

Evaluation of VoLTE Technology Based On Quality of Service, Quality of Experience and Network Performance Assessment

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Abstract: *Voice-Over Long Term Evolution [VoLTE] is a protocol that is used for high speed voice (data) transmission without a requirement for 2G/3G bands for calls between mobile phones. This new technology provides a very high transmission rate with benefits such as reduced network latency, higher throughput, better capability for voice services and HD Voice quality for audio. However this latest technology which Mobile Network Operators (MNO) are trying to implement across the present ecosystem comes with its due limitations. Limitations range from being able to deliver high Quality of Service (QoS) and Quality of Experience (QoE) standards, to being able to support direct USSD (Unstructured Supplementary Service Data) messages through VoLTE. There is an acute need for improving QoS and QoE in this network presently. The main objective of this survey is to provide a summary of the most competitive techniques that have been developed in the recent times to solve the various problems currently present along with its due advantages for a better performing and a more robust VoLTE technology implementation. Accordingly, various mechanisms are evaluated and the major issues are addressed in this paper.*

Keywords: VoLTE, QoS, QoE, USSD, Signalling Load

1. Introduction

It is predicted that by 2022, the data traffic between individual smartphones will be 10 times more than the current traffic rate. This means that by 2022, an average individual will generate and exchange about 25GB of data monthly compared to now, which is around 2.5GB to 5.1GB. In order to keep up with the growing data exchange rate and rising technology in the Mobile network, VoLTE needs to be deployed and implemented. VoLTE is a high-speed mode of communication that provides up to 3 times more data capacity than the currently used 3G system and 6 times more capacity than the 2G system. In VoLTE technology, even voice is converted into a data packet and sent across the LTE network causing it to be independent of the legacy 3G network that is broadly deployed and used. However, large-scale deployment of VoLTE is still in its infant stages. Issues such as inefficient QoE and QoS estimation still pose a problem along with other complications such as USSD support in VoLTE, and signaling load. The remaining paper is therefore divided into the following sections. Section 2 deals with the QoE estimation problem and the solution we deem is most suitable to use. In Section 3, the QoS assessment technique is discussed and in Section 4 and Section 5, two problems currently faced in VoLTE is described with the latest technique to optimize it, they include USSD support in VoLTE and Signaling Load consideration respectively. Solution to both these problems leads to an increased QoE/QoS delivery.

2. QoS Estimation for VoLTE

QoE (Quality Of Experience) is a factor that measures the holistic experience of a service that is provided by MNOs (Mobile Network Operator), from the viewpoint of the customer or subscriber using it. It is pertinent to estimate and assess the QoE of services in order to provide an improved, overall high quality experience within the VoLTE network for the customers. Often times, to measure experiences such as 'High Quality Call' a feedback mechanism is being used where the subscriber can give a feedback. According to [1], for estimating the QoE in the VoLTE system, a relationship has to be created between QoS and QoE as they are closely linked. This is known as QoS/QoE bottom-up approach. mathematical models are to be identified that will link the QoS attributes such as delay, jitter, etc. to the QoE attributes such as MOS (Mean Opinion Score).

2.1 Method for QoS/QoE Mapping

In the bottom-up approach[1], for QoS, 3 indicators are taken into consideration known as KPI (Key Performance Indicators) which include: Delay, Packet Loss Rate (PLR) and Jitter and for QoE, the considered attribute is MOS (Mean Opinion Score). According to[7], MOS values which indicate the quality of experience of the call/VoLTE service can range between 1 (bad quality) to 5 (excellent quality). Presently, there are 3 different mathematical mapping models that the curves can fit into that is used widely in scientific literature:

- Logarithmic Function:

$$QoE = \alpha * \ln(\beta * QoS) + \gamma \quad (1)$$

- Exponential Function:

$$QoE = \alpha * e^{(-\beta * QoS)} + \gamma \quad (2)$$

- Polynomial Function:

$$QoE = \alpha * QoS + \gamma \quad (3)$$

The meaning of each of the KPI terms is given below:

Delay: Total amount of time taken for a data packet to reach from the source UE/node to the destination UE/node.

Jitter: Refers to the variation in the packet arrival time. This occurs due to high network traffic, etc.

Packet Loss Rate: Rate at which packets are dropped in the network due to reasons like increased delay time.

As mentioned in [1], 48 different scenarios were considered for the purpose of real-world simulation testing.

- Scenario 1-12: Depicts the communication between two UE's who are engaged in a VoLTE call via direct link. (Fig. 1)
- Scenario 13-24: Depicts 3 UE's along with a HTTP Server where 2 UE's are engaged in a VoLTE call while the third UE is using the HTTP browsing services. (Fig. 2)
- Scenario 25-36: Depicts one UE performing VoLTE calls to another UE but both are affected by the IP cloud insertion. (Fig. 3)
- Scenario 37-48: Depicts 2 UE's performing a VoLTE call via direct link and interrupted by IP cloud while the third UE is using the HTTP web service. (Fig. 4)

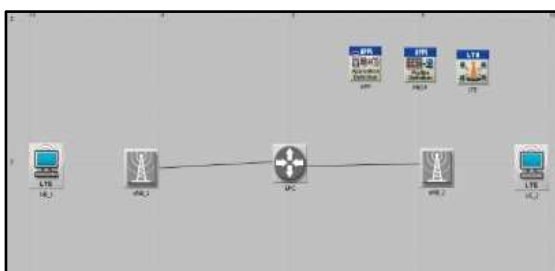


Figure 1: Scenario 1-12

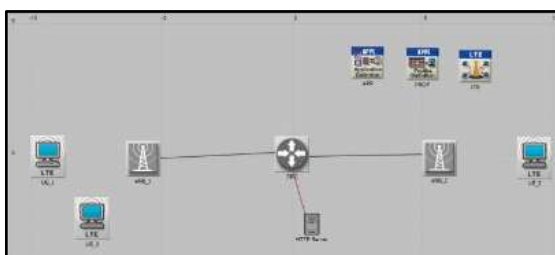


Figure 2: Scenario 13-24

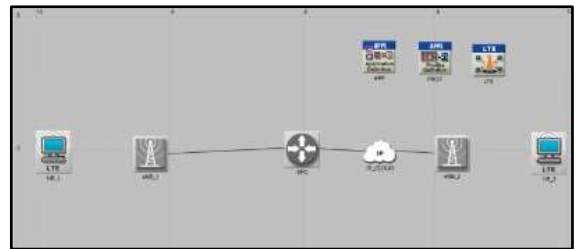


Figure 3: Scenario 25-36

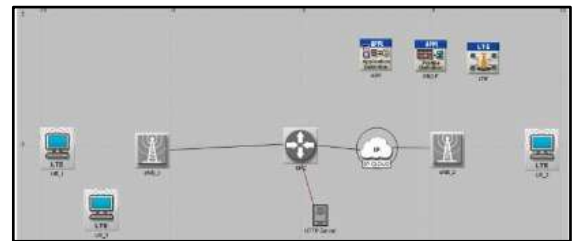


Figure 4: Scenario 37-48

2.2 Results and Advantages

According to the results in [1], it is proven that;

When MOS and Delay is correlated (i.e. a graphical plot is drawn with MOS vs Delay), Logarithmic function was highly suited for curve fitting.

When MOS and Jitter is correlated, exponential function was the best fitting curve with R-square value=0.9379 and RMSE value=0.2068.

When MOS and PLR is correlated, the best fitting curve would be the logarithmic function with the R-square value = 0.9024 and RMSE = 0.2592.

Thus using the above results, estimation of QoE can be done in a more efficient manner. Since real-world, non-linear scenarios were used to identify the various types of curves, a further assessment for future can mean, one can use domains such as cluster analysis, machine learning, neural networks etc. for improving the entire VoLTE network QoE estimation.

3. QoS Assessment for VoLTE

QoS is the capability of a network to prioritize and provide different services to applications and users, according to their requirements. QoS is used to manage delay, packet loss and jitter on the network. It is important for MNOs to have a very efficient QoS assessment system.. Applications use either the transmission control protocol (TCP) or User Datagram Protocol (UDP). The important difference between TCP and UDP is that UDP does not retransmit lost packets whereas TCP does. If a phone call is made through VoLTE, UDP protocol will be used. Hence if some of the packets are lost, it will not be retransmitted which will lead to a bad quality phone call. This is where QoS needs to be improved.

The areas that are to be managed and analysed for an efficient QoS assessment for VoLTE are [6]:

1. Voice codec
2. LTE QoS features
3. IP network routing enhancement
4. Network Impairments

MOS is one of the key performance indicators (KPI) which is used to check for the QoS of VoIP including VoLTE. [7] Table I shows the relationship between QoS perception of a call and MOS values.

Table 1: MOS values and QoS Perception by end user

MOS value	QoS perception
5	Imperceptible
4	Perceptible
3	not annoying
2	Slightly annoying
1	Annoying
0	Very annoying

3.1 Voice Codecs and Scenarios

Voice Codecs are the coder-decoder values used to convert voice or speech into compressed digital form and back to the uncompressed voice. These are one of the most important factors of QoE in VoIP. The techniques for coding and decoding should be integrated with QoS management features at the network level itself.

Five scenarios were considered for the simulations in [6]. Each scenario uses a different voice codec. The Codecs and the scenarios that were considered for simulation in [6] are shown in Table 2.

Table 2: As Mentioned in [6]

Id	Voice Service	Voice Codec	Type of Service (ToS)
1	PCM Quality Speech	G.711	Best Effort (BE)
2	GSM Quality Speech	GSM EFR	Best Effort (BE)
3	GSM Quality Speech	AMR 12.2k	Best Effort (BE)
4	GSM Quality Speech	IS 641	Best Effort (BE)
5	IP Telephony	G.729A	Best Effort (BE)

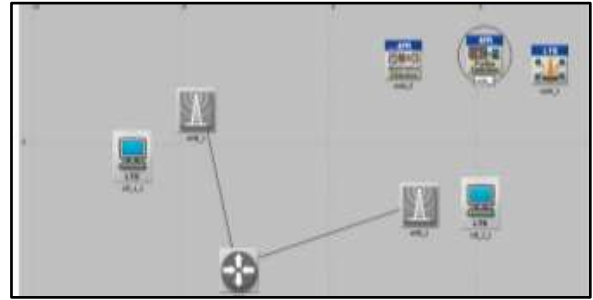


Figure 5: LTE network simulation

3.2 Results from Simulations

The simulated LTE network in OPNET is shown in figure 5 and the simulation results in [6] has shown the following:

G.711 and GSM EFR codecs have shown good performance, according to MOS. G.729A and GSM G711 has provided a better performance, according to sent/received voice traffic. AMR 12.2k performed better in terms of end-to-end packet delay. G.729A and GSM EFR performed well according to packet delay variation. IS 641 codec performed better in terms of LTE delay in both downlink and uplink. G.729 performed best in terms of end to end packet delay.

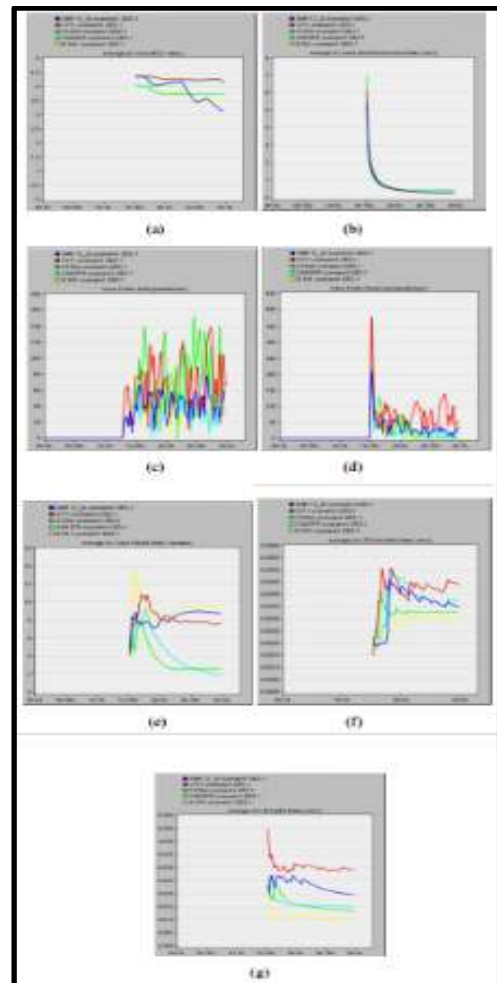


Figure 6: Graphical representation of Simulation results [6]

4. USSD Support in VoLTE Technology

USSD (Unstructured Supplementary Service Data) is a real-time communication technology that exists between a UE (User Equipment) and an application program within the network during a USSD session. USSD application and supplementary services include voice service charge displayed to the customers, booking tickets, blocking calls, prepaid roaming etc.

4.1 Existing Problem

VoLTE technology however, does not directly support USSD application. For the purpose of fast deployment of VoLTE in the ecosystem, CSFB (Circuit Switch Fall Back) method is used to handle the USSD service which proves to be inefficient, as it heavily deteriorates the QoE (Quality of Experience) within the network. In CSFB, if the subscriber receives a USSD message while engaged in multiple number of conference calls or voice services, all calls will be dropped in order to accommodate and receive the USSD service.

4.2 Solution to Increase the QoE

During the survey, it was found that one of the best ways to implement USSD over VoLTE is by using SRVCC [Single Radio Voice Call Continuity] as a replacement to CSFB when subscriber is engaged in other voice calls and services. As mentioned in [3], SRVCC procedure is invoked only when subscriber has to receive a USSD while engaged in other voice calls/ voice services. This procedure would not be invoked under other circumstances.

According to [3] there are 3 main steps to implement USSD over VoLTE:

1. An application server is setup in order to process USSD over IMS. This is known as "USSI-AS".
2. Integration of USSI-AS to Home Subscriber Server [HSS - subscriber database] through MAP interface. HSS will then transfer the original USSD received to USSD centre via an IMS services.
3. VoLTE device used by subscriber must support USSD through IMS.

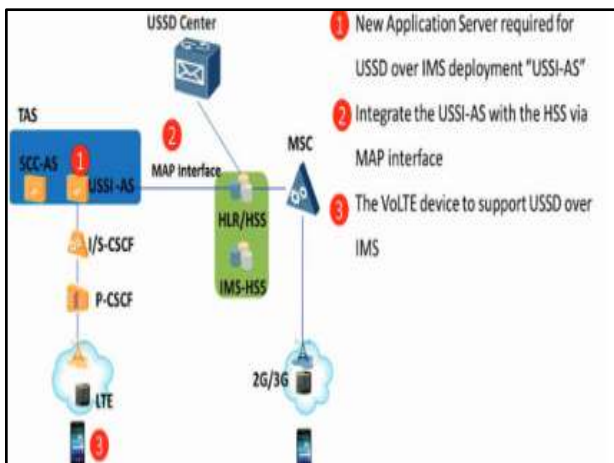


Figure 7: USSD over VoLTE [3]

But as per [2] a better proposed solution includes using SRVCC in the present architecture, mentioned in [3]. In the SRVCC technique, an eNodeB is considered which has information of the subscriber such as, whether the subscriber is engaged in voice services or not. Based on this report, the SRVCC technique is implemented.

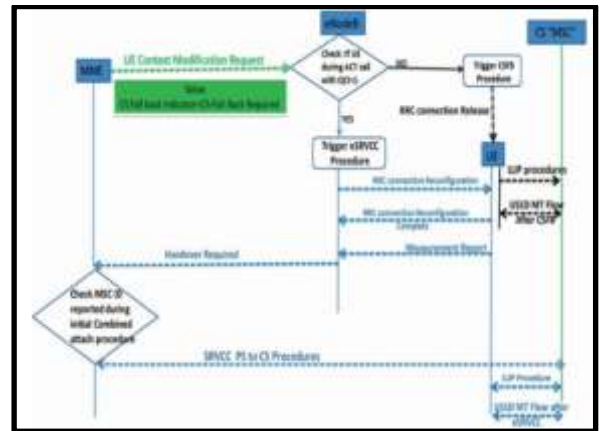


Figure 8: Algorithm to receive USSD during active voice calls [2]

Using this novel approach, subscriber will now receive USSD service present in the Circuit Switch network while being engaged in simultaneous voice services/calls which will then be handed over to the 3G network. The calls that the subscriber is engaged in will thus not be dropped while receiving the USSD.

4.3 Results and Advantages

Using a pilot VoLTE environment for the purpose of testing, considered call drop rate of CSFB = 100% and the formula from [2] used to measure the call drop rate =

$$\frac{\text{Release request [QCI = 1], bearers with "CSFB triggered"}}{\text{Release Response with cause "CSFB Triggered"}} \times 100$$

Using the formula, it was found that anytime a USSD was received according to the specified conditions, all active VoLTE calls were dropped. Similarly, call drop rate for SRVCC procedure was calculated using the formula from [2]:

$$1 - \frac{\text{Hand - over Requests with "CSFB Triggered"}}{\text{No. Of Context Release command}} \times 100$$

Final results [3] show that the call drop rate reduced from a 100% when using CSFB to about 10% when the SRVCC technique was used.

The advantages therefore include the reduction in the call drop rate in the VoLTE network. This hugely improves the Availability of Service feature of QoS in the present network. As call drop rate evidently decreases with the SRVCC technology implementation (as presented in the pilot test environment in [2]) in the VoLTE Network, the QoS improves and thus provides the subscriber with a better VoLTE service.

5. Signaling Load Considerations

Signaling in telecommunications are messages which are sent and received between phone switches. These messages are used to exchange information about the establishment and control of a circuit and managing the network (For example, call set up). The amount of messages is called the signaling load.

VoLTE Networks has many improvements over its predecessors but still has a lot of challenges as well.

VoLTE has only two Radio resource control (RRC) states (RRC-Idle and RRC-Connected) whereas there are four RRC states present in WCDMA (Wideband Code Division Multiple Access) networks. This is one of the improvements as this can largely increase the efficiency of RRC. Radio networks signaling load will also decrease as LTE has a flat architecture.

5.1 Existing Problem

One of the challenges of VoLTE is the signaling load on the control plane and The Policy and Charging Rules Function element (PCRF). PCRF element enables the transition to VoLTE services and reliable operation of the same. The over 10 fold increase in signaling load is going to affect the PCRF as it must specify QoS for every single voice call passing through the LTE network. Adding to the voice calls, for other services like streaming videos, online gaming, etc, the load increases further.

A report from Oracle has shown that the LTE Diameter signaling traffic, in a global level, will increase at a 78 percent compound annual growth rate (CAGR) from 2013 to 2018, growing from 12 million messages per second (MPS) to 216 million MPS., Oracle has also predicted that the LTE Diameter signaling traffic will increase at a 140 percent CAGR, from 1.2 million MPS in 2012 to nearly 99 million MPS by 2017.

5.2 Proposed Solution

One of the proposed solutions to decrease the signaling load significantly is with data plane decision making. [7] This is implemented in the following manner.

The PCRF first signals a service plan identifier to the Policy and Charging Enforcement (PCEF). The PCEF hosts the Traffic Flow Templates (TFT). The TFTs then manage the QoS of thousands of VoLTE-related flows per second. Upon implementation of this novel approach, we believe it will improve the QoS and QoE of the Network as the signaling load can be managed in a more efficient manner.

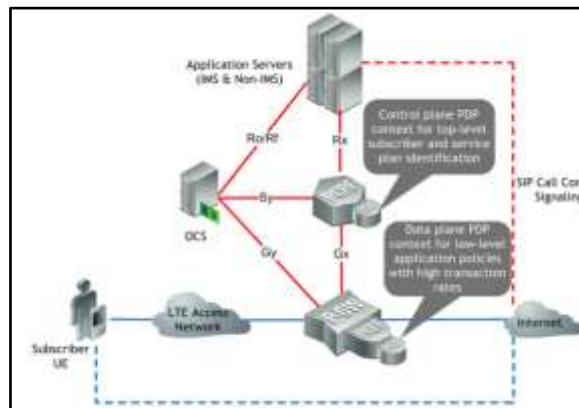


Figure 9: Control and Data Plane PDP reduces signaling and service latency

6. Conclusion

Since VoLTE is a new technology in the market today, it comes with its due challenges especially in terms of providing high QoS and QoE in the network. In the near future, VoLTE will become one of the most significant services provided by LTE. So, it is crucial to find the most optimizing solutions to the present day problems for fast and large-scale deployment of VoLTE in the networking ecosystem. In this paper, problems related to QoS and QoE estimations were discussed with solution techniques which can be used in real-world scenarios. Also, problems such as direct USSD support in the VoLTE network which decreases the QoS value and problems related to high signaling load were described with solutions. These solutions yielded in providing a higher value of QoE and QoS to the subscribed customers of the VoLTE service.

References

- [1] Alessandro Vizzarri, "Quality Of Experience Estimation for VoLTE Services" [2016 - 2nd International Conference on Frontiers of Signal Processing]
- [2] M.EL Wakiel, H.El Badawy and H.EL Hennawy, "VoLTE Deployment Scenarios: Perspectives and Performance Assessments"[2016-International Conference on Selected Topics in Mobile & Wireless Networking (MoWNeT)],
- [3] 3GPP TS 24.390,"Unstructured Supplementary Service Data (USSD) using IP Multimedia (IM) Core Network (CN) subsystem"
- [4] ETSI TS 103.189: "End-to-end QoS assessment for VoLTE and RCS Interop events"
- [5] P. Le Callet, S. Moller and A. Perkis, eds,"Qualinet White Paper on Definitions of Quality of Experience"[Version 1.2], March 2013.
- [6] Alessandro Vizzarri, "Analysis of VoLTE End-To-End Quality of Service using OPNET" [2014 UKSim-AMSS 8th European Modelling Symposium]
- [7] Industry whitepaper on "Voice over LTE: Challenges and Opportunities".
- [8] M.Chewe, "VoLTE by IP Multimedia Subsystem: Programmatic Implementation of Voice Service on LTE", Helsinki Metropolia University Of Applied Sciences, 2015.

- [9] T. Koshimizu, I. Tanaka and K. Nishida, "Improvement on the VoLTE Domain Handover with operator's vision", 2012.
- [10] M. Alreshoodi, J. Woods, "Survey on QoE/QoS correlation models for multimedia services", International Journal Of Distributed and Parallel Systems (IJDPS) Vol. 4, No. 3, May 2013.

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