MCMC MTSFB TC Gxxx:XXXX

TECHNICAL CODE

VOICE OVER LTE - SYSTEM AND DEVICE COMPATIBILITY

Developed by

Malaysian Technical Standards Forum Bhd

Registered by

MCMC

Registered date:

MCMC MTSFB TC Gxxx:XXXX

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Committee representation

This technical code was developed by VoLTE, VoNR & VoWiFi Sub Working Group under the International Mobile Telecommunications and Future Networks Working Group of the Malaysian Technical Standards Forum Bhd (MTSFB), which consists of representatives from the following organisations:

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Foreword

This technical code for Voice over LTE - System and Device Compatibility ('this Technical Code') was developed pursuant to Section 185 of the Communications and Multimedia Act 1998 (Laws of Malaysia Act 588) by the VoLTE, VoNR & VoWiFi Sub Working Group under the International Mobile Telecommunications and Future Networks Working Group of the Malaysian Technical Standards Forum Bhd (MTSFB).

This Technical Code shall continue to be valid and effective from the date of its registration until it is replaced or revoked.

VOICE OVER LTE - SYSTEM AND DEVICE COMPATIBILITY

0. Introduction

Voice over Long-Term Evolution (VoLTE) is a technology standard for delivering voice communications and multimedia services over 4G Long-Term Evolution (LTE) networks. It enables voice calls to be made over an LTE network originally designed primarily for high-speed data transfer. VoLTE replaces traditional circuit-switched voice networks with a packet-switched IP-based approach, leveraging LTE capabilities to enhance voice quality and efficiency. By transmitting voice as data packets over the LTE network and utilizing the IP Multimedia Subsystem (IMS) core network for session control and media services, VoLTE provides a seamless and efficient voice communication experience.

Key features of VoLTE include High Definition (HD) voice quality, which supports higher audio frequencies and offers clearer, crisper voice quality compared to traditional 2G and 3G networks. VoLTE also ensures faster call setup times, reducing the time it takes to establish a call and allows simultaneous voice and data usage, enabling users to make voice calls while using LTE data services without interruptions. Furthermore, VoLTE is more spectrum-efficient and reduces the load on legacy voice networks, allowing operators to reallocate spectrum for data services.

VoLTE works by utilizing the IMS core framework, which provides the necessary control and signalling functions for setting up and managing VoLTE calls. It relies on the Session Initiation Protocol (SIP) to initiate, maintain, and terminate real-time sessions, including voice calls. Additionally, Quality of Service (QoS) mechanisms ensure that voice packets are given priority and adequate bandwidth to maintain high-quality voice communication.

The VoLTE system relies on several key technical specifications to deliver high-quality voice services over LTE networks. The network architecture is centered around the IMS core network, which handles control, signaling, and media services, supported by components like the Call Session Control Functions (CSCF) and Home Subscriber Server (HSS). Signaling protocols such as SIP initiate to initiate, maintain, and terminate VoLTE sessions, while the Diameter protocol manages authentication, authorization, and accounting. Quality of Service (QoS) is ensured through the QoS Class Identifier (QCI), which prioritizes voice packets to maintain call quality. Media handling involves using the Real-Time Protocol (RTP) for audio stream transmission and codecs like Adaptive Multi-Rate Narrowband (AMR-NB) and Adaptive Multi-Rate Narrowband (AMR-WB) for encoding and decoding voice signals. These elements collectively ensure that VoLTE provides a seamless and efficient voice communication experience over LTE networks.

1. Scope

This Technical Code specifies the system and device requirements for implementation of VoLTE for:

a) VoLTE Emergency call;

b) VoLTE International/Domestic Roaming and interconnect;

c) Handover compatibility between VoLTE and Voice over New Radio (VoNR); and

d) VoLTE Supplementary services.

2. Normative references

The following normative references are indispensable for the application of this Technical Code. For dated references, only the edition cited applies. For undated references, the latest edition of the normative references (including any amendments) applies.

Refer to Annex A.

3. Abbreviations

For the purpose of this Technical Code, the following abbreviations apply:

See Annex B

4. Terms and definitions

For the purposes of this Technical Code, the following terms and definitions are applied.

4.1 Access and Mobility Function (AMF)

Is a 5G core function responsible for managing access and mobility for 5G devices

4.2 Access Point Name (APN)

Access Point Name identifies the packet data network that will be providing the services to the UE.

4.3 Allocation Retention Priority (ARP)

Use during network congest to determine whether existing bearer that has lower precedence be replaced with new bearer with higher precedence value.

4.4 Call Re-establishment (CRE)

A process that allows a UE to reconnect a dropped call by switching to a different cell or network to maintain call continuity.

4.5 Call Session Control Function (CSCF)

It is a key component in IMS architecture that manages the setup, maintenance, and termination of multimedia sessions such as voice and video call over IP in LTE network**.**

4.6 Emergency Access Transfer Function (EATF)

A logical function to enable access transfer between packet-switched and circuit-switched networks.

4.7 Evolved Packet Core (EPC)

A framework for providing converged voice and data on a 4G Long Term Evolution network.

4.8 Evolved Packet System (EPS)

The long-term evolution of Universal Mobile Telecommunication System, composed of E-UTRAN and EPC.

4.9 Evolved Universal Terrestrial Radio Access Network (E-UTRAN)

It is the radio technology used between mobile terminals and the base stations.

4.10 Home Subscriber Server (HSS)

A node that serves as a central database within LTE network. It stores essential information about network subscribers, including their service profiles, preferences, and authentication data.

4.11 Home Public Mobile Network (HPMN)

Identifies the public mobile network where the user's profile is held**.**

4.12 IP Multimedia System (IMS)

It is a framework for delivering IP multimedia services such as voice, video and text messaging over IP networks.

4.13 Location Retrieval Function (LRF)

A function that provides precise location information for mobile devices, especially during emergency calls, by interfacing with network systems.

4.14 Long Term Evolution (LTE)

Long Term Evolution is the 4th generation cellular networking technology that can reach speeds of around 100Mbit/s.

4.15 Mobile Management Entity (MME)

A key control node responsible for managing user authentication, session establishment, and mobility between LTE networks.

4.16 Mobile network operator (MNO)

A provider of wireless communication service that owns or controls the network infrastructure necessary to sell and deliver services to their subscribers.

4.17 Multi Operator Core network (MOCN)

A functionality for multiple MNO to share radio access network, instead of building each own radio network.

4.18 Next Generation Emergency Services 999 (NG999)

Next Generation Emergency Services 999 is an advanced emergency response system that enhances the traditional 999 service with improved technology for faster, more efficient communication and location tracking during emergencies.

4.19 Policy and Charging Control Function (PCRF)

Manages the service policy and sends QoS setting information for each user session and accounting rule information.

4.20 Public Safety Access Point (PSAP)

Public Safety Access Point that will terminate the emergency call and direct the call to the nearest public safety services.

4.21 QoS Class Identifies (QCI)

Used to categories LTE bearers with certain bit rate (guaranteed and non-guaranteed), priorities, delay and packet loss. Each services are then assigned with different QCI values.

4.22 Quality of Service (QoS)

Refers to the capability of a network to offer service with certain quality.

4.23 Routing Determination Function (RDF)

A network component that determines the optimal route for calls to travel through the network to reach their destination efficiently.

4.24 Serving Gateway (S-GW)

Serving Gateway. It is an essential element in LTE network handling mobility of mobile devices, routes and forwards user data packets between mobile devices and P-GW.

4.25 Session Management Function (SMF)

Responsible for managing the sessions between user devices and the 5G network.

4.26 Session Initiation Protocol (SIP)

A signalling protocol to create and control multimedia sessions in IP Multimedia System.

4.27 Telephony Application Server (TAS)

It is a key component in IMS architecture delivering advanced telephony features and services over IP in LTE network.

4.28 Unified Data Management (UDM)

Is a 5G core function that manages user subscription data.

4.29 User Plane Function (UPF)

Is the data plane of the 5G core, that responsible for packet routing and forwarding, interconnection to the data network, policy enforcement and data buffering.

4.30 User Equipment (UE)

Any device used directly by an end-user to communicate over LTE network including but not limited to, cellular mobile terminals, handheld, portable and vehicle-mounted equipment and Radio Frequency (RF) interface cards and modems as long as the UE support voice call.

4.31 Visited Public Mobile Network (VPMN)

Visited Public Mobile Network identifies the network that a mobile subscriber uses when roaming outside of their Home Public Mobile Network (HPMN).

4.32 Voice over LTE (VoLTE)

Where voice call is sent as data over the LTE data channel rather than being send over the cellular voice channel.

4.33 XML Configuration Access Protocol (XCAP)

A protocol that allows user to read, write and modify their supplementary subscription.

5. VoLTE Architecture

Based on Figure 1 as depicted in ITU-T X.1041, the VoLTE Architecture shall comprise the following key components.

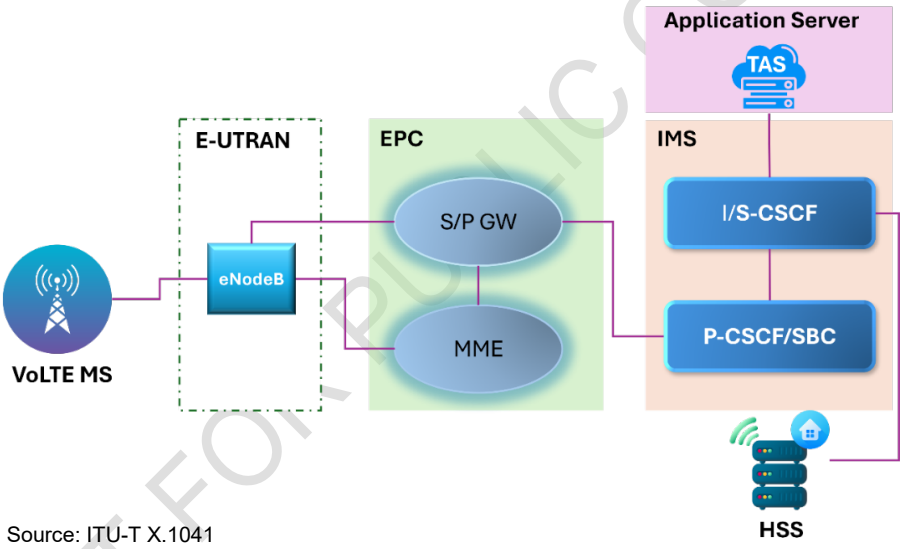


Figure 1. VoLTE architecture

a) VoLTE mobile station (MS)

The mobile device permitted to access the network and utilize the VoLTE service.

b) Evolved universal terrestrial radio access network (E-UTRAN)

Includes eNodeBs, responsible for wireless transceiving and base station control. eNodeBs handle signalling transmission via the Mobile Management Entity (MME), while data transmission is routed to the Serving Gateway (S-GW) and Public Data Network (PDN) Gateway (P-GW).

c) Evolved packet core (EPC)

Encompasses the MME and S/P-GW. The MME is vital in the core network, managing most control plane functions, while the S-GW ensures Quality of Service (QoS). The P-GW assigns IP addresses to user equipment (UE), selects routing paths, and provides interfaces to the Internet and IMS.

d) IMS

Connects the LTE network via the P-GW, facilitates VoLTE services through the Call Session Control Function (CSCF), which manages phone calls within the IMS network. The CSCF oversees VoLTE registration, call connections, and voice call transmissions and receptions. It is categorized into Proxy CSCF (P-CSCF), Interrogating CSCF (I-CSCF), and Serving CSCF (S-CSCF) based on their specific functions. The P-CSCF forwards all SIP messages between the UE and IMS, the I-CSCF locates the appropriate S-CSCF by querying the HSS, and the S-CSCF manages session-related tasks such as setup, deletion, and control.

e) Home Subscriber Server (HSS)

Contains subscriber information and shares these details with other network entities. Part of the HSS, the authentication center, generates authentication vectors for each subscriber.

f) Application servers

The telephony application server (TAS) handles signalling and media manipulation for services like local number portability, free-call routing, unified messaging, and conference bridging.

6. VoLTE interconnect and network interoperability

VoLTE and Voice over New Radio (VoNR) are essential technologies in contemporary mobile communication. VoLTE facilitates high-quality voice calls over 4G LTE networks, utilizing the all-IP infrastructure for improved call quality, reduced latency, and better connectivity.

6.1 VoLTE emergency call

The VoLTE UE and network shall support IMS emergency call according to the GSMA IR.92 standard. Emergency calls in the Circuit Switched (CS) domain shall also be supported. In areas where LTE radio coverage and/or IMS network is not available, the network shall be able to reject an IMS emergency attempt and the VoLTE UE shall support CS emergency calls as used today.

6.1.1 Delivery of emergency communication services

The Next Generation Emergency Services 999 (NG999) shall involve several key architectural and standard considerations as follows.

a) VoLTE uses the IP Multimedia Subsystem (IMS) to handle voice calls, including emergency calls.

To ensure reliable call setup, routing and prioritization of emergency services; a dedicated Emergency Access Point Name (APN) or SOS APN shall be used for emergency calls as depicted from 3GPP TS 23.167. The high level emergency call flow include the following processes and is illustrated in Figure 2.

i) The APN identifies the packet data network for assigning bearer resource for the emergency call;

ii) The UE shall recognise emergency number 999 for the UE to detect that this is an emergency call;

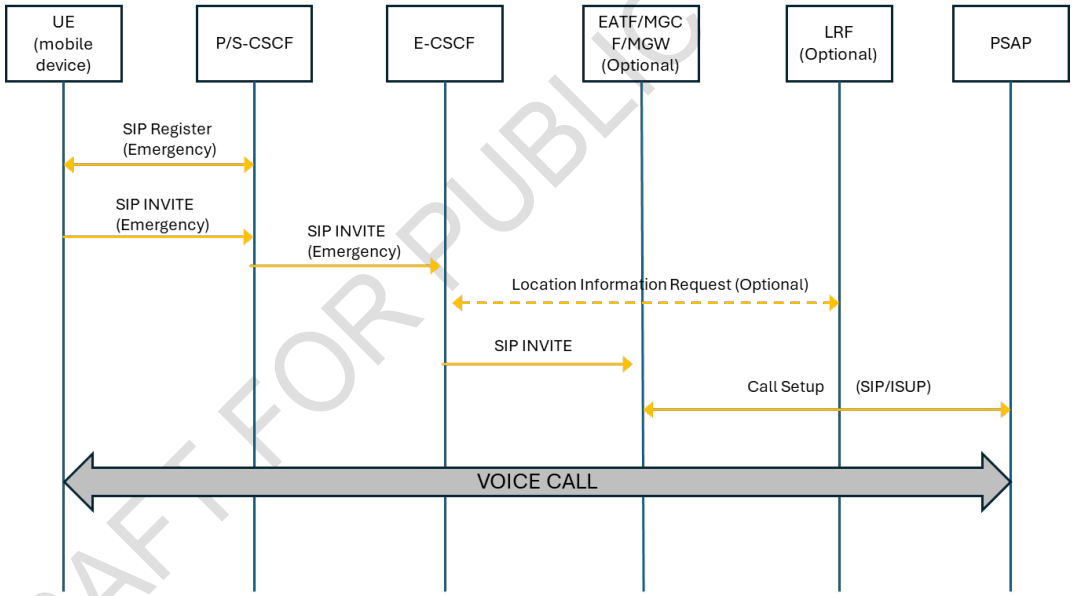
iii) The UE shall perform emergency registration to the Home Public Mobile Network (HPMN)'s P-CSCF (this registration shall contain an emergency indicator);

iv) Once P-CSCF detects the emergency request, it shall prioritize the call and select the Emergency Call Session Control Function (E-CSCF) to process it;

v) E-CSCF notified the corresponding Public Safety Answering Point (PSAP) and routed the call accordingly. In the event the PSAP terminated to non-IMS network (legacy circuit switch network) an EATF is used to transfer the call;

vi) The SIP INVITE message from UE to P-CSCF contains UE location information in the form of utran-cell-id. PSAP is required to map the cell-id information into actual coordinate or streetwise information; and

vii) P-CSCF contains location information to direct the emergency call to the nearest local emergency service.



Source: 3GPP TS 23.167

Figure 2. VoLTE Emergency Call Flow

b) Emergency call for inbound roamer

GSMA IR.88 recommended that the applicability of IMS emergency services shall be agreed between the Visited Public Mobile Network (VPMN) and the HPMN in the IMS voice roaming agreement.

c) Location Services

VoLTE shall support advanced location services in accordance with 3GPP TS 23.167 for emergency call routing and response.

d) NG999 Compliance

VoLTE shall comply with emergency call handling and effectively interface with national emergency systems. 999 shall be recognised as the primary emergency number under the NG999. VoLTE networks shall prioritise the 999-emergency number, ensuring correct routing to emergency responders and central agencies. NG999 shall integrate all emergency services under 999. Additionally, VoLTE shall recognise the international emergency number 112 and seamlessly redirect these calls to 999 for proper handling.

e) Priority and Pre-emption

VoLTE shall ensure that emergency calls receive priority over regular calls through QoS mechanisms, guaranteeing that emergency communication is not disrupted during network congestion. VoLTE emergency calls use a dedicated APN (SOS APN).

6.2 VoLTE international/domestic roaming and interconnect

This clause outlines the requirements and technical considerations for enabling seamless VoLTE services while users are roaming internationally or domestically, the QoS and the IMS interconnect.

6.2.1 VoLTE roaming

The VoLTE international roaming deployment shall comply with GSMA IR.65 and GSMA IR.88 guidelines. There are three IMS roaming architectures namely: Local Breakout VPMN Routing (LBO-VR), Local Breakout HPMN Routing (LBO-HR) and S8 Home Route (S8HR). S8HR architecture shall be deployed to support IMS services except for emergency service. S8HR is a model where the UE has obtained IP connectivity and IMS functionality from the HPMN. A high-level architecture diagram is represented in Figure 3.

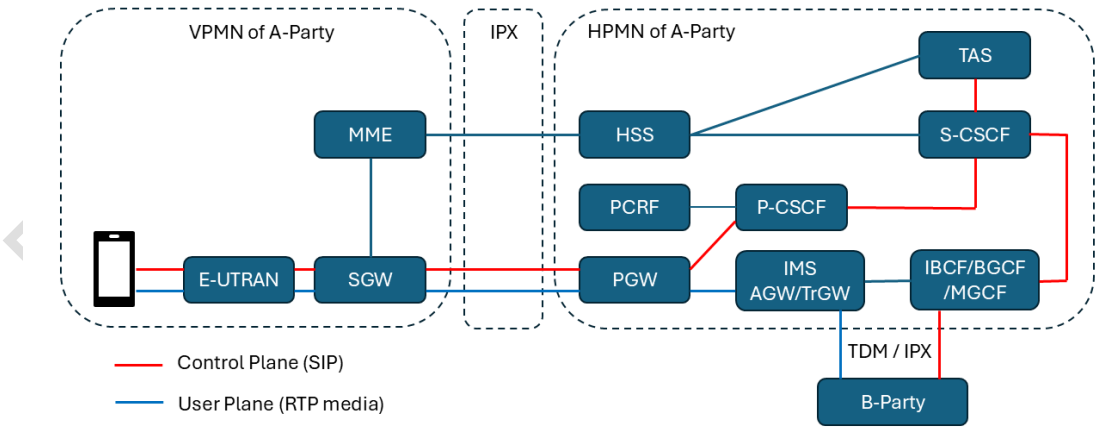


Figure 3. S8HR IMS Roaming Architecture

For S8HR VoLTE roaming, the VPMN and HPMN shall support the following conditions but not limited to as tabulated in Table 1.

Table 1. VPMN and HPMN conditions requirement for VoLTE roaming

Conditions	VPMN	HPMN
IMS APN	/	/
SIP Signalling with QCI=5;	/	/
Video media bearer with QCI=2 (or non-GBR QCI);	/	/
Voice media bearer with QCI=1;	/	/
Indication from MME to the UE “IMS VoPS (Support Indicator) = supported” if the VPMN has a roaming agreement that covers support of IMS voice with the HPMN	/	-
Indication from MME to the HSS "Homogeneous Support of IMS Voice over PS"	/	-

6.2.2 QoS for VoLTE Roaming

The VoLTE Roaming QoS policy shall follow the recommended minimum QoS parameters as stated in GSMA IR.88. However, bilateral agreements may allow operators to negotiate other values. Guidelines for proposed minimum QoS parameters for the S8HR roaming scenario, as stated in GSMA IR.88 are shown in Table 2.

Table 2. S8HR Roaming QoS Value

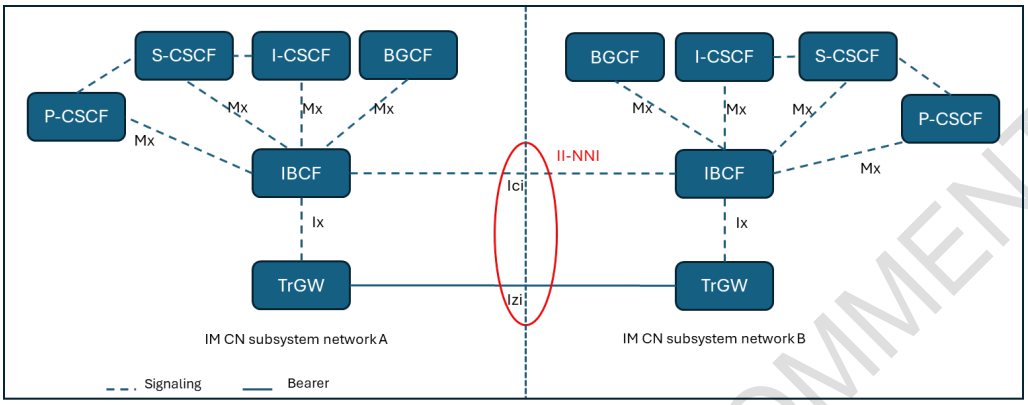
Parameter	Minimum recommended roaming QoS values						
Service	**IMS Voice**		**IMS Signaling**		**IMS Video**		**Internet**
QCI	1		5		8		9
ARP-PL	12		12		14		14
ARP-PVI	Disable[5]	Enable[5]	Disable[5]	Enable[5]	Enable[5]	-	Enable[5]
ARP-PCI	Enable[5]	Disable[5]	Enable[5]	Disable[5]	Enable[5]	Disable[5]	Disable[5]
MBR-UL	156[3]		-	-	-	-	-
MBR-DL	156[3]		-	-	-	-	-
GBR-UL	156[3]		-	-	-	-	-
GBR-DL	156[3]		-	-	-	-	-

Note:

1. Values not shown in the table are out-of-scope of this recommendation and should be agreed bilaterally between operators prior to use.
2. Values in this table are the values that an inbound operator at a minimum should support. If a lower value is requested for any parameter, it should be accepted (e.g. ARP-PL=14 has a lower priority than 12 hence it will be accepted for QCI=1).
3. Maximum Bit Rate (MBR) and Guaranteed Bit Rate (GBR) settings (in kbps) are based on the highest values needed to support three concurrent streams of QCI1 voice for all codecs, profiles, and level in 3GPP TS 26.114. Currently, AMR-NB, Round Trip Time (RTT), AMR-WB are covered.
4. IMS signalling may include SIP signalling for IMS Voice, IMS Video, SMS over IP, and Rich Communication Services (RCS) services.
5. These are recommended PCI and PVI values; however, the bearer request should not be denied based on PCI or PVI; instead, the VPMN can downgrade the requested PCI and/or PVI and accept the request. PVI downgrade is used to change the HPMN Disabled request to Enabled in the VPMN while PCI downgrade is used to change the HPMN Enabled request to disabled in the VPMN, and vice versa for PVI/PCI upgrade

6.2.3 VoLTE interconnection between Mobile Network Operators (MNO)

VoLTE interconnection, as defined by ITU-T Q.3640, shall enable end-to-end VoLTE calls between MNO. The architecture for inter-operator IMS interconnects shall follow the design outlined in GSMA IR.65, as shown in Figure 4.



Source: GSMA IR.65

Figure 4. Interconnection for inter-IMS scenario

6.3 VoLTE Service Continuity

VoLTE service shall support service continuity when a user moves between different network areas, such as from a 4G LTE network to a 2G network. It seamlessly transfers ongoing calls to the appropriate network without dropping the connection. This continuity is crucial for maintaining high-quality voice service and user experience during mobility.

6.3.1 Compatibility between VoLTE and VoNR

Voice over New Radio (VoNR) refer to the communication service that delivers voice calling capabilities over a 5G New Radio (NR) network. Both VoLTE and VoNR shall utilise IMS as the service platform for supporting communication services over Evolved Packet System (EPS) for 4G and 5G System (5GS) for 5G.

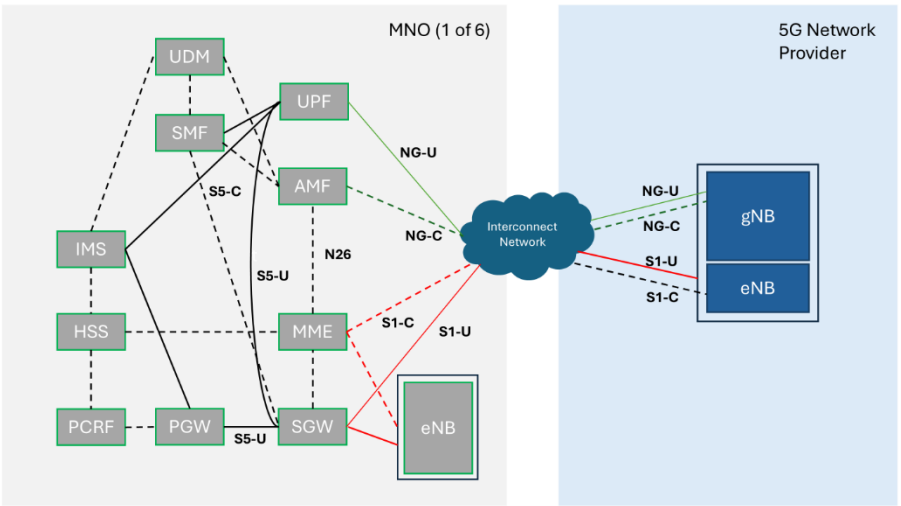


Figure 5. 5G Standalone and Non-Standalone Multi Operator Core Network (MOCN) architecture

Figure 5 shows the interworking interface between Evolved Packet Core (EPC) and 5G Core (5GC) required for NR - LTE mobility. The service continuity between VoLTE and VoNR will be supported with the N26 interface that connects AMF and MME. The support for the N26 interface between AMF in 5GC and MME in EPC is required to enable seamless session continuity for inter-system handover, which will be critical for voice services.

5G NSA uses the existing 4G LTE core network EPC and base stations (eNodeB) while adding new 5G NR base stations (gNodeB). UE registered with 5G NSA need to have EPS fallback directing the device to switch to LTE to establish voice calls via VoLTE.

5G UE with SA capability and supporting VoNR is able to make voice call on 5G bands. Interworking with VoLTE occur when UE moves from 5G bands to MNO LTE at 5G bands coverage edge. UE will move from MNO LTE to 5G bands when voice call is released and 5G bands coverage is available. UE with VoLTE call will not move to 5G bands while call is active.

For UE with SA capability but not supporting VoNR, UE need to perform EPS fallback to MNO LTE when voice call is made. When call terminates, UE returns to 5G bands.

6.3.2 VoLTE call continuity in 5G NSA

In a 5G NSA setup, which relies on LTE and uses 700MHz as the anchor band, the 5G provider shall provide smooth transitions between 5G and MNO's 4G networks. Poor optimisation of the 700MHz band, which only carries data and has wider coverage than LTE, can result in issues like VoLTE call drops and setup failures.

When a radio link failure occurs in the LTE network during VoLTE calls, the UE attempts for Call Re-Establishment (CRE) to the 5G network provider in 700MHz. 5G network provider in 700MHz shall allow QoS Class Identifier 1 (QCI1) during the CRE process and within two seconds the VoLTE call is handed back to the MNO's LTE network to ensure smooth call continuity. Figure 6 shows the layering strategy of call re-establishment setup in an area where 700MHz overlay with MNO's LTE layer.

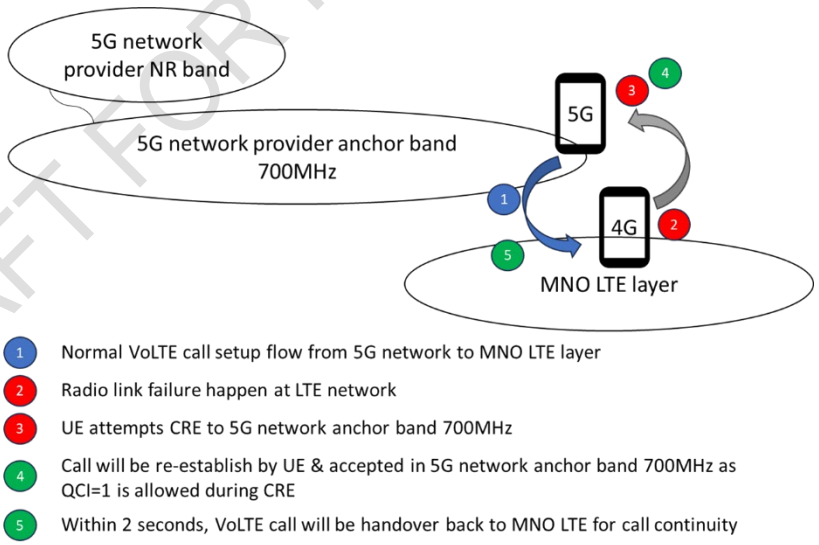


Figure 6. Layering strategy for VoLTE call re-establishment scenario

6.3.3 Compatibility between VoLTE and Circuit Switched (CS)

The VoLTE network shall support the single radio voice call continuity (SRVCC) procedure to allow customer to handover between LTE and GSM coverage according to the guidelines stipulated in GSMA IR.64.

6.4 VoLTE supplementary services

UE and IMS core shall support supplementary service configuration as depicted in GSMA IR.92, in which the support of XML Configuration Access Protocol (XCAP) over the Ut interface to carry the communications for supplementary service transactions. The supplementary services offered by devices are dependent on the network service provider. The list of supplementary services supported by the network and devices is not limited to:

a) originating identification presentation;

b) communication forwarding unconditional;

c) terminating identification presentation;

d) communication forwarding on busy;

e) communication forwarding on not reachable;

f) communication forwarding on no reply;

g) barring of all incoming calls;

h) barring of all outgoing calls;

i) barring of outgoing international calls;

j) communication hold;

k) message waiting indication;

l) communication waiting;

m) ad-hoc multi party conference; and

n) explicit communication transfer.

6.5 UE requirement

All UE shall support VoLTE and shall comply with the requirement stated in 3GPP TS 34.229-1 or equivalent standard.

The UE may include, but not limited to, cellular mobile terminals, handheld, portable and vehicle-mounted equipment, and Radio Frequency (RF) interface cards and modems. As long as the UE that support voice call it shall comply to the requirement.

The UE shall make sure it can support all supplementary services that support by the network functions according to this Technical Code whenever the UE Support the function according to Clause 6.4.

Annex A
(informative)

Normative reference

ITU-T Q.3640 (01/2018). Framework of interconnection of VoLTE/ViLTE-based networks

ITU-T X.1041 (05/2018). Security framework for voice-over-long-term evolution (VoLTE) network operation

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GSMA IR.64 Version 4.0 (4 July 2012). IMS Service Centralization and Continuity Guidelines

Annex B
(informative)

Abbreviations

For the purpose of this Technical Code, the following abbreviations apply:

AMF	Access and Mobility Management Function
AMR-NB	Adaptive Multi-Rate Narrowband
AMR-WB	Adaptive Multi-Rate Narrowband
APN	Access Point Name
ARP	Allocation Retention Priority
ARP-PCI	ARP pre-emption Capability
ARP-PL	ARP Priority Level
ARP-PVI	ARP Pre-emption Vulnerability (PVI)
BGCF	Breakout Gateway Control Function
CRE	Call Re-establishment
CSCF	Call Session Control Function
CS	Circuit Switched
E-CSCF	Emergency-Call Session Control Function
EATF	Emergency Access Transfer Function
enB	Evolved node B
EPC	Evolved Packet Core
EPS	Evolved Packet System
E-UTRAN	Evolved Universal Terrestrial Radio Access Network
GBR	Guaranteed Bit Rate
GBR-UL	Guaranteed Bit Rate - Uplink
GBR-DL	Guaranteed Bit Rate - Downlink
gnB	5G node B
HD	High Definition
HPMN	Home Public Mobile Network
HPLMN	Home Public Land Mobile Network
HSS	Home Subscriber Server
I-CSCF	Interrogating-Call Session Control Function
IBCF	Interconnection Border Control Function
IMS	IP Multimedia Subsystem
LTE	Long Term Evolution
LRF	Location Retrieval Function
MBR	Maximum Bit Rate
MBR-UL	Maximum Bit Rate-Uplink
MBR-DL	Maximum Bit Rate-Downlink
MGCF	Media Gateway Control Function
MGW	Media Gateway
MME	Mobile Management Entity
MNO	Mobile Network Operator

MOCN	Multi Operator Core Network
MS	Mobile Station
NG999	Next Generation Emergency Services 999
NSA	Non-Standalone
P-CSCF	Proxy-Call Session Control Function
P-GW	Packet Data Network Gateway
PCRF	Policy and Charging Control Function
PDN	Public Data Network
PSAP	Public Safety Access Point
QCI	QoS Class Identifier
QoS	Quality of Service
RCS	Rich Communication Services
RDF	Routing Determination Function
RTT	Round Trip Time
S-CSCF	Serving-Call Session Control Function
S-GW	Serving Gateway
SA	Standalone
SBC	Session Border Control
SIP	Session Initiation Protocol
SMF	Session Management Function
SRVCC	Single Radio Voice Call Continuity
TAS	Telephony Application Server
UDM	Unified Data Management
UPF	User Plane Function
UE	User Equipment
VoLTE	Voice over Long-Term Evolution
VoNR	Voice over New Radio
VPMN	Visited Public Mobile Network
VPLMN	Visited Public Land Mobile Network
XCAP	XML Configuration Access Protocol

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