A Performance Comparison on Mobility of 3G & 4G networks

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Abstract:- It is tremendous to these day, there are several ways by which a Wireless Internet Service Provider can deliver broadband service. It is known as PAN, LAN with MAN. We can say that these are the migration path to 4G. 3G and 4G networks are made to provide high speed of data transfer in full mobility. 4G is said to be a complete IP solution where voice, data and streamed multimedia can be given to users on an "Anytime, Anywhere and Anyhow", basis, and at higher data rates compared to previous generations. This paper explores standards and technology of 4G networks. With the help of Simulation experiments the performance of the 3G and 4G networks are analyzed. The experiments are performed using simulator Qualnet5.0. With the Simulation of various network setups as per requirement and performance of the both networks by selecting parameters such as throughput, collisions, end to end delay and packet delivery ratio are analyzed.

Keywords- 4G, 3G, OFDMA, UMTS, PDR.

I. INTRODUCTION

It is tremendous to these day, there are several ways by which a Wireless Internet Service Provider can deliver broadband service. It is known as PAN, LAN with MAN. We can say that these are the migration path to 4G. LAN network can be used covered limited coverage area at the hotspots. Wi-Max is developed to cover an entire city.

First generation (1G) mobile systems, introduced in early 1980's, initiated commercial mobile voice services. 1G mobile systems offered voice and low speed data transmission and were operated in circuit switched mode. The key technology used in 1G-network system was Frequency Division Multiple Access (FDMA) scheme and operated in the 450 and 800MHz frequency bands.

The major problems of 1G mobile system were internetworking between different networks and the quality was far from the standard offered by wire line telephony. These shortcomings were overcome with the advent of the Second Generation (2G) mobile systems. By using digital technology instead of analogy one, 2G systems such as Global System for Mobile Communications (GSM) increased the number of supported users within a cell and enhanced voice quality significantly. [1][9]

2G's success story prompted the development of 2.5G and 3G mobile systems. 3G technology supports 144 Kbps data rate, with high-speed movement (vehicles), 384 Kbps (on campus) and 2 Mbps for stationary (in building). [2]Even before 3G networks fully launched and utilized, various study groups were

3G is based on a wide-area concept applying circuit and packet switching for transmission with limited access technology, such as WCDMA, CDMA and TD-SOMA. However, the 4G standard will be based on broadband IP-based, entirely applying packet switching method of transmission with seamlessly access convergence. 4G mobile systems will include all systems from various networks. [2]

II. STANDARDS OF 3G AND 4G NETWORKS

Universal Mobile Telecommunication System i.e. UMTS is the standard of 3G networks and Mobile WiMAX is of 4G networks.

A. Universal Mobile Telecommunications System (UMTS)

3G (Third Generation) - Refers to the third generation of wireless networks, which enable broadband, packet-based transmission at rates up to and possibly higher than 2 megabits per second (Mbps). 3G networks provide a high-speed connection between a wireless device such as a CDMA handset and the Internet, offering the carrier of a wireless device a broad suite of wireless data, voice, video, and multimedia services.

The word wide revolution in mobile is changing our lives in term of the way we work, learn and interact. In the past few decades, mobile wireless technologies have experience 4 or 5 generations of technology revolution and evolution, namely from 0G to 4G.Current research in mobile wireless technology [1] concentrates on advance implementation of 4G technology and 5G technology.

Universal Mobile Telecommunications System (UMTS) is one of the 3G mobile telecommunications standards. The first deployment of the UMTS is the release99 (R99) architecture. It is specified by 3GPP and is part of the global ITU IMT-2000 standard. The most common form of UMTS uses W-CDMA (IMT Direct Spread) as the underlying air interface but the system also covers TD-CDMA and TD-SCDMA (both IMT CDMA TDD). Being a complete network system, UMTS also covers the radio access network (UMTS Terrestrial Radio Access Network, or UTRAN) and the core network (Mobile Application Part, or MAP), as well as authentication of users via USIM cards (Subscriber Identity Module). [3][4]

Unlike EDGE (IMT Single-Carrier, based on GSM) and CDMA2000 (IMT Multi-Carrier), UMTS requires new base stations and new frequency allocations. However, it is closely related to GSM/EDGE as it borrows and built upon concepts from GSM. Further, most UMTS handsets also support GSM, allowing seamless dual-mode operation. Therefore, UMTS is sometimes marketed as 3GSM, emphasizing the close relationship with GSM and differentiating it from competing technologies. The name UMTS, introduced by ETSI, is usually used in Europe. Outside of Europe, the system is also known by other names such as FOMA or W-CDMA. In marketing, it is often just referred as 3G. UMTS, using 3GPP, supports maximum theoretical data transfer rate of 42 Mbit/s, although at the moment users in deployed networks can expect a transfer rate of up to 384 kbit/s for R99 handsets, and 7.2 Mbit/s for HSDPA handsets in the downlink connection.[5] UMTS networks in many countries have been or are in the process of being upgraded with High Speed Downlink Packet Access (HSDPA), sometimes known as 3.5G. Currently, HSDPA enables downlink transfer speeds of upto 21 Mbit/s. Work is also progressing on improving the uplink transfer speed with the High-Speed Uplink Packet Access (HSUPA). The 3GPP Long Term Evolution project plans to move UMTS to 4G having speed of 100 Mbit/s down and 50 Mbit/s up, using a next generation air interface technology based upon Orthogonal frequency-division multiplexing. It is possible to negotiate and renegotiate the characteristics of a bearer service at session or connection establishment and during ongoing session or connection. Both connections oriented and connectionless services are offered for Point-to-Point and Point-to-Multipoint communication. Bearer services have different QoS parameters for maximum transfer delay, delay variation and bit error rate. Offered data rate targets are:

- 144 kbit/s satellite and rural outdoors
- 384 kbit/s urban outdoors
- 2048 kbit/s indoor and low range outdoor

B. Mobile WiMAX or 4G

Nowadays the use of 4G mobile communication systems seem to be the standard, while 5G stands for the next generation of wireless and mobile communications. This is the comparative study between 3G & 4G tells about the background and the vision for the 4G. We first present a review on the development history, characteristics, status of mobile communication and related 3G - 4G perspectives. An overall 4G framework features, having the basic keys (diversity and adaptability) of the three targets (terminals, networks, and applications). We present it in both external and internal diversity of each target to illustrate the causes and solutions of the adaptability feature. Then, the 4G domain of each feature in the framework is discussed from technical issues.

Mobile WiMAX was successfully adopted by ITU as one of the IMT-2000 technologies in November 2007. The main idea of Mobile WiMAX is broadband wireless communication and mobility. Mobile WiMAX offers high speed Internet service which provides various information and multimedia data with high data rate on broadband regardless of place and time. Despite the fact that the services are based on multimedia data transmission, it is difficult to transmit a large amount of data to each group of user in wireless environment because of limited bandwidth. To avoid this restriction, multicast and broadcast services (MBS) were initiated in Mobile WiMAX. The MBS concept is defined in IEEE802.16e standard [I] which supports mobility. Since then mobile WiMAX (a.k.a. IP-OFDMA) has officially become a major global cellular wireless standard along with 3GPP UMTS/HSPA and 3GPP2 CDMA/ EVDO. Mobile WiMAX is an OFDM-based technology available for deployment today, and new WIMAX devices come to market at much reduced cost than that of current 3G solutions. Currently over 260 service providers are deploying fixed, portable and mobile WiMAX networks in 110 countries. [6]

The Mobile WiMAX Release 1.0 System Profile, based on 802.16e or 802.16-2005, was completed in late 2006, and the radio-level certification of products began in 2007. Since early 2007, the WiMAX Forum and the IEEE 802.16 Working Group have started separate evolution projects to improve the performance of the current release of mobile WiMAX and keep the momentum of evolving mobile WiMAX as a leading mobile broadband wireless communication solution.
The target for 802.16m is to meet the requirements of IMT Advanced, the fourth generation (4G) successor of IMT-2000. In other words, 802.16m will be the 4G mobile WiMAX evolution. [7]

III. RESULT AND ANALYSIS

Fourth Generation (4G) and Third Generation (3G) are the next generation of wireless networks. We will describe the performance of Quality of service with the help of network simulator QUALNET. Qualnet is the most applicable network simulator; One of advantages of Qualnet is that it is more scalable. During the simulation time, it enables the user see all the signals being transmitted and received at each node, which assists in the understanding of what is happening in a freshly manner. Qualnet simulator used two main programs such as the analyzer and packet tracer.
When simulator runs the given simulation, analyzer displays the simulation results and packet tracer aids to realize the path of a packet through the network.[8] Qualnet allows investigation and evaluation of fixed and mobile WiMAX devices, applications and networks. WiMAX channel model of Qualnet includes co-channel interference, urban path loss, fading, and shadowing and mobility effects. Through detailed models, unrivaled speed and scalability, Qualnet [9] provides an environment for controlled and repeatable experimentation that leads to improved network performance and a better end-user experience.
These services are intended to provide data at high speed, high capacity. The analysis has been done by several simulation experiments that describe the performance of the system. With the help of some parameters and simulation experiments we can analyze the performance of both the networks 4G and 3G networks on their standards. In the simulation experiments we will change the number of nodes and mobility between them. Also we will use a client\server application CBR to send packets to a particular destination.
Then we will analyze the impact of changing nodes and mobility on the both services with the help of some metrics like packet delivery ratio, throughput etc. obtained from .stat file of QUALNET. We can also check out the performance. The simulation parameters used in experiments are listed below in table.

TABLE I: SIMULATION PARAMETERS

Parameters	**Values UMTS or 3G**	**Values MOBILE WiMAX or 4G**
Frequency	3.1 GHz	4.4 GHz
Channel Bandwidth	10 MHz	10MHz
Simulation Area	1500×1500	1500×1500
Simulation Time	20M	20M
Number of Nodes	0-25	0-25
Packet Size	2048	2048
Traffic Type	CBR	CBR
Mac Protocol	802.11	802.11
Routing Protocol	AODV	AODV
IP Version	IPv6	IPv6
Mobility Speed	0-50(m/s)	0-50(m/s)

i. Packet Delivery Ratio

It is the ratio between the number of packets that are received and the number of packets sent. This metric only considers backward path traffic i.e. the data packets from the gateways to the mesh nodes. PDR is most important metric that we should consider in packet forwarding. We can say that this is the best parameter to evaluate the performance of a network. It may be affected by different criteria such as packet size, group size, action range and

mobility of nodes. PDR performance with respect to mobility is plotted in figure below. From the results, we can see that the packet delivery ratio is almost same in scenarios in case of UMTS and MOBILE WiMAX. MOBILE WiMAX i.e. 4G receives more packets. The formula to find out PDR is

PDR = Total Number of Packets Received/ Total Number of Packets Sent×100

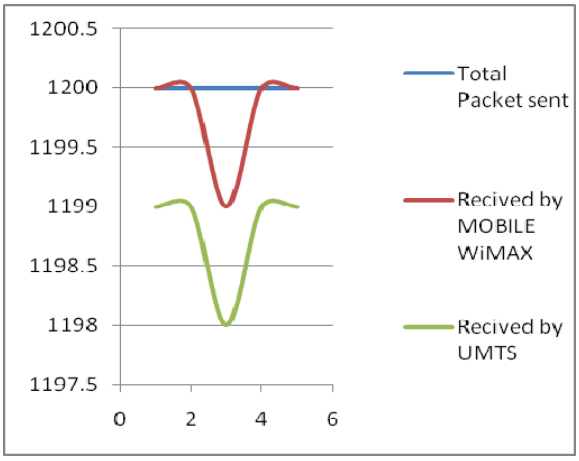

Fig.1 Packet Delivery Ratio

ii. Average End to End Delay

The delay is the total latency experienced by a packet to traverse the network from the source to the destination. At the network layer the end-to-end packet latency is the sum of processing delay, packetization, transmission delay, queuing delay, and propagation delay. The end-to-end delay of a path is the summation of the node delay at each node plus the link delay at each link on the path. . In wireless link, the propagation delays are very small and almost equal for each hop on the path. The queuing delay and MAC delay are considered as two main factors that accumulated the node's delay. As mobility increases links break frequently. Figure below shows end-to-end delay for the UMTS at different node mobility. In case of MOBILE WiMAX the delay is negligible.

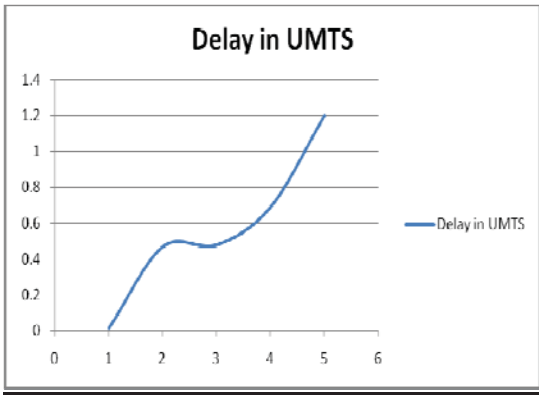

Fig.2 End to End Delay

iii. *Collisions*:When two or more nodes want to transmit data packets without sensing or listening to the transmission channel and if there is already congestion on the channel then a collision state occurs. In collision either the contents of the data packets are modified or the contents are completely lost and the data packet is of no use for the destination. So the source has to transmit those data packets again to the destination. So this metric is used to measure that how many collisions occurs during the transmission.

iv. *Collision Ratio* - In networks packet collision occurs when two or more packets from different source nodes arrive at the same destination node simultaneously. The simulation measures the number of total packets (total_pkt) arriving at a specific node and calculates how many packets encounter collision (collided_pkt); the packet collision ratio is the ratio of collided_pkt to total_pkt. The metric packet loss rate measures the

percentage of packets discarded at an end node, due to either collision or corruption. It is defined as the ratio of (collided_pkt + corrupted_pkt) to total_pkt. The collision ratio is more in case of UMTS.

v. Throughput

It defines the total number of sent bits in per second. The matrix explain the quality of technology which is best or not because best throughput lead to best performance. It may be input throughput or output throughput but output throughput is measured to calculate the performance. As we can see that in high mobility MOBILE WiMAX has the same throughput while UMTS throughput is falling in high mobility.

Throughput = Total No. of Bits Received/ Total No. of Bits Send×100

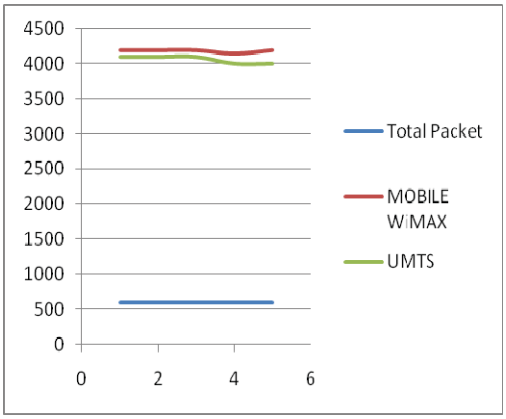

Fig.3 Throughput

IV. DISCUSSION AND CONCLUSIONS

From the results it is apparent that MOBILE WiMAX i.e. standard of 4G networks can provide an optimal solution of mobile broadband for users in high mobility rather than UMTS, standard of 3G networks. It means that user can access the data with the same speed as that of broadband service. 4G's performance is supposed to be four to ten times of 3G. In case of some ideal scenarios in Qualnet5.0 on 4G's most popular standard Mobile WiMax. We are sending fewer numbers of packets and mobility is also not too much. Yet, UMTS networks i.e. supposed to give a speed of 2Mbps in full mobility having much delay, less throughput, more collisions than MOBILE WiMAX. From the performance analysis of the Quality of Services parameters of 3G and 4G networks, we can say that 4G networks will provide better services than that of 3G. According to results the more end to end delay and collision in 3G shows that 4G provides optimal data transfer. Also speed of uplink and downlink is more in 4G than that of 3G, which makes 4G networks better than 3G networks.

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