AIN SHAMS UNIVERSITY

FACULTY OF ENGINEERING

Electronics Engineering and Electrical Communications

Planning for Quality of Service for Voice over Long Term Evolution "LTE" network

A Thesis submitted in partial fulfilment of the requirements of the degree of

Doctor of Philosophy in Electrical Engineering

(Electronics Engineering and Electrical Communications)

By

Mohamed ELSaid ELSayed Mohamed ELWakiel

Master of Science in Electrical Engineering

(Electronics Engineering and Electrical Communications)

Faculty of Engineering, Ain Shams University

Supervised By

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Cairo - (2016)

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Date: 26 December 2016

Statement

This thesis is submitted as a partial fulfilment of Doctor of Philosophy in Electrical Engineering, Faculty of Engineering, Ain shams University.

The author carried out the work included in this thesis, and no part of it has been submitted for a degree or a qualification at any other scientific entity.

Mohamed ELSaid ELWakiel

Signature

……...……

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Thesis Summary

The LTE (Long Term Evolution) technology was introduced to reduce the DATA network latency, in addition to provide higher data throughput. But the packet based nature of LTE network prohibits the transmission of voice related services. VoLTE (Voice over LTE) is a solution to transfer voice packets with special treatment over the LTE network, and get benefits from its low latency and quality of services capabilities to have high quality voice services jointly provided by the EPC (Evolved LTE packet core) and the IMS (IP Multimedia Subsystem).

As VoLTE is a new emerging technology for network and devices providers and not matured yet, it has some limitations in providing all voice related services over LTE.

Network initiated and user initiated USSD (Unstructured Supplementary Service Data) are not supported directly over VoLTE. CSFB (Circuit Switching Fall Back) is a temporary solution used to instruct the VoLTE device to fall back from the LTE domain to the 3G/2G CS (Circuit Switching) network domain to receive such USSD, then returning back again to VoLTE after completing the reception of the USSD.

If the VoLTE network tried to push a USSD notification to a VoLTE subscriber who is engaged in one or more voice calls “conference call”, the commercial network settings will make that subscriber to release all the LTE bearers to fall back to the CS network which causes the drop of all active calls owned by that VoLTE user, which affects negatively on the most important VoLTE QoS (Quality of service) parameters which is service availability and VoLTE call retainability.

This thesis introduces the investigation and development of design methodologies for the deployment of VoLTE network which requires strict and careful calculations of various QoS parameters, and also introducing perspectives of achieving different voice related services over VoLTE network without affecting the VoLTE subscribers QoE.

The work presented here relates to the evolving of retaining satisfied QoS philosophy of VoLTE technology.

This thesis presents a comprehensive study of VoLTE networks architecture and summary of each node functions, and various VoLTE traffic scenarios will be introduced and analyzed based on real traces collected from a real VoLTE network. The study includes the evolution of

voice technologies deployment scenarios over LTE and its related QoS parameters design.

The study identified the limitations could be faced when deploying voice related supplementary services and USSD services directly over VoLTE, and the temporary solution to overcome such limitations which could be the main reason for VoLTE call drops on various traffic scenarios

A novel solution will be introduced to overcome such limitations and prevents any active voice call from being dropped when receiving a USSD from the VoLTE network. This will be achieved by using SRVCC (Single Radio Voice Call Continuity) instead of CSFB when receiving USSD while being engaged in a voice call.

To verify such novel method, a real pilot VoLTE network is used to get practical traces and measurements to validate that novel solution to achieve such important QoS parameter. The performance of that solution is evaluated by measuring the call drop rate improvements achieved by using that novel technique that uses SRVCC compared to the existing technique which is using CSFB. Experiments show that the call drop rate is below 10% when using SRVCC, instead of all the calls being dropped when using CSFB, which showing that the proposed technique is a very promising way to enhance VoLTE network performance under heavy traffic scenarios.

Also some recommendations to enhance the system performance will be proposed based on the practical testing and experience. The study also introduced new eSRVCC scenarios like “aSRVCC, bSRVCC, mid-call SRVCC” which were not introduced by previous literatures.

As the successful VoLTE deployment requires strict design of the QoS parameters. To reach a perfect VoLTE network performance, QoS design parameters will be calculated to be applied on a pilot VoLTE network then getting its practical measurements.

By analyzing these real logs, a new mathematical method will be introduced to calculate the important QoS factors instead of depending on simulation results which couldn’t consider all the real networks conditions, the calculated values will be compared with previous studies results which were done using a simulation model, it is clearly shows that even the VoLTE calls performed under poor coverage conditions with real traffic scenarios and practical wireless environment, the proper design of QoS parameters leads to a perfect system performance, also the calculated QoS factors will be compared to related values measured by a standard performance tool to verify these calculated factors and show enhancement provided by VoLTE technology under congested LTE sites.

This work has demonstrated that the strict design and calculations of the bandwidth requirements for different QoS parameters in different VoLTE network nodes, will result in better values for the E2E delay, jitter and packet lose rate parameters which is matched with standard QoS factors values and enhancing the subscribers QoE under different radio coverage conditions. It has been found that the overall VoLTE average end-to-end delay was about 170 ms under bad coverage conditions and 156.7 ms under good coverage conditions with very high voice quality, and its packet loss rate was about 0.0061%, while jitter was almost 15 ms, which reflects the robust VoLTE capability.

For future work, the implementation of ICS (IMS Centralized Service) to enable the whole types of subscribers served by the IMS domain instead of having two domains "IMS and CS", which could affect some services like conference calls initiated on IMS domain then SRVCC performed while being on conference requires extensive study.

Also VoWiFi (Voice over Wi-Fi) is a promising technology to enhance the indoor QoS for VoLTE subscribers which requires more future studies.

Key words: *VoLTE; QoS; QoE; IP USSD; CSFB; eSRVCC; E2E delay MOS value, Packet Loss Rate, Jitter*.

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God blesses his soul.

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PUBLISHED PAPERS

1. M. El Wakiel, H. El Badawy and H. El Hennawy, "*VOLTE deployment scenarios: Perspectives and performance assessments*", in: Proc. of the International Conference on Selected Topics in Mobile & Wireless Networking (MoWNet), Cairo, 2016, pp. 1-8. Available at: http://ieeexplore.ieee.org/xpl/articleDetails.jsp?arnumber=7496607&filter%3DAND%28p_IS_Number%3A7496590%29.

2. M. El Wakiel, H. El Badawy and H. El Hennawy, *"Design of Quality of Service Parameters for Voice over Long Term Evolution "LTE" Network"*, International Journal of Sciences: Basic and Applied Research (IJSBAR), vol. 28, no. 2 (2016) pp. 107-125. Available at: http://gssrr.org/index.php?journal=JournalOfBasicAndApplied&page=article&op=view&path%5B%5D=5959&path%5B%5D=2955.

Table of Contents

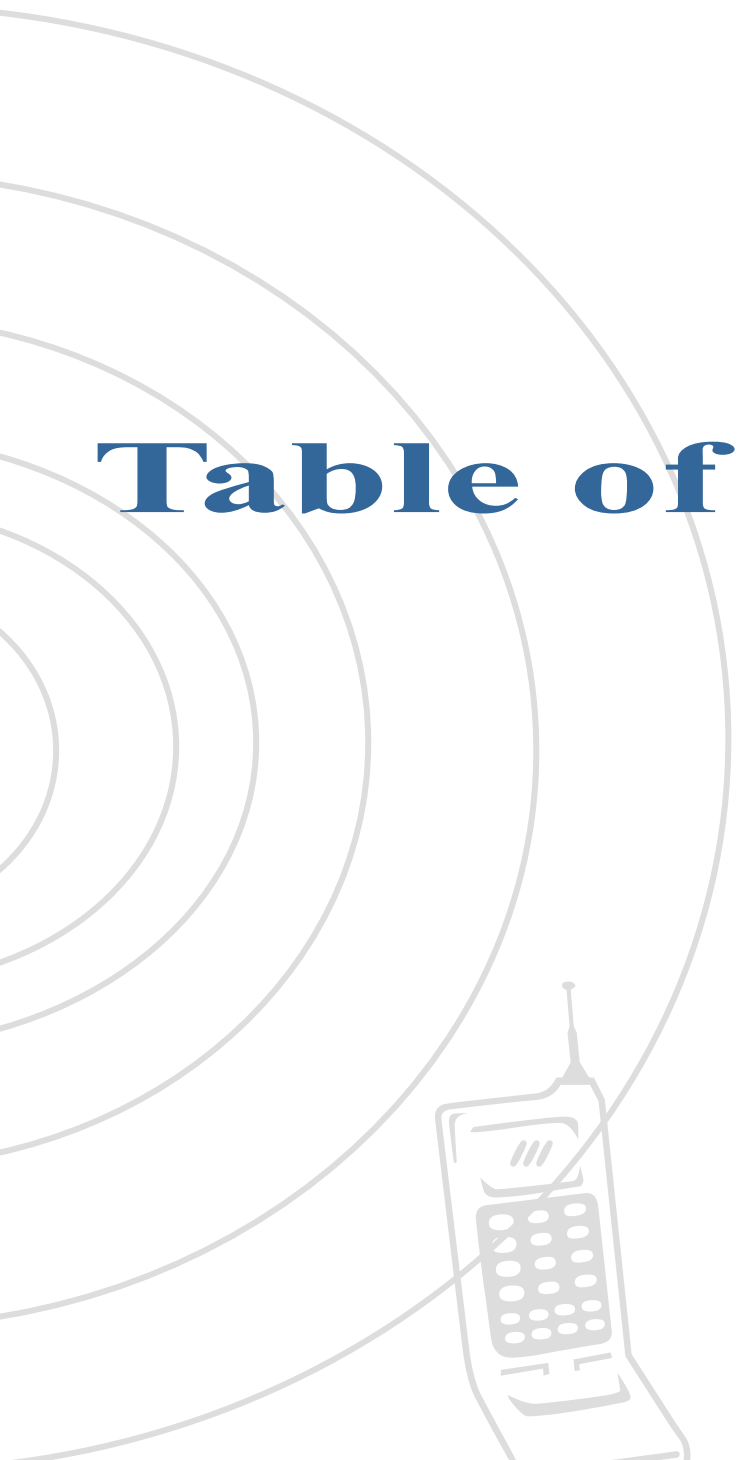

Table of Contents