QOS PERFORMANCE ANALYSIS FOR NON-REAL-TIME TRAFFIC IN LTE - 4G MOBILE NETWORK

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Abstract—In This work, QoS performance Analysis for non-real-time traffic such as Hypertext Transfer Protocol (HTTP), File Transfer Protocol (FTP) and Electronic Mail (E-Mail) over LTE -4G network studded. The framework of the study focused particularly on two areas, firstly, focused on the non-real time traffic major QoS parameters, such as FTP transfer average time, HTTP paging response average time and E-Mail uploading response average time for FTP, HTTP traffic applications respectively. The second area focused on the impact of presence the VoLTE traffic on these parameters in two cases, case 1, when the VoLTE traffic profile configured with G.711 codec and on the same time activated the Voice Activity Detection (VAD) feature. In case2, the VoLTE profile traffic configured with G.711 codec and deactivated the VAD features. Two scenarios designed and simulated using Optimized Network Engineering Tool (OPNET). The results show that, in the case of non-real time traffic generated and mixed with VoLTE G.711 codec traffic of VAD configuration profile, the average time performance for E-mail Uploading response, FTP transfer and HTTP paging response are better and significantly improved. In contrast, in the case of the VoLTE with codec G711 traffic of non-VAD deactivated profile, the performance of non-real time traffic degraded in term of average time compared to the first case. While the overall LTE network QoS performance still performing in the acceptable level in term of Throughput and end-to-end delay.

Keywords—QoS ,Non-real time;FTP; HTTP,E-Mail.VAD

I. INTRODUCTION

LTE-4G is a fully IP-based network technology [1]. Normally, both Real Time like (VoLTE) and non-real-time like (FTP, HTTP, and E-mail) Packets traffic delivered across LTE network [2]. HTTP is a protocol used by the World Wide Web that allows the transfer of files from a web server to a user's web browser for viewing web pages on the Internet, while the FTP protocol used to transfer files from a computer to and from an FTP server [13]. On the other hand, in real applications and scenarios, and from the practical configuration perspective, the real-time traffic (VoLTE) configured and setup with high priority traffic profile, in contrast, non-real time services always setup with low priority traffic profile. Therefore, within these circumstances, there is a problem facing LTE network operators that the LTE network bandwidth consuming by real-time applications and traffic like VoLTE, especial when the codec G711 with VAD feature activated used in VoLTE profile. In aggressive and peak VoLTE traffic time, the QoS performance for non-real time traffic significantly degraded because of consuming the most bandwidth by VoLTE traffic of G.711 codec with VAD activated feature. Therefore, LTE Operator under challenge of how to improve the QoS performance for non-real-time traffic and on the same time keeping the overall network QoS performance in acceptable level.

The aim of this work is to study and evaluate the major QoS Performance for non-Real-time traffic over LTE-4G Network. In addition, to investigate the impact of VoLTE Traffic with codec G711 profile over these mentioned major QoS parameters.

A. Literature Review

Different contributions and studies already addressed the QoS performance for non-real time traffic. For instance, Pan Wei.et al. [6], studied Performance Analysis of HTTP and FTP Based on OPNET. completes a simulation of HTTP protocol and FTP protocol, By comparing the queuing delay in different scenarios based on HTTP protocol, we find what do the link bandwidth and client node number effect on the performance of HTTP; through comparing the TCP Delay in HTTP protocol and FTP protocol scene, we learned the performance of FTP. Protocol and HTTP protocol on Web application under the same network environment. All the analysis based on simulation.

Ghassan A. Qas Marrogy et al. [7], studied Performance Analysis of Routing Protocols and TCP Variant under HTTP and FTP Traffic. The focus of this Paper is to study the impact scalability, mobility and traffic loads on routing protocols and TCP variants. The paper results show that the proactive protocols OLSR and GRP outperform the reactive protocols AODV and DSR with the same nodes size, nodes speed, and traffic load. On the other hand, the TCP variants research reveal the superiority of the TCP SACK variant over the other two variants in case of adapting to varying network size, while the TCP Reno variant acts more robustly in varying mobility speed and traffic loads. The study addresses the performance of the mobile ad-hoc network, also focused on the TCP protocol. .platform topology based on the computer, so, there is no LTE network implemented to study the TCP Variant under HTTP and FTP Traffic. Almutaz Ali Mohammed et al. [8] studied Performance Analysis of FTP, HTTP and

Database for IEEE802.11, IEEE802.11a, IEEE802.11b and IEEE802.11gusing OPNET. The work address performance analysis of WLAN in a simulated office for different applications (FTP, Database, and HTTP) for various WLAN standards (802.11b, 802.11a, 802.11 g, and 802.11 infrared and 8 02.11 frequency hopping).

The previous above-mentioned studies have some lake of reality, the first work based on the small size of LTE network, and this will not reflect the realities of non-real time traffic. The second work-study queuing delay for the computer network, while there is no simulation in LTE mobile network. While in the third work performed over WAN network rather over LTE network.

The rest of this paper organized as follows. In section II, It thoroughly introduces the LTE technology. Section III give a brief description about OPNET MODELER. In the section, IV describes the method and experiment of the simulation in detail. Section V present experimental results and discussions. Section IV concludes this Paper.

II. LTE TECHNOLOGY

B. LTE Architecture

The network architecture in below figure1 shows the Evolved Packet System (EPS). It has a flat and fully IP-based architecture, it divided into two parts, Evolved Universal Terrestrial Radio Access Network (E-UTRAN) and Evolved Packet Core (EPC), which Comprising of four elements: Charging Rules Function (PCRF), Home Subscriber Server (HSS), Serving Gateway (S-GW), Packet Data Network Gateway (P-GW) and Policy Charging & Role Faction (PCRF) [1].

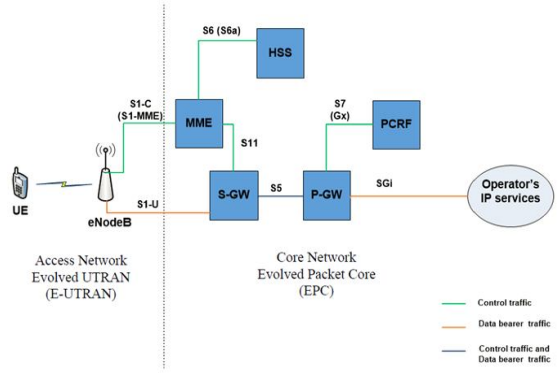


Figure 1. LTE Network Architecture

C. LTE Quality of Services Concept:

The quality of Service (QoS) defined as the broad term used to describe the overall experience a user or application will receive over a network. The standard LTE QoS architecture proposed by the ITU. QoS has many parameters like LTE Bearer, which divided into Default and Dedicated bearers, Granted Bit Rate (GBR), Non-GBR, Maximum Bit Rate GBR (MBRGBR), Maximum Bit Rate (MBR), Allocation and Retention Priority (ARP) used for deciding whether new bearer modification or establishment request should be accepted considering the current resource situation, Traffic Flow Template (TFT). APN Aggregate Maximum Bit Rate (A- AMBR), UE Aggregate Maximum Bit Rate (UE –AMBR), QoS Class of Identifier (QCI): this parameter defines IP level packets characteristics as shown in below QCI & EPS Bearer Definitions [3].

D. Voice Activity Detection Technique

Voice Activity Detection (VAD), also known as speech activity detection or speech detection or silence suppression, is a technique used in speech processing in which the presence or absence of human speech were detected. The main uses of VAD are in speech coding and speech recognition. It can facilitate speech processing, and can also be used to deactivate some processes during the non-speech section of an audio session, it can avoid unnecessary coding/transmission of silence packets in Voice over Internet Protocol applications, saving on computation and on network bandwidth [13].

E. HTTP Protocol

HTTP is an acronym for Hypertext Transfer Protocol. The purpose of HTTP is to serve as a means of accessing the World Wide Web. Web sites accessed using HTTP with the help of browsers. HTTP protocol is in use every time when open a site, check our email or update our blogs. This can easily checked by looking at the address bar and looking at the very first few letters; chances are its HTTP [14].

F. FTP protocol

FTP is an acronym for File Transfer Protocol. Ii is a client-server protocol that relies on two communications channels between client and server: a command channel for controlling the conversation and a data channel for transmitting file content. Clients initiate conversations with servers by requesting to download a file. Using FTP, a client can upload, download, delete, and rename, move and copy files on a server. A user typically needs to log on to the FTP server, although some servers make some or all of their content available without login, also known as anonymous FTP [15].

G. E-Mail

E-Mail Short for electronic mail, email (or e-mail).It is messages distributed by electronic means from one computer user to one or more recipients via a network or transmission of messages over communications networks. Typically, the messages are notes entered from the keyboard or electronic files stored on disk. Most mainframes, minicomputers, and computer networks have an email system [16].

H. Codec Scheming:

There are various codecs specified by the ITU-T. Codecs have different performance and impact on the LTE QoS performance, this impact based on the different degrees of compression. Table 1 represents the specifications of G.711 standard codec [8]. G.711 voice codec used in all simulations in this paper. The

codec has a bit rate of 64 Kbps with 20 milliseconds frame size and one frame per packet. In addition, G.711 codec does not use any compression and provides very good quality level in IP networks [10].

TABLE 1 G.711 CODEC SPECIFICATION

Codec Types	Bit Rate (kbps)	Ethernet Bandwidth (kbps)	Frame Sample
G711	64	95.2	160

III. TRAFFIC APPLICATIONS IN OPNET MODELER

OPNET MODELER offers user-friendly GUI (graphical user interface), which provides convenient operations over different wireless networks to build traffic model, design network, configure scenarios, set parameters of networks and analyze the performance of simulation. It supports VoLTE, E-Mail, FTP and HTTP-based applications and users can establish numerous scenarios containing multiple servers and clients.

IV. METHODS AND EXPERIMENT

I. LTE Network Model

To complete the work, the LTE network model created in the workspace of OPNET tool as shown in below Figure 2, and below components used in the simulation model.

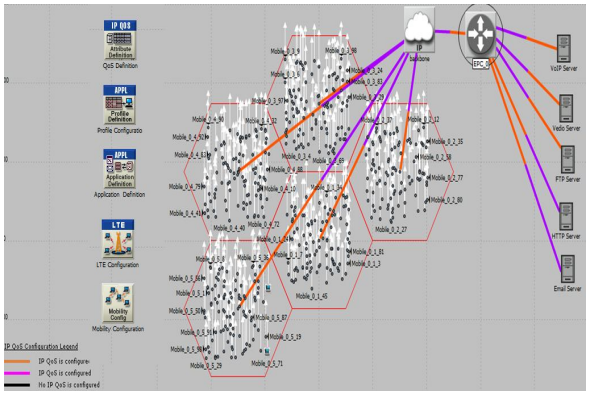


Figure 2. LTE Network Model

- One LTE Packet Core.
- Five eNB, each is located in the cell of diameter of 500 meters.
- The interface between eNB and EPC SONET/OC3 with capacity of 148 Mbps.
- OPNET tool configuration components like Application Configuration, Profile Configuration, LTE Parameters Configuration, Mobility Configuration, and IP QoS Configuration are used.
- Non-real-time applications traffic like HTTP, FTP, and Email are used in heavy traffic model to make the simulation is realistic
- Typical profiles for VoLTE and all background applications services are used.
- To generate the results in OPNET tool, the concept of adding 100 VoLTE users every 5 minutes during simulation execution processing till the number of subscribers is reached up to 500 VoLTE users is used.
- Finally, the major QoS parameters like FTP transfer average time, HTTP paging response average time and E-mail Uploading response average time for FTP, HTTP traffic (TP) used to evaluate the QoS Performance for Non-real time services.

J. Traffic Model Profiles

The below figures 2, 3,4and 5 are shows the traffic Profiles used during simulation processing for both VoLTE and non-real-time traffic (FTP, HTTP and E-Mail) respectively.

TABLE 2.VoLTE TRAFFIC PROFILE

Parameter Name	Value
Voice Symbol	PCM Quality Speech
Encoder Scheme	G.711
Voice Frame per Packet	1
Type of Services	Interactive (6)
VAD or Voice Silence Suppression	Enabled

TABLE 3.FTP TRAFFIC PROFILE

Parameter Name	Value
File size is constant	1000 byte
Inter arrival time	uniform(30-60) sec

TABLE 4.FTP TRAFFIC PROFILE

Parameter Name	Value
Number of pages per session	5

TABLE 5.FTP TRAFFIC PROFILE

Parameter Name	Value
Number of pages per session	5
Average page size,	100 Kbyte
number of Object per page /Object size	1 (frame = 1 Kbyte)/ (100 Kbyte)
Reading time is constant	(12 sec)
One TCP connection per user	yes

K. Assumptions and Scenarios:

The LTE mobile nodes configured to run VoLTE, HTTP, Email and FTP services. The Radio interface between the LTE UE's and eNB configured to be an error-free channel as the primary objective of this analysis is to investigate the impact of traffic congestion on QoS in the core network and IP Backbone. Hence, various physical layer effects like multipath and interference effects not modeled in these simulations.

1. Scenario 1:

The main objective of this scenario is to analyze and compare the QoS performance parameters for the two cases, case1, when LTE users generating only non-real time traffic applications and LTE users generating both non-real time and real time traffic application like. Also in these scenarios, there is no

focusing on others simulation factors impact, rather focusing on the impact of an added VoLTE as real-time traffic applications to mixed with non-real-time applications and analyze the effect on the QoS for the non-real time. Putting into consideration VoLTE traffic requires relatively low bandwidth while the non-real time traffic required very low bandwidth.

Case1: LTE users generating only non-real time traffic applications like (HTTP, FTP, and Email). All Traffic mapped to the same best effort QoS in the IPBB network. 6 profiles will be configured over 200 non-real time service of LTE users out of 500 users, with 40 users in each LTE cell out of the 5 cells, each profile includes more than one profile applications. VoLTE users mapped to none-GBR bearer (low priority).All packets entering the LTE and IPBB network elements served with First in First out Scheduling mechanism (FIFO). Configure the VoLTE traffic with G.711 codec without silence suppression enabled (without Voice Activity Detection VAD).

Case 2: LTE users generating both non-real time and real time traffic application like (VoLTE only) generated in the network. The packets will be traveling across all networks parts (eNB, IPBB, and EPC) without determination for the QoS parameters configuration, i.e. with defaults QoS setting parameters same as in case 1. IPBB and EPC Gateway configured with default queuing mechanism (FIFO Hard Queuing mechanism) in all network parts.

2. Scenario 2:

The main objective of this scenario is to analyze the QoS performance of non-real time service (HTTP, Email, and FTP) in the conditions of increasing the load on the network by giving the VoLTE high priority over non-real time services. The network will be on same conditions, same as in case2 in secnario1, except the only difference in this scenario, the all of VoLTE users configured with the highest priority (QCI=1).The main objective will be obtained by activating Voice Activity Detection. The network will be on same conditions as in scenario 2, except the only difference in this scenario, the VoLTE traffic configured with G.711 codec with silence suppression enabled (with Voice Activity Detection VAD).

V. RESULTS AND DISCUSSION

Based on the methods, experiments, scenarios assumptions in the previous section, the below results are obtained from the simulation.

L. Results and Discussion for Scenario 1:

The below results present the impact of mixed traffic which include real time (VoLTE) and non-real time (HTTP, FTP, and E-mail) traffic. Figure 3 shows the Average HTTP paging response time (sec).

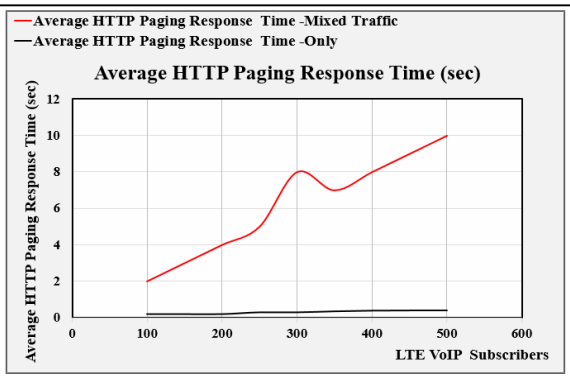


Figure 3. Average http paging response time

In figure 3, it clear that in the case of only Http traffic in the LTE network generated, the average HTTP paging response time approximately saturated around 0.3seconds. In spite of the VoLTE subscribers, increasing from 100 to 500, the reasons behind this, there is a huge bandwidth allocated to serve the HTTP only, while HTTP traffic is not consuming more bandwidth. On the other hand, in the case of mixed traffic (VoLTE and HTTP), the average HTTP Paging response time increases proportionally with the LTE VoLTE subscriber increasing. At value equal 300 VoLTE, the average HTTP paging response time reached the maximum value of 8 seconds. After this value, the more new VoLTE connections establishing between source and destination, the higher would be the HTTP paging response time until 500 VoLTE LTE users. Figure 4. Shows the Average FTP transfer time (sec).

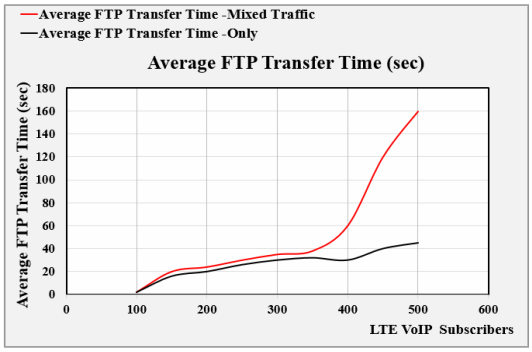


Figure 4. Average FTP Transfer Time

In figure 4, we can see that, in the case of only FTP traffic in the LTE network generated, and with increasing the VoLTE subscribers, the average FTP transfer time smoothly increases and almost steady around 29 seconds at the 300 VoLTE subscribers. The reasons behind this slight increase of transfer time are that FTP traffic is consuming more bandwidth (downloading big file) compare to the HTTP which browsing only. On the other hand, in the case of mixed traffic (VoLTE and FTP), the average FTP transfer time increases proportionally with the LTE VoLTE subscriber increasing. At value equal 300 VoLTE, the average HTTP paging response time reached the same value of unique FTP traffic, after

this point, the average FTP transfer time increased significantly, up to the maximum value of 200 seconds. The justification of this high value of average FTP transfer time, the throughput of overall LTE network is approaching to the high utilization. This due to the G711codec using 64kbps and in total 95.5 kbps (included overhead bits).This evidence, the sharp increase in the value of average FTP transfer time. Figure 5 shows the Average E-Mail uploading response rime (sec)

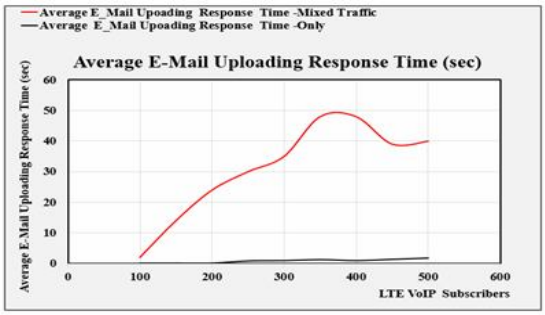


Figure 5. Average e-mail uploading response time

In figure 5, it clear that, in the case of only e-mail traffic generated in the LTE network, the average e-mail uploading response time approximately saturated around 1 seconds. In spite of the VoLTE subscribers, increasing from 100 to 500, the reasons behind this, there is a huge bandwidth allocated to serve the e-mail only compare to the throughput consuming by e-mail. On the other hand, in the case of mixed traffic (VoLTE and e-mail), the average e-mail uploading response time increases proportionally with the LTE VoLTE subscriber increasing. At value equal 350 VoLTE; the average e-mail uploading response time reached the maximum value of 50 seconds, and after that hard decreasing in time response up to the value of 40 seconds at VoLTE subscribers 500.

M. Results and Discussion for Scenario 2:

These scenarios are more realistic and practical compared to the first scenario. This because normally the real time traffic (VoLTE) configured with high priority traffic profiles, due to the sensitivity to the time and maintain the high quality of service.

The below results present the impact of mixed traffic which include real time (VoLTE) and non-real time (HTTP, FTP, and E-mail) traffics.

Figures 6,7and 8 shows the comparison of the impact of VoLTE users on the average E-mail uploading response time, Average FTP Transfer Time and Average HTTP Paging Response Time respectively in two cases, first when the VoLTE traffic configured with G.711 codec with silence suppression enabled (with Voice Activity Detection) and second case without VAD configuration (activation).

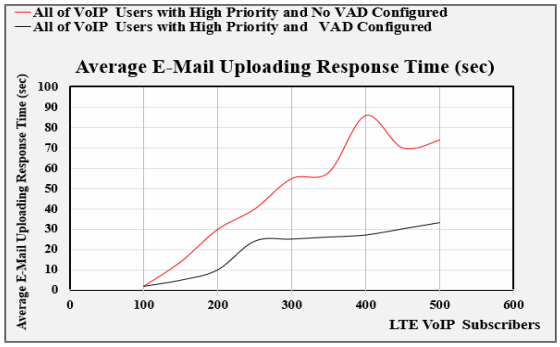


Figure 6 Average e-mail uploading response time

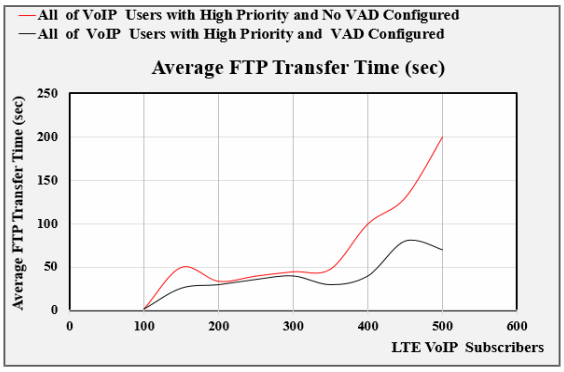


Figure 7. Average FTP Transfer Time.

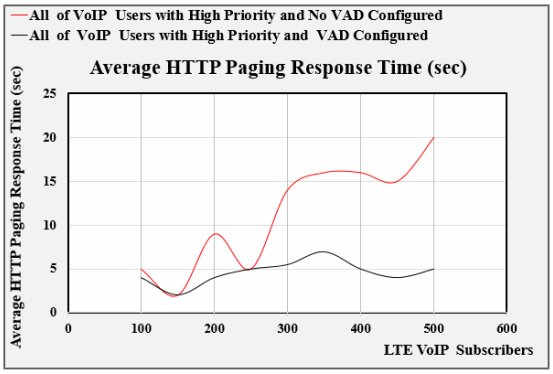


Figure 8. Average http paging response time

In figure 6, we can see that, while VoLTE subscribers number increasing during simulation time, the average e-mail uploading response time in both cases, when VoLTE traffic configured with silence suppression enabled (with Voice Activity Detection VAD) and without VAD configuration in the LTE network, the uploading response time have same value of 1 seconds as minimum value. After at 400 VoLTE subscribers, in the case of VAD configured, the average e-mail uploading response time approximately 27 seconds compared to the case of non-VAD configuration with 86 seconds for uploading response time. Which mean there is improve for average e-mail uploading response time by 68% [100*(86-27)/86].which is the significant improvement in the practical configuration. This due to the VAD technique, that data LTE network carrying voice traffic over the network to detect the absence of audio and conserve bandwidth by

preventing the transmission of "silent packets" over the network, i.e. saving bandwidth in silent duration.

In both figures 7 and 8 respectively, we can see that in the case of VAD configured to compare to the case of none VAD configured, there is the enhancement in QoS for both of average FTP transfer time and average HTTP paging response time of 65% and 75% respectively. This due to the same reason explained in the case of above figure (4.4).

Figures 9 and 10 shows the average end-to-end delay in both cases When configured VAD and when not configured the VAD feature

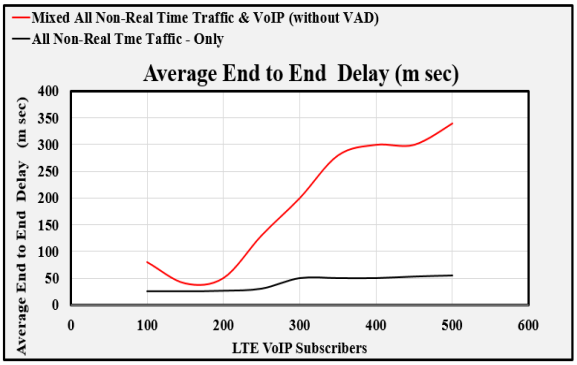


Figure 9. Average end-to-end delay (with VAD)

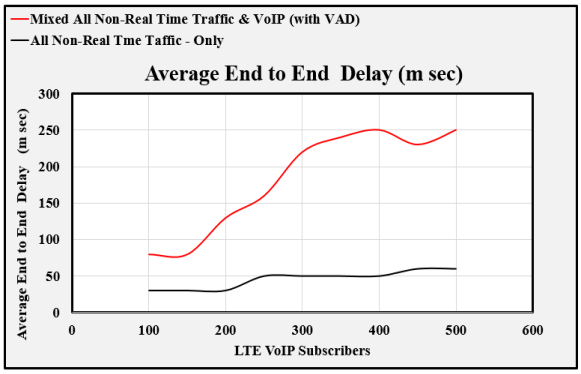


Figure 10. Average end-to-end delay (without VAD)

Figures 9 and 10 respectively , shows the average end-to-end delay in both cases, When configured VAD and when not configured the VAD feature., the overall E2E delay of the LTE Network is very slightly small in value and it increased from 40 m sec in case 1 to 60 m sec when all non-real time traffic only generated. The reason behind this, in this scenario there is no consuming for bandwidth by non-real time traffic compare to the VoLTE traffic, in addition to the huge bandwidth implemented and configured (149 Mbps) between EPC and IPBB which represent the maximum bandwidth that makes why the delay is very small. On the other hand, it clear in the case of the VAD featured configured, the average delay of LTE network starting from 80 m sec when the VoLTE users are 100. Moreover, when the users of VoLTE reached 300 there the significant increase in delay of 240 m sec and the delay in reached the maximum at 500 VoLTE users at the value of delay is approximately 260 m sec.

Figure 11 shows the Average End to End Delay comparison between both cases, when the VAD configured and when the VAD not configured for mixed traffic with nonretail time traffic.

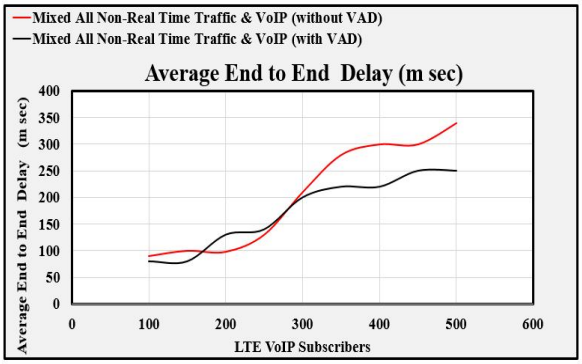


Figure 11.Average end-to-end delay-VAD Impact Comparison

Figure 12 shows the Throughputs comparison between both cases, when the VAD configured and when the VAD not configured for mixed traffic with nonretail time traffic

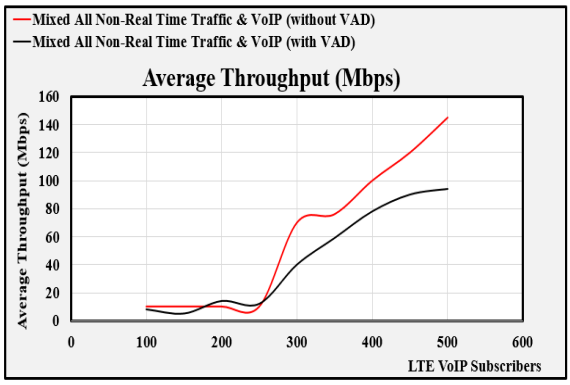


Figure 12.Average throughputs–VAD impact comparison

Similarly, in the case of when there is no VAD feature configured, the delay for mixed traffic is starting at 40 m sec at 100 LTE users, and it reached to the maximum value of 350 m sec. By comparing the cases in Figures 9 and 10, we can see that the delay is relatively high in the maximum in the case of VAD not configured compare to the case of VAD configured. The reason behind this is so logical, that the VAD activation (silence suppression) feature saves bandwidth due to the no transmission in the silent duration of voice period. Alternatively, from the definition, VAD allows an LTE network carrying voice traffic over the network to detect the absence of audio and conserve bandwidth by preventing the transmission of "silent packets" over the network. On the other hand, this will cause the overall delay increase the little bit and affected the QoS of overall LTE network. So, here the trade-off concept should use to balance the QoS and Bandwidth resources to

achieve the optimum performance, see figure (5.9) that present the impact of VAD.

CONCLUSION

In this paper, the QoS performance for non-real time traffic like HTTP, FTP, and e-mail studied. The framework of the study focused on the major QoS parameters. In addition to that, the impact of the Voice Activity Detection (VAD) for VoLTE Traffic investigated and analyzed in term of major non-real time traffic QoS parameters, delay and throughput. Two scenarios designed and simulated using Optimized Network Realistic LTE network configuration implemented to complete and achieve the results of the experiment, using One EPC packet core, 5 LTE cells and 500 VoLTE user with 100 users per each cell used. Engineering Tool (OPNET) version 18.5.1. The paper focused on the impact of the practical configuration of LTE networks.

The conclusion shows that the Overall performance for all non-real time traffic applications like HTTP, FTP, and Email impacted by the real-time application like VoLTE traffic. This due to the many factors, firstly, the real-time application are consuming more bandwidth by nature, and from the theoretical point of view, the VoLTE traffic in consuming more bandwidth compared to the non –real time traffic. In addition, the missing of packets scheduling and prioritizing is the significant reason, which causes random packets losses and more delay for non-real time traffic due to the large size of packets, compare to real time traffic. Therefore, based on the above-mentioned fact , in case of non-real time traffic generated mixed with VoLTE traffic, the results show that the average time performance for non-real time traffic of E-mail Uploading response, FTP transfer, HTTP paging response are better in performance and significantly improved by 68%, 65%, and 75% respectively. This improvement due to the VoLTE traffic profile configured with G.711 codec and activated Voice Activity Detection (VAD) feature, which save the bandwidth and give more throughput to the non-real time traffics. In contrast, in the case of comparing to the VoLTE of non-VAD configured, the performance of non-real time traffic degraded compared to the first case, this because the codec G.711 mixed traffic consuming more bandwidth as explained in section II in part of Voice Activity Detection Technique. While the overall LTE network QoS performance still performing in the acceptable level in term of Throughput, and end-to-end delay

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