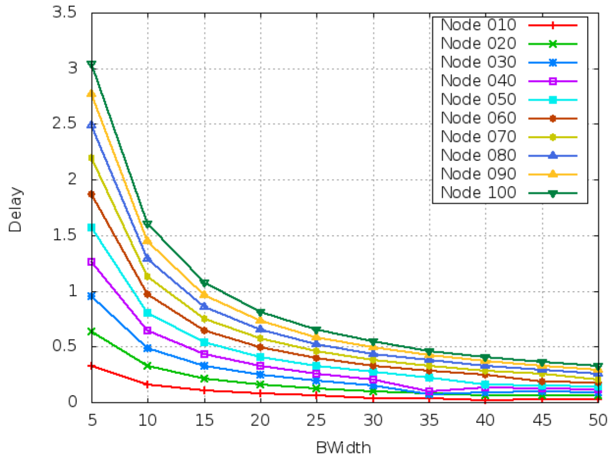


Fig 6: Average Delay as the function of number of nodes.

Fig 7 depicts total throughput of the system. With increasing number of nodes and increasing bandwidth the total throughput of the system remains same throughout the transmission of packets. With increasing nodes and bandwidth together the total passage of data packets remains same hence, its constant.

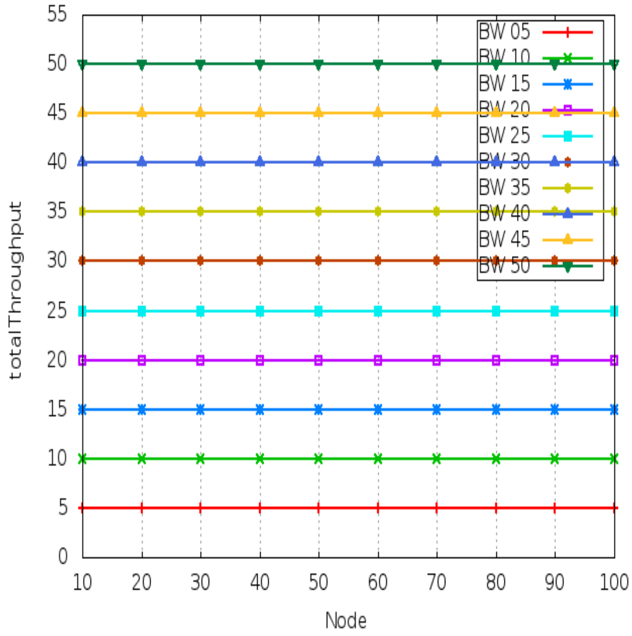


Fig 7. Total Throughput as the function of bandwidth.

**Simulation Results of LTE**

Fig 8. Depicts average delay of the network with the function of bandwidth. As we can see in the graph, delay is going negative with bandwidth being small. As the bandwidth increases the delay moves on a positive side i.e. the delay reduces as bandwidth increases. At the highest bandwidth the delay is the least.

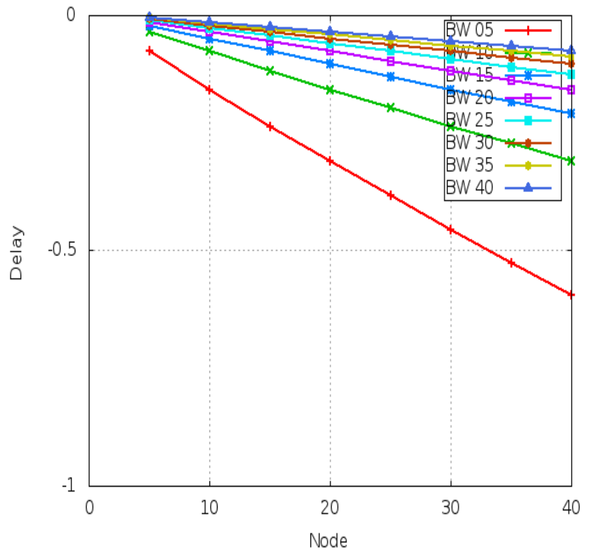


Fig 8: Average Delay as the function of bandwidth.

Fig 9. Represents Average Delay as the function of number of nodes with increasing bandwidth. With the graph we can conclude that for minimum number of nodes i.e 5 there is a considerable delay but as the bandwidth increases the delay becomes zero. For all the number of nodes taken into considerations as the number of nodes is increased for lower bandwidth there is a delay acquired but as the bandwidth increases the delay goes on reducing.

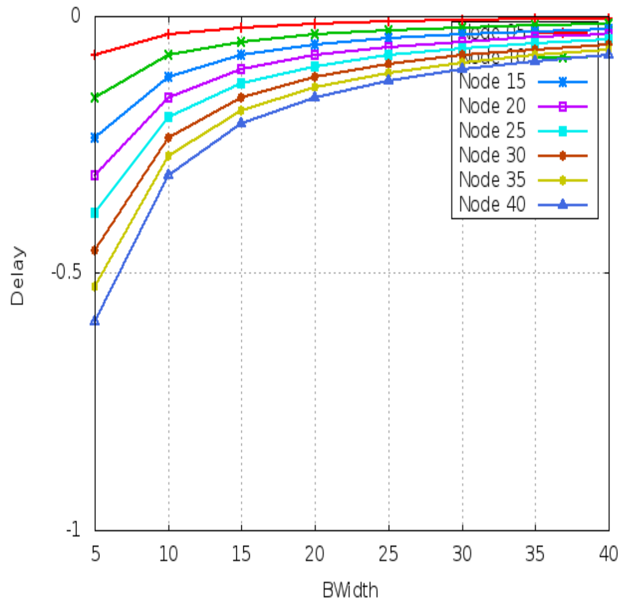


Fig 9: Average Delay as the function of number of nodes.

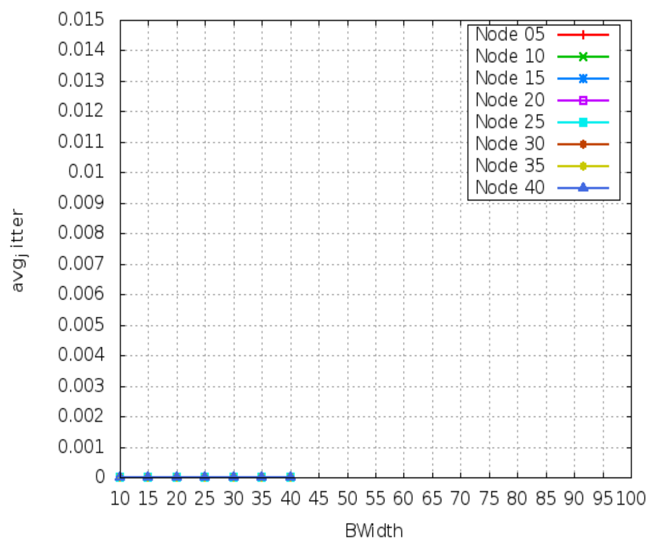


Fig 10. Average Jitter as the function of number of nodes depicting packet loss.

Fig 10. Represents Average Jitter as the function of number of nodes depicting packet loss. As we can see in LTE there is no packet loss even at lowest bandwidth. If we talk about the jitter function there is no jitter pertaining to the number of packets being transferred from one node to another or from base station to node. No packet loss signifies the better performance of LTE over WiMax .

Fig 11. Represents total throughput as the function of bandwidth with increasing number of nodes. As we can see with the help of graph that as the number of nodes is increased and consequently as the bandwidth is kept increasing then the total throughput of the system is constant for increasing bandwidth and increasing number of nodes. The number of packets per second transmitted remains constant throughout the system which depicts the total throughput of the system. However, in this scenario increase in bandwidth and increase in number of nodes is kept the even.

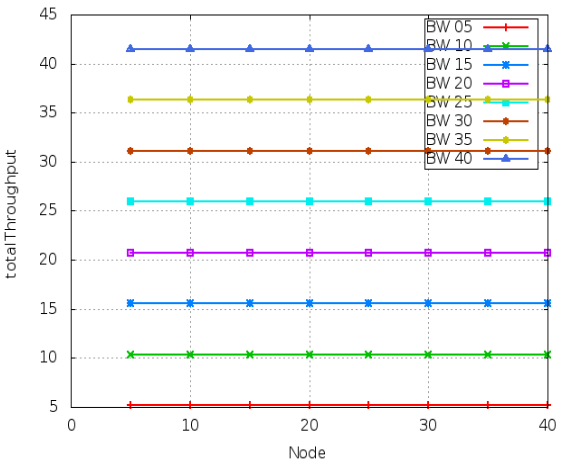


Fig 11. Total Throughput as the function of bandwidth.

Fig 12 represents total throughput as the function of number of nodes. As it has already been mentioned in the above graph that with increase in number of nodes and bandwidth the total throughput of the system remains constant throughout the transmission of the data packets. This is because when bandwidth is increased there is more propulsion space which consequently allows smooth transfer of the data packets with no jitter and packet loss. However, if the bandwidth is kept same and number of nodes are increased there may be a delay and jitter with little packet loss(referring to the graphs above). However in this scenario, the number of nodes and bandwidth are kept increasing at the same time hence no jitter or packet loss is encountered which eventually depicts constant throughput throughout the system.

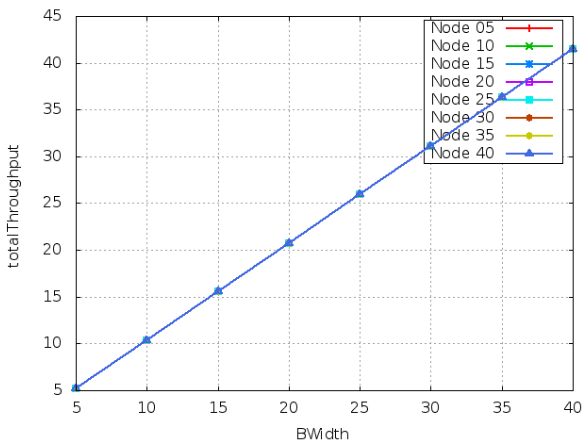


Fig 12. Total Throughput as the function of number of nodes.

## CONCLUSIONS

The In this paper, we presented the performance study for WiMAX and LTE 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 WiMax Line of sight is necessary for the propulsion of data packets from base station to nodes and from nodes to base station. WiMax depicts packet loss when increasing number of nodes and lesser bandwidth wherein with slight increase in the bandwidth LTE doesn't incorporate any packet loss or jitter on the data packets. Unlike WiMax, LTE doesn't need any line of sight. Without Line of sight it can propagate the data packets . With all these conclusions and considering the various scenarios under which the graphs have been plotted , LTE is better than WiMax in performance.

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