A Study on Voice over LTE (VoLTE) Performance and Comparison with Other Voice Technology of Mobile Communications

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***Abstract*— this paper presents the study of Voice over Long Term Evolution (VoLTE) performance and compare against other voice solutions on mobile such as Circuit Switched Fallback (CSFB) and Over-the-Top (OTT). Based on analysis [11], CSFB has many bad results in delivering voice services on LTE mobile network. The ultimate voice solution on LTE networks is VoLTE. TM Berhad joint and Packet One Network are offering VoLTE service soon and their challenge to validate VoLTE performance by using field-trials testing. This paper analyse performance VoLTE by measuring call setup time and media quality of the VoLTE signal. It is performed by taking the measured signals on field trial at Cyberjaya eNodeB with setting LTE FDD 850 MHz band 5. The field trial results which include determining the best measured and VoLTE signal are presented and discussed.**

***Index Terms*— VoLTE, call setup time, QoS, IMS.**

I. INTRODUCTION

The IP multimedia subsystem (IMS) has emerged as the future of mobile and fixed networks. Voice over Long Term Evolution (VoLTE) is ultimate voice solution for mobile networks to replace existing 2G and 3G voice calls which are not an ideal voice solution for LTE-capable mobile phone in the future. In order to raise the bar of maturity required for commercial deployment and number field and market trials must be conducted to validate VoLTE. This paper covers the key performance characteristics of VoLTE solution such as QoS assessment and call setup time according to the GSMA IR.92 specification.

Firstly in this work analyse VoLTE call setup time at excellent RF signal by varying user connection status for originating and terminating call either ECM-connected or ECM-idle. The next analysis is to measure VoLTE call setup time in various RF signal between excellent, good and medium condition. This study also evaluates the VoLTE QoS performance in terms of end-to-end delay, jitter, packet loss rate and MOS. All of measured data is captured at field trial platform at Cyberjaya eNodeB. Finally this paper does brief comparison call setup time performance between VoLTE and other mobile voice solution such as CSFB and OTT.

Myasar R. Tabany and Chris G. Guy et al in [1] analyses the E2E QoS performance evaluation of VoLTE in 4G E-UTRAN based wireless networks. Network performance is a crucial factor to be considered in order to improve service perception by end user. Vizzarri in [2] perform a simulation related to influence of Voice Codec on LTE end-to-end quality of service. Lennart Norell, Eric Parsons, and Per Synnergren et al in [3] underline telephony services over LTE end-to-end. Ren-Huang Liou, Yi-Bing Lin, Yingrong Coral Sung, Pang-Cheng Liu, and Christian Wietfeld in [4] analyse performance of CS Fallback for LTE mobile network. M. Wang, Petterson, Timner, Wanstedt and Hurd et al in [5] addressed efficient QoS over LTE.

The rest of this paper is structured as follow. Section II would explain more on the field trial VoLTE network settings. Section III would explain more call setup time methodology and performance result of the testing. While section IV would discuss on VoLTE QoS network assessment and the testing results. Section V would compare VoLTE call setup time against CFSB and OTT. Finally this study would be concluded and recommendations are highlight for future development through section VI.

II. FIELD TRIAL VOLTE NETWORK SETTINGS

A. IMS And Core Network

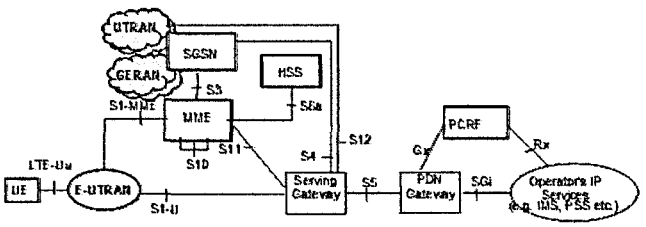

Figure 1 IMS architecture for 3GPP accesses [13]

Figure 1 Show set of core network allows voice calls to be delivered as data flows over an LTE network based on an IMS framework.

B. *Evolved Node B (eNodeB) Configuration Parameter*

Table 1 shows eNodeB field trial configuration parameters are set though out the study.

Table 1 eNodeB configuration parameters

Parameter	Value
Site Name	Cyberjaya
Latitude (Decimal)	2.920528
Longitude (Decimal)	101.664111
Transmit Power	20 W
Bandwidth	10 MHz
Carrier Frequency	850 MHz
Duplexing Scheme	FDD

C. *QoS Class of Identifier(QCI)*

QCI is mechanism used in 3GPP Long Term Evolution (LTE) networks to ensure bearer traffic is allocated appropriate Quality of Service (QoS) for air interface. All test cases were executed using QCI 5 for SIP signaling and QCI 1 for voice, whereas QCI 9 for default bearer as recommendation by 3GPP TS 23.203 standard Policy and Charging Control Architecture [6].

Table 2 3GPP recommendation on QCI

QCI	Bearer	Priority	Packet Delay Budget	Packet Error Loss Rate	Example
1	GBR	2	100 ms	10^{-2}	Conversational voice
2		4	150 ms	10^{-3}	Conversational video
3		3	50 ms	10^{-3}	Real-time games
4		5	300 ms	10^{-6}	Streaming video
5	Non-GBR	1	100 ms	10^{-6}	IMS Signaling
6		6	300 ms	10^{-6}	Streaming video
7		7	100 ms	10^{-3}	Voice, video, games
8		8	300 ms	10^{-6}	Streaming video, web, Email
9		9			

D. *CODEC*

The UE provided by the terminal vendor offered 2 codec selections for voice: AMR-WB sampling frequency at 16000Hz and AMR sampling frequency at 8000Hz. To benefit from the full capability and voice quality of mobile broadband, only AMR-WB at 16000Hz sampling frequency was used throughout the field trial.

III. CALL SETUP TIME

Call setup time of VoLTE is measured from the moment the originating UE sends the INVITE to the moment RINGING is received from the terminating UE. Figure 3 shows the elapsed time between the moment the originating UE sends a SIP INVITE to initiate the call and when 180 RINGING are received by the terminating UE.

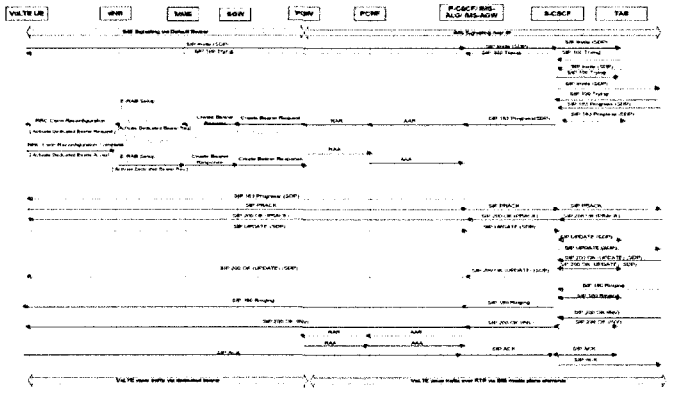

Figure 2 Basic VoLTE UE to VoLTE UE Call Establishment [14]

This test case conducted at excellent RF signalling whereby SINR is around 30.0dB and RSRP at -79.6 dBm. The call setup time is measured in many UE connection status scenarios such as ECM-connected and ECM-idle state. The results of testing are tabulated in table 2.

Table 3 Measured Call Setup time in varies UE state

Condition	Measured Setup Time (Seconds)
Connected - Connected	1.670
Connected - Idle	3.020
Idle - Connected	2.287
Idle - Idle	3.710

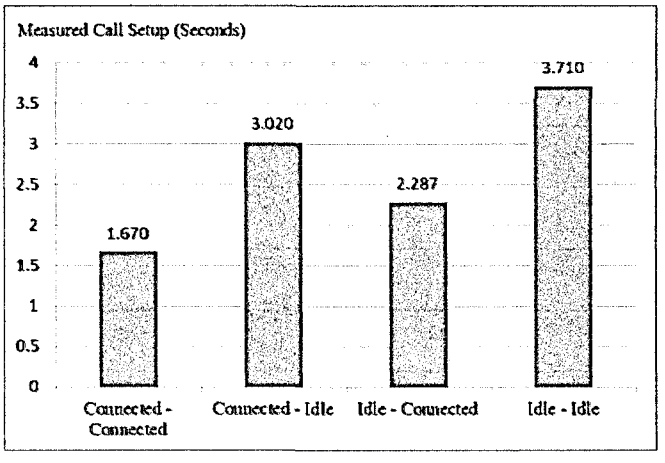

Figure 3 Measured Call Setup time in varies UE state

The fastest VoLTE call setup is clocked at 1.670s when both originating and terminating UE in ECM-Connected state. While the slowest call setup is both UEs in ECM-Idle state and the time is 3.71s. Non-Access Stratum (NAS) signalling connection (i.e. ECM connection) consists of S1 and RRC signalling connection established only when user traffic is being delivered. Therefore UE consume more time to complete call signalling due to Data Radio Bearer (DRB) and S1 bearer not available as shown in Figure 4. When terminating UE is ECM-idle state, the originating UE takes 3.02s to complete the call setup time. The call setup time is slightly fast if originating UE (ECM-idle) calls to ECM-connected terminating UE as much 2.287s.

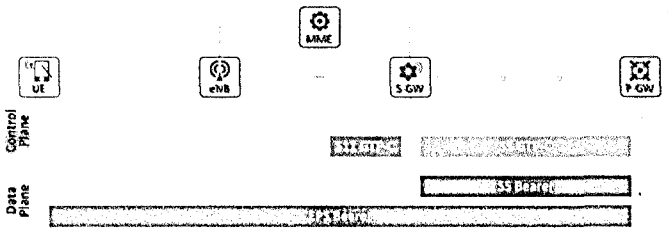

Figure 4 EPS bearer and signaling connections in ECM-Idle state [15]

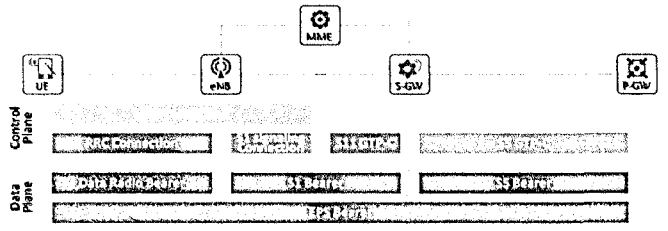

Figure 5 EPS bearer and signaling connections in ECM-connected state [15]

In order to ensure that the tests reflected real-world conditions, call setup time was executed with varying RF and mobility scenarios. The following conditions were used in the field trial referring Table 4.

Table 4 SINR and RSRP range

Location	SINR Range	RSRP Range
Excellent	> 28 dB	> -80 dBm
Good	> 18 dB	> -90 dBm
Medium	> 8 dB	> -100 dBm
Bad	> 0 dB	> -110 dBm

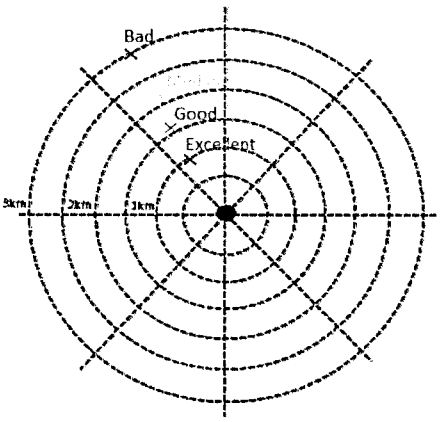

Figure 6 Functionality test conducted at different locations

Figure 7 shows measured setup time in different location areas which reflect RF condition. The excellent area gives the best measured call setup and the value is 1.670s. Slightly increases the call setup when perform at good area which is 1.961s. The VoLTE setup time is longer at medium area as much 2.898s. This testing shows that RF quality has significant impact to VoLTE call setup time.

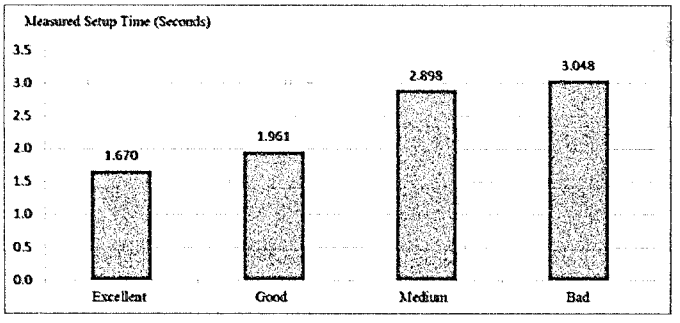

Figure 7 Measured call setup for different location

IV. QOS ASSESMENT

Another purpose of this work is to analyze impact of QoS on VOLTE end-to end performance. Following key performance index are measure:

- Jitter
- Latency
- Packet Drop
- Mean Opinion Score (MOS)

ITU-T G.114 recommends a maximum of a 150 ms one-way latency [14]. VOIP is not tolerant of packet loss. A minimum of 98% packets successful delivery rate and other more compressing codecs can tolerate even less packet loss [14]. Ideally, there should be no packet loss for VoIP. Table 5 describes on network quality based in the jitter measurement.

Table 5 Impacts on network quality based on network average jitter

Value Range (ms)	Impact on Network Quality
0 - 40	Network quality is not impacted
40-120	Network quality is slightly impacted
120-200	Network quality is perceptibly impacted but acceptable
200- infinity	Network quality is greatly impacted and unacceptable

A mean opinion score (MOS) provides a numerical indication of the quality of transmission in the range of 1 to 5 listed in Table 6.

Table 6 Mean Opinion Score (MOS)

MOS	Quality	Impairment
5	Excellent	Very satisfied
4	Good	Satisfied
3	Fair	Neutral
2	Poor	Dissatisfied
1	Bad	Not recommended

QOS assessment is measured in 3 different type RF conditions from excellent, good and medium. The results are shown in Table7. Measured MOS values are maintained across different RF strength due to CODEC AMR-WB is used through the testing which consumes 16kbit/s over dedicated bearer. Average network jitter is less than 10ms that shows network is stable and less variation in delay of packet delivery. No packet lost found in those 3 locations. Latency is less than 50ms in average and it comply ITU-T G.114 recommendation. Overall VoLTE meets the QoS key performance index (KPI) target.

Table 7 QOS assessment results

Location	QOS Assessment			
	Jitter	Loop Delay	Lose Packet	MOS
Excellent	9	0	0	4.1
Good	2	49	0	4.1
Medium	4	43	0	4.1
Bad	14	36	0	4.1

V. VOLTE COMPARISON WITH OTHER VOICE SERVICES

There are other mobile voice solutions that are widely solution such as CSFB and OTT over LTE. This paper compares their performance in term of call setup time between these 3 mobile voice solutions which is VoLTE, CFSB and OTT. Figure 8 shows the measured call setup time. The VoLTE call setup time is significant shorter than CSFB and OTT. The VoLTE call takes 1.67s to complete setup call whereas CSFB is 3.05s and OTT is 13s. It is clearly VoLTE is better and much faster than other mobile voice solution like CSFB and OTT in term of call setup time.

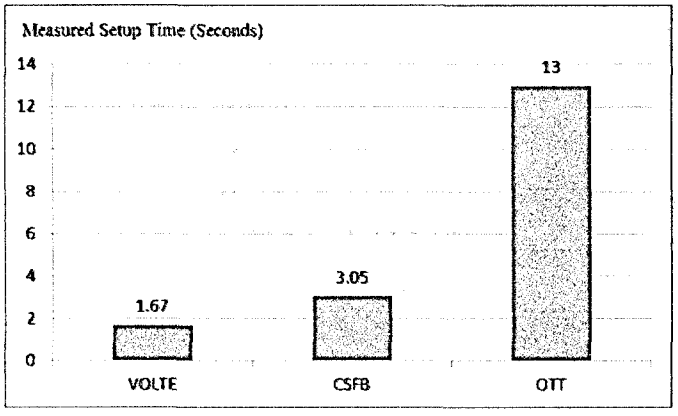

Figure 8 Call setup time VOLTE, CSFB and OTT

IV. CONCLUSIONS AND FURTHER WORKS

In this paper, the field testing results show that good VoLTE performance in term of call setup time and voice quality. They meet the criteria to validate VoLTE commissioning. VoLTE call will connect calls much faster than CSFB and OTT. In addition VOLTE will support higher quality calls as HD Voice. It means better audio fidelity to be delivered, and as a resulting in richer, warmer voices when connecting through LTE. In the end user is the most benefit from VoLTE service and plus network provider able to get rid from aging legacy technology and focus on data-only network platform. For future work, there more rigorous testing needs to be carried out especially VoLTE performance when RF is congest.

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