IARJSET

ISSN (Online) 2393-8021
ISSN (Print) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

ISO 3297:2007 Certified

Vol. 3, Issue 10, October 2016

LTE vs. WiMAX: A Case Study

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Abstract: The increasing use of wireless devices and in particular cell phones has led for the need of greater capacity and higher speed than the present wireless network technologies. Hence, Long Term Evolution (LTE) and Worldwide Interoperability for Microwave Access (WiMAX) has become the two foremost technologies. Cell phone services are rapidly shifting from voice services to data and from circuit-switching to packet-switching ones. The prior readiness of the WiMAX technology has already given it its edge over the LTE. Competition between the two is evened by the absences in considerable roll out plans due to cost factors of WiMAX. The goals for LTE indicate bandwidth as high as 100Mbps on the downlink, and up to 50Mbps on the uplink. However, this possible increase in bandwidth is just a minor part of the overall advancements, which LTE aims to provide. Keeping in the view the importance of the LTE & the WiMAX this study illustrates the comparison of these two technologies using the NS-3 network simulator. The evaluation of the network performance for two technologies is done on the basis of Quality of Service parameters which includes throughput, average jitter and packet lost. From simulation results, it is evident that with lesser node traffics the LTE works a little better but as the nodes traffic increases WiMAX starts to perform better. Throughput between 100 to 150 nodes both technologies are similar but beyond 150 nodes WiMAX performed better.

Keyword: 4th Generation (4G), Network Simulator-3 (NS-3), Long Term Evolution (LTE), Worldwide Interoperability for Microwave Access (WiMAX) Technologies.

I. INTRODUCTION

In wireless communication networks, 4G is the fourth generation of cell phone mobile communications standards. There are several features associated with 4G, which makes it promising. Alongside, new applications required to be integrated to the new mobile systems which include a variety; VoIP, video conferencing, multimedia messaging, multi-player gaming, Virtual Private Networks (VPN) etc.[1]. All of these applications requires higher throughput, wider bandwidths, smaller delays and advanced transmission methods that will give higher spectral effectiveness and good quality.

Two leading emerging technologies which satisfies the above requirements are: LTE, standardized by Third Generation Partnership Project(3GPP)and WiMAX (the IEEE802.16e,the worldwide interoperability for microwave access).These two technologies are considered to fulfil the 4G requirements publicised by International Telecommunication Union-Radio-communications(ITU-R)which represents for International Mobile Tele-Communications Advanced (IMT-Advanced)[2].Future scope of both these technologies is vast. Also, both the technologies have their own pros and cons. In future, a network may be developed which will combine the advantages of both these technologies into one. This study attempts to bring forth NS3 simulations of two of the most widely used wireless network technologies.

WIMAX

WiMAX (Worldwide Interoperability for Microwave Access), supports PMP (Point to Multi Point) broadband wireless access. WiMAX enables users to connect to the network on a fixed base or a mobile base. The WiMAX technology came to existence in the year of 2006 when Korea Telecom started using of a 2.3 GHz version of mobile WiMAX service also known WiBRO in the Seoul Metropolitan Area(SAM), to offer high capability for data and video[3]. In a market study published in the month April of 2008, "WiMAX Forum Subscriber and User Forecast Study", the WiMAX Forum projects a very aggressive forecast for more than 133 million WiMAX users globally by the year 2012 [4]. The basic interface of WiMAX technology is built on the IEEE 802.16 standards. In particular, it can be said that the current Mobile WiMAX technology is largely based on the IEEE 802.16e amendment. This amendment was authorised by the IEEE in December 2005, which postulates the Orthogonal Frequency Division Multiple Access (OFDMA) air interface and provides support for mobility. The IEEE wireless standard gives a range of up to 50 kilometres, and is capable of delivering broadband at around 75 megabits per second[3]. The basic WiMAX specifications are discussed in the Table 1,which mention basic features of the same [5].

TABLE 1 WiMAX SPECIFICATIONS [5]

Aspects	WiMAX
Legay	IEEE 802.16 a to d
Core Network	WiMAX forum ALL-IP network
Channel Bandwidth	Scalable from 1.25 to20 MHz with system

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ISSN (Print) 2394-1588
International Advanced Research Journal in Science, Engineering and Technology
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	profiles1.25,1.5,5,10&20 MHz
Peak Data Rate	DL:75 Mbps UL:25 Mbps
Cell Radius	Upto 20.7 Km
Cell Capacity	100-200 Users
Mobility Speed Handover	Upto 120 Kmph,Optimized hard handovers supported
Radio Access Modes	TDD & FDD

WiMAX is theoretically, at least 20 times faster than a currently available commercial wireless broadband. WiMAX can be used for wireless networking in a replacement for the popular Wi-Fi. WiMAX, which is a second generation protocol, allows us higher data rates over longer distances, more efficient use of bandwidth, and it avoids interference almost to a minimum level. WiMAX can also be termed partially asa successor of the Wi-Fi protocol, which is usually measured in feet, and works, over shorter distances.

LTE

Long Term Evolution (LTE) is a significant project of 3rd Generation Partnership Project (3GPP), initially proposed on the Toronto conference of 3GPP in 2004 and officially started as LTE project in 2006[6]. LTE, is a transition from the 3rd generation (3G) to the 4th generation (4G), and has achieved great capacity and high speed of mobile telephone networks.

It defines a new packet-only wideband radio with flat architecture and assumes a full Internet Protocol (IP) network architecture in order to assure voice supported in packet domain in design[6]. In addition, it is combined with top-of-the-line radio techniques in order to gain better performance than Code Division Multiple Access (CDMA) approaches. LTE provides scalable carrier bandwidths from 1.4 MHz to 20 MHz and Frequency Division Duplexing (FDD), as well as Time Division Duplexing (TDD)[6]. Table 2 shows the basic specifications of the LTE.

TABLE 2 LTE SPECIFICATIONS [5]

Aspects	LTE-Advanced
Legay	GSM/GPRS/EDGE/ UMTS/HSPA
Core Network	UTRAN moving towards AII-IP Evolved-UTRA (E-UTRA) core network with IMS with SAE Architecture.
Channel Bandwidth	Scalable from 1.25 to 20 MHz with system profiles 1.25,1.4,2.5,3,5,10,15&20 MHz
Peak Data Rate	DL:100 to 326.4 Mbps UL:50 to 86.4 Mbps
Cell Radius	5Km
Cell Capacity	>200 users @ 5MHz
	>400 users for longer BW
Mobility Speed Handover	Upto 350 Kmph Inter-Cell soft handovers supported
Radio Access Modes	TDD & FDD

Evolving from the 3GPP family, the LTE takes the 3G Universal Mobile Telecommunications System (UMTS) architecture as the baseline to define a simplified model in tandem with the 3GPP-System Architecture Evolution(SAE) and Evolved Packet Core(EPC).

II. LITERATURE SURVEY

In his paper Dieter Eberle[7], has analysed the various aspects of WiMAX & LTE theoretically and given a detailed overview of both LTE & WiMAX technology.

Shadwankhatim Osman Abdelrahman & Dr. Amin Babiker[8] in their simulation based study showed that how WiMAX responds to different load conditions. The simulation was done for WiMAX mobile nodes only.

Similar analysis of location based performance was carried out by Y. Zhang and H. Chen[9], in which critical QoS parameters delay and throughput (packets / seconds) were analysed. The values of the QoS parameters were not optimized and lesser number of nodes were taken into consideration.

Jeffrey G Andrews et al. [10] in their book, gave a detailed view of the WiMAX and its fundamentals. They discussed the system architecture and performance of the WiMAX theoretically. LTE and WiMAX comparison presented by Tejas Bhandare[5] presents an elaborated study of the two technologies and compare them theoretically very well. He has shown all the technical aspects of the two technologies.

Dr. Carsten Bell of Nokia Siemens Networks[11] in his report has mentioned all the parameters with respect to the radio perspective and compared them side to side. He also discussed the theoretical outputs of the two viz. Data Rates, Mobile Capability Limits.

Mehdi Alasti & Behnam Neekzad[12] of Intel Labs presents framework for the Quality of Service in WiMAX and LTE networks. This paper has discussed about each QoS parameters individually for each network.

Leo Yi et al.[13] has presented a comparative study of the two technologies for network architecture and network security.

III.OBJECTIVES

- To have an understanding of two key 4G technologies namely LTE & WiMAX.
- To empirically evaluate performance of these technologies using NS-3 Simulator.

IARJSET
ISSN (Online) 2393-8021
ISSN (Print) 2394-1588
International Advanced Research Journal in Science, Engineering and Technology
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IV. RESEARCH METHODOLOGY

To carry out the study both theoretical as well as empirical approach has been used. The theoretical approach includes literature survey, books, case studies etc.

In the empirical approach, NS-3 simulator has been used to evaluate the performance of these two technologies.

V. ANALYSIS

In this study performance comparison of two major 4G technologies is given using NS-3 simulator. The following section explains about simulation parameters considered for performance evaluation and simulation results.

A. About Simulator

Several network simulation softwares are available on the internet. Some of the leading network simulators are Qualnet, Network Simulator-2, JiST/SWANS, Opnet, Omnett, Netsim REAL, SSFNet, JSimetc.

But for this studyNetwork Simulator-3 (NS-3) is chosen because of its following features and advantages NS-3 offers over other simulators [14]:

- Popularly used for academic and industrial purposes.
- Open Source Software,
- Great accuracy and speed of testing,
- Supports several external protocols,
- Simulation scenarios can be developed using python script and/or C++,
- Provided with in built visualization tools,
- Support for complex scenarios.
- Discrete event packet level simulator.

The network simulator contains a very large number of applications consisting different kind of protocols for different network types including of different network elements and traffic models [16].

NS-3 is a powerful package of tools that can simulate behaviour of networks such as creating network topologies, logging events that happen under different loads, analyse the events and understand the network working. Platform required to run network Simulator [15] are:

1. UNIX and UNIX like systems
- Linux
- Free BSD
- SunOS/Solaris

2. Windows 95 / 98 / NT / 2000 / XP / 7 / 8.1 / 10 (requires Cygwin).

B. Parameters Compared

Following parameters are considered while comparing the two technologies:

Packet Delivery Ratio(PDR):
Packet dropping is a scenario network traffic fails to reach its destination in a timely manner.
Most commonly packets get dropped before the destination can be reached.
PDR = (No. of packets received / No of packets sent) *100

Throughput (T):
Network throughput can be defined as the average rate of successful message delivery of data over a communication channel. This data may be delivered over a physical or logical link, or pass through a certain network node.

The throughput is generally measured in bits per second (bit/s or bps), and sometimes in data packets per second or data packets per time slot.

Following is the formula to calculate the throughput of the network:
T =No.of bytes*8/(Finish time-Start time) bps

Packet Delivery Variance(Jitter):
Jitter is defined as the variation in delay of received packets. At the sending side, usually packets are sent in a constant stream with packets spread out consistently apart.

Due to network congestion, improper queuing algorithms, or any configuration errors, this steady stream can become uneven, and the delay between each packet can vary instead of remaining constant.
Jitter is considered very critical in real time networks e.g. video streams, online gaming etc.

C. Simulation Results

Packet Delivery Variance(Jitter)
Table 3 represents the data values of jitter for different number of nodes. The Figure 1 shows the graph between PDV(Jitter) and number of mobile nodes of WiMAX & LTE. Here it shows that a very low value of jitter is obtained for both the networks.

The value of jitter in WiMAX increases with increase in number of nodes but seems like reaching an optimum level. Figure 1 shows on the average 1.033x10-9 seconds of jitter is obtained, which is very low as per ITU standards.

On the other hand, jitter for LTE first increases then took a dip at node number 150, where it attained minimum value but then it gradually increases.

TABLE 3 DATA VALUES FOR JITTER

Nodes	WiMAX	LTE
50	1.031	1.032
100	1.033	1.033
150	1.034	1.032
200	1.035	1.034

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ISSN (Print) 2394-1588
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ISO 3297:2007 Certified
Vol. 3, Issue 10, October 2016

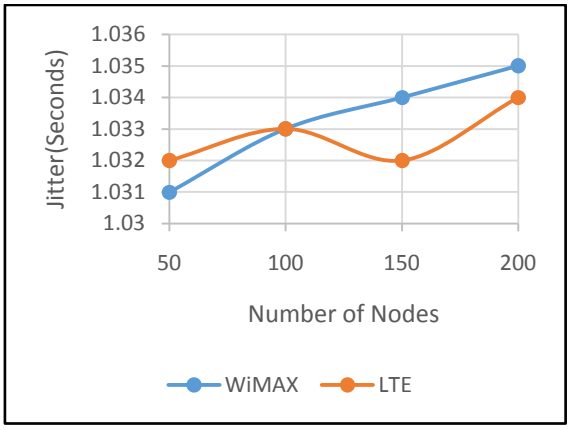

Figure 1: Jitter vs. No. of Nodes

Packet Delay Ratio(PDR)

It is evident from the Table 4 that the WiMAX has a PDR value for 200 nodes is 90.3% whereas LTE has 90.2%. Packet delivery ratio is the measure of successful delivery of packets.The graph is drawn between PDR and number of mobile nodes, which is shown in Figure 2. It seems like the packet delivery ratio of WiMAX increases a little with increase in the nodes but at one point it drops least. But it increases to optimum level after some packet number. LTE on another end seems like less fluctuating but its losing its ratio with the increase in the number of nodes.

TABLE 4 NODES VS. PACKET DELIVERY RATIO

Nodes	WiMAX	LTE
50	89.8	90
100	90	90.4
150	89.7	90.3
200	90.3	90.2

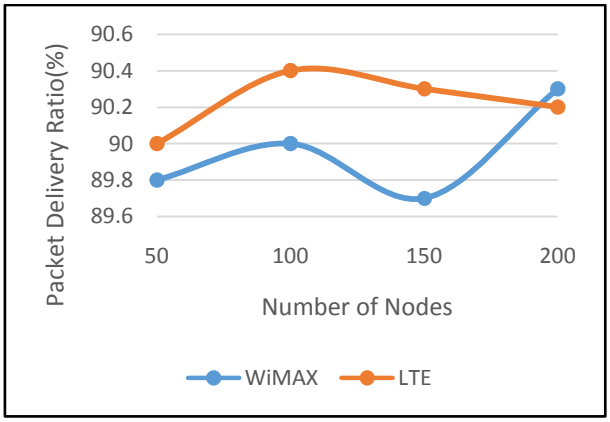

Figure 2: Packet Delivery Ratio vs. No. of Nodes

Throughput

Table 5 shows throughput of WiMAX overtakes the throughput of LTE at 200 nodes. Throughput is a measure of successful delivery of packets in a given interval of time. The graph between Throughputs vs. number of mobile nodes is shown in Figure 3. It depicts that for both networks as the number of mobile nodes increases, throughput increases as well. It might be due to the more load distributable nodes on the network. 200 nodes have better load distribution as compared to the 50 nodes which increases throughput.

But as we can see LTE throughput starts to dip a little as the node numbers passes a certain point, this phenomenon has to studied and check the causes behind it.

TABLE 5 NODES VS THROUGHPUT

Nodes	WiMAX	LTE
50	2.5	2.4
100	3	3.1
150	3.5	3.6
200	4	3.8

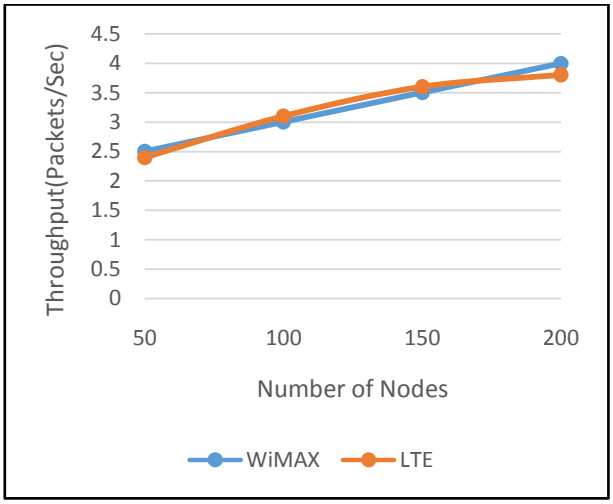

Figure 3: Throughput vs. No. of Nodes

VI. CONCLUSION & FUTURE SCOPE

The increase in demand for the faster data connections mobile wireless connections has reached the mile stone of 4th Generation of Networks. 4G networks are capable of providing faster data rates with lesser resource consumptions. Here, in this paper evaluation of the two key 4G technologies has been carried out. Study showed us that WiMAX technologies are better to handle larger loads as compared to LTE, but on the other hand LTE excels in smaller loads.

In jitter test LTE started better but it fluctuates, whereas WiMAX gave a steady performance. In PDR tests LTE reached its optimum value then it starts to dip, on the other hand WiMAX after a dip, overtook the LTE. WiMAX in the throughput tests showed steady results, and LTE starts to dip a little here also.

For future, there are scopes to enhance the smaller load handling capabilities of WiMAX networks and LTE needed to be optimized for larger loads compared to WiMAX.

DOI 10.17148/IARJSET.2016.31020

IARJSET

ISSN (Online) 2393-8021
ISSN (Print) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

ISO 3297:2007 Certified

Vol. 3, Issue 10, October 2016

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