VoLTE Implementation Guide

April 2020

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1 Introduction

1.1 Overview

LTE (Long Term Evolution), with its capability and optimized architecture to provide mobile broadband services, has been adopted aggressively by operators over the world and it is now provided by over 754[1] operators around the world. As LTE is an All-IP network, the voice and messaging services provided over CS (Circuit-Switched) domain in previous generations needed to be adapted and evolved to work over an LTE network.

VoLTE (Voice over LTE) addresses the migration to a PS (Packet Switched) only domain by leveraging on the capabilities of the IMS (IP Multimedia Subsystem) to offer voice and messaging services over LTE. In this context, VoLTE is important because it enables decommissioning of legacy CS networks as voice services can be migrated to LTE networks. Furthermore, VoLTE provides customers with enhanced voice quality, reduced time taken to establish call and the possibility of placing video calls.

An important further consideration is the support of VoLTE for roaming UEs. Such capability needs to be widespread before legacy CS networks can be decommissioned. There are two competing technologies for the provision of VoLTE Roaming, namely LBO (Local Break-Out) and S8HR (S8 Home Routing). Current deployments of VoLTE Roaming are all based on S8HR. All future deployments of VoLTE Roaming are recommended to be, and indeed expected to be, based on S8HR.

1.2 Scope

This document provides details of commercial S8HR VoLTE roaming deployments which roaming managers may find of use as they plan and execute their first S8HR VoLTE roaming project.

Information provided includes business plan considerations, fraud system impacts, considerations on roaming support (handsets and frequencies), billing considerations, regulatory considerations and finally it includes a sample checklist/ questionnaire that can be used by both the HPMN and the VPMN to assess if the other MNOs network will support their roamers and to assist in configuration requirements.

Technical solutions may be mentioned but their descriptions are out of scope. Rather, references to GSMA Network Group documents will be included for further information.

LBO Roaming is also out of scope for this document.

Note:

- BA.65[7] LTE Roaming Implementation Handbook covers issues related to implementing LTE, a network architecture for wireless access based on an all IP network.
- BA.50[6] Agreements Handbook has information on adding VoLTE Roaming to the International Roaming Agreement.

[1] GSMA.com as of January 13, 2020

1.3 References

Ref	Doc Number	Title
[1]	3GPP TS 23.167	IP Multimedia Subsystem (IMS) emergency sessions
[2]	IETF RFC 8147	Next-Generation Pan-European eCall
[3]	3GPP TS 34.229	User Equipment (UE) conformance specification
[4]	3GPP TS 36.101	Evolved Universal Terrestrial Radio Access (E-UTRA); User Equipment (UE) radio transmission and reception
[5]	GSMA PRD AA.13	STIRA Common Annexes
[6]	GSMA PRD BA.50	Agreements Handbook
[7]	GSMA PRD BA.65	LTE Roaming Implementation Handbook
[8]	GSMA PRD IR.21	Roaming Database Structure and Updating Procedures
[9]	GSMA PRD IR.25	VoLTE Roaming Tests
[10]	GSMA PRD IR.34	Guidelines for IPX Provider Networks
[11]	GSMA PRD IR.65	IMS Roaming, Interconnection and Interworking Guidelines
[12]	GSMA PRD IR.88	LTE and EPC Roaming Guidelines
[13]	GSMA PRD NG.119	Emergency Communications
[14]	GSMA PRD TD.50	TAP Test Cases for VoLTE Roaming Testing
[15]	GSMA PRD TD.58	TAP3.12 Implementation Handbook
[16]	GSMA PRD TD.201	Common Billing and Charging Processes
[17]	GSMA PRD TD.202	Billing and Charging Evolution Reports
[18]	GSMA PRD TS.11	Device Field & Lab Tests
[19]	GSMA PRD TS.32	Technical Adaptation of Device through late customisation

2 Business Drivers

This section contains information that the MNO can use in its business plan to justify launching VoLTE roaming outbound and/or inbound.

2.1 Business drivers of VoLTE on Home Network

VoLTE provides five benefits over traditional CS voice calls.

Migration to IP. VoLTE enables operators to migrate their circuit switched infrastructure (e.g. 3G) to a fully IP centric network. Without VoLTE, 4G networks cannot support voice service, therefore operators wishing to offer this communication capability will need to still support legacy technologies and use CSFB (CS Fallback) techniques to redirect the user towards them when a call is made or received.

Voice Quality. VoLTE offers higher voice quality than legacy circuit switched voice. As shown in Figure 1, VoLTE provides voice in wider range of frequency and enhances the voice quality significantly. With implementation of EVS (Enhanced Voice Services) codec, the range is even extended, and customers can enjoy very high-quality voice.

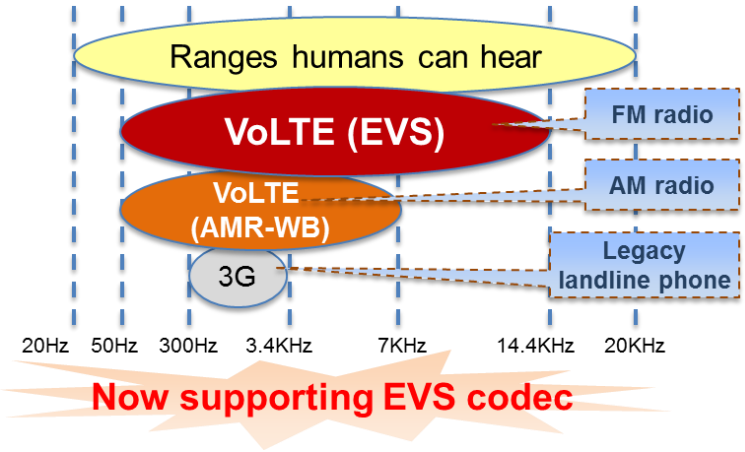

Figure 1 Higher voice quality offered by VoLTE

Fast Call setup. Another prominent advantage of VoLTE is the shorter call setup time compared to legacy circuit switched voice services. Call setup time is the time it takes from initiating the call to hearing from or speaking to the called party, and VoLTE reduces the call setup time to about a third of that of legacy circuit switched voices.

Multimedia communications. VoLTE also enables video calls to be provided in conjunction with HD voice (ViLTE: Video over LTE). This means that not only video calls are possible between VoLTE subscribers, but also switching between Video and Voice is supported.

Efficiency. As VoLTE calls are natively supported by LTE networks, the scarce radio resources are used much more efficiently than with legacy technologies.

2.2 Business Drivers for VoLTE Roaming

2.2.1 Customer Experience

VoLTE roaming extends all the benefits mentioned in 2.1 to subscribers that are roaming abroad resulting in the same user experience as at home. S8HR VoLTE roaming also unlocks two additional key benefits to subscribers:

- Firstly, S8HR enables exactly the same user experience as when non-roaming
- Secondly, voicemail is more reliable as there is no need to interwork with VPMN (Visited Public Mobile Network) and call forwarding is activated as it would be when the subscriber is at home.

2.2.2 Coverage

Launching VoLTE roaming provides better coverage in two ways:

- New Operators - There are a number of new operators that launched with 4G only. Launching VoLTE roaming provides access to those networks for inbound roamers.
- Existing Partners Closing 2G and/or 3G coverage - Operators are decommissioning 2G, 3G or both to re-farm the spectrum for 4G and 5G. Some operators maintain older networks but with minimal spectrum to support IoT devices. Even if other operators maintain legacy networks, coverage is never identical leading to coverage gaps and network congestion on the remaining networks.

2.3 Possible Business Case Justifications (quick bullet points)

- Operational efficiencies
    - Fewer network elements involved for S8 Home Routed VoLTE traffic
    - Simplified roaming agreements for VoLTE
    - Reduced development and implementation effort
    - Reduced testing effort
    - Bill shock mechanisms not impacted
    - Fewer billing touch points
    - Fewer IPX services associated with roaming
- Implementation Advantages of S8HR VoLTE Roaming
    - The reduction in complexity of development, deployment, and settlement represents a faster “time to market” solution
    - Roaming architecture model is similar to existing roaming for legacy network and LTE data networks
    - Accelerate implementation of VoLTE Roaming worldwide
- Strategy/Competition
    - Strategic objective to remain preferred roaming destination of choice for inbound roamers in relation to other competitors.
    - Competitive Pressures in-home market
    - Global circuit switched footprint is now in decline
    - With the number of operators that need to launch VoLTE roaming, a late transition will mean waiting in testing queues to enable launch
- Revenues and Expenses
    - Enables opportunity to expand into new roaming partner relations (e.g., new “greenfield” LTE operators), both international and domestic
    - IoT solutions with voice (such as eCalling in Automobiles) have to plan for 10+ years in the future. VoLTE is being selected by many as the solution to future proof deployments. Lack of VoLTE means those devices can’t access an operator’s network.
    - Lower deployment costs
    - Reduced contractual complexities while expanding contractual opportunities
    - Capitalize on revenue opportunities
    - Reduced operating expenses
    - Lower wholesale costs for Voice via volume-based charging, e.g. Voice as MB.
- Consumer
    - Provide customers with a world-class VoLTE/IMS Roaming solution
    - Provides customers with best global footprint including protecting from being impacted by the shrinking footprint of circuit switched networks.

3 Selecting Roaming Partners - Handsets, Coverage, and Capacity Bands

Handsets and the bands they support are very important in the launch of VoLTE roaming. Below is a summary of some key issues related to handsets and frequencies that will affect the selection of roaming partners and steering of roaming

3.1 Frequencies

When reviewing a roaming partner for compatibility, it is important to check that the frequency bands supported in the HPMN's VoLTE capable phones are available in the VPMN's network and that the supported bands have sufficient coverage. The voice quality experience with VoLTE highly depends on a match between device Radio Frequency (RF) capabilities and the serving LTE network's RF coverage. Operators prescribe RF bands in devices that they sell to their customers to match the RF bands that they use in their own network.

Low spectrum band is used as the primary coverage band (e.g. 800 MHz, B20). High spectrum band is used for capacity expansion (e.g. 2.7 GHz, B7). High spectrum has less geographical coverage vs. low spectrum. High spectrum also has trouble with in-building penetration, but can be reused more often to add capacity. It may be the case that the VPMN supports a high spectrum band that the VPMN has in its phone but that the VPMNs coverage band is one not supported by the HPMN's phone. As a result, devices that are optimized for use by the HPMN may not have a good user experience when roaming in the VPMN.

Below is a sample of some of the frequency bands in use[2] :

E-UTRA Operating Band	Uplink (UL) operating band BS receive UE transmit	Downlink (DL) operating band BS transmit UE receive	Duplex Mode
	F_{UL_low} – F_{UL_high}	F_{DL_low} – F_{DL_high}	
1	1920 MHz – 1980 MHz	2110 MHz – 2170 MHz	FDD
2	1850 MHz – 1910 MHz	1930 MHz – 1990 MHz	FDD
3	1710 MHz – 1785 MHz	1805 MHz – 1880 MHz	FDD
4	1710 MHz – 1755 MHz	2110 MHz – 2155 MHz	FDD
5	824 MHz – 849 MHz	869 MHz – 894MHz	FDD
6[1]	830 MHz – 840 MHz	875 MHz – 885 MHz	FDD
7	2500 MHz – 2570 MHz	2620 MHz – 2690 MHz	FDD
8	880 MHz – 915 MHz	925 MHz – 960 MHz	FDD
9	1749.9 MHz – 1784.9 MHz	1844.9 MHz – 1879.9 MHz	FDD
10	1710 MHz – 1770 MHz	2110 MHz – 2170 MHz	FDD
11	1427.9 MHz – 1447.9 MHz	1475.9 MHz – 1495.9 MHz	FDD
12	699 MHz – 716 MHz	729 MHz – 746 MHz	FDD
13	777 MHz – 787 MHz	746 MHz – 756 MHz	FDD
14	788 MHz – 798 MHz	758 MHz – 768 MHz	FDD
17	704 MHz – 716 MHz	734 MHz – 746 MHz	FDD
18	815 MHz – 830 MHz	860 MHz – 875 MHz	FDD
19	830 MHz – 845 MHz	875 MHz – 890 MHz	FDD
20	832 MHz – 862 MHz	791 MHz – 821 MHz	FDD
21	1447.9 MHz – 1462.9 MHz	1495.9 MHz – 1510.9 MHz	FDD
22	3410 MHz – 3490 MHz	3510 MHz – 3590 MHz	FDD
23[1]	2000 MHz – 2020 MHz	2180 MHz – 2200 MHz	FDD
24	1626.5 MHz – 1660.5 MHz	1525 MHz – 1559 MHz	FDD

[2] 3GPP TS 36.101[4], Table 5.5-1 E-UTRA operating bands

E-UTRA Operating Band	Uplink (UL) operating band BS receive UE transmit F_{UL_low} – F_{UL_high}	Downlink (DL) operating band BS transmit UE receive F_{DL_low} – F_{DL_high}	Duplex Mode
25	1850 MHz – 1915 MHz	1930 MHz – 1995 MHz	FDD
26	814 MHz – 849 MHz	859 MHz – 894 MHz	FDD
27	807 MHz – 824 MHz	852 MHz – 869 MHz	FDD
28	703 MHz – 748 MHz	758 MHz – 803 MHz	FDD
30[15]	2305 MHz – 2315 MHz	2350 MHz – 2360 MHz	FDD
31	452.5 MHz – 457.5 MHz	462.5 MHz – 467.5 MHz	FDD
33	1900 MHz – 1920 MHz	1900 MHz – 1920 MHz	TDD
34	2010 MHz – 2025 MHz	2010 MHz – 2025 MHz	TDD
35	1850 MHz – 1910 MHz	1850 MHz – 1910 MHz	TDD
36	1930 MHz – 1990 MHz	1930 MHz – 1990 MHz	TDD
37	1910 MHz – 1930 MHz	1910 MHz – 1930 MHz	TDD
38	2570 MHz – 2620 MHz	2570 MHz – 2620 MHz	TDD
39	1880 MHz – 1920 MHz	1880 MHz – 1920 MHz	TDD
40	2300 MHz – 2400 MHz	2300 MHz – 2400 MHz	TDD
41	2496 MHz 2690 MHz	2496 MHz 2690 MHz	TDD
42	3400 MHz – 3600 MHz	3400 MHz – 3600 MHz	TDD
43	3600 MHz – 3800 MHz	3600 MHz – 3800 MHz	TDD
44	703 MHz – 803 MHz	703 MHz – 803 MHz	TDD
45	1447 MHz – 1467 MHz	1447 MHz – 1467 MHz	TDD
46	5150 MHz – 5925 MHz	5150 MHz – 5925 MHz	TDD[8]
47	5855 MHz – 5925 MHz	5855 MHz – 5925 MHz	TDD11
48	3550 MHz – 3700 MHz	3550 MHz – 3700 MHz	TDD
49	3550 MHz – 3700 MHz	3550 MHz – 3700 MHz	TDD16
50	1432 MHz - 1517 MHz	1432 MHz - 1517 MHz	TDD13
51	1427 MHz - 1432 MHz	1427 MHz - 1432 MHz	TDD13
65	1920 MHz – 2010 MHz	2110 MHz – 2200 MHz	FDD
66	1710 MHz – 1780 MHz	2110 MHz – 2200 MHz	FDD[4]
68	698 MHz – 728 MHz	753 MHz – 783 MHz	FDD
70	1695 MHz – 1710 MHz	1995 MHz – 2020 MHz	FDD[10]
71	663 MHz – 698 MHz	617 MHz – 652 MHz	FDD
72	451 MHz – 456 MHz	461 MHz – 466 MHz	FDD
73	450 MHz – 455 MHz	460 MHz – 465 MHz	FDD
74	1427 MHz – 1470 MHz	1475 MHz – 1518 MHz	FDD

3.2 Handsets

Once ready to roam, HPMNs need to ensure that their handsets have VoLTE roaming enabled. Initial setting of VoLTE enabled handsets distributed by most operators were found to not have VoLTE roaming enabled. Operators must work with their handset vendors to modify the defaults. The restriction is typically removed with software updates or OTA configuration settings, which requires collaboration and support from device manufacturers.

To facilitate interoperability, GSMA PRD TS.32 [19] documents a minimum set of configuration parameters to be supported on devices and includes (inter alia) both LTE and IMS settings. Subsequently, the GSMA launched its Network Settings Exchange (NSX) database (see https://www.gsma.com/services/nsx/) which enables MNOs to specify their preferred configuration settings and for OEMs to access these settings and thus customize their devices on SIM insertion. In addition, work is ongoing to limit differences between MNOs (e.g. in a country or region) to encourage commonality of settings and reduce the testing overhead in proving devices for all of the required configuration settings.

On attaching to a VPMN, the device is provided with the VOPS (Voice over Packet Switched) Indicator which informs the device whether VoLTE is applicable. This indicator

must only be set by the network if a S8HR VoLTE Roaming agreement exists for the inbound roamer.

3.3 Device based Steering of Roaming

Due to the varying array of VPMN frequencies, and bands in use as well as the potential for handset incompatibility as noted in Section 3.1, VoLTE roaming presents an increased risk for incompatibility between HPMN handsets and corresponding VPMN networks. VoLTE roaming introduces an additional set of potential conditions that could impact the ability for HPMN devices to achieve and maintain an optimized roaming experience. Examples of such conditions include:

- device that does not have the software update or configuration required to use VoLTE roaming;
- device is capable of VoLTE roaming but does not have the correct spectrum band to function well with the preferred roaming partner.

As such, HPMNs should consider a device based steering solution to ensure that their devices can efficiently register only on desired compatible networks prior to launching VoLTE roaming.

4 Billing Issues

4.1 Comparison of QCI-based charging and APN-based charging

Prior to S8HR VoLTE roaming, LTE data services were provided as best effort. With VoLTE S8HR Roaming, the data bearers are assigned different QCI values and the QCI value affects network resource usage differently and the QoS (Quality of Service) is assigned to a specific bearer. Regardless of whether the operators decide to charge differently for S8HR data bearers, it is recommended that operators be able to identify the traffic to enable billing and reporting.

It is possible to charge based on QCI of the bearer used or on APN used by roamers. MNOs will need to discuss in advance the billing options that their Roaming Partner supports.

The difference between QCI-based charging and APN-based charging is best depicted by Figure 2. While APN-based and QCI-based charging would most likely not make a difference for data roaming, it would be significantly different for S8HR VoLTE Roaming as there are potentially three different QCI values (voice media, video media and IMS signalling) involved. If APN-based charging is employed, all of the three types of bearers would be treated the same in charging (i.e. APN-based charging would consider 100kb of IMS signalling to be same as 100kb of voice media). On the other hand, QCI-based charging would differentiate charging based on QCI and allows operators to apply different rates for different QCIs. However, the effort to differentiate by QCI may not be beneficial when considering the relative data volumes over the IMS-APN between IMS signalling (<15KBytes/call), IMS voice media (0.31Mbytes/minute for AMR-WB using the highest mode-set at 23.85Kbits/second) and IMS video media (conservatively at around 2.9Mbytes/minute for H.264). Of course, the total data volume on the IMS-APN is in turn dwarfed by that on the data/INTERNET APN using QCI=9.

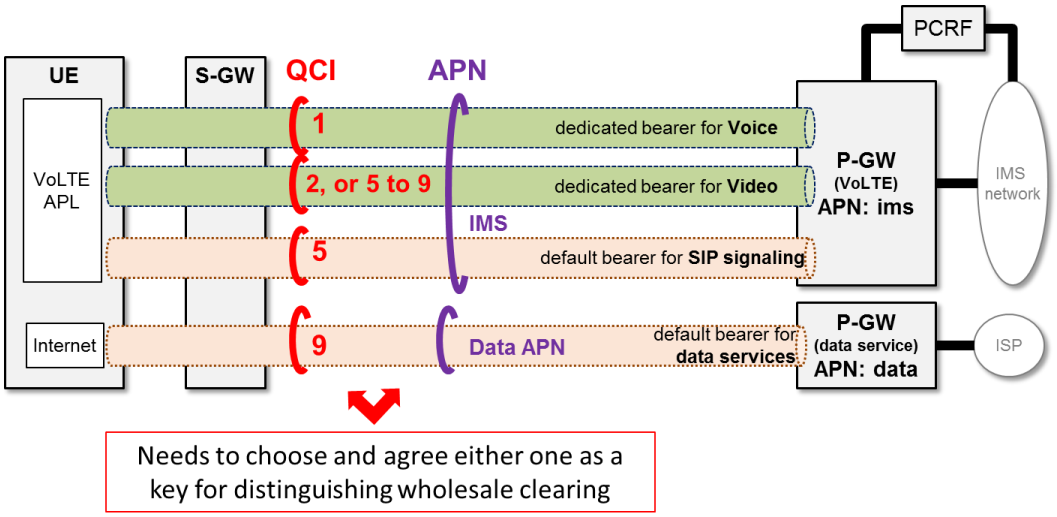

Figure 2 Wholesale clearing based on QCI or APN

Whilst the S8HR model resembles existing LTE data roaming, different charging models for IMS based services can be used to allow differentiation from LTE data. Charging for IMS services can be APN-based, QCI-based based or based on the actual service, as currently in use by Operators. All approaches are valid and the chosen model must be agreed by roaming partners based the capabilities of each partner.

Charging by QCI will require either the use of TAP version 3.12, as detailed in GSMA PRD TD.58[15], which provides the fields required for differential charging by QCI or by using a Billing and Charging Evolution process as outlined in TD.201[16] and TD.202[17].

4.2 Signalling

As the HPMN has visibility of all calls in real time, the HPMN can retail charge based on TAS (Telephony Application Server) billing records for voice calls. SMS can also be part of IMS SIP (Session Initiation Protocol) signalling used over default IMS bearer or sent in the NAS signalling; in both cases, SMS should be rated based on SMSC (Short Message Service Centre) billing records.

4.3 Retail Presentation

4.3.1 Billing from Home Network Elements

To bill the S8HR VoLTE Roaming CDRs, the HPMN needs to modify its home back office systems to identify VoLTE roaming calls separately from on-network VoLTE calls. Information on identifying serving networks can be found in IR.65**Error! Reference source not found.** under “P-CSCF Identifier Coding”.

4.3.2 Time Zones

For S8HR, the ideal solution is for the NetLoc (“Network Provided Location Information for IMS”) information element to be sent by the VPMN to the HPMN. However, this information element is optional and is not provided by all VPMNs.

In addition, where the VPMN has more than one-time zone in the country, retail bills could be incorrect as all calls would be recoded in a single time zone, regardless of the actual time zone applicable to the call.

There are thus three potential scenarios:

- Scenario 1: VPMN provides “NetLoc”. The HPMN is thus provided with the correct time zone. This is the correct and preferred solution.
- Scenario 2: VPMN does not provide “NetLoc” but the HPMN has a time zone offset table indexed by the visited country. In this case, the time may be incorrect if there are multiple time zones in the visited country.
- Scenario 3: Visited Network does not provide “NetLoc, and the HPMN does not have an entry for the visited country in the time zone offset table. This scenario should not happen as the HPMN should populate the time zone offset table for all countries with which it has a VoLTE Roaming agreement.

In terms of the impact on retail billing, it is recommended that:

- Call are stamped with the correct local time for scenario 1.
- Calls are stamped with a single country local time from the time zone offset table for scenario 2, which may be incorrect if multiple time zones in that country.
- Calls are stamped with an unknown time for scenario 3.

5 Technical Issues Important to Roaming Managers

5.1 QCI Settings

As operators deploy VoLTE services on their own network, they will design QoS policy as per their requirements and network design. The QoS policies on the visited network and home network will have differences in most cases. Care must be taken when designing the QoS policy for inbound roamers and communicated early on with the roaming partner. For example, for ViLTE service, some operators have chosen to use GBR (Guaranteed Bit Rate) QCI 2, whereas, some have chosen to use a Non-GBR (typically QCI 8). The QCI values to be supported for roaming are dependent on the roaming agreement. In order to simplify VoLTE Roaming, it is recommended that standard settings are applicable to all VoLTE Roaming agreements. Such a recommendation is provided in annex E of GSMA PRD IR.88[12].

5.1.1 GBR Configurations

Mismatches in GBR requirements between the HPMN and VPMN can result in call failure during S8HR VoLTE roaming.

Therefore, it is recommended that there be a standard configuration to be applied to all VoLTE Roaming agreements see Annex E of GSMA PRD IR.88[12].

5.2 Lawful Intercept

Lawful intercept requirements are market specific, with the following variations:

- Local regulations require that the entire data stream of the inbound roaming subscriber is provided to the authorities,
- No regulatory requirements for inbound roamers,

Therefore, roaming agreements must either enable/disable the encryption of IMS signalling to reflect the requirements of the VPMN. The 3GPP specifications mandate the use of IPSEC to be used on IMS signalling but permit encryption to be either enabled or disabled.

It is observed that there have been some observed problems with devices as the encryption policy has differed dependent on whether the UE is roaming or not. This behaviour is incorrect and OEMs should obey the 3GPP standards and negotiate the encryption policy as part of the IMS registration sequence.

5.3 SRVCC

SRVCC was introduced to provide voice continuity in the early days of VoLTE deployment where LTE coverage was patchy and the voice call was transferred to legacy RAN and CS-voice on moving out of LTE coverage. As LTE / VoLTE deployments has increased over the years, the need for SRVCC has steadily diminished. Therefore, in the context of S8HR Roaming, it is assumed that SRVCC is not required.

5.4 Fraud Systems

With S8HR VoLTE roaming, the VPMN can see QCI1 flows and therefore is voice flow aware however the VPMN is not IMS Service Aware The HPMN is handling the call so it must ensure that the roaming calls being handled by the home network are appropriately identified within its Fraud Management Systems (FMS) as roaming. This will likely require changes to the FMS feeds.

5.5 Emergency Calling

A Standards Based solution is described in GSMA PRD IR.65[11].

On detecting an emergency call, the UE must support emergency call procedures via both CS-domain and IMS, and support domain selection as described in 3GPP TS 23.167[2] Annex H.

In the case of S8HR VoLTE Roaming, emergency calls can either be provided by the CS network or via the VPMN IMS. It is assumed that the long term goal is to switch off the CS network at which point emergency calls for inbound roamers must be handled by the VPMN IMS. The device is informed by the N/W whether emergency calls are supported via LTE via the Emergency Bearer Services Supported indicator.

Emergency calls via the VPMN IMS for inbound roamers are completed using so-called anonymous IMS emergency calls. On detecting an emergency call, the device shall initially attempt to perform an IMS emergency Registration to the VPMN's IMS. This registration is rejected as there is no inter-IMS interface between the VPMN and HPMN. The rejection message indicates that anonymous IMS emergency call is supported. The VPMN must therefore enable support of anonymous IMS emergency call.

There is also a need for non-UE detected emergency calls to be handled. In this case, for S8HR VoLTE Roaming, the call would be routed to the HPMN IMS. The HPMN IMS must be

aware of the emergency digit strings in the VPMN (see GSMA PRD NG.119[13]) and recognise a non-UE detected emergency call. The SIP session is rejected with an indication to the UE that the call was an emergency call. The UE then behaves as for a UE detected emergency call. It is also recommended that the VPMN provide the UE with a list of local emergency number during the initial attach to minimise the occurrence of a non-UE detected emergency call being initially offered to the HPMN IMS.

5.5.1 eCall

A variant of emergency calling that must also be considered is that of eCall.

eCall is a European initiative to reduce response times in the event of a serious road traffic accident. An eCall system can initiate either an automatic emergency call as well as a manually initiated eCall. Original eCall standards were based on CS technology with use of an in-band modem to transfer the eCall Minimum Set of Data (MSD) comprising such things as location, vehicle identity etc.

Subsequently, 3GPP standards were enhanced to support an IMS based version of eCall with the MSD carried in an XML body using procedures in IETF RFC 8147**Error! Reference source not found.**. There is also the capability to exchange additional information to that of the CS-based version.

The LTE network broadcasts support of eCall to the UE. The requirements for IMS based eCall are defined in 3GPP TS 23.167[1] Annex H.6.

5.6 Testing Considerations

Network Testing for VoLTE Roaming is covered in GSM PRD IR.25[9] & TADIG Testing for VoLTE Roaming is covered in GSMA PRD TD.50[14].

Regarding devices the required test cases are in GSMA PRD TS.11[18] and 3GPP TS 34.229[3]. The former is used for field trial testing and the latter for more in-depth certification testing.

However, there are a number of practical problems in the testing of VoLTE/Roaming:

- OEM Blocking of VoLTE – open market devices deliberately disable their VoLTE/IMS capability on insertion of a SIM indicating a network (MCC/MNC) that has not been tested sufficiently. Such blocking is carried out by the OEM to prevent a bad user experience when connecting to an « untested » network and resulting reputational damage to the device. Such blocking also tends to impact to a greater extent on smaller MNOs.
- OEM Blocking of VoLTE Roaming – This issue is believed to be caused by historical reasons due to incorrect setting of the VOPS indicator.
- Device Settings – It is observed that there is a testing overhead due to the need to test the different device settings preferences of a given MNO for a given device. Despite a previous GSMA initiative to standardise the configuration parameters in PRD TS.32[19] in order to facilitate interoperability between devices and networks, there is still too much deviation between different MNOs and the need to test all combinations.

- Shipping of Devices – It is noted that there is currently a need to ship devices around the globe to enable them to be tested in a given network with its settings reflecting the preferences of that network. The shipping of devices incurs inherent delays and costs (e.g. import duties).
- Testing Overhead – There are over 1800 hundred VoLTE capable devices and currently circa 200 VoLTE launches, with variations between the MNOs regarding their TS.32[19] parameter preferences. VoLTE Roaming enables any device to appear in any network. The need to test “everything everywhere” is overwhelming. There is a need to have a methodology and testing strategy to break down the problem into a manageable task.
- Lack of Education / Confusion – MNOs complain that it is not clear exactly what needs to be tested in order to deploy VoLTE Roaming.

The GSMA is working on a number of initiatives to facilitate VoLTE Roaming testing. These include:

- Use of a standard set of tests. This already exists in 3GPP TS 34.229[3]. These tests can be broken down into a number of different suites to address VoLTE, S8HR Inbound VoLTE Roaming, S8HR Outbound VoLTE Roaming and interaction with the VPMN IMS (i.e. for emergency calls).
- Use of a standard testing methodology using commercial test tools. The methodology is to firstly test the Network and (when the Network is proven) the move to testing devices on a proven Network.
- Limit differences of configuration settings in MNO Networks to minimise differences and required testing. Promote the use of NSX and commonality of configuration settings within NSX to a limited number.
- Set up a distributed framework of testing locations who would co-operate as needed and share test results for the common good. Locations can test co-operatively using IP-VPN technology.
- Minimise the shipping of devices. Ship only SIMs instead.
- Use the sharing of testing and test results to create a “snowballing effect” to make the overall task more practical / manageable. It is thus impossible to test every device in every N/W within any reasonable timescale. The best that can be done practically is to provide a framework that gives a degree of confidence in a given device / Network based on the common test suites. The test results (i.e. which device was tested for which configuration setting) needs to be shared and accessible to all.
- Last but not least, no testing is possible if OEMs persist with disabling IMS on the device for “untested networks”.

Annex A VoLTE Roaming Checklist

These questions are all optional. The checklist can be modified to fit the operator's needs with additions or deletions.

Please note AA.13[5] Annex C14 contains the VoLTE Roaming Agreement Annex and a Commercial Launch Letter can be found as an Annex to BA.50[6].

VoLTE Roaming Questionnaire:

Questions	MNO A	MNO B (sample answers in italics)
Deployment Status & Readiness Questions:		
Have you launched IMS-based VoLTE services on your network?		*Yes, VoLTE services launched on mm/dd/yyyy.* *No, planned launch of VoLTE services on mm/dd/yyyy.*
What architecture will you use for VoLTE roaming enablement?		*S8HR, LBO, or both?*
Can you share your VoLTE coverage map?		*Coverage information is available at https://www.MNO_B.com/maps/wireless-coverage.html*
VoLTE Roaming Status - have you launched VoLTE roaming yet? If so, a. inbound VoLTE roaming? B. outbound VoLTE roaming?		*VoLTE roaming is bilaterally launched in x countries Country 1, Country 2, Country 3. . .) with Y carriers.*
When will you be ready to start commercial testing for inbound VoLTE roaming? Are there any restrictions on inbound roaming?		*mm/yyyy.* *Note: Do not have CSFB.*
When will you be ready to start commercial testing for outbound VoLTE roaming?		*mm/yyyy.* *Note: list restrictions if needed*
Technical Questions:		
Are you compliant with the recommendations in IR.88[12]? If not, what are your deviations?		*MNO B is compliant with IR.88[12] with a deviation of QCI 8 for video and for CODEC s MNO B only allows 0-3. MNO B provides up to 512kbps minimum for inbound VoLTE roamers. MNO B outbound roamers*

		require 51kbps minimum for VoLTE on the serving network
What QCI do you support on your network?		*Support QCI=1 for VoLTE, QCI=2 for ViLTE, QCI=5 for SIP Signaling and QCI=9 for internet access.*
Which IPX provider(s) will be used for VoLTE roaming?		*Have several IPX providers; specific provider subject to bilateral discussion between roaming partners.*
What is your Emergency calling policy for inbound roamers?		*Provide emergency services via VoLTE and CSFB.*
What emergency numbers does your network support? If your MME announces your emergency number(s) list, does it follow the standards?		*Network supports both 911 and 112.* *MME does not announce emergency number(s) list.*
What is your legal/regulatory requirement for support of Lawful Intercept? Does the VPMN require the HPMN to turn IMS encryption off?		*Yes, VPMN requires IMS encryption turned off for inbound roamers.* *No, do not require the HPMN to turn off IMS encryption*
Does your network support IPv6 PDN type?		*Yes, IPv6 is supported.*
Do you support the NetLoc procedure to provide time zone information?		*Yes, NetLoc is currently supported and MNO B requires NetLoc for its outbound roamers*
Additional Supported Services Questions:		
What method of SMS are you supporting for VoLTE?		*SMS over IMS* *SMS over SGs (EPC)*
Do you support SRVCC for inbound roamers to your network? * * Only applicable where HPMN supports SRVCC (as it requires both partners		*Yes* *No*

for this to be successful (device and network)		
If the visited network broadcasts multiple MCC/MNCs, which MCC/MNC will be in the ULI field. Are these MCC/MNC's being used by the ECGI provided on the IR.21[8]?		
End to end QoS, especially over IPX - Any E2E QoS requirement on IPX carrier (e.g. DSCP tagging based on GSMA IR.34[10])		*Yes, we can.*
Wholesale Charging Questions:		
Do you support the standard volume-based charging for VoLTE?		*Yes*
Do you charge by APN, QCI or both?		*Can charge by APN or QCI*
Do you support TAP 3.12? **(note: 3.12 and beyond supports VoLTE)**		*Yes.*
Can you support a BCE file exchange and settlement process?		*Yes.*
IREG/TADIG Planning:		
Testing environment (On Production or Lab environment)		*On Production*
What devices (make, model) do you offer to your subscribers that are VoLTE-capable?		*Total XX models as of dd/mm/yyyy:* *iPhone: iPhoneX, iPhone 8, iPhone 7, iPhone 7 Plus, iPhone 6s, iPhone 6s Plus, iPhone SE.* *Android: LG G3 Vigor, LG G5, LG V10, LG V20, LG K10; Samsung Galaxy S7, Samsung Galaxy S7 Edge, Samsung Galaxy S7 Active, Samsung Galaxy S6, Samsung Galaxy S6 Active, Samsung Galaxy J3, Samsung Galaxy S5; HTC One*

		A9; PRIV by Blackberry; Microsoft Lumia 950, Microsoft Lumia 640 XL; Kyocera DualForce XD.)
Are additional SIMs required for testing or can exiting LTE SIM cards be modified and used?		*MNO B does not require additional SIM cards be shipped. It plans to modify existing LTE cards by adding VoLTE profile.*
Any needs of VoLTE handsets shipped to roaming partners for VOLTE roaming?		Yes - # of devices and types are To Be Determined, but MNO B is anticipating device/SIM exchange for IREG/TADIG testing.
Are you compliant with IR.25[9] VoLTE Roaming for IREG testing? If not, please provide your test plan.		*Yes, use PRD IR.25[9] and/or a condensed version for IREG/TADIG testing, but may seek to perform additional testing.*
Do you restrict test SIMs during VoLTE roaming testing and if so how?		*MNO B can restrict test SIMs just for IREG/TADIG testing.* *a. For Outbound roaming, if no, how is this enforced? Is Screening of IMS APN by HSS?* *b. For serving network, do you restrict MMEs to test IMSI's only during IREG testing?*
Do you send TD test files?		*Have capability to screen out IMS APN except for test SIMs used during testing of IREG.*
LTE/eUTRAN, HSS, EPC (SGW/PGW/PCRF) and IMS infrastructure vendor		Vendor 1 and Vendor 2
Contacts		
Contacts		*1. Name 1/ employee1@MNO_B.com / +X.XXX.XXX.XXXX / Title 1* *2. Name2 / employee2@MNO_B.com / +X.XXX.XXX.XXXX / Contact Title (VoLTE Roaming)* *3. Name3 / IamGroot@MNO_B.com / +X.XXX.XXX.XXXX / Technical Contact-IREG Coordinator* *4. Name4 / employee4@MNO_B.com/ +X.XXX.XXX.XXXX/ Technical Lead – Implementation/Onboarding*