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Video steaming Throughput Performance Analysis over LTE

[1]Mohamed Hassan Babiker, [2]Hala Eldaw Idris
Neelain University, Faculty of Engineering

Abstract: *Mobile data usage has been on the rise in relation to the streaming media such as video conferencing and on-line multimedia gaming. As a result, Long Term Evolution (LTE) has earned a rapid rise in popularity during the past few years. The aim of this paper thesis is to analyze the video is streamed throughput over LTE. Using OPNET (Optimized Network Engineering Tool), the performance can be simulated having Downlink (DL) and Uplink (UL) scenarios for video conferencing including web traffic. Further we also measured the performance of packet End-to-End (E2E) delay.*
Keywords: *LTE, Real time application, Video.*

I. Introduction

Wireless communication has been seeing a rapid technological development within the last 20 years. A subscriber was only able to make a voice call or send an SMS in second generation mobile technology (2G). With the latest cellular technology like long term evolution (LTE), other than voice calling or short messaging service (SMS), a variety of other activities like accessing high speed internet, on line gaming, video calling, and video conferencing are possible. Continuous demand to perform personal as well as business activities while on the go fundamentally fuels the popularity of today's mobile communication. Data traffic in mobile communication has grown tremendously in recent years. This is achieved due to the developments of latest mobile terminals which support internet based applications, deep penetration of mobile internet across the globe, and high speed internet access over wireless. A significant portion of this data traffic comes from the video services. According to the Ericson mobility report, (90%) of total network traffic will originate from video services by the year 2018 [2].

The growing popularity of video services over cellular network is fuelled by the latest smart phones and tablets, which are able to provide better display, better sound quality, large screen size, and easy to use application on touch. Moreover, developers are also creating applications which mostly use video services like video telephony, conferencing, and on line video streaming. To summarize, growth in data traffic fuelled by video services, faster wireless networks, and powerful user friendly devices have created a burgeoning market for video services and Telecom service providers are putting their best effort to capitalize this opportunity. This is why it becomes so important to understand the implication of video services on cellular network [7]. Long Term Evolution (LTE) is a field of interest throughout the world due to the demand of using data in mobile device in terms of streaming of media, for instance, internet TV, video conferencing, single or multi player on-line gaming as well as communicating through mobile video boggling. Long Term Evolution (LTE) is promising radio access network technology standardized in Third Generation Partnership Project (3GPP) in release 8. It is a system towards the 4G technology promising to be increased in data rates and more improved performance. Wireless networks are heading to their third phase. Where the first phase was concerned about voice traffic for voice calling, the second phase emphasized on data traffic. Now it is the period of video traffic in the third phase. As it will be more complex to manage, more efficient way of optimization is required to preclude saturation. Moreover, with the evolution of new technological devices like I Phone, there are plenty of powerful mobile devices. Those are capable to display high quality video contents. It is a pretty challenging task to do video communication through mobile broadband because of bandwidth limitation and demand of maintaining high reliability and quality. Furthermore, it is mandatory to guarantee Quality of Service (QoS) [1].

II. LTE Background:

The next evolution of the Radio Access Network (RAN) is Long Term Evolution (LTE). This is also known as Evolved Universal Terrestrial Radio Access Network (E-UTRAN). 3GPP LTE targets to support increase data rates and high efficiency, increased signal range with better user response time, interoperability with circuit switched legacy networks compared to systems of today [12]. LTE supports a wide range of bandwidth such as 1.4MHz, 3.0MHz, 5MHz, 10MHz, 15MHz and 20MHz bandwidths. LTE uses Orthogonal Frequency Multiple Access (OFDMA) for downlink and uplink Single Carrier Frequency Division Multiple Access (SC-FDMA). LTE is specified to provide downlink peak rates over 150Mbps, RAN round trip time less than 30ms and three times higher spectral efficiency than High Speed Packet Access (HSPA) in 3GPP Release [9].

2.1 LTE Architecture:

Long Term Evolution (LTE) grants solitary packet switched services as it has designed for seamless and trouble free Internet Protocol (IP) connectivity among user equipment (UE) and the packet data network (PDN). LTE includes the Universal Mobile Telecommunications Systems (UMTS) radio admission through the Evolved UTRAN (E-UTRAN). Whereas system Architecture Evolution (SAE) is evolution of the non-radio aspects, which encompasses the Evolved Packet Core (EPC) network and accompanied by the E-UTRAN. Hence, LTE and SAE embrace the Evolved Packet Systems (EPS). EPS offers IP connectivity among UE and PDN for accessing the Internet and other running services [4].

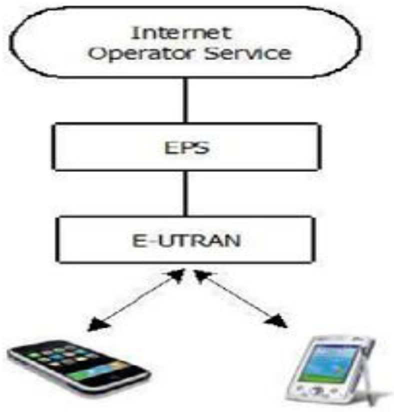

Figure1 EPS (LTE/SAE) Architecture

The EPS architecture comprised of the CN (EPC) and an E-UTRAN radio access network. Whereas, Core Network (CN) provides access to external packet IP networks and ensures privacy, security, QoS, mobility and terminal context management. Following Figure (2) demonstrates the network elements and the standardized interface comprising the overall network architecture [12].

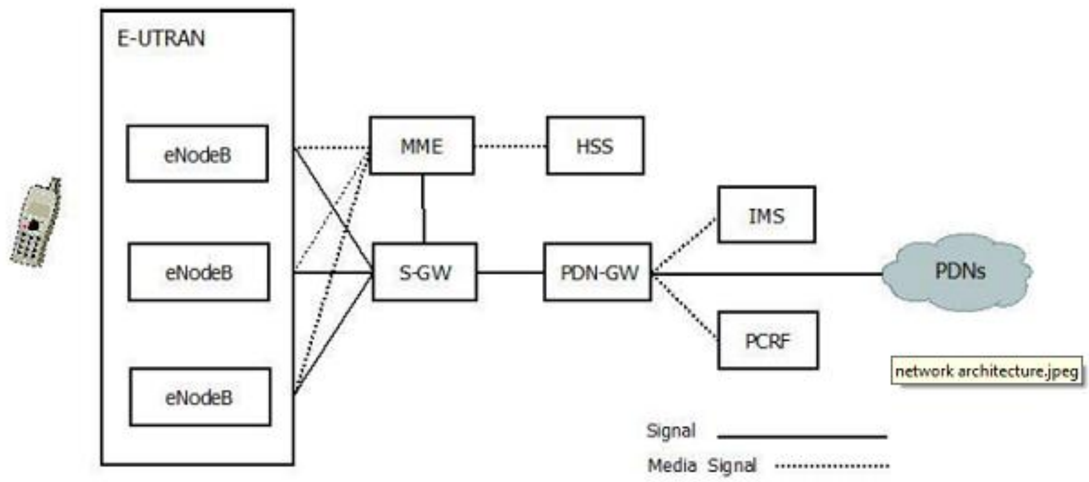

Figure 2 Network Architecture.

2.2 Core Network:

The core network is also known as EPC in SAE, where it establishes the bearers for the overall control of the UE. There are three core logical nodes in EPC.

- PDN Gateway (P-GW).
- Serving Gateway (S-GW).
- Mobility Management Entity (MME), Besides, EPS comprises with other logical nodes and functions, such as, Home Subscriber Server (HSS) and Policy Control and charging Rules Function (PCRF).

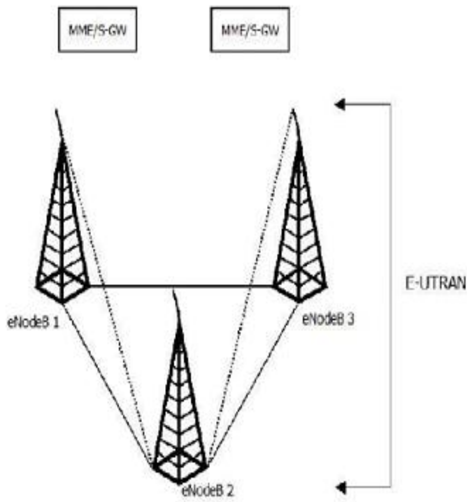

Figure 3 E-UTRAN Architecture.

2.3 Physical Layer Frame Structure:

Transmission signals are divided in to frames and each of the frames includes 10 sub frames. Each sub frame formed by two slots and time duration 0.5ms that can allocate both uplink and downlink transmission. Each slot contains 7 SC-FDMA symbols. Here, the general frame structure of the physical layer is shown [7].

Uplink Frame Structure:

This frame structure is similar as downlink frame, sub-frames duration and slot. The uplink frame contains 20 slots and each sub-frame contains 2 slots. Time duration of each slot is 0.5ms.

Resource Block:

In LTE, a resource element is the smallest time frequency component for downlink transmission, which is assigned by the base station scheduler. In this Figure (4), data assigned to each UE in part of RB.

The physical resource blocks are using standard CP (Cyclic Prefix). In one slot RB (Resource Block) length 12 contagious sub-carriers with 15 KHz sub-carrier spacing. Over a slot, time duration is 0.5 ms for 7 consecutive symbols and CP is added for each symbol as a protector interval. Therefore, in one slot RB consist of 84 (12 sub-carriers x 7 symbols) resource elements in the time domain and resource of 180 KHz (12 sub-carrier x 15KHz) in the frequency domain. All bandwidths are same for each RB size. As a result, the physical resource block depends on the transmission bandwidth [11].

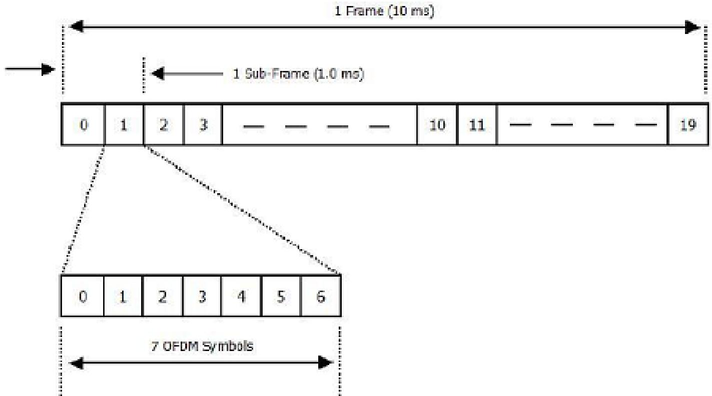

Figure 4 Frame Structure

2.3.1 OFDMA Downlink Transmission:

The growing demand for prime transmission and high data broadcast rates in the wireless communication system over a channel; the OFDMA (Orthogonal Frequency Division Multiple Access) downlink transmission system is the best option for multiple access technique for accessing mobile broadband wireless 3G and 4G system. OFDMA has recommended multi carrier resolution of wireless transmission. It is a multiple access scheme based on OFDM (Orthogonal Frequency Division Multiplexing) which provides high data flow each part adjusted with the separate sub-carriers. Benefit of OFDM is that maintaining physical layer of present and future high speed data transmission within the wireless communication like WMAN (Wireless Metropolitan Area Networks) and MBWA (Mobile Broadband Wireless Access) standards. In single user OFDM system, when CSI (Channel State Information) is accessible to the transmitter. It transmits power that every sub-carrier can be modified consistently with the CSI which increases high data rate. The single user OFDM, the data rate, is customized in the frequency time domain by sup-porting the necessity of common transition power [7].

In multi user OFDM, provides better flexible and improved data communication system that the analyzers focused their research to hold out the goal of improving the flexible data communication techniques. These techniques are higher than different TDMA and FDMA which may operate secure and prearranged sub-carrier and time slot allocation schemes. Though OFDMA based on OFDM techniques, the immunity of OFDM symbols that collected information of multi users division in wireless system. The BS (Base Station) is responsible for this and manages how the existing sub-carriers are going to be circulated between different users. In this Figure (5), OFDMA transmission is shown [5].

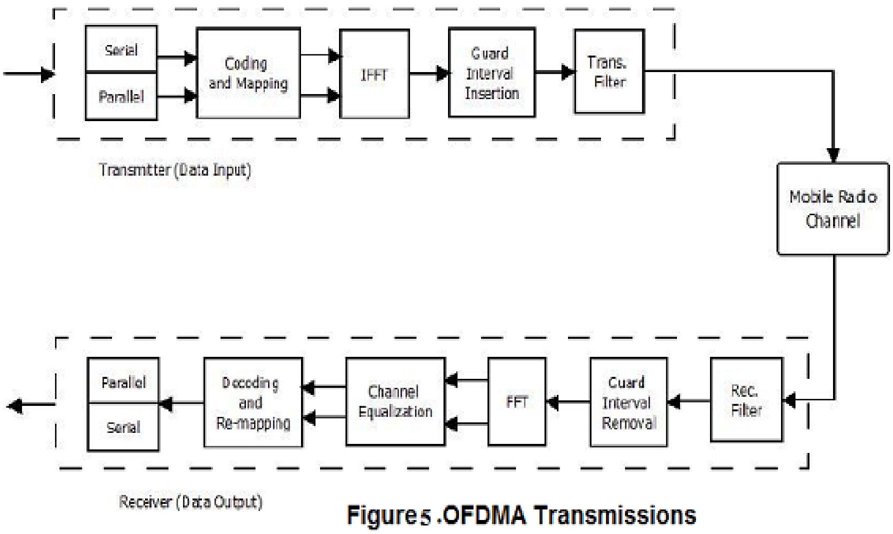

Figure 5 .OFDMA Transmissions

2.3.1 SC-FDMA Uplink Transmission:

Single Carrier Frequency Division Multiple Access (SC-FDMA) is a new developed technology for high data rate uplink transmission rate that accepted by 3GPP (3rd Generation Partnership Project) for present and next generation cellular system which is referred as LTE (Long Term Evolution). It is the most powerful technique used uplink over wireless broadband communication in LTE. So, it can support 1.25-20 MHz bandwidth and up to 20 Mbps transmission rate. SC-FDMA is adapted by the OFDM that in the result same of throughput activity and complexity. The most benefits of SC-FDMA are low PAPR (Peak- to-Average Power Ratio) than the OFDMA which is lower power consumption for uplink channel that creates longer battery lifetime of mobile stations and production cost. In this Figure (6) SC-FDMA transmissions had shown [3].

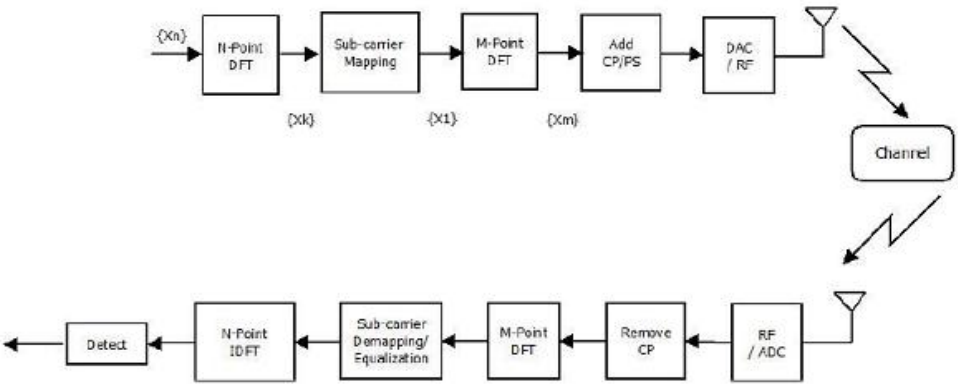

Figure 6. SC-FDMA Transmissions.

2.5 Quality of Service (QoS) in LTE:

In a 4G network, subscriber traffic is classified based on the QoS Class Identifier (QCI), which is associated with priority, specify delay, and packet loss values, and determines the user plane treatment for IP packets transported on a bearer. The QCI determines which bearers are categorized as GBR (dedicated) and which are categorized as non-GBR (default). The broadband gateway supports only default bearers, which correspond to QCI values 5 through 9. QCI values 1 through 4 correspond to dedicated bearers, which the broadband gateway does not support [10].

QCI	Bearer Type	Priority	Packet Delay	Packet Loss	Example
1	GBR	2	100 ms	10	VOIP Call
2		4	150 ms	10	Video Call
3		3	50 ms		Online Gaming (Real Time)
4		5	300 ms	10	Video Streaming
5	Non-GBR	1	100 ms		IMS Signaling
6		6	300 ms		Video, TCP based services e.g. email, chat, ftp etc.
7		7	100 ms	10	Voice, Video, Interactive gaming
8		8	300 ms	10	Video, TCP based services e.g. email, chat, ftp etc.
9		9			

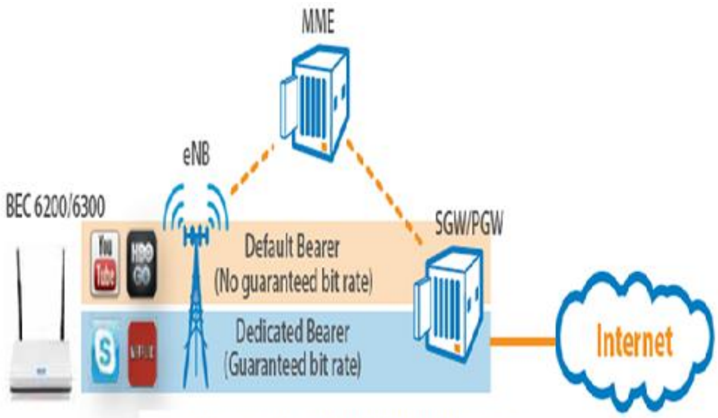

Figure 7 . 4G QoS Dedicated Bearer

III. 3 Overview of video streaming and communication application:

There exist a very diverse range of different video communication and streaming applications, which have very different operating conditions or properties. For example, video communication application may be for point to point communication or for multicast or broadcast communication, and video may be pre-encoded (stored) or may be encoded in real-time (e.g. interactive videophone or video conferencing). The video channels for communication may also be static or dynamic, packet-switched or circuit switched, may support a constant or variable bit rate transmission, and may support some form of Quality of Service (QoS) or may only provide best effort support. The specific properties of a video communication application strongly influence the design of the system. Therefore, we continue by briefly discussing some of these properties and their effects on video communication system design [6].

1. Point to point, multicast, and broadcast communications.
2. Real-time encoding versus pre-encoded (stored) video.
3. Interactive versus Non-interactive Applications.
4. Static versus Dynamic Channels.
5. Constant-bit-rate (CBR) or Variable-bit-rate (VBR) Channel.
6. Packet-Switched or Circuit-Switched Network.
7. Video compression.

Tabel 1. Video Compression Standards.

Video Coding Standard	Primary Intended Applications	Bit Rate
H.261	Video telephony and teleconferencing over ISDN	p x 64 kb/s
MPEG-1	Video on digital storage media (CD-ROM)	1.5 Mb/s
MPEG-2	Digital Television	2-20 Mb/s
H.263	Video telephony over PSTN	33.6 kb/s and up
MPEG-4	Object-based coding, synthetic content, interactivity, video streaming	Variable
H.264/MPEG-4 Part 10 (AVC)	Improved video compression	10's to 100's of kb/s

3.1 Video Models:

They are two types of video streaming **Real time (RT) Streaming** and **HTTP Streaming [6].**

3.2 Basic Problems in Video Streaming:

There are a number of basic problems that afflict video streaming. We focus on the case of video streaming over the LTE since it is an important, concrete example that helps to illustrate these problems. Video streaming over the LTE is difficult because the LTE only offers best effort service [6].That is it provides no guarantees on bandwidth, delay jitter, or loss rate. Specifically, these characteristics are unknown and dynamic. Therefore, a key goal of video streaming is to design a system to reliably deliver high quality video over the Internet when dealing with unknown and dynamic:

- Bandwidth.
- Delay jitter.
- Loss rate.

IV. Simulation Scenarios and Discussion:

4.1 Methodology:

This thesis work analyzes performance of QoS metrics i.e. packet delay variation, packet loss and end-to-end delay for video conferencing in LTE networks under different network scenarios. Using OPNET modeler 16.0, we validate network models and analyze the results while video conferencing is going on with real time applications under two different network scenarios.

The aims of this paper are to analyze the performance of delivering video conferencing traffic over LTE. The Network performance measuring tool OPNET (Optimized Network Evaluation Tool) modeler 16.0 is used to develop simulation scenario of Downlink (DL) and Uplink (UL) for video conferencing. Survey of existing literature and network design over LTE. Creation of the simulation model for Video conferencing using OPNET. Investigating network simulation and analyzing the simulation results.

4.2 Simulation Scenarios:

OPNET Modeler 16.0 has been used for the simulation analysis. Video Conferencing Application at varying speeds as a High Load Network.

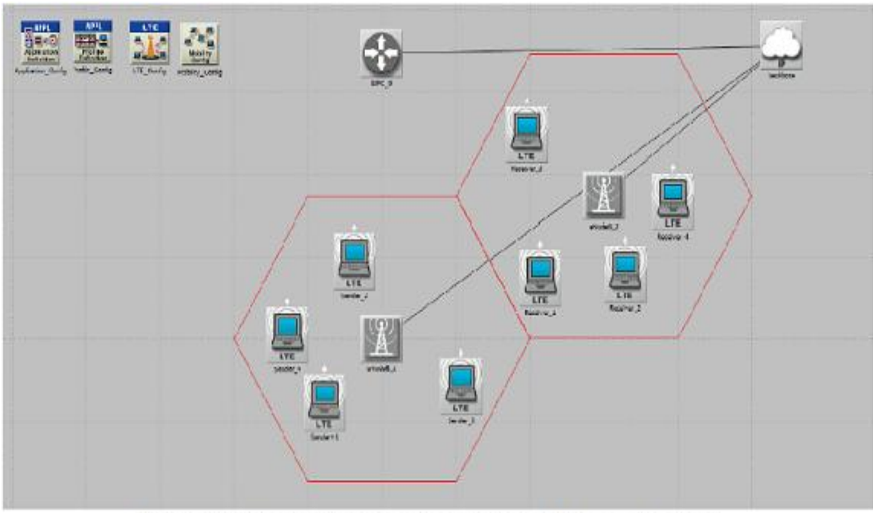

Figure 8.Video Conferencing Application under varying speed

In this scenario, the aim is to investigate the throughput performance of Video Conferencing at varying speed. The Application Definition Attribute is set as Video Conferencing with 30 Frame/sec and traffic mix as (50 Percentage). The speed of the UEs were set to zero in case one while the in case two, the speeds were set to 30 m/s respectively. The simulation was allowed to run for 400 sec and the performance analysis based on the packet end-to-end performance and packet delay variation, were collected.

4.3 Packet Delay Variation Results under Varying Speed of Video Conferencing Users:

Packet Delay Variation (PDV) or jitter is the difference in the E2E one-way delay of some selected packets with any lost packets ignored in the network. We simulated our Video Conferencing application in order to measure the PDV experienced by users as a results of mobility of the users. We obtained the results of PDV tabulated in Table 2 below and plotted the variation in the performance of some selected video conferencing users as simulated in our different mobility cases.

Table2: Packet Delay Variation (millisecond) of Video Conferencing Users at Varying Nodes speed

Selected Nodes	Static	30 m/s
Sender 1	1.90	0.012
Receiver 1	0.69	0.020
Sender 3	2.3	0.030
Receiver 3	1.0	0.015

From the graph in Figure (9), we observed that the Video Conferencing Users at static mobility case experienced more PDV than those in motion. The reason for these results could be attributed to high traffic accumulation in the case of static nodes while little or less traffic are allowed to transverse from sender nodes to destination nodes in the cases of mobile nodes in motion.

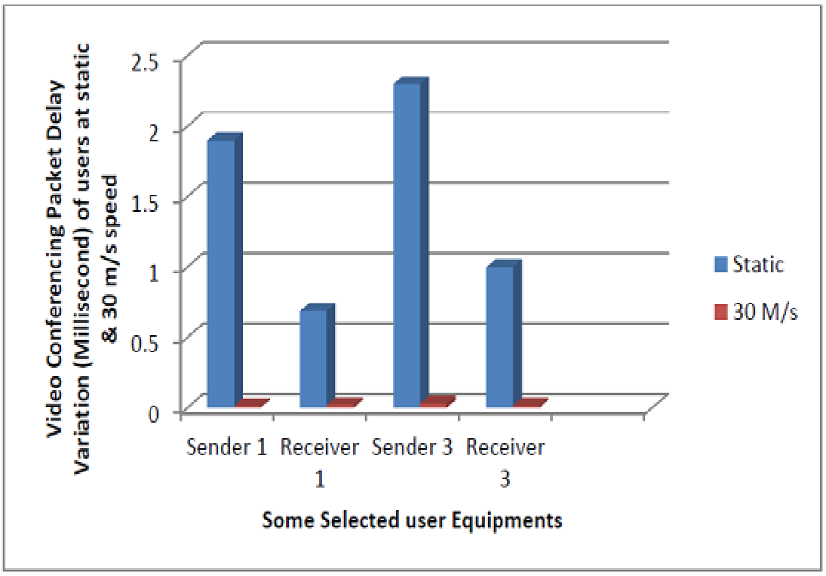

Figure 9Graph of PDV of Video Conferencing Users at Varying Nodes speeds

4.3 Packet E2E Delay Variation Results under Varying Speed of Video Conferencing Users:

End-to-end packet delay which is the time needed for a UE (Sender) to send packet to another UE (Destination). As earlier explained, it comprises of the Sender delay, Receiver delay and the Network delay. The Packet E2E delay of Static Nodes and that of nodes moving at 30 m/s for some selected nodes are tabulated in the Table 3.

Table 3 : E2E delay performance of Video Conferencing at Varying speed (Millisecond).

Selected Nodes	Static	30 m/s
Sender One	40	20.1
Receiver One	42	22.3
Sender Three	56	21.9
Receiver Three	38	21.2

The result of the E2E delay performance of Video Conferencing at static and 30 m/s speeds are plotted in the graph in Figure (10) below. From the result, we observed the E2E performance of nodes running at 30 m/s to be better than those nodes at static mode owing to the reason earlier stated that static nodes try to accept as much as possible GBR bearers which result to much delay whereas mobile nodes rather drop the packets and admit less GBR bearers and hence less E2E delays.

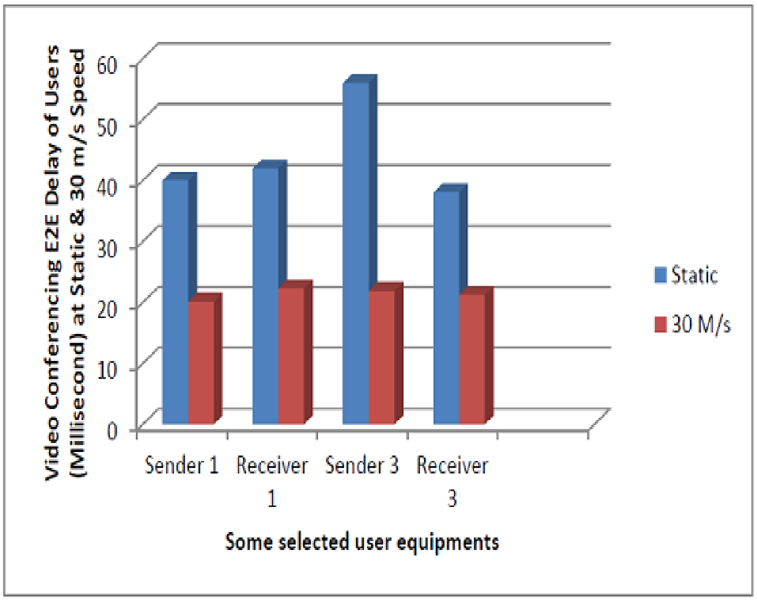

Figure10: Graph of PDV of Video Conferencing Users at Varying

V. Conclusion

In this paper we have investigated the effect of throughput analyses performance for video conferencing in the LTE network with E2E delay. LTE, a new standard for wireless communication, has so many promises in terms of speed and performance metric of multimedia applications users. We set up two different scenarios using OPNET 16 network simulator to investigate the throughput performances of video steaming based on the effect of mobility of end users on their QoS. We set the load on Video Conferencing to a fixed value in this paper. For further research studies, we recommend that the load could be varied study, how varying load responds to speeds in LTE.

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