ETSI TS 103 905 V1.1.1 (2024-11)

TECHNICAL SPECIFICATION

**Core Network and Interoperability Testing (INT);
VoNR/ViNR and VoLTE/ViLTE interconnection testing for interworking and roaming scenarios with QoS/QoE**

Reference
DTS/INT-00196

Keywords
QoE, QoS, ViLTE, ViNR, VoLTE, VoNR

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Foreword

This Technical Specification (TS) has been produced by ETSI Technical Committee Core Network and Interoperability Testing (INT).

The test case list and test selection are contained in archive ts_103905v010101p0.zip which accompanies the present document.

Modal verbs terminology

In the present document "**shall**", "**shall not**", "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the ETSI Drafting Rules (Verbal forms for the expression of provisions).

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Introduction

Voice over LTE (VoLTE) and Voice over 5G utilize the same IMS (IP Multimedia Subsystem) as defined in 3GPP. While the IP IMS framework remains the same, technological improvements in radio, core and devices are expected to provide superior user experience in VoNR compared to VoLTE.

1 Scope

The present document aims to ensure the verification of various interconnections, including interoperability, interworking, and roaming, in compliance with national and international requirements and Service Level Agreements (SLAs) among operators.

Voice over LTE (VoLTE) and Voice over 5G both use the IP Multimedia Subsystem (IMS) framework as defined in 3GPP. Although the IMS framework remains the same, technological advancements in radio, core, and devices are expected to deliver a better user experience in Vo5G compared to VoLTE. Therefore, the end-to-end scenarios and tests for interconnection and roaming described in ETSI TS 103 397 [2] respectively ETSI TS 101 585 [11] remain valid.

Additionally the present document provides a series of test suites for Quality of Service (QoS) and Quality of Experience (QoE) based on KPI for voice quality measurements and KPI for voice quality measurements.

NOTE: Clauses 4.2, 4.3, 4.4 and 4.5 describe the establishment of connections on the 5G core. This is repeated information which serves solely the purpose of a better understanding of the configurations and use cases defined for VoNR in the present document.

2 References

2.1 Normative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

Referenced documents which are not found to be publicly available in the expected location might be found in the ETSI docbox.

NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long term validity.

The following referenced documents are necessary for the application of the present document.

[1] IETF RFC 3261 (2002): "SIP: Session Initiation Protocol".

[2] ETSI TS 103 397 (V1.1.2): "Core Network and Interoperability Testing (INT); VoLTE and ViLTE interconnect, interworking and roaming test specification with QoS/QoE (3GPP™ Release 12)".

[3] ETSI TS 123 316 (V17.5.0): "5G; Wireless and wireline convergence access support for the 5G System (5GS) (3GPP TS 23.316 version 17.5.0 Release 17)".

[4] ETSI TS 123 501 (V17.11.0): "5G; System architecture for the 5G System (5GS) (3GPP TS 23.501 version 17.11.0 Release 17)".

[5] ETSI TS 123 502 (V17.11.0): "5G; Procedures for the 5G System (5GS) (3GPP TS 23.502 version 17.11.0 Release 17)".

[6] ETSI TS 124 301 (V17.11.0): "Universal Mobile Telecommunications System (UMTS); LTE; 5G; Non-Access-Stratum (NAS) protocol for Evolved Packet System (EPS); Stage 3 (3GPP TS 24.301 version 17.11.0 Release 17)".

[7] ETSI TS 124 501 (V17.13.0): "5G; Non-Access-Stratum (NAS) protocol for 5G System (5GS); Stage 3 (3GPP TS 24.501 version 17.13.0 Release 17)".

[8] ETSI TS 138 300 (V17.7.0): "5G; NR; NR and NG-RAN Overall description; Stage-2 (3GPP TS 38.300 version 17.7.0 Release 17)".

[9] ETSI TS 138 331 (V17.7.0): "5G; NR; Radio Resource Control (RRC); Protocol specification (3GPP TS 38.331 Version 17.7.0 Release 17)".

[10] ETSI TS 123 216 (V17.1.0): "Digital cellular telecommunications system (Phase 2+) (GSM); Universal Mobile Telecommunications System (UMTS); LTE; Single Radio Voice Call Continuity (SRVCC); Stage 2 (3GPP TS 23.216 version 17.1.0 Release 17)".

[11] ETSI TS 101 585 (V2.1.1): "Core Network and Interoperability Testing (INT); IMS interconnection tests at the Ic Interface; (3GPP™ Release 13); Test Suite Structure and Test Purposes (TSS&TP)".

[12] ETSI TS 123 401 (V16.14.0): "LTE; General Packet Radio Service (GPRS) enhancements for Evolved Universal Terrestrial Radio Access Network (E-UTRAN) access (3GPP TS 23.401 version 16.14.0 Release 16)".

[13] ETSI TS 138 508-1 (V17.11.0): "LTE; 5G; 5GS; User Equipment (UE) conformance specification; Part 1: Common test environment (3GPP TS 38.508-1 version 17.11.0 Release 17)".

[14] ETSI TS 124 229 (V17.13.0): "Digital cellular telecommunications system (Phase 2+) (GSM); Universal Mobile Telecommunications System (UMTS); LTE; 5G; IP multimedia call control protocol based on Session Initiation Protocol (SIP) and Session Description Protocol (SDP); Stage 3 (3GPP TS 24.229version 17.13.0 Release 17)".

[15] ETSI TS 138 413 (V17.7.0): "5G; NG-RAN; NG Application Protocol (NGAP) (3GPP TS 38.413 version 17.7.0 Release 17)".

[16] ETSI TS 103 222-3 (V1.2.1): "Speech and multimedia Transmission Quality (STQ); Reference benchmarking, background traffic profiles and KPIs; Part 3: Reference benchmarking, background traffic profiles and KPIs for UMTS, VoLTE and VoNR".

[17] ETSI TS 129 165 (V17.6.0): "Digital cellular telecommunications system (Phase 2+) (GSM); Universal Mobile Telecommunications System (UMTS); LTE; 5G; Inter-IMS Network to Network Interface (NNI) (3GPP TS 29.165 version 17.6.0 Release 17)".

[18] ETSI TS 137 340 (V17.7.0): "Universal Mobile Telecommunications System (UMTS); LTE; 5G; NR; Multi-connectivity; Overall description; Stage-2 (3GPP TS 37.340 version 17.7.0 Release 17)".

[19] ETSI TS 138 509 (V17.4.0): "LTE; 5G; 5GS; Special conformance testing functions for User Equipment (UE) (3GPP TS 38.509 version 17.4.0 Release 17)".

[20] ETSI TS 138 306 (V17.7.0): "5G; NR; User Equipment (UE) radio access capabilities (3GPP TS 38.306 version 17.7.0 Release 17)".

[21] ETSI TS 183 043 (V3.4.1): "Telecommunications and Internet converged Services and Protocols for Advanced Networking (TISPAN); IMS-based PSTN/ISDN Emulation; Stage 3 specification".

[22] ETSI TS 183 036 (V3.7.1): "Core Network and Interoperability Testing (INT); ISDN/SIP interworking; Protocol specification".

[23] Recommendation ITU-T Q.761 (12/99): "Signalling System No. 7 - ISDN User Part functional description".

[24] Recommendation ITU-T Q.764 (12/99): "Signalling System No. 7 - ISDN User Part signalling procedures".

[25] ETSI TS 129 163 (V17.3.0): "Digital cellular telecommunications system (Phase 2+) (GSM); Universal Mobile Telecommunications System (UMTS); LTE; 5G; Interworking between the IP Multimedia (IM) Core Network (CN) subsystem and Circuit Switched (CS) networks (3GPP TS 29.163 version 17.3.0 Release 17)".

[26] Recommendation ITU-T Q.1912.5 (1/18): "Interworking between session initiation protocol (SIP) and bearer independent call control protocol or ISDN user part".

[27] GSMA NG.114: "IMS Profile for Voice, Video and Messaging over 5GS", Version 5.0.

[28] GSMA IR.65 V.34.0 (May 2021): "IMS Roaming, Interconnection and Interworking Guidelines".

[29] GSMA NG.113: "5GS Roaming Guidelines", Version 4.0, 28 May 2021.

[30] ETSI TS 136 331 (V17.7.0): "LTE; Evolved Universal Terrestrial Radio Access (E-UTRA); Radio Resource Control (RRC); Protocol specification (3GPP TS 36.331 version 17.7.0 Release 17)".

[31] ETSI TS 136 355 (V18.0.0): "LTE; Evolved Universal Terrestrial Radio Access (E-UTRA); LTE Positioning Protocol (LPP) (3GPP TS 36.355 version 18.0.0 Release 18)".

[32] ETSI TS 124 587 (V18.7.0): "5G; Vehicle-to-Everything (V2X) services in 5G System (5GS); Stage 3 (3GPP TS 24.587 version 18.7.0 Release 18)".

2.2 Informative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long term validity.

The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

Not applicable.

3 Definition of terms, symbols and abbreviations

3.1 Terms

Void.

3.2 Symbols

Void.

3.3 Abbreviations

For the purposes of the present document, the following abbreviations apply:

2G	Second Generation
3G	Third Generation
3GPP	3rd Generation Partnership Project
4G	4G - Fourth Generation
4G/LTE	Fourth Generation/Long-Term Evolution
5G SA	5G Stand Alone
5GC	5th Generation Core Network
5GCN	5G Core Network
5G-CP	5G Control Plane
5G-EHC	5G Enhanced Handover Control
5G-LCS	5G Location Services
5GMM	5GMM - 5G Mobility Management
5G-NR	5G New Radio
5G-RG	5G Radio Gateway
5GS	5G, or 5GS

NOTE: System defined by 3GPP from Release 15.

5G-UP	5G User Plane
5QI	5G QoS Identifier
ACR	Anonymous Communication Rejection

ACR-CB	Anonymous Call Rejection and Call Barring
AKA	Authentication and Key Agreement
AMF	Access and Mobility Management Function
AMR	Adaptative Multi-Rate
AMR-WB	Adaptive Multi Rate - Wide Band
AN	Access Network
API	Application Programming Interface
AS	Access Stratum
ATS	Abstract Test Suite
ATSSS	Access Traffic Steering, Switching and Splitting
AUSF	Authentication Server Function
BCALL	Basic CALL
BSSID	Basic Service Set IDentifier
CB	Communication Barring
CC	Call Control
CCBS	Completion of Communications to Busy Subscriber
CCNR	Completion of Communications by No Reply
CD	Communication Deflection
CDIV	Communication DIVersion
CE	Customer Edge
CFB	Communication Forwarding Busy
CFNL	Communication Forwarding Not Logged in
CFNR	Communication Forwarding No Reply
CFU	Communication Forwarding Unconditional
CIoT	Cellular Internet of Things
CLIP	Calling Line Identification Presentation
CN	Core Network
COLP	Connected Line Identification Presentation
CONF	CONFerence
CP	Control Plane
CS	Circuit Switched
CSFB	Circuit Switched Fall Back
CUG	Closed User Group
CW	Communication Waiting
DC	Dual Connectivity
DL	DownLink
DRB	Data Radio Bearers
DTMF	Dual Tone Multi Frequency
E2E	End-to-End
ECT	Explicit Communication Transfer
eLTE	evolved LTE
eMBB	enhanced Mobile Broadband
EmC	Emergency Call
EMC	E-UTRAN Management and Configuration
EMCN3	E-UTRAN Management and Configuration in N3
EMF	E-UTRAN Measurement Framework
EMM	EPS Mobility Management
eNB	E-UTRAN Node
EN-DC	E-UTRA NR Dual Connectivity
EPC	Evolved Packet Core
ePCO	extended Protocol Configuration Options
ePDG	evolved Packet Data Gateway
EPS	3GPP Evolved Packet System
E-UTRA	Evolved Universal Terrestrial Radio Access
E-UTRAN	Evolved Universal Terrestrial Radio Access Network
EVS	Enhanced Voice Services
FDD	Frequency Division Duplex
FN-RG	Forwarding Node - Radio Gateway
GERAN	GSM EDGE Radio Access Network
gNB	3GPP 5G Next Generation base station
gNodeB	Next Generation Node B
GNSS	Global Navigation Satellite System.

GSM	Global System for Mobile communications
GSMA	GSM Association
GUTI	Globally Unique Temporary Identifier
HD	High Definition
HO	HandOver
HOLD	communication HOLD
HPLMN	Home Public Land Mobile Network
HPMN	Home Public Mobile Network
HR	Handover Request
HSPA	High-Speed Packet Access
ID	IDentifier
IE	Information Element
IMPU	IMS Private User identity
IMS	IP Multimedia Subsystem
IND	INDividual
IoT	Internet of Things
IP	Internet Protocol
IPHC	IP Header Compression
IR	International Roaming
ISDN	Integrated Services Digital Network
ISUP	ISDN User Part
IWK	Interworking
LBO	Local Break Out
LPP	LTE Positioning Protocol
LTE	Long-Term Evolution
M2M	Machine to Machine
MCG	Master Control Group
MCID	Malicious Communication IDentification
MCS	Multimedia Communication Service
MCSI	Multimedia Communication Service Identifier
MGCF	Media Gateway Control Function
MIB	Master Information Block
MIMO	Multiple Input, Multiple Output
MME	Mobility Management Entity
MMTEL	Multimedia Telephony
MN	Mobile Network
MO	Mobile Originated
MPS	Multimedia Priority Service
MPSI	Multimedia Priority Service Identifier
MT	Mobile Terminated
MWI	Message Waiting Indication
N/A	Not Applicable
N1	N1 Interface
N2	N 2 Interface
N3	N 3 Interface
N3GPP	3rd Generation Partnership Project
N3IWF	Non-3GPP InterWorking Function
N5CW	Non-5G-Capable over WLAN
NAS	Non-Access-Stratum
NB-N1	Narrow Band Non-Standalone 1
NE-DC	5G NR-E-UTRA Dual Connectivity
NEF	Network Exposure Function
NFV	Network Function Virtualisation
NG	Next Generation
NGEN	Next Generation Network
NG-RAN	Next Generation Radio Access Network
NNI	Network to Network Interface
NR	New Radio
NR-DC	NR-NR Dual Connectivity
NR-E	NR in EPS
NR-NR	NR in NR
NSA	Non Stand Alone

NSSAI	Network Slice Selection Assistance Information
NSSF	Network Slice Selection Function
NubP	Network utility backPlane
NWK	Network
OIP	Originating Identification Presentation
OIR	Originating Identification presentation Restriction
OTT	Over-the-Top
PC5	Packet Data Network over Control Plane
PCC	Policy and Charging Control
PCF	Policy Control Function
PCRF	Policy and Charging Rules Function
P-CSCF	Proxy Call Session Control Function
PDCP	Packet Data Convergence Protocol
PDN	Public Data Network
PDU	Packet Data Unit
PES	PSTN /ISDN Emulation Subsystem
PGW	Packet Data Network Gateway
PGW-C	PDN GTW - Control plane function
PICS	Protocol Implementation Conformance Statement
PLMN	Public Land Mobile Network
PMN	Public Mobile Network
PRD	Product Requirement Document
PS	Packet Switched
PSSCH	Physical Sidelink Control Channel
PSTN	Public Switched Telephone Network
QoE	Quality of Experience
QoS	Quality of Service
RAN	Radio Access Network
RAN-CN	Radio Access Network - Core Network
RAT	Radio Access Technology
RCS	Rich Communication Services
REFER	REason for reFERral
RoHC	Robust Header Compression
RRC	Radio Resource Control
RTP	Real-time Transport Protocol
S1	Signalling Interface 1
SA	Standalone
SBA	Service-Based Architecture
SCG	Secondary Cell Group
SDP	Session Description Protocol
SDU	Service Data Unit
SE	Security Edge
SEPP	Security Edge Protection Proxy
SGC	Serving Gateway Control
SGW	Serving Gateway
SIB1	System Information Block Type 1
SIM	Subscriber Identity Module
SIP	Session Initiation Protocol
SIP-I	Session Initiation Protocol - ISUP

NOTE: SIP with encapsulated ISUP.

SL	Signalling Layer
SLA	Service Level Agreement
SM	Session Management
SMF	Session Management Function
SMS	Short Message Service
SN	Serving Network
SRB2	Signalling Radio Bearer 2
SRVCC	Single Radio Voice Call Continuity
SSC	Security Serving Class
SSID	Service Set Identifier

SSS	Secondary Synchronization Signal
STQ	Speech and multimedia Transmission Quality
SUB	Subaddressing
TAU	Tracking Area Update
TIP	Terminating Identification Presentation
TIR	Terminating Identification Restriction
TNAP	Telecommunication Network API
TP	Test Purpose
TSS	Test Suite Structure
UDM	Unified Data Management
UE	User Equipment
UE-5GC	User 5G Core Network
UE-NR	UE in NR
UL	UpLink
ULI	User Location Information
UMTS	Universal Mobile Telecommunications System
UPF	User Plane Function
URLLC	Ultra-Reliable Low Latency Communication
UTRA	Universal Terrestrial Radio Access
UTRAN	UMTS Terrestrial Radio Access Network
UUS	User-to-User Signalling
V2X	Vehicle-to-Everything
Vo5G	Voice over 5G
VoIP	Voice over Internet Protocol
VoLTE	Voice over LTE
VoNR	Voice over New Radio
VoPS	IMS Voice over PS session
VPLMN	Visited Public Land Mobile Network
VPMN	Visited Public Mobile Network
WB-N1	Wide Band Non-Standalone 1
WLAN	Wireless Local Area Network
X2	X2 interface
XML	Extensible Markup Language

4 General principles of interconnection of Vo5G and VoLTE-based networks

4.1 Overview

Voice over LTE (VoLTE) and Voice over 5G both use the same IP Multimedia Subsystem (IMS) framework as defined in 3GPP. However, improvements in radio, core, and device technology are expected to provide a better user experience for VoNR compared to VoLTE.

Vo5G and Vi5G services are considered "managed" voice and video services, respectively, which are based on standardized SIP/IMS signalling and provided by telecommunication operators. On the other hand, Over-The-Top (OTT) applications are services provided on the public internet by independent third parties, without standardized signalling protocols, traffic prioritization, and guaranteed quality of service.

ETSI TS 138 300 [8] provides an overview and overall description of the NG-RAN and focuses on the radio interface protocol architecture of NR connected to 5GC (E-UTRA connected to 5GC is covered in the 36 series).

An IMS platform is utilized as a service control layer for managing Vo5G sessions. The 5G System Architecture reference model is illustrated in Figure 1.

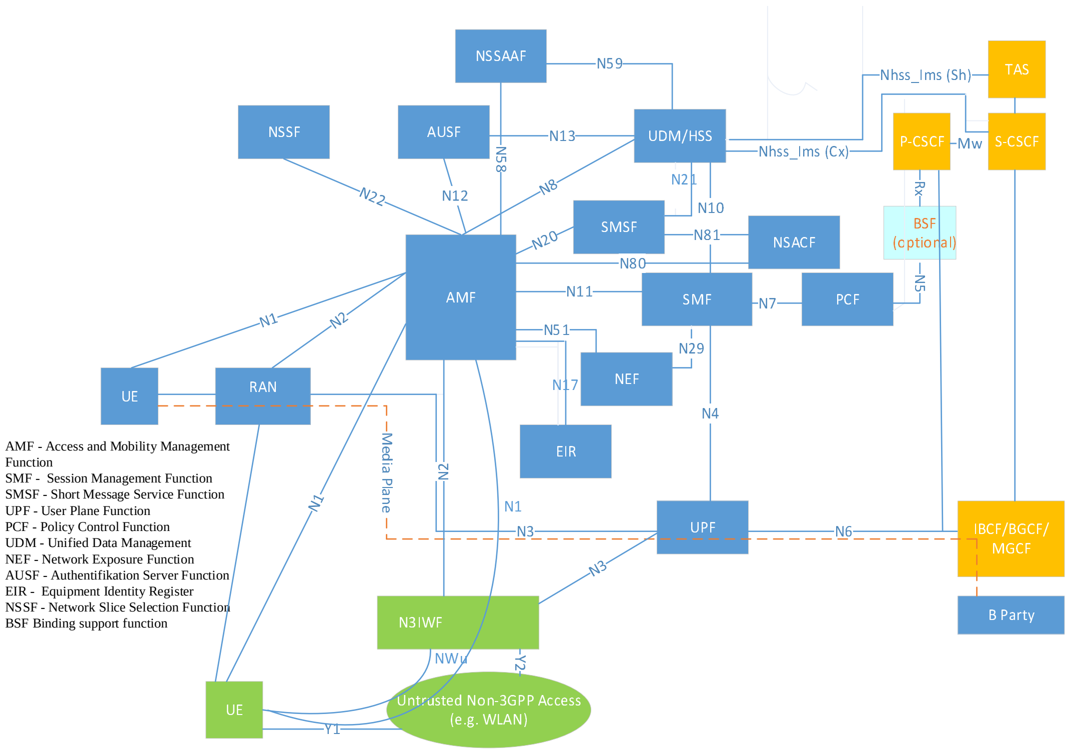


Figure 1: Non-Roaming 5G System Architecture in reference point representation

NOTE: Here is a high-level overview of the Key elements and functions of the 5G architecture:

User Equipment (UE): User Equipment refers to the devices used by end-users, such as smartphones, tablets, IoT devices, and other wireless devices. UEs communicate with the 5G network to send and receive data.

Radio Access Network (RAN): The RAN is responsible for wireless communication between the User Equipment (UE) and the core network. It includes base stations, also known as gNodeBs (gNBs), which transmit and receive wireless signals. The RAN manages radio resources and implements functions like beamforming and beam management to optimize network performance.

Core Network (CN): The Core Network is responsible for managing and controlling the overall 5G network. It consists of several key elements:

- Access and Mobility Management Function (AMF): The AMF handles functions related to the access and mobility of user equipment, including authentication, session management, and mobility management.
- Session Management Function (SMF): The SMF manages session-specific aspects, such as assigning IP addresses to UEs, Quality of Service (QoS) enforcement, and policy control.
- The User Plane Function (UPF) is a crucial component in 5G mobile networks. It plays a significant role in the transmission of user data between the User Equipment (UE), such as smartphones and IoT devices, and the core network. The UPF is primarily responsible for handling the user data traffic, including both uplink (data from the UE to the network) and downlink (data from the network to the UE) traffic.
- Network Slice Selection Function (NSSF): The NSSF selects the appropriate network slice for a UE based on factors like application requirements, QoS, and user preferences.
- Network Exposure Function (NEF): The NEF provides standardized Application Programming Interfaces (APIs) to external applications and services, enabling them to interact with the 5G network and access network capabilities.

- Authentication Server Function (AUSF): The AUSF handles authentication and security-related functions, including generating and verifying security credentials for UEs.
- Policy Control Function (PCF): The PCF manages policy and QoS enforcement across the network. It determines the appropriate policies for each UE and ensures that the network resources are allocated efficiently.
- Edge Computing: 5G introduces edge computing capabilities, which involve deploying computing resources closer to the network edge. This enables low-latency processing, real-time analytics, and faster response times for applications. Edge computing is essential for time-sensitive use cases like autonomous vehicles, industrial automation, and augmented reality.
- Network Slicing: 5G introduces network slicing, which allows the creation of multiple virtual networks on a shared physical infrastructure. Each network slice can be tailored to specific requirements, such as latency, bandwidth, and security, to support diverse applications and industries.
- Service-Based Architecture (SBA): 5G utilizes a service-based architecture, where network functions are decoupled and communicate with each other via standardized APIs. This modular approach allows for more flexibility, scalability, and interoperability within the network.
- Network Function Virtualisation (NFV): 5G incorporates NFV principles, which involve virtualizing network functions to run them on commodity hardware. This enables greater flexibility, scalability, and cost efficiency in deploying and managing network functions.
- Network Management and Orchestration: 5G networks require advanced management and orchestration systems to monitor, configure, and optimize network resources. These systems ensure efficient allocation of network resources, fault management, and dynamic scaling to meet changing demands. various QoS requirements. Its functionalities are essential for delivering a seamless and high-quality mobile communication experience to users.
- The Policy Control Function (PCF) is a fundamental component within 4G Long-Term Evolution (LTE) and 5G mobile networks. Its primary function is to enforce policy control and management for subscriber services and network resources. The PCF plays a vital role in ensuring that network resources are allocated efficiently, Quality of Service (QoS) is maintained, and subscribers' policy requirements are met.
- The Unified Data Management (UDM) plays a critical role in fifth-generation (5G) networks, particularly in terms of managing user-related data and authentication. Here is an overview of the functions of the UDM in 5G.

4.2 Registration procedure aspects for voice support in 5GS

4.2.1 Introduction

In 5G networks, the registration procedure is vital for effective voice transport, ensuring seamless and high-quality communication. Here is why the registration procedure is important, particularly from the aspect of voice transport, in 5G networks:

- Network Slicing and QoS Configuration: 5G networks support network slicing, allowing the creation of dedicated slices optimized for specific services like voice. During registration, the appropriate network slice with customized QoS parameters is assigned, ensuring prioritized and reliable voice transport.
- Ultra-Reliable Low Latency Communication (URLLC) Support: URLLC is a crucial aspect of 5G that ensures extremely low latency and high reliability. During registration, the UE's support for URLLC is identified and the necessary configurations are made to enable ultra-reliable voice transport, critical for real-time voice communication.
- Efficient Codec Negotiation: The registration procedure in 5G involves negotiation of codecs supported by both the UE and the network. Efficient codec negotiation is critical for voice transport, ensuring that the most suitable and efficient codecs are selected for optimal voice quality and bandwidth utilization.

- Latency Optimization: The registration process enables the network to configure and optimize latency parameters specific to voice transport. Lower latency is crucial for real-time voice communication, and the registration procedure ensures that the network is appropriately configured to meet latency requirements.

- Dual-Connectivity and Handover Enhancements: 5G supports dual-connectivity, allowing the UE to connect to multiple cells simultaneously. The registration process plays a key role in optimizing dual-connectivity parameters, facilitating seamless handovers and ensuring uninterrupted voice transport even during cell transitions.

- Network Synchronization and Timing: Proper registration helps in synchronization and timing adjustments within the network, which is crucial for voice transport. Accurate timing synchronization is essential to prevent jitter and ensure synchronization of voice packets, maintaining voice quality.

- Emergency Voice Services Optimization: The registration procedure is essential for optimizing voice services during emergency calls. It ensures that emergency voice calls are given the highest priority and are routed with minimal latency, potentially life-saving for the users.

- Redundancy and Failover Mechanisms: During registration, redundancy and failover mechanisms can be established to ensure voice transport remains resilient even in case of network failures. These mechanisms are crucial for providing continuous voice service availability.

- Security Configuration and Privacy: Registration involves setting up security parameters, including encryption keys and authentication, to ensure secure voice transport and protect user privacy during communication.

At high level, 5G SA Registration call flow includes the following Steps, also shown in Figure 2:

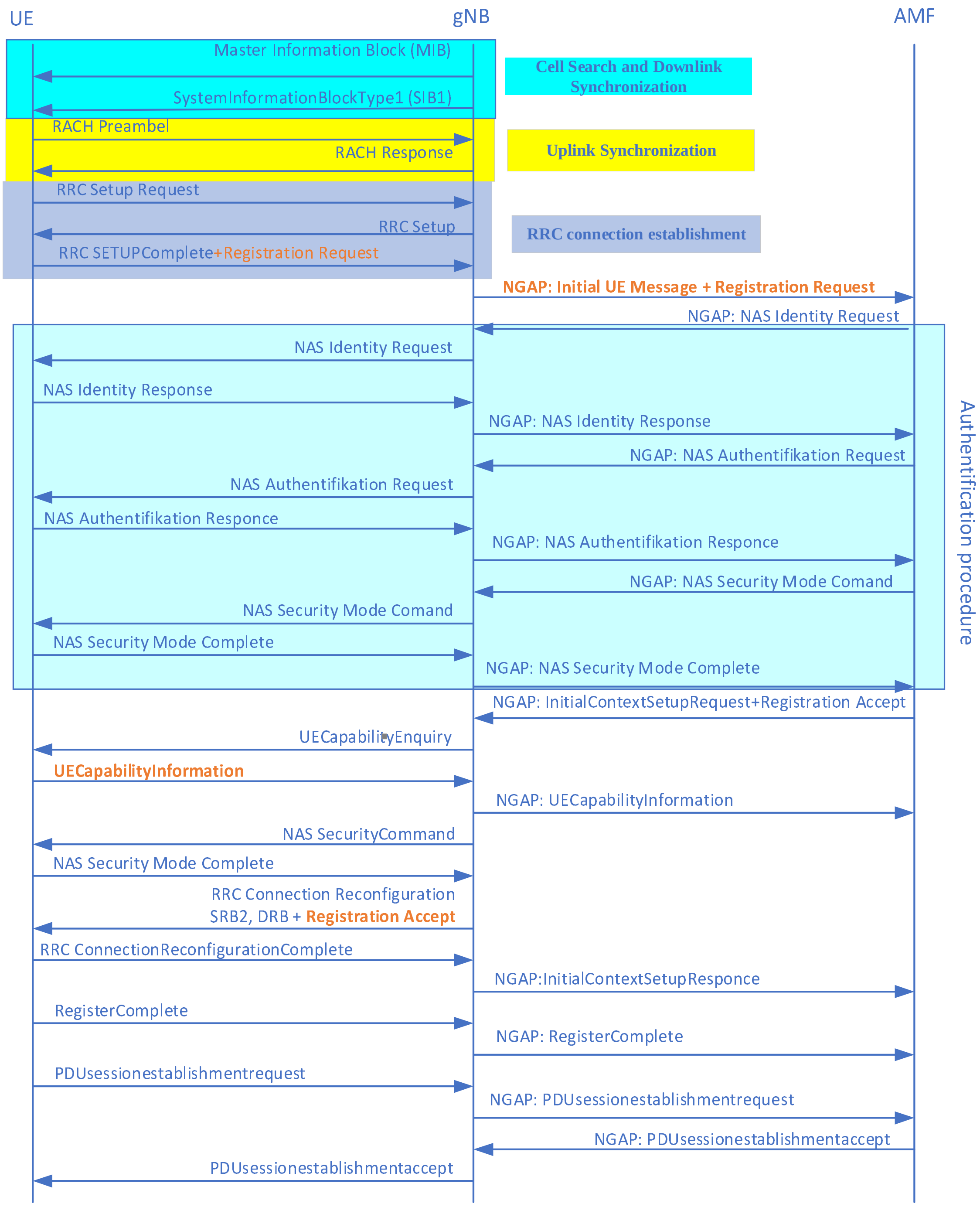


Figure 2: Registration procedure aspects for voice support in 5GS

- **Cell Search and Downlink Synchronization:**

  The UE searches for nearby cells and attempts to synchronize its time and frequency with the downlink signals from a specific cell. This involves acquiring the Cell ID and decoding essential broadcast information like Master Information Block (MIB).

- **Uplink Synchronization:**

  Once downlink synchronization is achieved, the UE works to synchronize its uplink transmission timing with the cell, ensuring effective communication with the base station.

- **RRC connection establishment**

  The purpose of this procedure is to establish an RRC connection. The procedure is also used to transfer the initial NAS dedicated information/ message from the UE to the network.

  The network applies the procedure e.g. as shown in Figure 3:

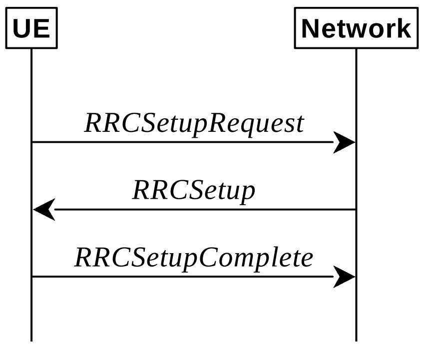


Figure 3: RRC connection establishment (from ETSI TS 138 331 [9])

  When establishing an RRC connection, the UE receives *RRCSetup* and responds with *RRCSetupComplete*. This message may also contain a Registration Request, indicating the UE's intent to register on the network.

- **UE Capability Transfer and AS Security:**

  The UE transfers its capabilities and requirements to the Access Stratum (AS) of the network, allowing for appropriate configuration and optimization. AS security procedures are carried out to ensure the security of the AS messages (see Figure 4).

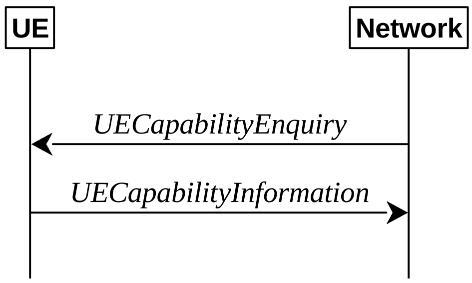


Figure 4: UE capability transfer (from ETSI TS 138 331 [9])

  The network initiates the procedure to a UE in RRC_CONNECTED when it needs (additional) UE radio access capability information.

- **UE NAS Identity Transfer:**

  The UE transfers its Network Attach Sublayer (NAS) identity to the network, providing essential information for identification and authentication.

- **Authentication and NAS Security:**

  The network authenticates the UE by verifying its identity and credentials using procedures such as Authentication and Key Agreement (AKA). NAS security mechanisms are established to ensure secure communication between the UE and the network.

- **SRB2 and DRB establishment:**

  Signalling Radio Bearer (SRB2) is established for signalling purposes, facilitating communication between the UE and the network. Data Radio Bearers (DRBs) are also established to handle user data transmission.

- **Registration Complete and PDU session Establishment:**

  The network acknowledges the successful registration and activation by sending a Registration Complete message to the UE. Additionally, the establishment of Packet Data Unit (PDU) sessions is initiated, enabling the UE to access data services and applications.

4.2.2 5G NAS and RRC Signalling Parameters for Voice Support

The **Radio Resource Control (RRC)** signalling parameters for IMS in 5G are specific signalling messages and parameters used to establish and manage IMS sessions over the radio interface. These parameters are essential for ensuring proper communication and quality of service for IMS-based services in a 5G network.

See Figure 5 and Figure 6 for graphical support of the descriptions in the present clause.

Overall, 5G NR Information Block 1 (SIB1) is crucial for the initial access and synchronization of UEs with a 5G network. It provides essential information about the network's identity, frame structure, access parameters, and other relevant configuration details, enabling UEs to establish a connection and operate efficiently within the network. The specific contents and format of SIB1 can vary depending on the network operator's configuration and the 5G NR specifications in use. It includes parameter like emergency call support parameters ims-EmergencySupport, eCallOver-IMS-Support and UACBarringInformation

The Non-Access Stratum (NAS) forms the highest stratum of the control plane between UE and AMF (reference point "N1", see ETSI TS 123 501 [4]) for both 3GPP and non-3GPP access.

NAS signalling exchange the information between the UE and the 5GC. RAN does not use it and transparently transfer the information. 5G System indicates the voice service support NAS during the registration procedure. This is required to provide higher granularity in feature support indication and in access restrictions.

UE sends it all network capability within Registration Request and IE UE's Usage Setting' indicates that the higher layers of the UE support the IMS Voice service

An important flag in this control message is the S1 mode flag contained in the 5G Mobility Management (5GMM) capability element (see Table B-1). The purpose of the **5GMM capability information element** is to provide the network with information concerning aspects of the UE related to the 5GCN or interworking with the EPS (**if EPC NAS supported (S1 mode)** and if LPP in N1 mode is supported). The contents might affect the manner in which the network handles the operation of the UE.

ETSI TS 123 501 [4] defines certain interworking scenarios between 5GS and EPC and provides more information on interfaces such as N26.

S1 mode indicates a successful **EPS** attach and **N1** mode indicates a successful **5GC** attach. The definition in ETSI TS 124 501 [7] is that in N1 mode, the UE has access to the 5G core network via the 5G access network.

Single or dual registration indicates simultaneous handling of mobility states.

In single registration mode, there is only one active mobility state at any given time. The UE stays in either 5GC NAS mode or EPC NAS mode.

Concerning the UE identifiers, the UE maps the EPC Globally Unique Temporary Identify (EPC-GUTI) to 5G-GUTI during mobility between EPC and 5GC.

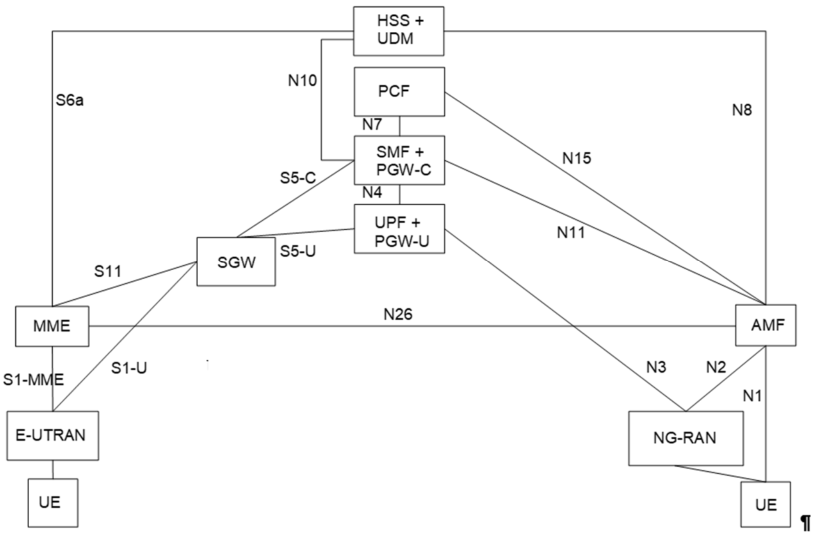


Figure 5: Non-roaming architecture for interworking between 5GS and EPC/E-UTRAN (from ETSI TS 123 501 [4])

If the network supports the N26 interface (N26 interface is used to provide seamless session continuity for single registration mode UE. Interworking between EPS and 5GS is supported with IP address preservation by assuming SSC mode 1), the UE keeps 5G context such as IP address allocations for re-use when moving from 5GC to EPC.

In order to interwork with **E-UTRAN connected to EPC**, a UE supporting both S1 mode and N1 mode can operate in single-registration mode or dual-registration mode.

The single-registration mode is mandatory for UEs supporting both S1 mode and N1 mode.

Dual-registration mode requires the UE to handle 5GMM and EMM context independently and simultaneously.

Typically, the network requirement is communicated to the User Equipment (UE) during registration, and the UE indicates which capabilities it supports.

In this mode, the UE maintains the identifiers 5G-GUTI and EPC-GUTI independently. The UE can perform 5GC or EPC re-registration/TAU using the corresponding GUTIs.

A UE operating in **dual-registration** mode may register to N1 mode only, S1 mode only, or to both N1 mode and S1 mode. During the EPS attach procedure or initial registration procedure, the mode for interworking is selected if the UE supports both S1 mode and N1 mode and the network supports interworking.

Depending on the N26 interface support, the UE has different options to operate in single- or dual-registration mode and certain submodes. If both 5GMM and EPS Mobility Management (EMM) are enabled, a UE operating in single-registration mode should maintain one common registration for 5GMM and EMM. Coordination between 5GMM and EMM is not needed for a UE which is capable of N1 mode and S1 mode and operates in dual-registration mode. ETSI TS 124 501 [7] defines the details of the coordination between 5GMM and EMM in single-registration mode depending on whether the N26 interface is supported or not.

5GS provides **feature support Information Elements (IEs**) which indicates support for certain features to the UE with Registration Accept message.

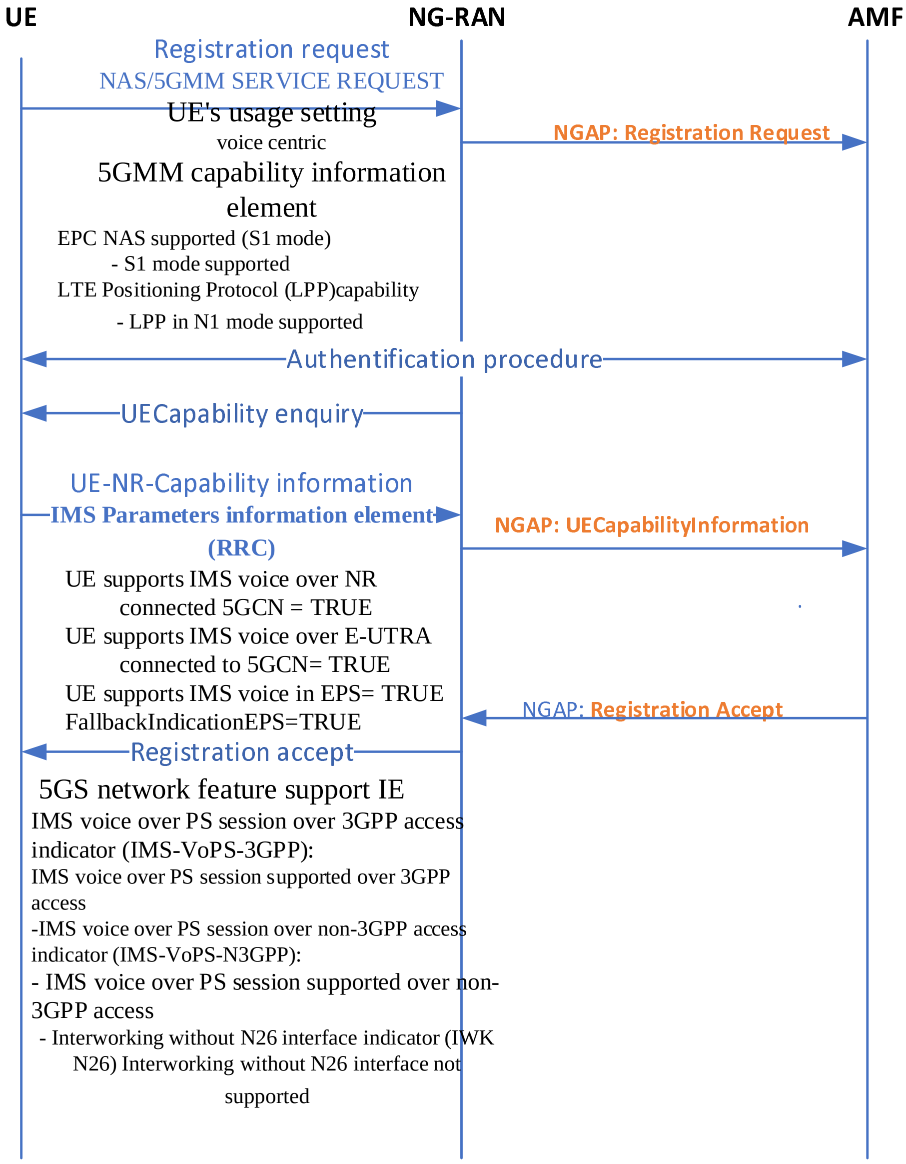


Figure 6: NAS and RRC Signalling Parameters for Voice Support

With the **registration accept message**, the network not only confirms the successful transfer but also confirms the support for voice call related features. This Information Element (IE) contains flags such as the support for "IMS voice over Packet Switched (PS) session supported over 3GPP access", "non-3GPP voice support", "emergency call services" or "emergency call fallback support" and whether the N26 network interface does or does not exist. Further details on the NAS registration procedure are available in ETSI TS 124 501 [7].

From ETSI TS 138 300 [8]: For IMS voice support in NG-RAN, the following is assumed:

- Network ability to support IMS voice sessions, i.e. ability to support QoS flows with 5QI for voice and IMS signalling (ETSI TS 123 501 [4]), or through EPC System fallback;
- UE capability to support "IMS voice over PS", see ETSI TS 124 501 [7].

The capabilities indications check is handled at NAS layer. To maintain the voice service in NG-RAN, the UE provides additional capabilities over RRC (see ETSI TS 138 331 [9]), that are used to determine accurate NR voice support options. Further MMTEL IMS voice and video enhancements are facilitated by the mechanisms described in the following clauses.

4.2.3 RRC Signalling Parameters for Voice Support

Via the capability information exchange, the UE discloses its IMS-related parameters. Common IMS parameters the UE may support are, for example, the indication of voice over E-UTRA support, voice over Secondary Cell Group (SCG) bearer support and an indication of voice fallback into EPS.

The User Equipment (UE) radio access capabilities are described in ETSI TS 138 306 [20] (see Annex D), UECapabilityInformation and related information are specified in:

- ETSI TS 136 331 [30]: This standard, titled "Evolved Universal Terrestrial Radio Access (E-UTRA); Radio Resource Control (RRC); Protocol specification," defines the Radio Resource Control (RRC) protocol, including messages like UECapabilityInformation for LTE.

- ETSI TS 138 331 [9]: For 5G New Radio (NR), this standard specifies the RRC protocol, including UECapabilityInformation for 5G NR.

  - **voiceOverNR:** Indicates whether the UE supports IMS voice over NR. It is mandated to the UE if the UE is capable of IMS voice over NR. Otherwise, the UE does not include this field. If this field included and the UE is capable of E-UTRA with EPC, the UE shall support IMS voice over E-UTRA via EPC.

    If the UE does not support voice over NR but only EPS fallback, it is recommended to set the parameter flag as voiceOverNR = False and voiceFallbackIndicationEPS-r16 = True. Note that the UE capability is a procedure between the UE and NG radio Access Network (NG-RAN) (ETSI TS 138 331 [9]).

  - **voiceOverEUTRA-5GC:** Indicates whether the UE supports IMS voice over E-UTRA via 5GC. This capability is mandatory for the UE if it supports IMS voice over E-UTRA via 5GC. Otherwise, this field is not included. If the field is present and the UE also supports E-UTRA with EPC, the UE must support IMS voice over E-UTRA via EPC.

  - **voiceOverSCG-BearerEUTRA-5GC:** Indicates whether the UE supports IMS voice over the SCG bearer in NE-DC. This parameter is forward-looking; in the current release, IMS voice over split bearer is not supported with either NR-DC or NE-DC.

  - **voiceFallbackIndicationEPS:** This indicates the support for EPS fallback. If this field is included, the UE should support IMS voice over NR and IMS voice over E-UTRA via EPC.

  - **RoHC Profile:** An IMS voice capable UE shall indicate support of RoHC profiles 0x0000, 0x0001, 0x0002 and be able to compress and decompress headers of PDCP SDUs at a PDCP SDU rate corresponding to supported IMS voice codecs.

  - **voiceOverSCG-BearerEUTRA-5GC:** Indicates whether the UE supports IMS voice over SCG bearer of NE-DC.

  - **handoverUTRA-FDD-r16:** Indicates whether the UE supports NR to UTRA-FDD CELL_DCH CS handover. If the UE supports Handover (HO) to UTRA-FDD, it is required to support both UTRA-FDD measurement with event B-triggered reporting and periodic UTRA-FDD measurement and reporting. If this field is present, the UE must also support IMS voice over NR.

  - **voiceFallbackIndicationEPS-r16:** Indicates whether the UE supports voiceFallbackIndication in RRCRelease and MobilityFromNRCommand. If this field is included, the UE must support IMS voice over NR as well as IMS voice over E-UTRA via EPC.

4.2.4 NAS Parameters for Voice Support

From ETSI TS 124 301 [6]: **UE's usage setting** indicates whether the UE has preference for voice services over data services or vice-versa. If a UE has preference for voice services, then the UE's usage setting is "voice centric". If a UE has preference for data services, then the UE's usage setting is "data centric". A UE whose setting is "data centric" may still require access to voice services. A UE whose setting is "voice centric" may still require access to data services. If the UE is capable of both S1 mode and N1 mode, there is a single UE's usage setting which applies to both 5GS and EPS (see ETSI TS 124 501 [7]).

Table 1: UE's usage setting information element

UE's usage setting (octet 3, bit 1)	
0	voice centric
1	data centric
All other bits in the octet 3 are spare and shall be coded as zero.	

The **5GS network feature support information element**, which purpose is to indicate whether certain features are supported by the network is coded as shown in Table B-1 (Table 9.11.3.5.1 of ETSI TS 124 501 [7]).

EPS network feature support information element, which purpose is to indicate whether certain features are supported by the network is coded as shown in Table 9.9.3.12A.1 of ETSI TS 124 301 [6]).

4.3 5G IMS support

4.3.1 Introduction

See Figure 7 and Figure 8 for graphical support of the descriptions in the present clause.

The 3GPP vision for the IMS is that introduction of the 5GC or NG-RAN shall be transparent to the IMS. In a 5G network, when a **User Equipment (UE) needs to establish a Packet Data Unit (PDU)** session for IP Multimedia Subsystem (IMS) services, several steps are involved in the procedure. IMS is a framework used for delivering multimedia services over IP networks, and it plays a crucial role in enabling services like Voice over IP (VoIP) and video calling. Here is a high-level overview of the procedure:

1) Before establishing the PDU session, the UE needs to authenticate itself with the 5G Core Network (5GC). The UE sends its credentials (e.g. SIM card information) to the Authentication Server Function (AUSF) for authentication and authorization.

2) Obtaining IMS Credentials:

   - After successful authentication, the UE obtains IMS-specific credentials, including an IMS Private User identity (IMPU) and IMS Security Material (IMS-AKA keys). These credentials are crucial for IMS service authentication and encryption.

3) PDU Session Establishment Request:

   - With the IMS credentials in hand, the UE sends a request to the Access and Mobility Management Function (AMF) to establish a PDU session for IMS services. This request includes the IMS-specific requirements and identifiers.

4) AMF Processing:

   - The AMF processes the PDU session establishment request and checks if the UE has the necessary permissions for IMS services. It also ensures that the session aligns with the requested Quality of Service (QoS) parameters.

5) Access Authentication and Authorization:

   - If required, the AMF communicates with the AUSF and the Security Edge Protection Proxy (SEPP) to perform access authentication and authorization for IMS services. This step is crucial for ensuring security.

6) Establishing the PDU Session:

   - Once all authentication and authorization checks pass, the AMF communicates with the User Plane Function (UPF) and the Session Management Function (SMF) to establish the PDU session for IMS services. The UPF handles data routing and forwarding, while the SMF manages session policies and QoS.

7) IMS Service Registration:

- With the PDU session successfully established, the UE can register with the IMS core network by sending a registration request to the Proxy Call Session Control Function (P-CSCF) or other relevant IMS entities. This step ensures that the UE is reachable for IMS services.

8) IMS Service Usage:

- Once the IMS session is established and registered, the UE can utilize IMS services such as VoIP calls, video calls, or instant messaging.

9) Session Termination:

- When the IMS session is no longer needed (e.g. call ends), the UE or the network can initiate the session termination process. This involves releasing resources and terminating the PDU session.

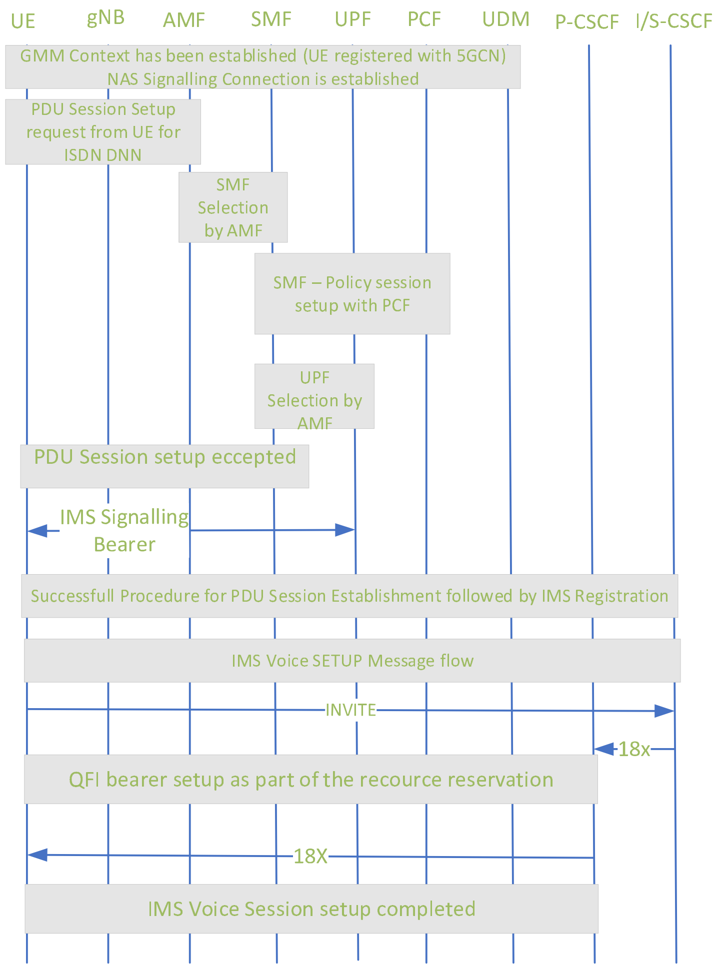


Figure 7: Sample Call Flow for VoNR session establishment

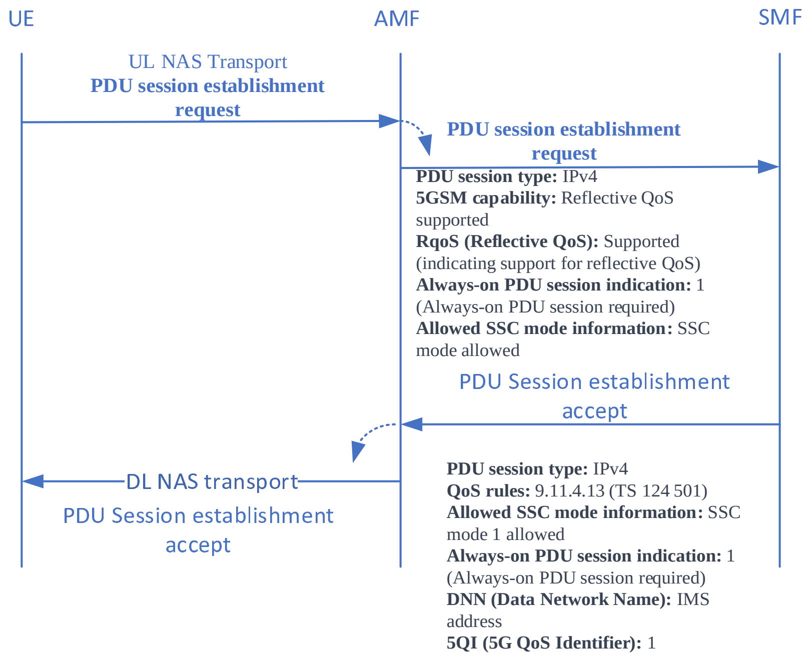


Figure 8: Establishing PDU Session

The **Initial Packet Data Unit (PDU) Session Establishment Request** procedure in a 5G network involves the User Equipment (UE) initiating a request to establish a PDU session with the 5G Core Network (5GC). This request is a critical step in setting up the necessary parameters for efficient data transfer. Here is a detailed breakdown of this procedure.

UE Request Generation:

The UE generates a request to establish a PDU session, typically triggered by a user or a service/application running on the UE that requires data connectivity.

Request Contents:

The request includes essential information such as the requested Quality of Service (QoS) parameters, addresses, traffic handling priorities, and other relevant session establishment parameters.

UE-5GC Communication:

The UE sends this request to the Access and Mobility Management Function (AMF) in the 5G Core Network (5GC).

AMF Processing:

The AMF processes the initial request and performs necessary checks, including authentication and authorization. It ensures the UE's identity and validates the request.

QoS Negotiation:

The AMF may engage in QoS negotiation with the UE to determine the appropriate QoS levels for the PDU session. This negotiation aims to align the requested QoS with the capabilities and policies of the network.

Traffic Redirection and Steering:

Based on the request and network policies, the AMF might decide to steer traffic to a specific User Plane Function (UPF) or redirect it to other network elements to optimize the data path.

Policy Enforcement:

The AMF interacts with the Policy Control Function (PCF) to enforce the policy rules for the PDU session. These rules govern aspects such as data handling, charging, and traffic management based on the UE's request and network policies.

Session Management Function (SMF) Involvement:

The AMF interacts with the SMF, which is responsible for managing session-related functionalities. The SMF gets involved to configure and prepare for the PDU session establishment at the core network level.

Session Establishment Request Forwarding:

The AMF forwards the request to the appropriate SMF for further processing and initiation of the PDU session establishment in the core network.

Session Configuration and Binding:

The SMF configures the session with the required parameters and binds the session to appropriate user plane resources, ensuring efficient data transfer.

Confirmation to UE:

Upon successful processing and configuration, the AMF sends a confirmation back to the UE, indicating that the PDU session has been established and is ready for data transfer.

The initial PDU session establishment request procedure lays the foundation for the PDU session, enabling the efficient transfer of packet data between the UE and the 5G core network.

The Packet Data Unit (PDU) Session Establishment Request in a 5G network involves several important parameters that are exchanged between the User Equipment (UE) and the core network (5GC) to establish a PDU session. These parameters provide essential information for configuring the session and ensuring proper data transfer. Here are the key parameters involved in the PDU Session Establishment Request:

Session Type (SSS):

Specifies the type of the PDU session, indicating whether it is a dedicated session for a specific service or a default bearer.

Session Establishment Cause:

Indicates the reason for initiating the PDU session establishment, such as initial attach, service request, or handover.

User Location Information (ULI):

Provides information about the UE's location, including the geographic area and cell ID, to assist in session establishment.

Request Type:

Specifies whether the request is for initial attach, handover, or other service-related purposes.

Single Network Slice Selection Assistance Information (S-NSSAI):

Describes the desired network slice selection information to guide the selection and setup of the appropriate network slice instance for the session.

PDU Session ID:

Unique identifier for the PDU session, allowing for differentiation and tracking of multiple PDU sessions established by the UE.

QoS Profile:

Defines the Quality of Service (QoS) requirements for the PDU session, including parameters such as maximum data rate, guaranteed data rate, priority, and maximum latency.

Allowed Network Slice Selection Assistance Information (Allowed NSSAI):

Specifies the allowed network slice selection information that the UE can request for the PDU session.

Recovery Time:

Indicates the maximum acceptable duration for the session recovery in case of a failure or interruption.

DL and UL Configuration Parameters:

Parameters related to the Downlink (DL) and Uplink (UL) configurations, including radio resource settings and modulation schemes.

DL and UL Path Selection Information:

Information guiding the selection of the downlink and uplink paths for the session, including the intended User Plane Function (UPF).

IPv4 Address Allocation:

Specifies the requested IPv4 address allocation method for the session.

IPv6 Address Allocation:

Specifies the requested IPv6 address allocation method for the session.

PDU Address Allocation:

Specifies the type of PDU address allocation (e.g. dynamic or static) for the session.

Charging Characteristics:

Describes charging-related information for the session, including how charging data is to be collected and processed.

These parameters collectively define the characteristics and requirements of the PDU session, allowing the network to configure the session appropriately to meet the desired service expectations and QoS needs of the UE. The successful negotiation and configuration of these parameters ensure efficient and effective data transfer during the PDU session.

The Packet Data Unit (PDU) Session Establishment Accept message in a 5G network is sent by the core network (5GC) in response to the PDU Session Establishment Request from the User Equipment (UE). It confirms the successful establishment of the PDU session and provides essential parameters to configure the session. Here are the key parameters included in the PDU Session Establishment Accept message:

PDU Session ID:

Indicates the unique identifier for the PDU session that corresponds to the PDU Session ID provided in the establishment request.

Cause:

Specifies the reason for the PDU Session Establishment Accept, indicating whether the request was accepted, rejected, or modified.

QoS Profile:

Provides the agreed-upon Quality of Service (QoS) parameters for the PDU session, including maximum data rate, guaranteed data rate, priority, and maximum latency.

DL and UL Configuration Parameters:

Contains configuration details for the Downlink (DL) and Uplink (UL), such as radio resource settings, modulation schemes, and other relevant parameters.

DL and UL Path Selection Information:

Specifies the selected downlink and uplink paths for the session, including the intended User Plane Function (UPF) and associated details.

IPv4 Address Allocation:

Specifies the allocated IPv4 address for the PDU session if applicable.

IPv6 Address Allocation:

Specifies the allocated IPv6 address for the PDU session if applicable.

PDU Address Allocation:

Specifies the allocated PDU address for the PDU session, confirming the type of address allocation (e.g. dynamic or static).

Charging Characteristics:

Describes charging-related information for the session, including how charging data will be collected and processed.

Recovery Time:

Indicates the maximum acceptable duration for session recovery in case of a failure or interruption.

Packet Flow ID:

Identifies the packet flow associated with the PDU session, used for managing and steering data traffic within the session.

Service Name:

Specifies the name of the service or application associated with the PDU session.

5G SM Cause:

Provides further cause information related to the session management, offering additional context if needed.

These parameters provide the necessary information to configure the PDU session on both the UE and the core network side, ensuring that the session is set up with the appropriate QoS, address allocations, and other characteristics required for efficient data transfer during the session.

4.3.2 Extended protocol configuration options

In the context of 5G networks, extended Protocol Configuration Options (ePCO) are used to provide additional configuration parameters and information during the establishment or modification of a Packet Data Unit (PDU) session. This extension enables greater customization and flexibility, allowing operators and vendors to optimize network performance and meet the diverse requirements of various services and applications. ePCO is a container that carries specific configuration details and options related to the PDU session, allowing for customization and flexibility.

4.4 5G Connectivity solutions

4.4.1 Introduction

In 5G networks, there are five connectivity solutions that play crucial roles in enabling seamless communication and connectivity. These solutions are:

- Voice over New Radio (VoNR);
- Radio Access Technology (RAT) options;
- EPS (Evolved Packet System) fallback;
- 5G SRVCC under study with 3GPP R16;
- VoLTE/CSFB (Emergency Services Fallback to EPS can be followed by an onward movement to GERAN or UTRAN via CSFB procedures if the PLMN does not support IMS emergency services.

In the Release specification ETSI TS 123 501 [4], the following types of non-3GPP access networks are defined:

- Untrusted non-3GPP access networks;

- Trusted non-3GPP access networks; and - Wireline access networks.

The architecture to support Untrusted and Trusted non-3GPP access networks is defined in clause 4.2.8.2 of ETSI TS 123 501 [4]. The architecture to support Wireline access networks is defined in clause 4.2.8.4 of ETSI TS 123 501 [4] and in ETSI TS 123 316 [3].

The | IMS Profile for Voice, Video and Messaging over Untrusted WLAN Connected to 5GC is described in GSM NG 115 Version 2.0.

4.4.2 Voice over New Radio (VoNR)

Voice over New Radio is a connectivity solution in 5G that enables the delivery of voice services over the 5G network infrastructure. VoNR allows voice calls to be transmitted using the IP-based 5G core network and the 5G Radio Access Network (RAN), eliminating the need for fallback to previous-generation networks like 4G (LTE) or 3G (UMTS) for voice communication.

VoNR brings several advantages over older voice technologies, such as improved call quality, reduced latency, and enhanced capacity. It leverages the high bandwidth and low latency capabilities of 5G to provide High-Definition (HD) voice calls and support advanced features like simultaneous voice and data transmission. VoNR ensures a seamless voice experience within the 5G ecosystem, offering users enhanced voice communication capabilities.

4.4.3 EPS Fallback

The following clause contains the summary of clause 4.13.6.1 of ETSI TS 123 502 [5] EPS fallback for IMS voice.

Voice over NR with EPS Fallback allows a smartphone to utilize 5G Core (5GC) with New Radio (NR) for voice calls but may switch to LTE during call setup if necessary. Reasons for this fallback include incomplete voice over NR features in the phone, temporary radio resource shortages in NR, or inadequate NR configuration for voice in certain areas. During call setup, if the NR base station cannot establish the necessary voice Quality of Service (QoS) flow, it rejects the setup and initiates a transfer of all data sessions from 5G Core to LTE. This transfer can occur through standardized procedures like Release with Redirect or Inter-System Handover, ensuring continuity of communication.

The EPS fallback for IMS voice are described in the following standards:

- ETSI TS 123 502 [5], clause 4.13.6.1;
- ETSI TS 124 229 [14];
- ETSI TS 124 501 [7];
- ETSI TS 124 301 [6];
- ETSI TS 123 501 [4];
- ETSI TS 138 331 [9];
- ETSI TS 138 413 [15].

When the UE is served by the 5G System, the UE has one or more ongoing PDU Sessions each including one or more QoS Flows. The serving PLMN AMF has sent an indication towards the UE during the Registration procedure that IMS voice over PS session is supported and the UE has registered in the IMS. If N26 is not supported, the serving PLMN AMF sends an indication towards the UE during the Registration procedure that interworking without N26 is supported.

In the 5G System (5GS), a User Equipment (UE) camps on Next Generation Radio Access Network (NG-RAN) to initiate a Mobile Originated (MO) or Mobile Terminated (MT) IP Multimedia Subsystem (IMS) voice session:

1) NG-RAN modifies the Packet Data Unit (PDU) Session to establish Quality of Service (QoS) flow for voice.
2) NG-RAN, configured for Enhanced Packet System (EPS) fallback for IMS voice, decides whether to trigger EPS fallback based on UE capabilities, AMF indications, network configuration, and radio conditions. If not triggered, the process stops.
3) NG-RAN responds to PDU Session modification rejection with an indication of ongoing mobility due to voice fallback and reports to Policy Control Function (PCF) if subscribed.

4) NG-RAN initiates handover or Access Network Release for EPS redirection, considering UE capabilities and reports RAT type change to PCF.

5) Depending on scenario: 6a. UE initiates Tracking Area Update (TAU) for 5GS to EPS handover or inter-system redirection with N26 interface; or 6b. UE initiates attach with PDN connectivity request, if supported and indicated.

6) SMF+PGW-C re-initiates dedicated bearer setup for maintained PCC rules after mobility procedure, reporting to PCF. IMS signalling for voice call continues, and E-UTRAN avoids triggering handover during EPS voice call duration.

Figure 9 and Figure 10 describe the EPS fallback procedures.

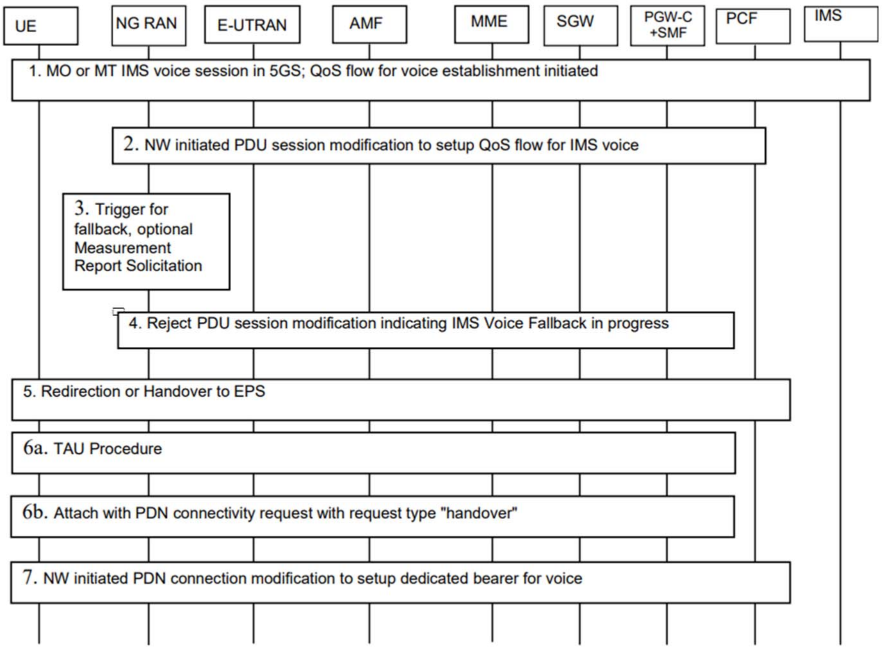
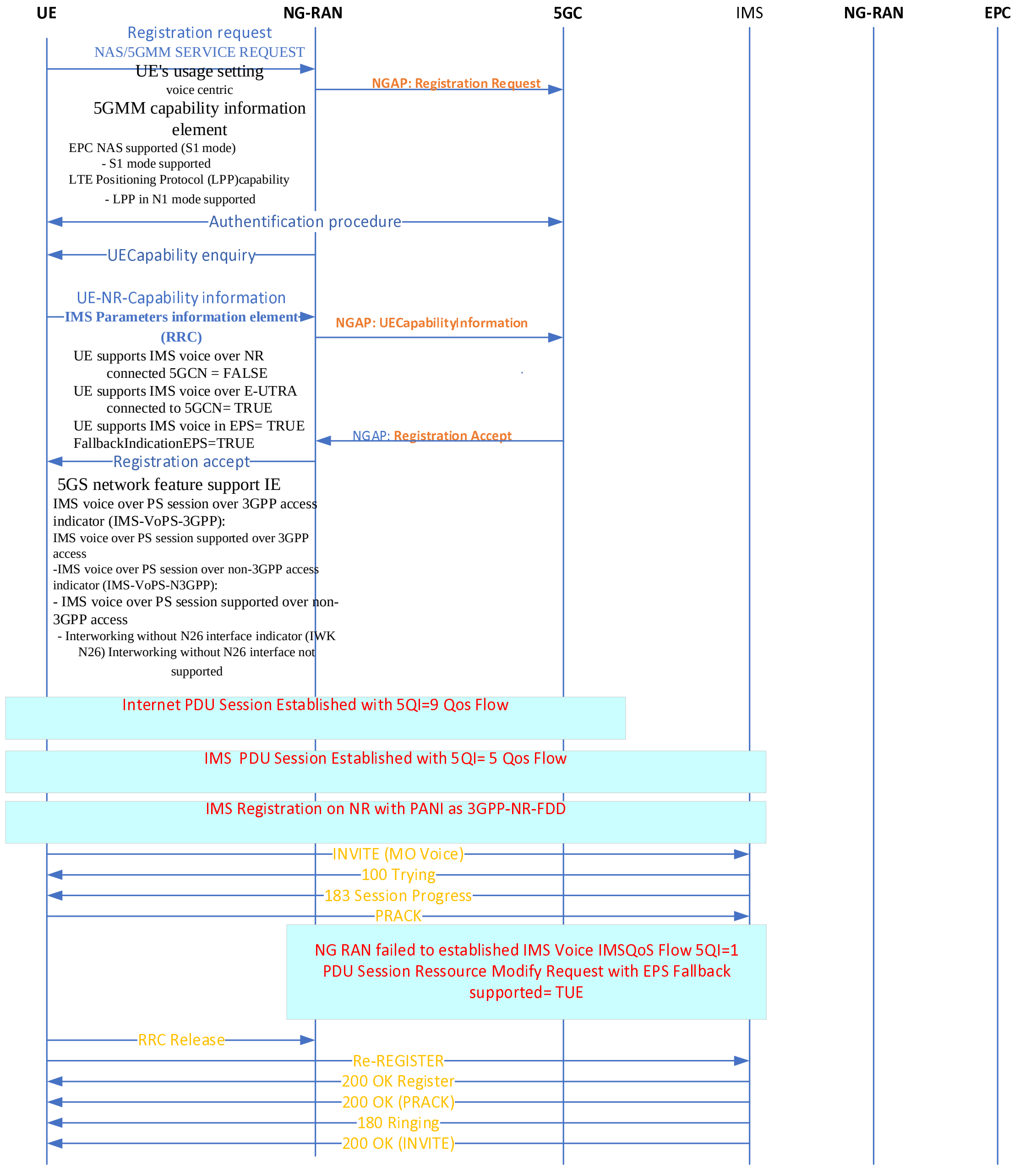


Figure 9: EPS Fallback for Voice IMS Voice (from ETSI TS 123 502 [5])



NOTE: Reasons for this fallback include incomplete voice over NR features in the phone.

Figure 10: End-to-End EPS Fallback with N26 and Redirection Supported

4.4.4 Radio Access Technology (RAT) Fallback

The following clause contains the summary of clause 4.13.6.2 of ETSI TS 123 502 [5] Inter RAT Fallback in 5GC for IMS voice.

The Inter RAT Fallback in 5GC for IMS voice is described in clause 4.13.6.2 of ETSI 123 502 [5]. Figure 11 describes the RAT fallback procedure in 5GC for IMS voice.

When the UE is served by the 5GC, the UE has one or more ongoing PDU Sessions each including one or more QoS Flows. The serving PLMN AMF has sent an indication towards the UE during the Registration procedure that IMS voice over PS session is supported, see clause 5.16.3.10 in ETSI TS 123 501 [4] and the UE has registered in the IMS.

1) In the 5G System (5GS), a User Equipment (UE) camps on the source Next Generation Radio Access Network (NG-RAN) to initiate a Mobile Originated (MO) or Mobile Terminated (MT) IP Multimedia Subsystem (IMS) voice session.

2) The network initiates Packet Data Unit (PDU) Session modification to establish Quality of Service (QoS) flow for IMS voice at the source NG-RAN.

3) If the source NG-RAN supports Radio Access Technology (RAT) fallback for IMS voice, it decides to trigger RAT fallback based on UE capabilities, network configuration, and radio conditions. Measurement report solicitation from the UE to the target NG-RAN may be initiated.

4) The source NG-RAN responds with rejection of the PDU Session modification for IMS voice, indicating ongoing mobility due to fallback. The Session Management Function (SMF) maintains associated QoS rules.

5) The source NG-RAN initiates Inter NG-RAN handover or redirection to E-UTRA connected to 5G Core Network (5GC), with reporting of RAT type change to Policy Control Function (PCF).

6) After completion of the handover or redirection, the SMF re-initiates PDU Session modification for IMS voice. Successful resource allocation and access network information are reported to PCF. IMS signalling for voice call establishment continues, and during the IMS voice call, the target NG-RAN avoids triggering handover back to the source NG-RAN.

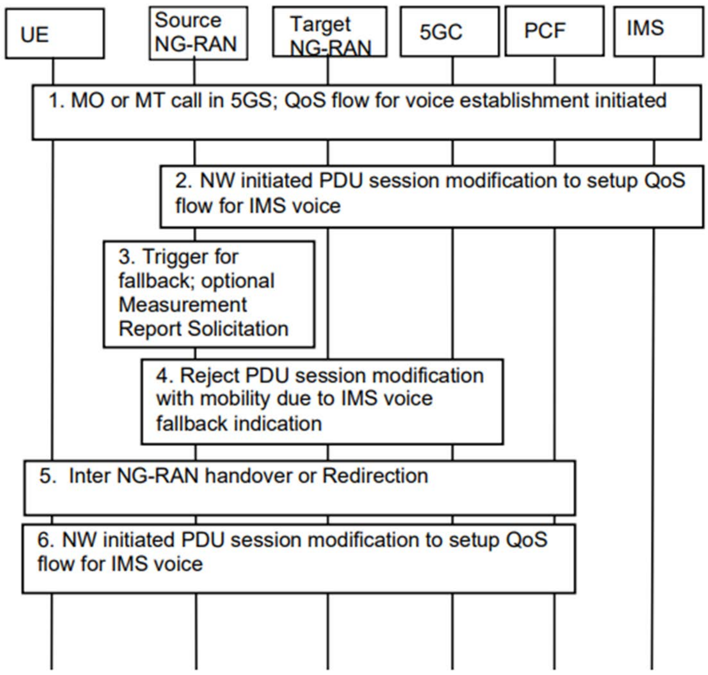


Figure 11: RAT Fallback for IMS voice (from ETSI TS 123 502 [5])

4.4.5 Transfer of PDU session used for IMS voice from non-3GPP access to 5GS

The following clause contains the summary of clause 4.13.6.3 of ETSI TS 123 502 [5] Transfer of PDU session used for IMS voice from non-3GPP access to 5GS.

When a User Equipment (UE) has an ongoing IP Multimedia Subsystem (IMS) voice session via non-3rd Generation Partnership Project (3GPP) access using either ePDG or N3IWF, and the session is transferred to Next Generation Radio Access Network (NG-RAN), the following steps occur, applicable to scenarios involving either IMS voice session continuation over NG-RAN or triggering of EPS/inter-RAT fallback:

1) The UE, triggered to move to 3GPP access, camps in NG-RAN.

2) If not registered via 3GPP access, the UE initiates a Registration procedure.

3) The UE initiates Packet Data Unit (PDU) session establishment for IMS voice service handover from EPC/ePDG to 5GS or from N3IWF to 3GPP access in 5GC. The Session Management Function (SMF) accepts the PDU session transfer.

4) NG-RAN decides to trigger EPS or inter-RAT fallback, considering UE capabilities, AMF indications, network configuration, and radio conditions. Measurement report solicitation from the UE may occur. If fallback is not triggered, the procedure halts.

5) NG-RAN responds with rejection to set up QoS flow for IMS voice or the entire PDU session, indicating ongoing mobility due to fallback. The SMF reports the EPS Fallback event to the Policy Control Function (PCF). If rejection occurs, subsequent steps from the respective clauses are executed, and SMF releases resources in the non-3GPP Access Network (AN).

6) Depending on NG-RAN's response, the SMF either maintains PDN connection/PDU Session at the non-3GPP side, or NG-RAN performs AN release with redirection or handover procedure.

7) If the entire PDU session establishment request is rejected by NG-RAN, the SMF stops the ongoing procedure. Depending on UE implementation, the UE may re-initiate handover to EPS if the inter-system change is triggered by NG-RAN and no response is received to the PDU session establishment request.

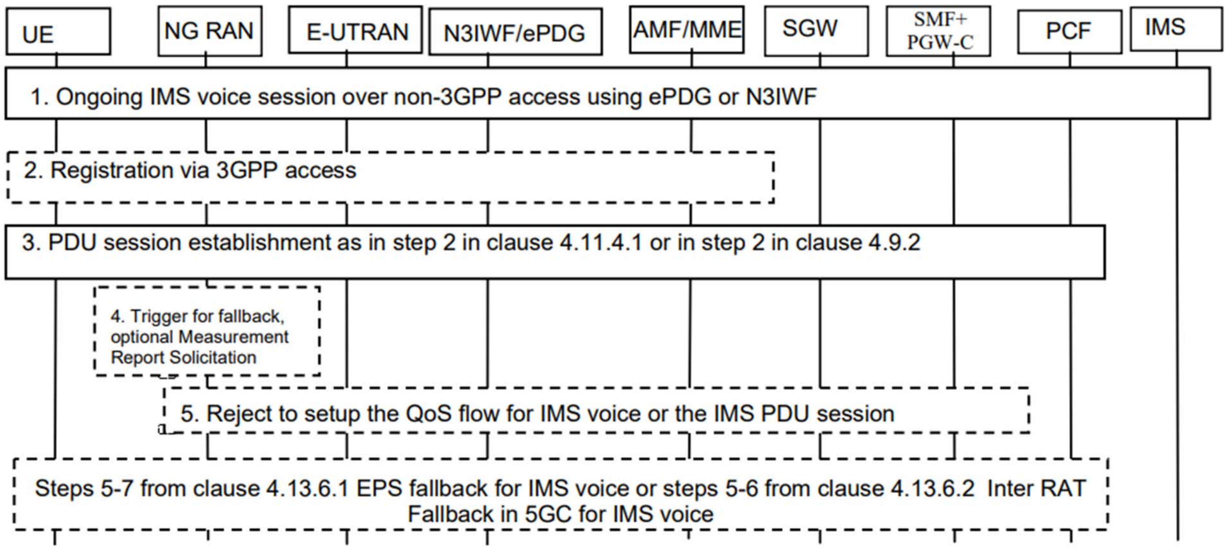


Figure 12: Transfer of PDU session used for IMS voice from non-3GPP access to 5GS (from ETSI TS 123 502 [5])

4.4.6 5G SRVCC

5G SRVCC is a topic under study with 3GPP R16. With 5G SRVCC, 5G UE camps on 5G NR and implements voice service using VoNR. At the edge of NG-RAN, voice can be handed over to UTRAN CS by using 5G SRVCC technology; or UE falls back to UTRAN CS for call establishment and returns to NR immediately after the call is terminated.5G Single Radio Voice Call Continuity (SRVCC) is described in ETSI TS 123 501 [4], clause 5.4.4 and in ETSI TS 123 401 [12].

A 3GPP SRVCC UE is a UE enhanced for IMS Service Continuity with the additional UE capabilities for SRVCC NG-RAN to 3GPP UTRAN and/or between E-UTRAN and 3GPP UTRAN and/or between E-UTRAN and 3GPP GERAN and/or between UTRAN (HSPA) and 3GPP UTRAN and 3GPP GERAN.

ETSI TS 123 216 [10] covers the following NG-RAN scenarios:

- SRVCC from NG-RAN/E-UTRAN/UTRAN (HSPA) access and 3GPP UTRAN/GERAN CS accesses for voice calls that are anchored in the IMS, as well as the coordination between the SRVCC for voice call and the handover of non-voice PS bearers.
- SRVCC with IMS emergency call continuity from E-UTRAN/UTRAN (HSPA) to 3GPP UTRAN/GERAN CS accesses and from NG-RAN to UTRAN.

4.4.7 VoLTE/CSFB

Emergency Services Fallback to EPS can be followed by an onward movement to GERAN or UTRAN via CSFB procedures if the PLMN does not support IMS emergency services.

4.5 5G Architecture Options

See Figures 13 through 18 for details.

Table 2: 5G connectivity options

Connectivity option	Core Network	Master RAT	Secondary RAT	3GPP term
Option 1 SA	EPC	LTE		LTE
Option 2 SA	**5GC**	**NR**	**-**	**NR**
Option 3 NSA	EPC	LTE	NR	EN-DC (Evolved-Universal Terrestrial Radio Access-New Radio) **NR for data only**
Option 4 NSA	5GC	NR	eLTE	NE-DC (Evolved-Universal Terrestrial Radio Access-New Radio)
Option 5 SA	5GC	eLTE	-	eLTE enhanced LTE (*eLTE*) eNB which can communicate with *5G* Core (5GC) and gNB
Option 7 NSA	5GC	eLTE	NR	NGEN-DC **NR for data only**

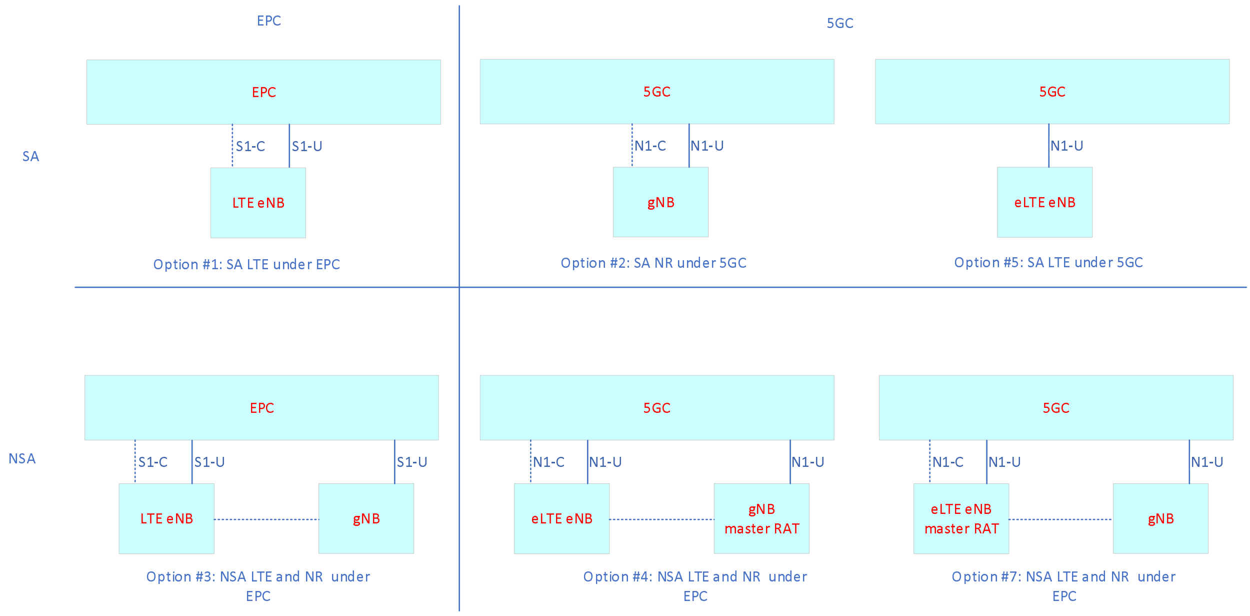


Figure 13: 4G and 5G Deployment Options

The following options for providing NR access to suitably capable UEs should be considered in discussions on the RAN-CN interface, and the interface between E-UTRA and NR RAT.

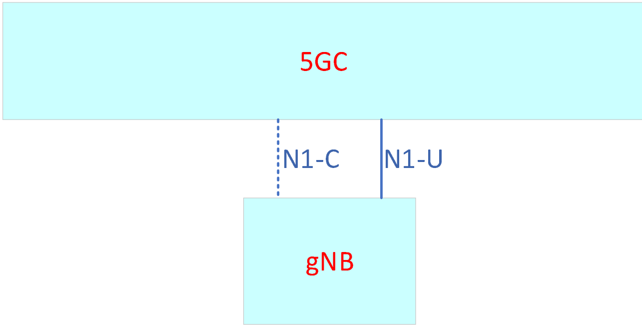


Figure 14: Option 2

In Option 2, the gNB is connected to the 5GC.

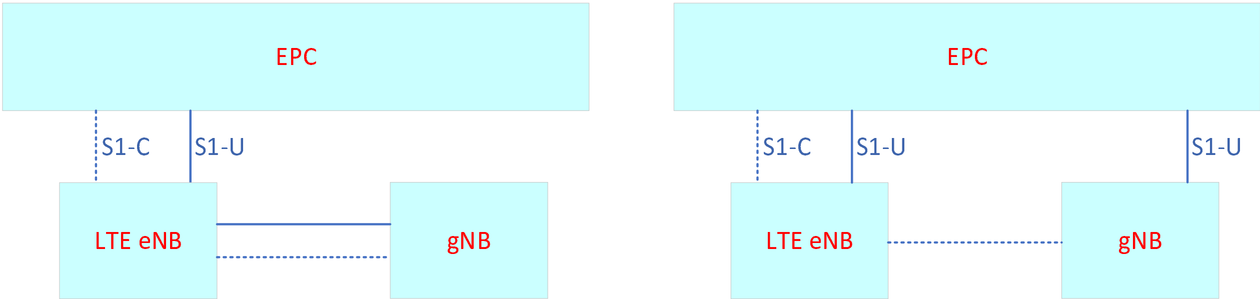


Figure 15: Options 3 and 3A

In Option 3/3A, the LTE eNB is connected to the EPC with Non-standalone NR. The NR user plane connection to the EPC goes via the LTE eNB (Option 3) or directly (Option 3A).

NOTE: Terminology related to Option 3/3A can be further discussed in normative phase, if needed.

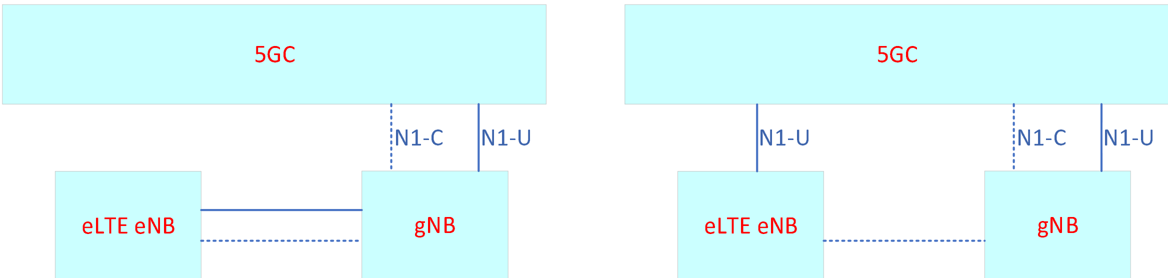


Figure 16: Options 4 and 4A

In Option 4/4A, the gNB is connected to the 5GC with Non-standalone E-UTRA. The E-UTRA user plane connection to the 5GC goes via the gNB (Option 4) or directly (Option 4A).

Option 4 Series is divided into Option 4 and 4a. As can be seen from Figure 16, the only difference between the options is whether the data split anchor is in the 5G base station or in the 5G core network. Both of these are new network elements and do not involve the upgrading and transformation of legacy equipment, so both options are acceptable.

The application scenario for Option 4 series is in the middle and late stages of 5G deployment. 5G has achieved continuous coverage, completely leaving 4G behind as a complement to 5G.

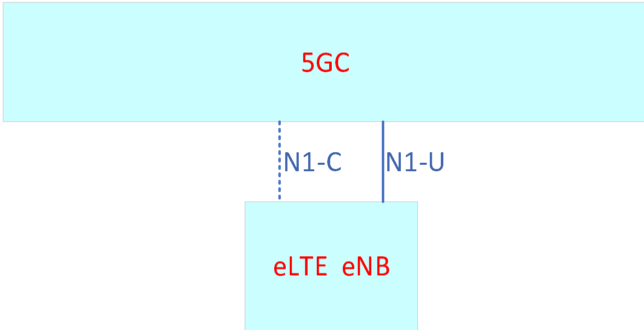


Figure 17: Option 5

In Option 5, the eLTE eNB is connected to the 5GC.

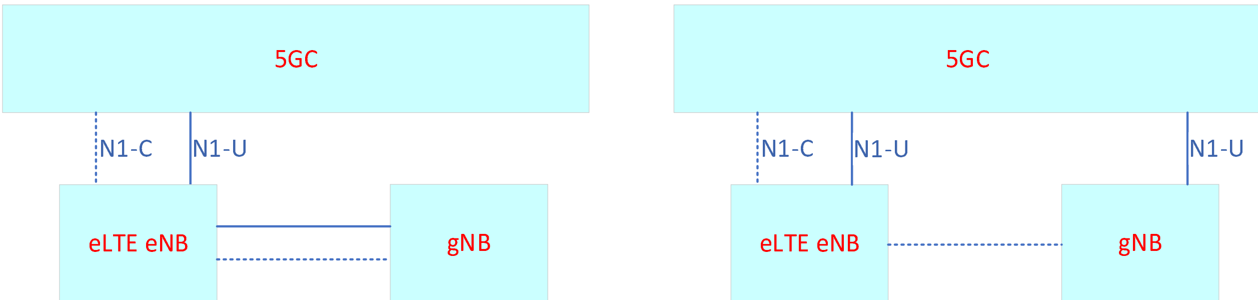


Figure 18: Options 7 and 7A

In Option 7/7A, the eLTE eNB is connected to the 5GC with Non-standalone NR. The NR user plane connection to the 5GC goes via the eLTE eNB (Option 7) or directly (Option 7A).

4.6 E2E scenarios in terms of interworking, interconnection and roaming

4.6.1 Introduction

The e2e tests shall be executed based on a test case selection expression and the types of end devices contained in the Excel test list, which is included as an electronic attachment to this Recommendation. The excel list is a normative part of the present document. The interconnection and roaming scenarios should be selected depending on the network infrastructure and company strategy.

To perform an interconnection test between two network operators, the reference configuration depicted in Figure 19 should be used. The reference point to observe the message flow is at the 'Ic' interface between the two networks.

The test descriptions provided in clause 4.6.2 are contained in the Excel file in archive ts_103905v010101p0.zip which accompanies the present document.

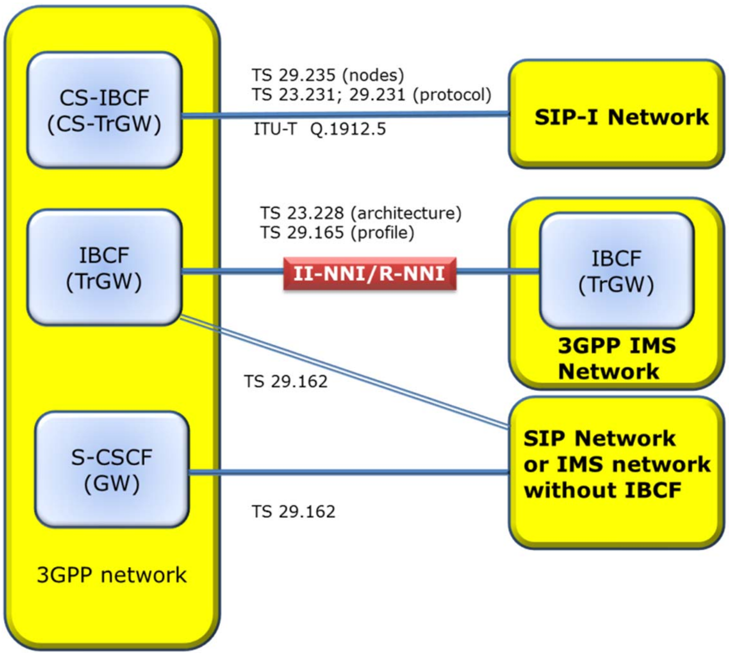


Figure 19: Reference configuration for the interconnection test

4.6.2 Interconnection and roaming scenarios test selection description

4.6.2.1 First step - Identification of the Networks

During the first step Table 3 should be completed.

Table 3: Identification of the Networks, with examples

	Network A	Network B
Network under Test identification	Telekom Austria	Deutsche Telekom
Responsibility		
Name:	Martin Brand	Gerhard Ott
Telephone number:		
Facsimile number:		
Additional information:		
Product Supplier	Nokia	Huawei
Date of the statement:		
Dates of Testing (from .. to ..)		

4.6.2.2 Second step - Selection Expression

During the second step the Selection Expression form sheet should be completed. The Selection Expression depicted in Table 4 was developed to select the scope of the compatibly test between network operator A and network operator B. By doing that, test purposes are selected automatically. The table shall be filled out (yes/no). This table can be used as a PICS form as used in a conformance test.

Table 4: Selection Expression applicable in the Test Purposes

Selection Expression		Support Network A	Support Network B
Network capabilities			
SE 1:	The originating network (Network A) sends the P-Charging-Vector header?		
SE 2:	The originating network (Network A) sends a subset of parameters in the P-Charging-Vector header?		
SE 3:	The P-Early-Media header is supported?		
SE 4:	Overlap procedure using multiple INVITE method is supported?		
SE 5:	Overlap sending using in-dialog method is supported?		
SE 6:	Network A supports the PSTN XML schema?		
SE 7:	The resource reservation procedure is supported?		
SE 8:	Does the network perform the "Fall back" procedure (PSTN or MGCF)?		
SE 9:	The network is untrusted?		
SE 10:	Originating network does not have a number portability data base, the number portability look up is done in the interconnected network?		
SE 11:	The network supports the REFER method?		
SE 12:	The Network supports the 3 party call control procedure (REFER interworking)?		
SE 13:	The Number Portability is supported?		
SE 14:	Carrier Selection is performed?		
SE 15:	The Network is a Long distance carrier?		
SE 16:	SIP Support of Charging is supported?		
SE 17:	The interworking ISUP - SIP I is performed in the network?		
Supplementary services			
SE 18:	The network supports the Originating Identification Presentation (OIP)?		
SE 19:	The network supports the "Special arrangement" procedure for the originating user?		
SE 20:	The network supports the Originating Identification Restriction (OIR)?		
SE 21:	The Network supports the Terminating Identification Presentation (TIP)?		
SE 22:	The network supports the "Special arrangement" procedure for the terminating user?		
SE 23:	The Network supports the Terminating Identification Restriction (TIR)?		
SE 24:	The Network supports the session HOLD procedure?		
SE 25:	The network supports Communication Forwarding Unconditional (CFU)?		
SE 26:	The network supports Communication Forwarding Busy (CFB)?		
SE 27:	The network supports Communication Forwarding No Reply (CFNR)?		
SE 28:	The Network supports Communication Forwarding Not Logged in (CFNL)?		
SE 29:	The Network supports Communication Deflection?		
SE 30:	The Network supports the CDIV Notification procedure?		
SE 31:	The Network supports conference (CONF)?		
SE 32:	The Network supports the Communication Barring procedure (CB) - (Blacklist for incoming calls)?		
SE 33:	The Network supports the Anonymous Communication Rejection (ACR)?		
SE 34:	The Network supports the Closed User Group (CUG)?		
SE 35:	The Network supports the Communication Waiting (CW) service?		
SE 36:	The Network supports the T_{AS-CW} timer?		
SE 37:	The Network supports Explicit Communication Transfer (ECT)?		
SE 38:	The network supports Malicious Communication Identification (MCID)?		
SE 39:	The Network supports Message Waiting Indication (MWI)?		
SE 40:	The Network supports Completion of Communications to Busy Subscriber (CCBS)?		
SE 41:	The Network supports Completion of Communications by No Reply (CCNR)?		
Terminal capabilities			
SE 42:	Void.		
SE 43:	The End device supports Fax transmission via G.711 codec?		

Selection Expression		Support Network A	Support Network B
SE 44:	The End device supports Fax transmission via V.152 codec?		
SE 45:	The End device supports Fax transmission via m-line T.38 codec?		
SE 46:	A SIP end device is used supporting an ISDN user equipment and the PSTN XML Schema is used?		
SE 47:	End device is located in the PSTN or PLMN?		
SE 48:	The terminating UE supports the from-change tag procedure and sends a second user identity in an UPDATE request after the dialogue is confirmed?		
SE 49:	The end device performs ECT using the 'Blind/assured transfer'?		
SE 50:	The end device performs ECT using the 'Consultative transfer'?		
SE 51:	The end device supports the Resource reservation procedure?		
PSTN/PLMN Supplementary services			
SE 52:	CLIP/CLIR is supported in the PSTN/PLMN part of the network?		
SE 53:	COLP/COLR is supported in the PSTN/PLMN part of the network?		
SE 54:	HOLD is supported in the PSTN/PLMN part of the network?		
SE 55:	CDIV is supported in the PSTN/PLMN part of the network?		
SE 56:	CONF/3PTY is supported in the PSTN/PLMN part of the network?		
SE 57:	ACR is supported in the PSTN/PLMN part of the network?		
SE 58:	CUG is supported in the PSTN/PLMN part of the network?		
SE 59:	CW is supported in the PSTN/PLMN part of the network?		
SE 60:	ECT is supported in the PSTN/PLMN part of the network?		
SE 61:	MCID is supported in the PSTN/PLMN part of the network?		
SE 61A:	Call Completion is supported in the PSTN/PLMN part of the network?		
SE 62:	SUB is supported in the PSTN/PLMN part of the network?		
SE 63:	UUS is supported in the PSTN/PLMN part of the network?		
SE 64:	TP is supported in the PSTN/PLMN part of the network?		
DTMF transmission			
SE 65:	The Network supports DTMF transmission in the RTP stream.		
SE 66:	The Network supports DTMF transmission indicating in the SDP offer in the RTP stream.		
SE 67:	The Network supports DTMF transmission by the SIP INFO/NOTIFY Method for DTMF tone generation.		
5G Network feature support information			
SE 68:	The network supports IMS voice over PS session over 3GPP access.		
SE 69:	The network supports IMS voice over PS session over non-3GPP access.		
SE 70:	Emergency services not supported from the network.		
SE 71:	Emergency services supported in NR connected to 5GCN only from the network.		
SE 72:	Emergency services supported in E-UTRA connected to 5GCN only from the network.		
SE 73:	Emergency services supported in NR connected to 5GCN and E-UTRA connected to 5GCN from the network.		
SE:74:	Emergency services fallback not supported from the network.		
SE 75:	Emergency services fallback supported in NR connected to 5GCN only from the network.		
SE 76:	Emergency services fallback supported in E-UTRA connected to 5GCN only from the network.		
SE 77:	Emergency services fallback supported in NR connected to 5GCN and E-UTRA connected to 5GCN.		
SE 78:	Interworking without N26 interface not supported from the network.		
SE 79:	Interworking without N26 interface supported from the network.		
SE 80:	Access identity 1 not valid from the network.		
SE 81:	Access identity 1 valid from the network.		
SE 82:	Emergency services not supported over non-3GPP access from the network.		
SE 83:	Emergency services supported over non-3GPP access from the network.		
SE 84:	Access identity 2 not valid from the network.		
SE 85:	Access identity 2 valid from the network.		
SE 86:	Both CE mode A and CE mode B are not restricted from the network.		
SE 87:	Both CE mode A and CE mode B are restricted from the network.		
SE 88:	CE mode B is restricted from the network.		

Selection Expression		Support Network A	Support Network B
SE 89:	Use of enhanced coverage is not restricted from the network.		
SE 90:	Use of enhanced coverage is restricted from the network.		
SE 91:	Control plane CIoT 5GS optimization not supported from the network.		
SE 92:	Control plane CIoT 5GS optimization supported from the network.		
SE 93:	N3 data transfer supported from the network.		
SE 94:	N3 data transfer not supported from the network.		
SE 95:	IP header compression for control plane CIoT 5GS optimization not supported from the network.		
SE 96:	IP header compression for control plane CIoT 5GS optimization supported from the network.		
SE 97:	User plane CIoT 5GS optimization not supported from the network.		
SE 98:	Location services via 5GC not supported from the network.		
SE 99:	Location services via 5GC supported from the network.		
SE 100:	ATSSS not supported from the network.		
SE 101:	ATSSS supported from the network.		
SE 102:	Ethernet header compression for control plane CIoT 5GS optimization not supported from the network.		
5GMM capability information element			
SE 103:	Is EPC NAS supported (S1 mode)from the UE?		
SE 104:	Is LTE Positioning Protocol (LPP) capability from the UE?		
SE 105:	Is Restriction on use of enhanced coverage support from the UE?		
SE 106:	Is Control plane CIoT 5GS optimization supported from the UE?		
SE 107:	Is Service Gap Control (SGC) supported from the UE.		
SE 108:	Is User plane CIoT 5GS optimization (5G-UP CIoT) supported from the UE?		
SE 109:	Is V2X not supported from the UE?		
UE's usage setting information element			
SE 110:	Is UE's usage setting voice centric supported from the user?		
SE 111:	Is UE's usage setting data centric supported from the user?		

4.6.2.3 Third step- Access and End Devices Types

During the third step the **Access and End Devices Types** form sheet should be completed (see Table 5). With the specified Test Purposes in the present document, the compatibility between the interconnected networks and the used access and end devices Selection Expression shall be assured. Each Test Purpose can be performed by using a physical end device to assure end-to-end compatibility between the two interconnected networks.

Table 5: Overview of Accesses and End Devices Types

List of Type of End devices in both networks

	Network A	**Network B**
	Telekom Austria	**Deutsche Telekom**
SIP-VoIP		
POTS		
ISDN		
GSM-PLMN		
VoUMTS		
VoLTE / VoNR /VoWLAN		
PSTN	X	X

Highlight color	Explanation	Reference
	The user equipment is a SIP hardphone or a SIP soft client on a PC in the fixed network. The user equipment is a 4G mobile device in an LTE network. The user equipment is a 3G mobile device in an UMTS network.	ETSI TS 124 229 [14]
	The user equipment is an **Integrated Access Device (IAD)** in the fixed network - access via a legacy analogue device.	ETSI TS 183 043 [21]
	The user equipment is an **Integrated Access Device (IAD)** in the fixed network - access via a legacy ISDN device.	ETSI TS 183 036 [22]
	The user equipment is a 2G mobile device in an GSM network. SS7 / SIP interworking applies. The user equipment is located in a fixed SS7 network (analogue or ISDN).	Recommendations ITU-T Q.761 [23] - Q764 [24] ETSI TS 129 163 [25] Recommendation ITU-T Q.1912.5 [26]

4.6.2.4 Fourth step- activation

In the fourth step in the Test list (Table 6), activate the filter "Selected" in row "G" (deactivate the "no" entry). In addition to hide the title of the test case deselect also the "empty" entry.

Table 6: Test list - example

IMS interconnection tests at the Ic Interface; Test Suite Structure and Test Purposes (TSS&TP)

Test case number	Test name	Dir	Originating end devic	Terminating end devic	Selected	Executed	Verdict	Observation
BCALL								
BCALL/successful								
SS_bcall_002_a_pstn_sip	Basic call normal call clearing from the calling user.	NA -> NB	PSTN	SIP-VoIP	yes	no		2
SS_bcall_002_a_pstn_pots	Basic call normal call clearing from the calling user.	NA -> NB	PSTN	POTS	yes	no		2
SS_bcall_002_a_pstn_pstn	Basic call normal call clearing from the calling user.	NA -> NB	PSTN	PSTN	yes	no		2
SS_bcall_002_b_sip_pstn	Basic call normal call clearing from the calling user.	NB -> NA	SIP-VoIP	PSTN	yes	yes		
SS_bcall_002_b_pots_pstn	Basic call normal call clearing from the calling user.	NB -> NA	POTS	PSTN	yes	yes		
SS_bcall_002_b_pstn_pstn	Basic call normal call clearing from the calling user.	NB -> NA	PSTN	PSTN	yes	yes		
SS_bcall_003_a_pstn_sip	Request line in the INVITE.	NA -> NB	PSTN	SIP-VoIP	yes	yes		
SS_bcall_003_a_pstn_pots	Request line in the INVITE.	NA -> NB	PSTN	POTS	yes	yes		

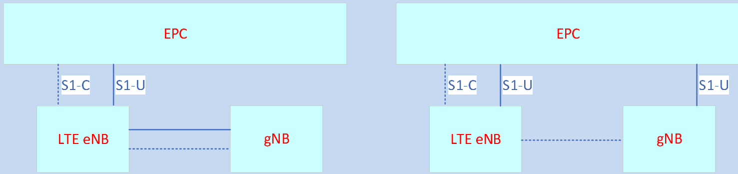
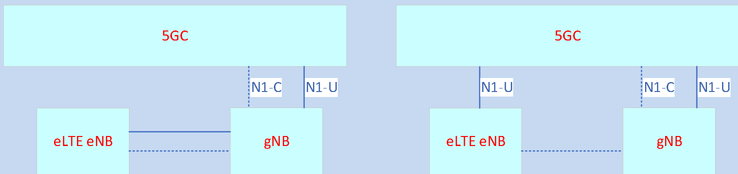
4.6.2.5 Fifth step - Definition of 5G access networks in terms of interconnection and roaming

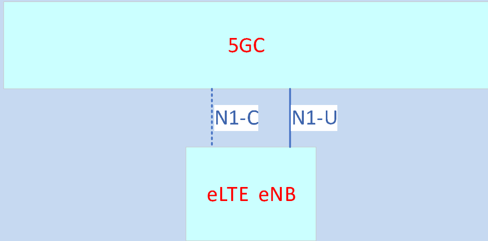
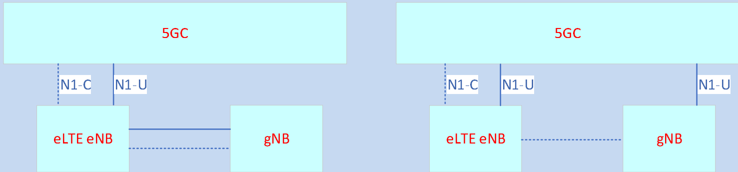
The definition provided in the present clause are NOT contained in the Excel file in archive ts_103905v010101p0.zip which accompanies the present document.

Table 7: Definition of 5G access networks in terms of interconnection and roaming

No.	Scenario	Description	Roaming options
Support of non-3GPP access			
1	1.1	Untrusted non-3GPP access networks.	
2	1.2	Trusted non-3GPP access networks.	
3	1.3	Wireline access networks.	
Trusted and Untrusted Non-3GPP Accesses			
Non-roaming			
4	1.1.1	Non-roaming architecture for 5G Core Network with untrusted non-3GPP access (ETSI TS 123 501 [4], clause 4.2.8.2.1, Figure 4.2.8.2.1-1).	
5	1.1.2	Non-roaming architecture for 5G Core Network with trusted non-3GPP access.	
6	1.1.3	5GC	LBO Roaming for 5G Core Network with untrusted non-3GPP access: • N3IWF in the same VPLMN as 3GPP access (ETSI TS 123 501 [4], clause 4.2.8.2.2, Figure 4.2.8.2.2-1).
7	1.1.4	5GC	LBO Roaming for 5G Core Network with untrusted non-3GPP access: • N3IWF in a different PLMN from 3GPP access (ETSI TS 123 501 [4], clause 4.2.8.2.2, Figure 4.2.8.2.2-2).
8	1.1.5	5GC	LBO Roaming for 5G Core Network with trusted non-3GPP access using the same VPLMN as 3GPP access (ETSI TS 123 501 [4], clause 4.2.8.2.2, Figure 4.2.8.2.2-3).
9	1.1.6	5GC	LBO Roaming for 5G Core Network with trusted non-3GPP access using a different PLMN than 3GPP access (ETSI TS 123 501 [4], clause 4.2.8.2.2, Figure 4.2.8.2.2-4).
Home-routed Roaming			
10	1.1.7	5GC	HR Roaming for 5G Core Network with untrusted non-3GPP access - N3IWF in the same VPLMN as 3GPP access (ETSI TS 123 501 [4], clause 4.2.8.2.3, Figure 4.2.8.2.3-1).
11	1.1.8	5GC	HR Roaming for 5G Core Network with untrusted non-3GPP access - N3IWF in a different VPLMN than 3GPP access (ETSI TS 123 501 [4], clause 4.2.8.2.3, Figure 4.2.8.2.3-2).
12	1.1.9	5GC	HR Roaming for 5G Core Network with untrusted non-3GPP access - N3IWF in HPLMN (ETSI TS 123 501 [4], clause 4.2.8.2.3, Figure 4.2.8.2.3-3).
13	1.1.10	5GC	HR Roaming for 5G Core Network with trusted non-3GPP access using the same VPLMN as 3GPP access (ETSI TS 123 501 [4], clause 4.2.8.2.3, Figure 4.2.8.2.3-4).

No.	Scenario	Description	Roaming options
Support of Wireline Access			
Non- roaming architecture			
14	1.3.1	5G Core Network for 5G-RG with Wireline 5G Access network and NG RAN (ETSI TS 123 501 [4], clause 4.2.8.2.4, Figure 4.2.8.2.4-1).	
15	1.3.2	5G Core Network for FN-RG with Wireline 5G Access network and NG RAN (ETSI TS 123 501 [4], clause 4.2.8.2.4, Figure 4.2.8.2.4-2).	
Access to 5GC from devices that do not support 5GC NAS over WLAN access			
16	1.3.3	Non-roaming and LBO Roaming supporting 5GC access from N5CW devices (ETSI TS 123 501 [4], clause 4.2.8.5.2, Figure 4.2.8.5.2-1).	
Interworking with EPC (ETSI TS 123 501 [4], clause 4.3)			
Non-roaming scenarios (ETSI TS 123 501 [4], clause 4.3.1)			
17	1.4.1	Non-roaming scenarios for interworking between 5GS and EPC/E-UTRAN (ETSI TS 123 501 [4], clause 4.3.1, Figure 4.3.1-1).	
Roaming scenarios			
18	1.4.2	Interworking between 5GS and EPC/E-UTRAN.	Local breakout roaming for interworking between 5GS and EPC/E-UTRAN (ETSI TS 123 501 [4], clause 4.3.2, Figure 4.3.2-1).
19	1.4.3	Interworking between 5GS and EPC/E-UTRAN.	Home-routed roaming architecture for interworking between 5GS and EPC/E-UTRAN (ETSI TS 123 501 [4], clause 4.3.2, Figure 4.3.2-2).
Interworking between 5GC via non-3GPP access and E-UTRAN connected to EPC			
Non-roaming scenarios			
20	1.5.1	Non-roaming for interworking between 5GC via non-3GPP access and EPC/E-UTRAN (ETSI TS 123 501 [4], clause 4.3.3.1, Figure 4.3.3.1-1).	
Roaming architecture			
21	1.5.2	Interworking between 5GS and EPC/E-UTRAN.	Local breakout roaming architecture for interworking between 5GC via non-3GPP access and EPC/E-UTRAN (ETSI TS 123 501 [4], clause 4.3.3.2, Figure 4.3.3.2-1).
22	1.5.3	Interworking between 5GS and EPC/E-UTRAN.	Home-routed roaming architecture for interworking between 5GC via non-3GPP access and EPC/E-UTRAN (ETSI TS 123 501 [4], clause 4.3.3.2, Figure 4.3.3.2-2).
Interworking between ePDG connected to EPC and 5GS			
Non-roaming scenarios			
23	1.6.1	Non-roaming scenarios for interworking between ePDG/EPC and 5GS (ETSI TS 123 501 [4], clause 4.3.4.1, Figure 4.3.4.1-1).	
Roaming scenarios for interworking between ePDG/EPC and 5GS			
24	1.6.2	Interworking between ePDG/EPC and 5GS.	Local breakout roaming for interworking between ePDG/EPC and 5GS (ETSI TS 123 501 [4], clause 4.3.4.2, Figure 4.3.4.2-1).
25	1.6.3	Interworking between ePDG/EPC and 5GS.	Home-routed roaming for interworking between ePDG/EPC and 5GS (ETSI TS 123 501 [4], clause 4.3.4.2, Figure 4.3.4.2-2).

No.	Scenario	Description	Roaming options
5G scenarios in terms of 5G-NR(EN-DC) Bearer Concept			
26	1.7.1	5G (NSA) VoLTE with EN-DC split-bearer (LTE upgrade to support EN-DC (Option 3)) (note 1).  	The 3GPP standards related to roaming for 5G (NSA) VoLTE with EN-DC split-bearer are specified in the following documents: • ETSI TS 123 501 [4]. • ETSI TS 123 502 [5]. Overall, 5G (NSA) VoLTE with EN-DC split-bearer (LTE upgrade to support EN-DC) supports roaming and enables users to take advantage of both 5G NR and LTE networks for voice and data.
27	1.7.2	5G (NSA) VoLTE without EN-DC split-bearer (LTE upgrade to support EN-DC (Option 3)) (note 1).	The 3GPP standards related to roaming for 5G (NSA) VoLTE with EN-DC split-bearer are specified in the following document: • ETSI TS 123 502 [5]. These standards provide detailed technical specifications for the implementation of 5G (NSA) VoLTE with EN-DC split-bearer, including the network architecture, protocols, and procedures required to support roaming. The split-bearer feature of EN-DC allows the 5G NR and LTE networks to be used simultaneously for voice and data transmission. The VoLTE (Voice over LTE) allows for high-quality voice calls over the LTE network, and with the support of EN-DC split-bearer, users can continue to make VoLTE calls while utilizing both the 5G NR and LTE networks for improved coverage and capacity. Overall, 5G (NSA) VoLTE with EN-DC split-bearer (LTE upgrade to support EN-DC) supports roaming and enables users to take advantage of both 5G NR and LTE networks for voice and data.
28	1.7.3	5G Single Radio Voice Call Continuity (SRVCC).	5G Single Radio Voice Call Continuity (SRVCC) is described in ETSI TS 123 501 [4], clause 5.4.4 and ETSI TS 123 216 [10].
29	1.7.4	5G (NSA) Circuit-Switched Fallback (CSFB) mode using 2G or 3G (note 2).	
	1.7.5	5G (NSA) eLTE-NR; Dual Connectivity with 5GC. In Option 4/4A, the gNB is connected to the 5GC with Non-standalone E-UTRA. The E-UTRA user plane connection to the 5GC goes via the gNB (Option 4) or directly (Option 4A) (Option 4) (note 3).  	The 5G (NSA) eLTE-NR; Dual Connectivity with 5GC (Option 4) roaming is described in ETSI TS 123 501 [4], which covers the System Architecture for the 5G System. Specifically, the details of the 5G (NSA) eLTE-NR; Dual Connectivity with 5GC (Option 4) roaming are provided in clause 5.2.2.5, which covers the interworking between the 5G System and LTE. Additionally, the details of the roaming are provided in clause 8.5, which covers the roaming architecture and procedures for the 5G System.

No.	Scenario	Description	Roaming options
31	1.7.6	In Option 5, the eLTE eNB is connected to the 5GC 	
32	1.7.7	5G (NSA) NR-eLTE; Dual Connectivity (Option 7) (note 4) 	The roaming of 5G (NSA) NR-eLTE; Dual Connectivity (Option 7) is described in ETSI TS 123 501 [4]. Specifically, the details of the roaming are provided in clause 8.5, which covers the roaming architecture and procedures for the 5G System. Clause 5.2.2.5 also provides some information on the interworking between the 5G System and LTE, which is relevant to Option 7 of the Dual Connectivity feature.

NOTE 1: E-UTRA-NR Dual Connectivity (EN-DC) is a 5G technology that allows 5G devices to use both 4G LTE and 5G networks simultaneously. This technology improves network performance by enabling devices to use the best available connection for a given task, depending on factors such as network coverage, signal strength, and bandwidth requirements.
Split-bearer is a 5G technology that allows for the separation of data traffic between the 5G network and the 4G LTE network. It allows the 5G network to handle high-speed, low-latency traffic, while the 4G LTE network can handle slower-speed, high-latency traffic.
In the context of LTE upgrade to support EN-DC (Option 3), this refers to a specific configuration that allows for the use of both 4G LTE and 5G networks simultaneously. Option 3 involves using the Evolved Universal Terrestrial Radio Access (E-UTRA) as the anchor for both the 4G LTE and 5G networks. This enables devices to use both networks simultaneously, with the 4G LTE network acting as a secondary connection to support 5G data traffic.
Overall, the combination of 5G (NSA), VoLTE, and EN-DC split-bearer (LTE upgrade to support EN-DC (Option 3)) offers improved network performance, faster data speeds, and better call quality for users.
The main difference between 5G (NSA) VoLTE with EN-DC split-bearer and 5G (NSA) VoLTE without EN-DC split-bearer is in the way data traffic is handled between the 4G LTE and 5G networks.
In 5G (NSA) VoLTE with EN-DC split-bearer, the 5G network handles high-speed, low-latency traffic, while the 4G LTE network handles slower-speed, high-latency traffic. This is achieved through the use of split-bearer technology, which separates the data traffic between the 4G LTE and 5G networks.
In contrast, 5G (NSA) VoLTE without EN-DC split-bearer does not use split-bearer technology. Instead, it relies on the 5G network to handle all data traffic, including slower-speed, high-latency traffic that would typically be handled by the 4G LTE network. This can result in reduced network performance and slower data speeds, especially in areas where 5G coverage is limited or weak.
In summary, the key difference between the two is that 5G (NSA) VoLTE with EN-DC split-bearer uses split-bearer technology to enable both 4G LTE and 5G networks to handle data traffic simultaneously, while 5G (NSA) VoLTE without EN-DC split-bearer relies solely on the 5G network to handle all data traffic.
In the Option 3 networking mode, the X2 interface traffic between eNB and gNB has NSA user plane traffic. This traffic is huge. The core network needs to increase the bandwidth of the S1-U interface to meet the LTE/NSA transmission requirements.
In the Option 3a networking mode, there is only control plane traffic in the X2 interface. So the X2 traffic is very small.
In the Option 3x networking mode, there is a little LTE user plane traffic in the X2 interface.
From the perspective of the impact on the existing network, the Option 3x is relatively small and has become the mainstream choice for NSA networking. By using 4G as the anchor point of the control plane, it can meet good service continuity and support rapid network construction in the initial stage of 5G deployment.

No.	Scenario	Description	Roaming options
NOTE 2: 5G (NSA) Circuit-Switched Fallback (CSFB) mode is a fallback mechanism used when a 5G device needs to make a voice call or send an SMS message. In this mode, the device falls back to the 2G or 3G network to complete the call or message. The reason for this fallback is that 5G networks are primarily designed for data traffic, and there may be limitations in supporting voice and SMS traffic. As a result, when a voice call or SMS is made from a 5G device, the device falls back to the legacy 2G or 3G network to complete the transaction. CSFB mode involves establishing a voice or SMS session on the 2G or 3G network while simultaneously maintaining a data session on the 5G network. This enables users to continue using their 5G device for data services while making a voice call or sending an SMS message. One limitation of CSFB mode is that it can result in a delay in call setup time as the device switches from the 5G network to the 2G or 3G network. Additionally, the quality of the voice call or SMS message may be affected if the network signal is weak or if there is interference on the legacy network. Overall, CSFB mode is a fallback mechanism used by 5G (NSA) devices to enable voice and SMS services using the legacy 2G or 3G networks. While it may result in some limitations and delays, it ensures that users can continue to make voice calls and send SMS messages even when 5G network coverage is limited or weak. NOTE 3: The eLTE network serves as an anchor for the 5G NR radio access network, allowing for faster deployment and a smoother transition to full 5G Standalone (SA) networks in the future. This architecture enables the deployment of 5G services while leveraging existing infrastructure and spectrum. Dual connectivity with 5GC (5G Core) refers to the capability of devices to simultaneously connect to both the eLTE and 5G NR networks, while also being able to utilize the features and services of the 5G Core. This allows for improved data rates, lower latency, and better coverage and capacity. Overall, 5G (NSA) eLTE-NR with dual connectivity to 5GC is a flexible and efficient way to introduce 5G capabilities into existing networks, while also providing a foundation for future expansion and innovation in 5G technology. NOTE 4: 5G (NSA) NR-eLTE dual connectivity, also known as Option 7, is a network architecture that combines Non-Standalone (NSA) 5G New Radio (NR) with an enhanced Long Term Evolution (eLTE) network. This architecture allows for the deployment of 5G services while leveraging existing infrastructure and spectrum, while also allowing devices to simultaneously connect to both networks. In this architecture, the eLTE network serves as an anchor for the 5G NR radio access network, enabling faster deployment and a smoother transition to full 5G Standalone (SA) networks in the future. The 5G NR network provides the higher data rates, lower latency, and improved coverage and capacity that are characteristic of 5G technology. Dual connectivity allows devices to simultaneously connect to both the eLTE and 5G NR networks, resulting in improved data rates and coverage. In addition, the 5G Core (5GC) can be utilized to provide advanced services and features, such as network slicing, which enables the creation of virtual networks with customized performance characteristics to meet specific use cases. Overall, 5G (NSA) NR-eLTE dual connectivity (Option 7) is a flexible and efficient way to introduce 5G capabilities into existing networks, while also providing a foundation for future expansion and innovation in 5G technology.			

4.7 Interworking scenarios

According to the general principles described in step 3 below, Access and end devices types, three key e2e interworking scenarios can be identified:

1) Vo5G - IMS interconnection scenarios;

   VoNR - IMS interconnection scenarios;

   EPS Fallback - IMS interconnection scenarios;

   RAT Fallback - IMS interconnection scenarios;

   5GSRVCC - IMS interconnection scenarios;

   VoLTE/CSFB - IMS interconnection scenarios.

2) Vo5G - Legacy network scenarios;

   VoNR - Legacy network scenarios;

   EPS Fallback - Legacy network scenarios;

   RAT Fallback - Legacy network scenarios;

   5GSRVCC - Legacy network scenarios;

   VoLTE/CSFB - Legacy network scenarios.

3) Vo5G - Vo5G and Vi5G - Vi5G interconnection and roaming scenarios are described in clause 4.6.2.5.

5 Roaming Guidelines for 5G

Roaming Guidelines for 5G are described in GSMA PRD IR.65 [28]. Chapter 2A.2 outlines the IMS Roaming architecture for 5GS, while chapter 2.A.4 describes the requirements for the IMS roaming architecture. The Official Document GSMA NG.113 [29] - 5GS Roaming Guidelines aims to provide a standardized view on how 5G System (5GS) networks making use of the 5G Core (5GC) can interconnect and/or interwork when users roam onto a network different to their Home Public Mobile Network (HPMN). This will be applicable when New Radio (NR) radio bearers are used, connected to a 5GC, and both User Equipment (UE) and Visited PMN (VPMN) have matching capabilities. The main focus is to describe 5GC, NR and interworking with EPS during roaming.

6 IMS Profile for Voice, Video and Messaging over 5GS

The IMS Profile for Voice, Video and Messaging over 5GS is described in the GSMA NG.114 [27].

7 5G interconnect and roaming tests

7.1 Test Suite Structure (TSS)

Table 8: Test Suite Structure

BCALL	Successful NNI	SS_bcall_NNI_xxx	
	DTMF	SS_DTMF_xxx	
	Fax transmission	SS_bcall_FAX_xxx (see note 2)	
	Successful SIP-I	SS_bcall_SIP-I_xxx	
	Codec_Negotiation	SS_codec_xxx	
	Resource_Reservation	SS_resource_xxx	
	Unsuccessful NNI	SS_unsucc_NNI__NNI_xxx	
	Unsuccessful SIP-I	SS_unsucc_NNI__SIP-I_xxx	
	Successful Video	SS_bcall_video_xxx	
SIP-SIP	Service	OIP	SS_oip_NNI_xxx
		OIP	SS_oip_SIP-I_xxx
		OIR	SS_oir_NNI_xxx
		OIR	SS_oir_SIP-I_xxx
		TIP	SS_tip_xxx
		TIR	SS_tir_xxx
		HOLD	SS_hold_xxx
		CFU	SS_cfu_xxx
		CFB	SS_cfb_xxx
		CFNR	SS_cfnr_xxx
		CFNL	SS_cfnl_xxx
		CD	SS_cd_xxx
		CONF	SS_conf_xxx
		ACR-CB	SS_acr-cb_xxx
		CUG	SS_cug_xxx
		CW	SS_cw_xxx
		ECT	SS_ect_xxx
		MCID	SS_mcid_xxx
		MWI	SS_mwi_xxx
		CC	SS_cc_xxx
	SIP-I	UUS	SS_uus_xxx
		SUB	SS_sub_xxx
		TP	SS_tp_xxx
	NubP	SS_NP_xxx	
	ACCOUNTING	SS_acc_xxx	
	CS	SS_csel_xxx	
	EmC	SS_ecall_xxx	
	SIP_charging	SS_sipc_xxx	

NOTE 1: The tests are specified in ETSI TS 101 585 [11].
NOTE 2: This clause contains three basic fax transmission tests without QoS requirements for the case when both networks are supporting the same transmission capabilities.

7.2 VoNR Consideration

The Radio and Packet Core Feature Set is described in GSMA NG.114 [27].

8 Test purposes

8.1 General

The application usage procedures in the ATS shall be compliant with ETSI TS 129 165 [17], ETSI TS 124 229 [14] and IETF RFC 3261 [1]. The validation of the registration procedure is out of scope of the present document.

8.2 Testing of SIP protocol requirements

The test purposes are described in clause 7.1 of ETSI TS 103 397 [2].

9 QoS/QoE/Test requirements

The offer of 5G services requires new KPIs, QoS measurement and benchmarking methods which are needed to ensure the quality of new services. To ensure the comparability of test results, reference benchmarking methods and background traffic load profiles are needed.

ETSI TS 103 222-3 [16] is a technical specification that outlines procedures for the configuration and deployment of Voice over New Radio (VoNR) services within 5G networks. It covers aspects such as network architecture and Quality of Service (QoS) parameters. Additionally, it provides guidelines for selecting appropriate VoNR configurations to ensure optimal performance and compatibility with various network environments. Overall, ETSI TS 103 222-3 [16] serves as a comprehensive resource for network operators and service providers seeking to deploy VoNR services efficiently and effectively within their 5G infrastructure.

10 Selection of VoNR configurations

The selections provided in the present clause are NOT contained in the Excel file in archive ts_103905v010101p0.zip which accompanies the present document.

The network features indicated by the mentioned bits in the context of IP Multimedia Subsystem (IMS), emergency services, interworking, Mobile Private Network for Public Safety (MPS), Mission-Critical Services (MCS), enhanced coverage, Cellular Internet of Things (CIoT), IP header compression, location services, Access Traffic Steering, Switching and Splitting (ATSSS), and Ethernet header compression have various implications and use cases. Here are some use cases and implications for these features:

- Standalone cell network scenarios:
  - Standalone E-UTRA single cell and multi cell network scenarios;
  - Standalone NR single cell network scenarios;
  - Standalone NR single mode multi cell network scenarios;
  - Standalone NR dual mode multi cell network scenarios;
  - Standalone NR 3GPP Inter-RAT network scenarios.
- Non-standalone cell network scenarios:
  - Non-standalone E-UTRA single cell and NR single cell network scenarios;
  - Non-standalone E-UTRA single cell and NR single mode multi cell network scenarios;
  - Non-standalone E-UTRA single mode multi cell and NR single mode multi cell network scenarios;
  - Non-standalone E-UTRA single cell and NR dual mode multi cell network scenarios.
- Non-3GPP Access network scenarios:
  - WLAN network scenario;
  - Bluetooth network scenario.

Table 9: Generic procedure parameters based on Table 4.5.1-1 from ETSI TS 138 508-1 [13]

Parameter	Values	Description	Parameter condition
Connectivity	*1) GSMA Option #5 E-UTRA/5GC*	E-UTRA connected to 5GC E-UTRA connected to 5GC refers to the scenario where a device is connected to a 5G Core (5GC) network via a 4G LTE radio access technology (E-UTRA). This is possible through the Non-Standalone (NSA) mode of 5G deployment. In this deployment, the 5G NR network is deployed as an overlay on top of the existing 4G LTE infrastructure, allowing devices to access both 4G and 5G services simultaneously. E-UTRA connected to 5GC allows for improved data rates, reduced latency, and enhanced network capacity compared to traditional 4G LTE networks, while still maintaining backward compatibility with existing 4G devices.	Mandatory. For value *NR* (see note).
	2) GSMA option #2 NR	NR connected to 5GC	
	3) GSMA Option #3 EN-DC	E-UTRA-NR Dual Connectivity with E-UTRA connected to EPC (ETSI TS 137 340 [18]). E-UTRA-NR Dual Connectivity with E-UTRA connected to 5GC refers to a scenario where a device is connected to both a 4G LTE network (E-UTRA) and a 5G NR network, while being anchored to a 5G Core (5GC) network. This deployment scenario is achieved through the Non-Standalone (NSA) mode of 5G deployment, where the 5G NR network is deployed as an overlay on top of the existing 4G LTE infrastructure. E-UTRA-NR Dual Connectivity allows the device to benefit from the improved data rates and reduced latency of the 5G NR network while still maintaining a reliable connection to the 4G LTE network for voice and other services. By anchoring the connection to a 5GC network, the device can access advanced 5G services such as network slicing, which allows operators to allocate dedicated network resources to specific services or customers.	
	4) GSMA Option# 7 NGEN-DC	E-UTRA-NR Dual Connectivity with E-UTRA connected to 5GC.	
	5) GSMA Option#4 NE-DC	NR E-UTRA Dual Connectivity 5G NR-E-UTRA Dual Connectivity (NE-DC), which is a technology that allows a User Equipment (UE) to be simultaneously connected to both a 5G New Radio (NR) network and a 4G LTE network (E-UTRA). In NE-DC, the 5G NR network is the Master Node and the 4G LTE network is the Secondary Node. The UE communicates with both networks at the same time, allowing for improved data rates and reduced latency compared to using either network alone. NE-DC is also known as 5G Non-Standalone (NSA) mode, which is the initial deployment mode for 5G networks that rely on existing 4G LTE infrastructure. In this mode, the 5G NR network is deployed as an overlay on top of the 4G LTE network, allowing devices to access both 4G and 5G services simultaneously.	

Parameter	Values	Description	Parameter condition
	6) NR-DC	NR-NR Dual Connectivity NR-NR Dual Connectivity (NR-DC) is a technology that enables a User Equipment (UE) to be simultaneously connected to two NR Base stations (gNBs) via two different carriers. One of these carriers is known as the Master Node (MN) and the other is known as the Secondary Node (SN). The primary purpose of NR-NR Dual Connectivity is to improve the data rates and overall performance of the UE.	
	7) WLAN	Un trusted non 3GPP access over WLAN	
	8) GSMA Option 1 E-UTRA/EPC	E-UTRA connected to EPC E-UTRA/EPC refers to the combination of the 4G LTE radio access technology (E-UTRA) and the Evolved Packet Core (EPC) network architecture. E-UTRA is the air interface used to connect mobile devices to the LTE network, while EPC is the core network responsible for managing user traffic, signalling , and network operations. EPC is a packet-based network architecture that provides connectivity and mobility management between the LTE network and external networks such as the internet or other cellular networks. It consists of several functional entities including the Mobility Management Entity (MME), Serving Gateway (SGW), Packet Data Network Gateway (PGW), and Policy and Charging Rules Function (PCRF). E-UTRA/EPC provides high-speed data services with low latency and improved spectral efficiency compared to previous cellular technologies. It is widely deployed around the world and is used by billions of mobile devices to access high-speed internet and other mobile services.	
Bearers	*MCG(s) and SCG*	MCG and SCG.	Mandatory when Connectivity is set to *EN-DC*, *NGEN-DC, NE-DC* and *NR-DC* and when the generic procedures are used by test cases to get UE under test into RRC_CONNECTED state. s=1 if MULTI_PDN=FALSE and s=2 if MULTI_PDN=TRUE. N/A otherwise.
	MCG(s) and split	MCG and split.	
Test Mode	*On*	UE test mode active as specified in ETSI TS 138 509 [19], clause 5.2.2.	Optional.
Test Loop Function	*On*	UE test mode active with one of the UE test loop modes activated as specified in ETSI TS 138 509 [19], clauses 5.2.2 and 5.3.2.	Optional.
Connected without release	*On*	Enter RRC_Connected with Ipsec_SA_Established and without any release.	Optional. N/A for *NR-DC.*
Interworking without N26 interface supported	*On*	The NWK sets the REGISTRATION ACCEPT message, IE 5GS network feature support, IWK N26 (octet 3, bit 7) = 1.	Optional. Depends on test case scenario. Default message content for REGISTRATION ACCEPT is set to Interworking without N26 interface NOT supported.

Parameter	Values	Description	Parameter condition
Unrestricted nr PDN	*On*	Allow unrestricted numbers of PDNs.	Optional for Connectivity *E-UTRA/EPC*. N/A otherwise.
Sidelink	*On*	NR sidelink.	Optional.
Cast type	*Unicast*	To establish unicast sidelink and PC5-RRC connection.	Optional.
GNSS Sync	*On*	To use GNSS as the synchronization reference source.	Optional.
SL MIMO	*On*	To transmit PSSCH with 2 spatial layers, i.e. SL MIMO.	Optional.
NOTE: The ETSI TS 138 331 [9] abbreviation for NR connected to 5GC is NR/5GC.			

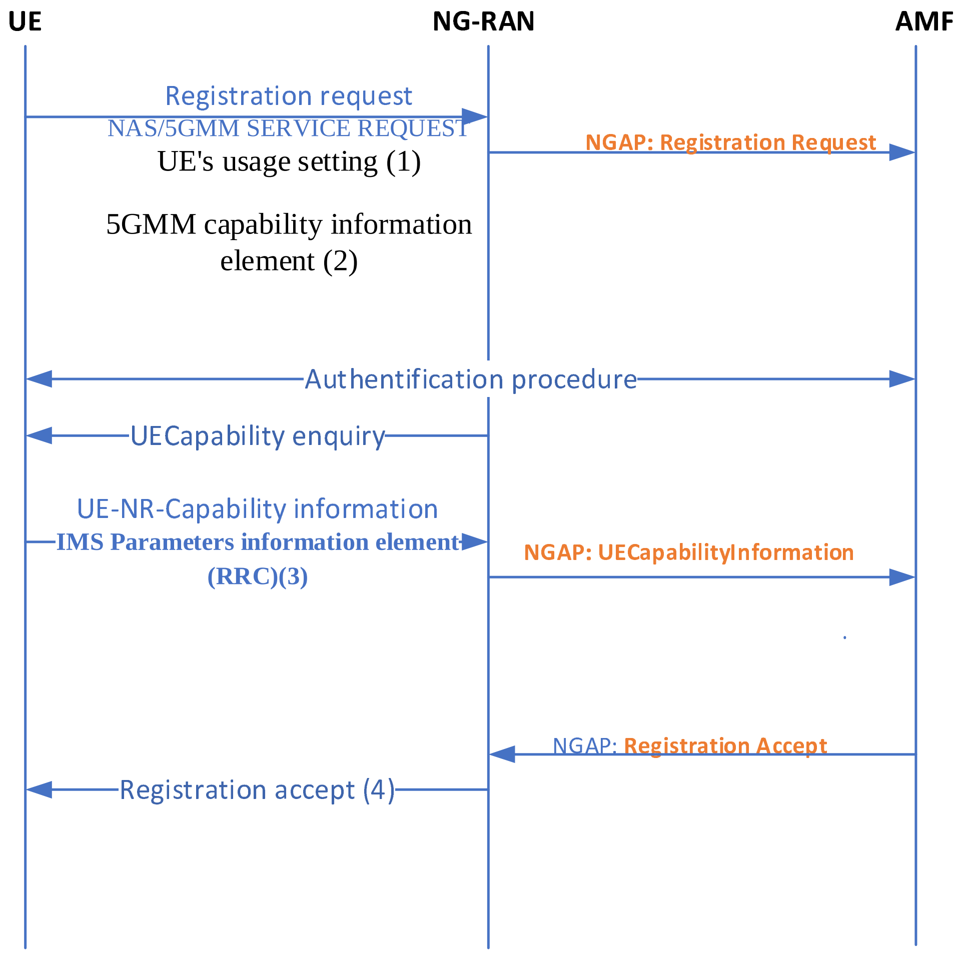


Figure 20: NAS and RRC Signalling Message Overview for the parameters which are described in the Use Cases

Table 10: Configuration Use Cases

Group	Configuration
1	**Use Cases for Voice Centric and Single-Registration Mode for originating and terminating Vo5G calls**
	Case 1.1 **Expected Behaviour:** UE/Network should prioritize voice services for 5GS over NR-connected 5GCN. **Configuration:** **Network Feature Support IMS:** NR connected to 5GC or NR-NR Dual Connectivity **(GSMA Option#2)**. **UE Settings (RRC)(1):** Usage Setting: Voice Centric. **5GMM Capability IE (2):** S1 mode supported. LPP in N1 mode supported. **UE-NR-Capability / UE-NR-Capability information element UE Capability Information / IMS Parameters information element / IMS Parameters information element (RRC) (3):** UE supports IMS voice over NR connected 5GCN = TRUE. UE supports IMS voice over E-UTRA connected to 5GCN = NOT CHECKED. voiceOverSCG-BearerEUTRA-5GC= NOT CHECKED. FallbackIndicationEPS = NOT CHECKED. **5GS network feature support IE in the REGISTRATION ACCEPT message (4):** **IMS Voice over PS Session over 3GPP Access Indicator (IMS-VoPS-3GPP):** IMS voice over PS session supported over 3GPP access. **IMS Voice over PS Session over Non-3GPP Access Indicator (IMS-VoPS-N3GPP):** NOT CHECKED. **Interworking without N26 Interface Indicator (IWK N26) (octet 3, bit 7):** NOT CHECKED.

Group	Configuration
	Case 1.2 **Expected Behaviour:** Call is not established. **Configuration:** **Network Feature Support IMS:** NR connected to 5GC **or** NR-NR Dual Connectivity **(GSMA Option#2)**. **UE Settings (RRC)(1):** Usage Setting: Voice Centric. **5GMM Capability IE (2):** S1 mode supported. LPP in N1 mode supported. **UE-NR-Capability / UE-NR-Capability information element UE Capability Information / IMS Parameters information element / IMS Parameters information element (RRC) (3):** UE supports IMS voice over NR connected 5GCN = FALSE. UE supports IMS voice over E-UTRA connected to 5GCN = TRUE. voiceOverSCG-BearerEUTRA-5GC= NOT CHECKED. FallbackIndicationEPS = NOT CHECKED **(see note 5)**. **5GS network feature support IE in the REGISTRATION ACCEPT message (4):** **IMS Voice over PS Session over 3GPP Access Indicator (IMS-VoPS-3GPP):** IMS voice over PS session supported over 3GPP access. **IMS Voice over PS Session over Non-3GPP Access Indicator (IMS-VoPS-N3GPP):** NOT CHECKED. **Interworking without N26 Interface Indicator (IWK N26) (octet 3, bit 7):** NOT CHECKED.
	Case 1.3 **Expected Behaviour:** UE/Network should prioritize voice services over LTE connected to EPC. NOTE 1: LTE uses a different RRC protocol than NR, and the parameters are beyond the scope of the present document. **Configuration:** **Network Feature Support IMS:** **E-UTRA-NR Dual Connectivity with E-UTRA connected to EPC (GSMA Option#3)** UE-NR-Capability / UE-NR-Capability information element UE Capability Information / IMS.
	Case 1.4 **Expected Behaviour:** UE/Network should prioritize voice services for 5GS over NR-connected 5GCN. **Configuration:** **Network Feature Support IMS:** **EN-DC (Evolved-Universal Terrestrial Radio Access-New Radio) (GSMA Option#4)** **UE Settings (RRC)(1):** Usage Setting: Voice Centric. **5GMM Capability IE (2)**: S1 mode supported. LPP in N1 mode supported. **UE-NR-Capability / UE-NR-Capability information element UE Capability Information / IMS Parameters information element / IMS Parameters information element (RRC) (3):** UE supports IMS voice over NR connected 5GCN = TRUE. UE supports IMS voice over E-UTRA connected to 5GCN = TRUE. voiceOverSCG-BearerEUTRA-5GC= TRUE. FallbackIndicationEPS = NOT CHECKED. **5GS network feature support IE in the REGISTRATION ACCEPT message (4):** **IMS Voice over PS Session over 3GPP Access Indicator (IMS-VoPS-3GPP):** IMS voice over PS session supported over 3GPP access. **IMS Voice over PS Session over Non-3GPP Access Indicator (IMS-VoPS-N3GPP):** NOT CHECKED. **Interworking without N26 Interface Indicator (IWK N26) (octet 3, bit 7):** NOT CHECKED.

Group	Configuration
	Case 1.5 **Expected Behaviour:** UE/Network should prioritize voice services over E-UTRA connected to 5GCN. **Configuration:** **Network Feature Support IMS:** **EN-DC (Evolved-Universal Terrestrial Radio Access-New Radio) (GSMA Option#4)** **UE Settings (RRC)(1):** Usage Setting: Voice Centric. **5GMM Capability IE (2)**: S1 mode supported. LPP in N1 mode supported. **UE-NR-Capability / UE-NR-Capability information element UE Capability Information / IMS Parameters information element / IMS Parameters information element (RRC) (3):** UE supports IMS voice over NR connected 5GCN = FALSE. UE supports IMS voice over E-UTRA connected to 5GCN = TRUE. voiceOverSCG-BearerEUTRA-5GC= TRUE. FallbackIndicationEPS = NOT CHECKED. **5GS network feature support IE in the REGISTRATION ACCEPT message (4):** **IMS Voice over PS Session over 3GPP Access Indicator (IMS-VoPS-3GPP):** IMS voice over PS session supported over 3GPP access. **IMS Voice over PS Session over Non-3GPP Access Indicator (IMS-VoPS-N3GPP):** NOT CHECKED. **Interworking without N26 Interface Indicator (IWK N26) (octet 3, bit 7):** NOT CHECKED.
	Case 1.6 **Expected Behaviour:** UE/Network should prioritize IMS voice over E-UTRA connected to 5GCN. **Configuration:** **Network Feature Support IMS:** *E-UTRA/5GC* - E-UTRA connected to 5GC **(GSMA Option#5)** **UE Settings (RRC)(1):** Usage Setting: Voice Centric. **5GMM Capability IE (2):** S1 mode supported. LPP in N1 mode supported. **UE-NR-Capability / UE-NR-Capability information element UE Capability Information / IMS Parameters information element / IMS Parameters information element (RRC) (3):** UE supports IMS voice over NR connected 5GCN = NOT CHECKED. UE supports IMS voice over E-UTRA connected to 5GCN = TRUE. voiceOverSCG-BearerEUTRA-5GC= NOT CHECKED. FallbackIndicationEPS = NOT CHECKED. **5GS network feature support IE in the REGISTRATION ACCEPT message (4):** **IMS Voice over PS Session over 3GPP Access Indicator (IMS-VoPS-3GPP):** IMS voice over PS session supported over 3GPP access. **IMS Voice over PS Session over Non-3GPP Access Indicator (IMS-VoPS-N3GPP):** NOT CHECKED. **Interworking without N26 Interface Indicator (IWK N26) (octet 3, bit 7):** NOT CHECKED.

Group	Configuration
	Case 1.7 **Expected Behaviour:** Call is not established. **Configuration:** **Network Feature Support IMS:** E-UTRA connected to 5GC **(GSMA Option#5)** **UE Settings (RRC)(1):** Usage Setting: Voice Centric. **5GMM Capability IE (2):** S1 mode supported. LPP in N1 mode supported. **UE-NR-Capability / UE-NR-Capability information element UE Capability Information / IMS Parameters information element / IMS Parameters information element (RRC) (3):** UE supports IMS voice over NR connected 5GCN = TRUE. E supports IMS voice over E-UTRA connected to 5GCN = FALSE. voiceOverSCG-BearerEUTRA-5GC= NOT CHECKED. FallbackIndicationEPS = NOT CHECKED (see note 5). **5GS network feature support IE in the REGISTRATION ACCEPT message (4):** **IMS Voice over PS Session over 3GPP Access Indicator (IMS-VoPS-3GPP):** IMS voice over PS session supported over 3GPP access. **IMS Voice over PS Session over Non-3GPP Access Indicator (IMS-VoPS-N3GPP):** NOT CHECKED. **Interworking without N26 Interface Indicator (IWK N26) (octet 3, bit 7):** NOT CHECKED. NOTE 5: The UE should usually set the parameters "FallbackIndicationEPS" to TRUE. In this use case, EPS Fallback in the network should be disabled to avoid EPS Fallback, or the parameter "the UE supports IMS voice in EPS" in the UE should be set to FALSE.
	Case 1.8 **Expected Behaviour:** UE/Network should prioritize voice services for 5GS over NR-connected 5GCN. **Configuration:** **Network Feature Support IMS:** *NSA NGEN-DC* - E-UTRA-NR Dual Connectivity with E-UTRA connected to 5GC **(GSMA Option#7)** **UE Settings (RRC)(1):** Usage Setting: Voice Centric. **5GMM Capability IE (2):** S1 mode supported. LPP in N1 mode supported. **UE-NR-Capability / UE-NR-Capability information element UE Capability Information / IMS Parameters information element / IMS Parameters information element (RRC) (3):** UE supports IMS voice over NR connected 5GCN = TRUE. UE supports IMS voice over E-UTRA connected to 5GCN=TRUE. voiceOverSCG-BearerEUTRA-5GC= NOT CHECKED. FallbackIndicationEPS = NOT CHECKED . **5GS network feature support IE in the REGISTRATION ACCEPT message (4):** **IMS Voice over PS Session over 3GPP Access Indicator (IMS-VoPS-3GPP):** IMS voice over PS session supported over 3GPP access. **IMS Voice over PS Session over Non-3GPP Access Indicator (IMS-VoPS-N3GPP):** NOT CHECKED. **Interworking without N26 Interface Indicator (IWK N26) (octet 3, bit 7):** NOT CHECKED.

Group	Configuration
	Case 1.9 **Expected Behaviour:** UE/Network should prioritize IMS voice over E-UTRA connected to 5GCN. **Configuration:** **Network Feature Support IMS** E-UTRA-NR Dual Connectivity with E-UTRA connected to 5GC **(GSMA Option#7)** **UE Settings (RRC)(1):** Usage Setting: Voice Centric. **5GMM Capability IE (2):** S1 mode supported. LPP in N1 mode supported. **UE-NR-Capability / UE-NR-Capability information element UE Capability Information / IMS Parameters information element / IMS Parameters information element (RRC) (3):** UE supports IMS voice over NR connected 5GCN = FALSE. UE supports IMS voice over E-UTRA connected to 5GCN = TRUE. voiceOverSCG-BearerEUTRA-5GC= NOT CHECKED. FallbackIndicationEPS = NOT CHECKED. **5GS network feature support IE in the REGISTRATION ACCEPT message (4):** **IMS Voice over PS Session over 3GPP Access Indicator (IMS-VoPS-3GPP):** IMS voice over PS session supported over 3GPP access. **IMS Voice over PS Session over Non-3GPP Access Indicator (IMS-VoPS-N3GPP):** NOT CHECKED. **Interworking without N26 Interface Indicator (IWK N26) (octet 3, bit 7):** NOT CHECKED.
2	**Configuration IMS voice over PS session over non-3GPP access (IMS-VoPS-N3GPP)** Trusted Non-3GPP Access (TNAP) procedures in the context of 3GPP are designed to enable secure and authenticated access to 5G services from non-3GPP networks.
	Case 2.1 **Wi-Fi® Offloading for Enhanced Mobile Broadband (eMBB):** **Expected Behaviour: Use Case:** A user with a 5G-enabled device enters a location served by a Wi-Fi network. The TNAP procedures facilitate secure and seamless handover from the 5G network to the Wi-Fi network for Voice transmission. The summary of the procedure is described in clause 4.3.4. of ETSI TS 123 501 [4] **Configuration:** **Wi-fi Parameters:** Non-3GPP access network identifier: This is the unique identifier for the Wi-Fi network that the user's device will connect to. It could be the Wi-Fi network Service Set Identifier (SSID), Basic Service Set Identifier (BSSID), or some other identifier. This parameter is used by the user's device to detect the presence of a nearby Wi-Fi network and initiate the handover process. User identity or credentials: This parameter identifies the user to the Wi-Fi network, such as a username and password. It is used by the Wi-Fi network to authenticate the user and grant them access to the network. This parameter is typically stored on the user's device and provided to the Wi-Fi network during the handover process. Security keys for authentication and integrity protection: These are the keys that are used to encrypt and decrypt data transmitted between the user's device and the Wi-Fi network. They are used to ensure that the data is secure and protected against unauthorized access. This parameter is typically generated during the handover process and shared between the user's device and the Wi-Fi network. Quality of Service (QoS) parameters: Maximum latency: Typical maximum latency values for voice transmission over the eMBB network range from 100 to 150 milliseconds. Packet loss rate: Typical packet loss rate values for voice transmission over the eMBB network range from 0,1 % to 1 %. Jitter: Typical maximum jitter values for voice transmission over the eMBB network range from 10 to 20 milliseconds. Bandwidth: Typical bandwidth values for voice transmission over the eMBB network range from 12 to 64 kilobits per second (Kbps). Priority: This parameter specifies the priority level for voice transmission over the eMBB network. The priority level may vary depending on the specific use case and network architecture, but typically voice traffic is given a high priority over other types of traffic on the network. Handover decision criteria: Signal strength: Network load: Available bandwidth: Codecs: AMR , EVS, G.711, Opus

Group	Configuration
	Network Feature Support IMS: **Wi-Fi Offloading for Enhanced Mobile Broadband (eMBB):** **UE Settings (RRC)(1):** Usage Setting: Voice Centric. **5GMM Capability IE (2):** S1 mode: NOT CHECKED. LPP in N1 mode supported. **UE-NR-Capability / UE-NR-Capability information element UE Capability Information / IMS Parameters information element / IMS Parameters information element (RRC) (3):** UE supports IMS voice over NR connected 5GCN = TRUE. UE supports IMS voice over E-UTRA connected to 5GCN = TRUE. voiceOverSCG-BearerEUTRA-5GC= NOT CHECKED. FallbackIndicationEPS = TRUE. **5GS network feature support IE in the REGISTRATION ACCEPT message (4):** **IMS Voice over PS Session over 3GPP Access Indicator (IMS-VoPS-3GPP):** IMS voice over PS session supported over 3GPP access. **IMS Voice over PS Session over Non-3GPP Access Indicator (IMS-VoPS-N3GPP):** TRUE. **Emergency service support indicator for 3GPP access (EMC) (**emergency services in 5GS for 3GPP access**)** NOT CHECKED. **Emergency services fallback indicator for 3GPP access (EMF) (octet 3, bit 5 and bit 6)** NOT CHECKED. **Emergency service support for non-3GPP access indicator (EMCN3) (octet 4, bit 1)** NOT CHECKED. **Interworking without N26 Interface Indicator (IWK N26) (octet 3, bit 7):** NOT CHECKED.
3	**Use Cases for Dual Registration Mode** Dual Registration Mode, allows users to register on both 4G and 5G networks simultaneously. This mode is ideal for users who require high-speed data connectivity and also need to make voice calls on a regular basis. With Dual Registration Mode, users can seamlessly switch between 4G and 5G networks, depending on network coverage and data requirements. This mode is particularly useful for business users who need to stay connected while on the move and require uninterrupted voice and data connectivity. Here are some possible useful combinations for Dual Registration Mode:
	Case 3.1 **Expected Behaviour:** UE/Network should prioritize voice services for 5GS over NR-connected 5GCN. **Configuration:** **Network Feature Support IMS:** **EN-DC (Evolved-Universal Terrestrial Radio Access-New Radio) (GSMA Option#4)** **UE Settings (RRC)(1):** Usage Setting: Voice Centric. **5GMM Capability IE (2)**: S1 mode supported. LPP in N1 mode supported. **UE-NR-Capability / UE-NR-Capability information element UE Capability Information / IMS Parameters information element / IMS Parameters information element (RRC) (3):** UE supports IMS voice over NR connected 5GCN = TRUE. UE supports IMS voice over E-UTRA connected to 5GCN = TRUE. voiceOverSCG-BearerEUTRA-5GC= TRUE. FallbackIndicationEPS = NOT CHECKED. **5GS network feature support IE in the REGISTRATION ACCEPT message (4):** **IMS Voice over PS Session over 3GPP Access Indicator (IMS-VoPS-3GPP):** IMS voice over PS session supported over 3GPP access. **IMS Voice over PS Session over Non-3GPP Access Indicator (IMS-VoPS-N3GPP):** NOT CHECKED. **Interworking without N26 Interface Indicator (IWK N26) (octet 3, bit 7):** NOT CHECKED.
	Case 3.2 **5G Data Offload to LTE:** When the 5G network is heavily loaded or unavailable, the device offloads data to the 4G LTE network while still maintaining a presence on both networks.
	Case 3.3 Seamless Handover between 4G and 5G: The device seamlessly transitions between 4G and 5G networks based on coverage and service requirements, ensuring continuous connectivity without interruptions.

Group	Configuration
	Case 3.4 Dual Registration for Redundancy: Dual Registration provides redundancy; if one network experiences issues, the device can rely on the other network for uninterrupted service.
	Case 3.5 Low-Latency Applications on 5G, Others on LTE: The device prioritizes low-latency applications (e.g. gaming, real-time communication) on the 5G network while using LTE for other less latency-sensitive tasks.
	Case 3.6 Load Balancing: The device intelligently balances network load by using both 4G and 5G connections based on current network conditions and requirements. Fallback to 4G during 5G Network Issues: If the 5G network encounters issues, the device falls back to the 4G network to maintain connectivity and ensure a stable connection.
	Case 3.7 Selective Data Offloading: The device selectively offloads specific types of data or applications to the 4G network while keeping others on the 5G network, optimizing performance.
	Case 3.8 5G for High-Volume Downloads, LTE for Uploads: The device utilizes the high download speeds of the 5G network for content downloads while relying on LTE for uploads, providing a balanced approach.
4	**Standalone New Radio (NR) dual-mode multi-cell network scenarios** refer to situations where a network deploys multiple cells, each supporting both 5G NR and another Radio Access Technology (RAT), such as LTE. Here are some use cases for Standalone NR dual-mode multi-cell network scenarios:
	Case 4.1 **Enhanced Capacity and Throughput:** Use Case: Deploying dual-mode cells allows for improved capacity and higher throughput in areas with high user density or increased data demand. NR and LTE cells can work together to efficiently handle data traffic.
	Case 4.2 **Smooth Migration to 5G:** Use Case: In areas where the transition to full 5G NR coverage is gradual, dual-mode cells provide a seamless migration path. Users can experience 5G services while maintaining connectivity through LTE in areas where NR coverage is not available.
	Case 4.3 **Dynamic Spectrum Allocation:** Use Case: Dual-mode cells enable dynamic spectrum allocation, allowing the network to optimize the use of available frequencies between NR and LTE based on traffic patterns, interference, and network conditions.
	Case 4.4 **Load Balancing and Cell Offloading:** Use Case: Managing network traffic efficiently by load balancing between NR and LTE cells. During periods of high demand, dual-mode cells can offload traffic between the two technologies to prevent congestion and maintain quality of service.
	Case 4.5 **Coverage Extension:** Use Case: Extending coverage in areas with challenging terrain or obstacles by deploying both NR and LTE cells. The combined coverage of dual-mode cells helps provide a reliable connection for users in diverse geographical environments.
	Case 4.6 **Inter-Technology Carrier Aggregation:** Use Case: Aggregating carriers across NR and LTE technologies to boost data rates and improve overall network performance. This allows users to benefit from the combined bandwidth of both technologies.
	Case 4.7 **Flexible Service Continuity:** Use Case: Ensuring service continuity for users moving between cells by seamlessly handing over connections between NR and LTE. This is particularly important for applications that require uninterrupted connectivity, such as voice calls or real-time communication.
	Case 4.8 **Multi-RAT Support for IoT and M2M Communication:** Use Case: Supporting diverse devices, including Internet of Things (IoT) and Machine-to-Machine (M2M) devices, that may operate on different radio access technologies. Dual-mode cells cater to the connectivity needs of a wide range of devices.

Group	Configuration
	Case 4.9 **Optimized Network Resource Allocation:** Dynamically allocating resources among NR and LTE cells based on user demand and application requirements. This ensures efficient utilization of available spectrum and infrastructure resources.
	Case 4.10 **Energy-Efficient Network Operation:** Use Case: Optimizing power consumption and network resources by intelligently activating and deactivating cells based on demand. This can lead to improved energy efficiency in the overall network operation.
5	**Use cases for EPS Fallback**
	Case 5.1 **Device Fallback** **NSA (GSMA Option#4) EPS Fallback:** Voice over NR with EPS Fallback allows a smartphone to utilize 5G Core (5GC) with New Radio (NR) for voice calls but switch to LTE during call setup due to the specific 5G services are unsupported. **Settings:** Network Feature Support IMS: **EN-DC (Evolved-Universal Terrestrial Radio Access-New Radio) (GSMA Option#4)** **UE Settings (RRC)(1):** Usage Setting: Voice Centric. **5GMM Capability IE (2):** S1 mode: supported. LPP in N1 mode supported. **UE-NR-Capability / UE-NR-Capability information element UE Capability Information / IMS Parameters information element / IMS Parameters information element (RRC) (3):** UE supports IMS voice over NR connected 5GCN = FALSE. UE supports IMS voice over E-UTRA connected to 5GCN = FALSE. FallbackIndicationEPS = TRUE. **5GS network feature support IE in the REGISTRATION ACCEPT message (4):** IMS Voice over PS Session over 3GPP Access Indicator (IMS-VoPS-3GPP): NOT CHECKED. IMS Voice over PS Session over Non-3GPP Access Indicator (IMS-VoPS-N3GPP): NOT CHECKED. Interworking without N26 Interface Indicator (IWK N26) (octet 3, bit 7): Not Supported.
	Case 5.2 **RAN-Based EPS Fallback** **EN-DC EPS Fallback:** Voice over NR with EPS Fallback allows a smartphone to utilize 5G Core (5GC) with New Radio (NR) for voice calls but switch to LTE during call setup due to the specific device moves out of the 5G coverage area or specific 5G services are not supported. **Settings:** **Network Feature Support IMS:** **EN-DC (Evolved-Universal Terrestrial Radio Access-New Radio) (GSMA Option#4)** **UE Settings (RRC)(1):** Usage Setting: Voice Centric. **5GMM Capability IE (2):** S1 mode: supported. LPP in N1 mode supported. **UE-NR-Capability / UE-NR-Capability information element UE Capability Information / IMS Parameters information element / IMS Parameters information element (RRC) (3):** UE supports IMS voice over NR connected 5GCN = TRUE. UE supports IMS voice over E-UTRA connected to 5GCN = TRUE. FallbackIndicationEPS = TRUE. **5GS network feature support IE in the REGISTRATION ACCEPT message (4):** IMS Voice over PS Session over 3GPP Access Indicator (IMS-VoPS-3GPP): NOT CHECKED. IMS Voice over PS Session over Non-3GPP Access Indicator (IMS-VoPS-N3GPP): NOT CHECKED. Interworking without N26 Interface Indicator (IWK N26) (octet 3, bit 7): Not Supported.

Group	Configuration
	Case 5.3 **EPS Fallback in Standalone Mode:** During call setup, if the NR base station cannot establish the necessary voice Quality of Service (QoS) flow, it rejects the setup and initiates a transfer of all data sessions from 5G Core to LTE. This transfer can occur through standardized procedures like Release with Redirect or Inter-System Handover, ensuring continuity of communication Settings **Settings a):** Network Feature Support IMS: NR connected to 5GC **or** NR-NR Dual Connectivity **(GSMA Option#2); N26 not supported** **UE Settings (RRC)(1):** Usage Setting: Voice Centric. **5GMM Capability IE (2):** S1 mode supported. LPP in N1 mode supported. **UE-NR-Capability / UE-NR-Capability information element UE Capability Information / IMS Parameters information element / IMS Parameters information element (RRC) (3):** UE supports IMS voice over NR connected 5GCN = FALSE. UE supports IMS voice over E-UTRA connected to 5GCN = NOT CHECKED. FallbackIndicationEPS = TRUE. **5GS network feature support IE in the REGISTRATION ACCEPT message (4):** IMS Voice over PS Session over 3GPP Access Indicator (IMS-VoPS-3GPP): NOT CHECKED. IMS Voice over PS Session over Non-3GPP Access Indicator (IMS-VoPS-N3GPP): NOT CHECKED. Interworking without N26 Interface Indicator (IWK N26) (octet 3, bit 7): Not Supported. **Coverage-Driven Fallback:** **Device falls back** to LTE when 5G coverage is weak or unavailable, ensuring continuous connectivity. **Settings b):** **Network Feature Support IMS:** NR connected to 5GC **or** NR-NR Dual Connectivity **(GSMA Option#2); N26 Supported** **UE Settings (RRC)(1):** Usage Setting: Voice Centric. **5GMM Capability IE (2):** S1 mode supported LPP in N1 mode supported. **UE-NR-Capability / UE-NR-Capability information element UE Capability Information / IMS Parameters information element / IMS Parameters information element (RRC) (3):** UE supports IMS voice over NR connected 5GCN = FALSE. UE supports IMS voice over E-UTRA connected to 5GCN = NOT CHECKED. voiceOverSCG-BearerEUTRA-5GC= NOT CHECKED. FallbackIndicationEPS = TRUE. **5GS network feature support IE in the REGISTRATION ACCEPT message (4):** **IMS Voice over PS Session over 3GPP Access Indicator (IMS-VoPS-3GPP):** IMS voice over PS session supported over 3GPP access. **IMS Voice over PS Session over Non-3GPP Access Indicator (IMS-VoPS-N3GPP):** NOT CHECKED. **Interworking without N26 Interface Indicator (IWK N26) (octet 3, bit 7):** Supported.

Group	Configuration
	Case 5.4 **Congestion-Driven Fallback:** Voice over NR with EPS Fallback allows a smartphone to utilize 5G Core (5GC) with New Radio (NR) for voice calls but switch to LTE during call setup due heavy network congestion on the 5G network for a more stable connection. **Settings:** Network Feature Support IMS: **UE Settings (RRC)(1):** Usage Setting: Voice Centric. **5GMM Capability IE (2):** S1 mode: supported. LPP in N1 mode supported. **UE-NR-Capability / UE-NR-Capability information element UE Capability Information / IMS Parameters information element / IMS Parameters information element (RRC) (3):** UE supports IMS voice over NR connected 5GCN = TRUE. UE supports IMS voice over E-UTRA connected to 5GCN = TRUE. FallbackIndicationEPS = TRUE **5GS network feature support IE in the REGISTRATION ACCEPT message (4):** IMS Voice over PS Session over 3GPP Access Indicator (IMS-VoPS-3GPP): NOT CHECKED. IMS Voice over PS Session over Non-3GPP Access Indicator (IMS-VoPS-N3GPP): NOT CHECKED. Interworking without N26 Interface Indicator (IWK N26) (octet 3, bit 7): Not Supported.
6	Standalone NR 3GPP Inter-Radio Access Technology (Inter-RAT) network scenarios refer to situations where communication occurs between 5G NR networks and other legacy or non-5G radio access technologies.
	Case 6.1 LTE to NR Handover (Intra-frequency Handover): A user is actively using a mobile device connected to an Long-Term Evolution (LTE) network. As the user moves into an area covered by a Standalone NR network, the system triggers a handover from LTE to NR for a seamless transition to 5G services.
	Case 6.2 LTE to NR Handover (Inter-frequency Handover): Similar to the first use case, but involves a handover between LTE and NR where the frequencies used for communication are different. This allows for optimized spectrum usage and improved network performance.
	Case 6.3 NR to LTE Handover A user is in an area covered by a Standalone NR network and moves into an area where only LTE coverage is available. The network initiates a handover from NR to LTE, ensuring continuous connectivity and service delivery.
	Case 6.4 NR to 3G Handover: Similar to the previous use case, but involves a handover from NR to a 3G network (such as UMTS or HSPA) when NR coverage is not available. This helps maintain connectivity in areas with different network technologies.
	Case 6.5 Inter-RAT Mobility for Voice Services: Ensuring voice continuity when a user transitions between NR, LTE, and 3G networks. This is crucial for providing a consistent user experience during voice calls as the device moves across different coverage areas.
	Case 6.6 Optimized Network Resource Allocation: Dynamically allocating resources between NR and other legacy technologies based on network conditions and traffic demand. This ensures efficient utilization of available resources and enhances overall network performance.
	Case 6.7 Enhanced Coverage and Capacity: Leveraging the capabilities of NR for enhanced coverage and capacity, particularly in dense urban areas or locations with high user demand. This can be complemented by seamless handovers to legacy technologies as needed.
	Case 6.8 Multi-RAT Support for IoT Devices: Use Case: Supporting Internet of Things (IoT) devices that may operate on different radio access technologies. Standalone NR networks can provide connectivity for IoT devices with the ability to handover to LTE or 3G when necessary.

Group	Configuration
7	**Use cases for Voice Centric Roaming** Voice Centric Roaming Voice over 5G (Vo5G) introduces voice services over 5G networks, enabling enhanced voice quality and new features. Voice Centric Roaming refers to the capability of making and receiving voice calls while roaming on 5G networks. Here are some configuration use cases for Vo5G calls in a roaming scenario.
	Case 7.1 Seamless Vo5G Roaming: Configuration to ensure seamless handover of voice calls between home 5G networks and visited 5G networks when a user roams.
	Case 7.2 Voice Quality Optimization: Configuration to prioritize high-quality voice codecs and ensure optimal voice quality during roaming on 5G networks.
	Case 7.3 Fallback to 4G/LTE for Voice: Configuration allowing devices to fall back to 4G/LTE for voice calls when 5G coverage is unavailable or weak in a roaming area.
	Case 7.4 Inter- Public Land Mobile Network (PLMN) Roaming: Configuration for voice-centric roaming across different mobile network operators' 5G networks, enabling users to make and receive calls seamlessly.
	Case 7.5 Multi- Radio Access Technology (RAT) Roaming: Configuration to support voice calls when transitioning between 5G, 4G/LTE, and potentially other legacy technologies (3G, 2G) during roaming.
	Case 7.6 Voice Continuity across RATs: Configuration to ensure voice continuity when a user moves between different radio access technologies, maintaining the call session during handovers.
	Case 7.7 Preferred 5G Roaming for Voice: Configuration allowing devices to prioritize 5G networks for voice calls during roaming when both 4G/LTE and 5G are available.
	Case 7.8 Local Breakout for Voice Services: Configuration enabling local breakout of voice traffic in the visited 5G network to optimize routing and reduce latency for Vo5G calls.
	Case 7.9 Quality of Service (QoS) Enforcement for Vo5G: Configuration to enforce specific QoS parameters, such as low latency and high bandwidth, for Vo5G calls during roaming.
	Case 7.10 Vo5G Roaming for International Travelers: Configuration supporting voice-centric roaming for international travellers, ensuring they can make and receive calls over 5G networks abroad.
	Case 7.11 Vo5G Roaming in Multi-Vendor Networks: Configuration to enable voice-centric roaming between 5G networks provided by different vendors, ensuring interoperability and consistent service quality.
	Case 7.12 Interworking with IP Multimedia Subsystem (IMS): Configuration to facilitate seamless interworking with IMS, ensuring compatibility with existing voice services and features during roaming.
	Case 7.13 Emergency Services Roaming: Configuration to support Vo5G calls for emergency services during roaming, ensuring critical voice communication in different regions.
	Case 7.14 Vo5G Roaming for IoT Devices: Configuration to support voice calls for Internet of Things (IoT) devices that require voice communication capabilities during roaming.

Group	Configuration
8	**Use cases for 5G SRVCC** The following use cases highlight the versatility of 5G SRVCC in ensuring continuous voice services during transitions between different network technologies, deployment modes, and coverage areas. The specific configurations may vary based on network operator preferences, equipment capabilities, and regional considerations.
	Case 8.1 SRVCC from NG-RAN/E-UTRAN/UTRAN (HSPA) access and 3GPP UTRAN/GERAN CS accesses for voice calls that are anchored in the IMS, as well as the coordination between the SRVCC for voice call and the handover of non-voice PS bearers.
	Case 8.2 SRVCC with IMS emergency call continuity from E-UTRAN/UTRAN (HSPA) to 3GPP UTRAN/GERAN CS accesses and from NG-RAN to UTRAN.
9	**Use cases for Circuit Switched Fallback (CSFB)** Circuit Switched Fallback (CSFB) is a mechanism used in mobile networks to handle voice calls on legacy circuit-switched networks (2G or 3G) when a device is in an LTE (4G) coverage area. Voice over LTE (VoLTE) is a technology that enables high-quality voice calls over LTE networks. CSFB is employed when a device initiates or receives a voice call, and the call shall be switched to a circuit-switched network. These use cases highlight various configurations to manage voice calls using CSFB when VoLTE is not available or practical, ensuring a smooth transition between LTE and legacy circuit-switched networks for voice services.
	Case 9.1 VoLTE to CSFB Handover: Configuration for handing over an ongoing VoLTE voice call to a circuit-switched network (2G or 3G) when needed, ensuring continuity of the call.
	Case 9.2 CSFB Call Setup: Configuration for initiating a voice call on the circuit-switched network when VoLTE is not available or not supported.
	Case 9.3 CSFB with Pre-emption: Configuration allowing ongoing data sessions over LTE to be temporarily interrupted (pre-empted) to facilitate the setup of a CSFB voice call.
	Case 9.4 CSFB Delay Optimization: Configuration to minimize the delay during CSFB, ensuring a quick transition from VoLTE to circuit-switched networks for voice calls**.**
	Case 9.5 CSFB for Emergency Calls: Configuration prioritizing CSFB for emergency calls, ensuring immediate access to voice services even in areas where VoLTE may not be available.
	Case 9.6 CSFB for Emergency Calls: Configuration prioritizing CSFB for emergency calls, ensuring immediate access to voice services even in areas where VoLTE may not be available.
	Case 9.7 CSFB in Roaming: Configuration to enable CSFB when a subscriber is roaming on LTE networks outside their home network, allowing voice calls on legacy networks.
	Case 9.8 CSFB with SMS Integration: Configuration integrating CSFB with SMS services, allowing devices to fall back to 2G or 3G for voice calls while maintaining SMS capabilities over LTE.
	Case 9.9 CSFB in Dual SIM Devices: Configuration for CSFB in dual SIM devices, enabling voice fallback for one SIM while the other continues using LTE for data services.
	Case 9.10 CSFB in Limited LTE Coverage Areas: Configuration to trigger CSFB in areas with limited LTE coverage, ensuring users can make voice calls on legacy networks when necessary.
	Case 9.11 CSFB for Unsupported VoLTE Devices: Configuration for devices that do not support VoLTE, ensuring voice calls are handled through CSFB on circuit-switched networks.

Group	Configuration
	Case 9.12 CSFB and Data Session Continuity: Configuration allowing simultaneous CSFB voice calls and LTE data sessions, ensuring uninterrupted data connectivity during voice calls.
	Case 9.13 CSFB in Multi-Vendor Networks: Configuration ensuring interoperability between different vendors' implementations of CSFB and VoLTE for seamless voice services in multi-vendor LTE networks.
10	**Use cases for Handover scenarios** These scenarios highlight different types of handovers within a 5G network, including transitions between LTE and 5G NR, intra-NR handovers, and inter-RAT handovers between 4G and 5G. The goal of handovers is to ensure seamless connectivity and optimal performance as devices move within or between different network coverage areas.
	Case 10.1 LTE to NR Handover: Seamless transition from LTE to 5G NR as the device moves into a 5G coverage area, ensuring continuity of service with the higher data rates and capabilities of 5G.
	Case 10.2 NR to LTE Handover: Smooth handover from 5G NR to LTE when the device moves out of the 5G coverage area or when specific 5G services are not available, ensuring continuous connectivity using LTE.
	Case 10.3 Dual Connectivity Handover: Handover between 5G NR and LTE in scenarios where the device is using both connections simultaneously, ensuring optimal performance and service quality.
	Case 10.4 Intra-NR Handover: Handover between different 5G NR cells to maintain a stable and optimized connection as the device moves within the 5G coverage area.
	Case 10.5 Inter-RAT Handover (5G to 4G): Handover from 5G to 4G LTE in cases where the 5G coverage becomes insufficient or unavailable, allowing the device to continue communication using the LTE network.
	Case 10.6 Inter-RAT Handover (4G to 5G): Handover from 4G LTE to 5G NR when the device moves into a 5G coverage area, ensuring a smooth transition to the higher-speed 5G network.
	Case 10.7 Soft Handover: Soft handover between neighbouring cells or sectors within the same technology (e.g. 5G NR) to maintain connectivity without noticeable service interruption.
	Case 10.8 Hard Handover: Hard handover involves a more abrupt transition between cells or technologies, often with a brief interruption in service as the device switches connections.
	Case 10.9 **Handover (Xn and N2 based)** Test cases for Xn and N2 based handovers: The terminology used is "Xn-based Handover." The Xn interface is associated with handovers between two 5G base stations. The Xn and N2 interfaces play different roles in the context of 5G networks. Let me clarify the differences between Xn and N2 in the context of handovers: **Xn Interface:** **Role:** The Xn interface is used for communication between two 5G gNBs (Next-Generation NodeBs). It facilitates inter-gNB communication within the 5G Radio Access Network (RAN). **Use Case:** Xn interface is utilized for various functions, including handovers between 5G base stations, inter-gNB mobility management, and coordination between gNBs. **Scenario:** Xn-based handovers occur when a device moves from one 5G base station (gNB) to another within the same 5G network. **N2 Interface:** **Role:** The N2 interface is used for communication between two gNBs within the 5G RAN. It is part of the NG-RAN architecture and facilitates inter-gNB signalling and data transfer. **Use Case:** N2 interface is primarily used for mobility-related signalling , such as handovers, between two 5G base stations (gNBs) within the same 5G network. **Scenario:** N2-based handovers occur when a device moves between two 5G base stations, and signalling is required for the handover procedure.

Group	Configuration
	Case 10.9.1 **Test Case for N2-based Handover:** Scenario: Device moves from one 5G base station to another, triggering an N2-based handover. **Initiation:** VoLTE call on the 5G network. **Verification:** Poor call quality due to the device moving away. **Expected behaviour:** Device hands over to the target 5G base station while maintaining the VoLTE call. Improved call quality as the device moves closer to the target 5G base station. **Measurements:** Call quality before and after the handover. Time taken for the handover.
	Case 10.9.2 Test Case for Xn-based Handover: **Scenario:** Device moves from one 5G base station to another, triggering an Xn-based handover. **Initiation:** VoLTE call on the 5G network. **Verification:** Poor call quality due to the device moving away. **Expected behaviour:** Device hands over to the target 5G base station while maintaining the VoLTE call. Improved call quality as the device moves closer to the target 5G base station. **Measurements:** Call quality before and after the handover. Time taken for the handover.
11	**Use cases for SMS over 5G** Testing SMS over 5G involves verifying various aspects of the Short Message Service in the context of a 5G network. These test cases cover various aspects of SMS over 5G, including basic functionality, performance under different conditions, network handovers, and support for advanced features like RCS. The goal is to ensure the reliability, security, and efficiency of SMS services in the context of 5G networks.
	Case 11.1 Basic SMS Delivery: Verify that standard SMS messages are delivered successfully over 5G networks.
	Case 11.2 SMS Delivery Time: Measure and verify the time it takes for an SMS message to be delivered over 5G, ensuring low latency.
	Case 11.3 Large-Scale SMS Delivery: Test the ability of the 5G network to handle a large volume of SMS messages simultaneously.
	Case 11.4 SMS Delivery during Network Handover: Validate that SMS messages are delivered without interruption when a device undergoes a handover between different cells or locations within the 5G network.
	Case 11.5 SMS Delivery in Low-Coverage Areas: Test the reliability of SMS delivery in areas with low 5G coverage, ensuring fallback mechanisms to legacy networks work as expected.
	Case 11.6 SMS Delivery in High-Traffic Situations: Evaluate SMS delivery performance during periods of high network traffic, simulating scenarios with increased message loads.
	Case 11.7 SMS Delivery with 5G Network Slicing: Test SMS delivery within different network slices, ensuring that each slice provides the required quality of service for SMS communication.
	Case 11.8 SMS Delivery with QoS Variations: Validate SMS delivery under different Quality of Service (QoS) configurations, ensuring the network prioritizes SMS messages appropriately.
	Case 11.9 SMS Delivery in Emergency Situations: Verify that SMS messages, especially emergency alerts, are delivered promptly and reliably in critical situations.
	Case 11.10 SMS Delivery in Roaming Scenarios: Test SMS delivery when a user is roaming between different 5G networks or between 5G and legacy networks.

Group	Configuration
	Case 11.11 SMS Delivery in Multi-Vendor Environments: Validate SMS delivery across 5G networks from different vendors, ensuring interoperability and compatibility.
	Case 11.12 SMS Delivery with Rich Communication Services (RCSs) features: Test SMS messages enriched with features such as read receipts, multimedia attachments, and typing indicators, ensuring compatibility with RCS.
	Case 11.13 SMS Delivery to IoT Devices: Verify that SMS messages are successfully delivered to and from IoT devices connected to the 5G network.
	Case 11.14 SMS Delivery in Private Networks: Test SMS delivery within private 5G networks, ensuring secure and reliable communication for enterprise scenarios.
	Case 11.15 SMS Delivery with Network Security Tests: Perform security testing to ensure the confidentiality and integrity of SMS messages over 5G networks.
	Case 11.16 SMS Continuity Across Devices: Test the continuity of SMS messages across multiple devices, ensuring that messages are synchronized and accessible from different endpoints.

Table 11: Configuration Use Cases for VoNR Emergency calls

Number	Configuration Use Cases for VoNR Emergency calls
12	Testing emergency voice calls over 5G involves ensuring that critical communication services are reliable, resilient, and adhere to regulatory requirements. These test cases aim to ensure the reliability, resilience, and effectiveness of emergency Vo5G calls, meeting regulatory requirements and providing users with the critical communication services they need in emergency situations. Testing should cover a range of scenarios to validate the network's ability to handle emergency calls under various conditions.
	Case 12.1 Emergency Call Setup Time: Test the time it takes to initiate an emergency voice call, ensuring that the call setup is rapid and meets regulatory requirements.
	Case 12.2 Location Accuracy for Emergency Calls: Verify that the 5G network provides accurate location information for emergency calls, meeting the specified accuracy standards.
	Case 12.3 Priority and Pre-emption Testing: Test the priority and preemption mechanisms to ensure that emergency Vo5G calls take precedence over regular voice calls, ensuring timely access to emergency services.
	Case 12.4 Fallback to Lower Generations (CSFB/SRVCC): Test the fallback mechanisms (Circuit Switched Fallback - CSFB, Single Radio Voice Call Continuity - SRVCC) to ensure that emergency calls are maintained when moving to areas with different radio access technologies (4G, 3G). Network Resilience Testing: Simulate network failures and congestion scenarios to verify that emergency calls can still be initiated and maintained during adverse network conditions.
	Case 12.5 Quality of Service (QoS) Verification: Test the QoS parameters for emergency Vo5G calls, ensuring that voice quality, latency, and reliability meet or exceed specified standards.
	Case 12.6 Vo5G Roaming for Emergency Calls: Test the capability of initiating emergency Vo5G calls when a user is roaming in different 5G networks, ensuring seamless connectivity.
	Case 12.7 Interworking with Public Safety Networks: Test the interworking between 5G networks and dedicated public safety networks to ensure that emergency Vo5G calls can be routed through specialized emergency services.

Number	Configuration Use Cases for VoNR Emergency calls
	Case 12.8 Emergency Call Handovers: Test the handover procedures for emergency Vo5G calls between different cells and areas, ensuring continuity of communication.
	Case 12.9 Multi-Vendor Interoperability: Validate the interoperability of emergency Vo5G calls across networks and infrastructure from different vendors.
	Case 12.10 Device Compatibility Testing: Test emergency Vo5G calls on a variety of devices, ensuring that different handsets and IoT devices can successfully initiate and receive emergency calls.
	Case 12.11 Location-Based Emergency Services: Test services that use location information for emergency calls, such as routing the call to the nearest emergency service point.
	Case 12.12 Vo5G Emergency Calls in Dual Registration Mode: Test the ability to initiate emergency Vo5G calls when the device is in dual registration mode, connected to both 4G and 5G networks simultaneously.
	Case 12.13 Emergency Services Vo5G Roaming: Test the initiation and successful completion of emergency Vo5G calls when a user is roaming internationally on 5G networks.
	Case 12.14 Vo5G Emergency Calls in Private Networks: Test emergency Vo5G calls within private 5G networks, ensuring that critical communication services are reliable in enterprise scenarios.
	Case 12.15 End-to-End Test with Emergency Services Infrastructure: Conduct end-to-end testing involving the entire emergency services infrastructure to validate the entire process, from call initiation to emergency response.
	Configuration:1 Emergency services supported **Network Feature Support IMS:** NR connected to 5GC or NR-NR Dual Connectivity **(GSMA Option#2)** **UE Settings (RRC)(1):** Usage Setting: Voice Centric. **5GMM Capability IE (2):** S1 mode: NOT CHECKED. LPP in N1 mode supported. **UE-NR-Capability / UE-NR-Capability information element UE Capability Information / IMS Parameters information element / IMS Parameters information element (RRC) (3):** UE supports IMS voice over NR connected 5GCN = TRUE. UE supports IMS voice over E-UTRA connected to 5GCN = NOT CHECKED. FallbackIndicationEPS = NOT CHECKED. **5GS network feature support IE in the REGISTRATION ACCEPT message (4):** **IMS Voice over PS Session over 3GPP Access Indicator (IMS-VoPS-3GPP):** IMS voice over PS session supported over 3GPP access. **IMS Voice over PS Session over Non-3GPP Access Indicator (IMS-VoPS-N3GPP):** NOT CHECKED. **Emergency service support indicator for 3GPP access (EMC)** (emergency services in 5GS for 3GPP access) Emergency services supported in NR connected to 5GCN only. **Emergency services fallback indicator for 3GPP access (EMF)** Emergency services fallback not supported. **Emergency service support for non-3GPP access indicator (EMCN3) (octet 4, bit 1)** NOT CHECKED. **Interworking without N26 Interface Indicator (IWK N26) (octet 3, bit 7):** NOT CHECKED.

Number	Configuration Use Cases for VoNR Emergency calls
	Configuration:2 Emergency services not supported; Emergency services fallback supported. **Network Feature Support IMS:** NR connected to 5GC or NR-NR Dual Connectivity **(GSMA Option#2)** **UE Settings (RRC) (1):** Usage Setting: Voice Centric. 5GMM Capability IE (2): S1 mode supported. LPP in N1 mode supported. **UE-NR-Capability / UE-NR-Capability information element UE Capability Information / IMS Parameters information element / IMS Parameters information element (RRC) (3):** UE supports IMS voice over NR connected 5GCN = TRUE. UE supports IMS voice over E-UTRA connected to 5GCN = NOT CHECKED. FallbackIndicationEPS = TRUE. **5GS network feature support IE in the REGISTRATION ACCEPT message (4):** IMS Voice over PS Session over 3GPP Access Indicator (IMS-VoPS-3GPP): IMS voice over PS session supported over 3GPP access. IMS Voice over PS Session over Non-3GPP Access Indicator (IMS-VoPS-N3GPP): NOT CHECKED. **Emergency service support indicator for 3GPP access (EMC)** (emergency services in 5GS for 3GPP access) Emergency services not supported. **Emergency services fallback indicator for 3GPP access (EMF)** Emergency services fallback supported. **Emergency service support for non-3GPP access indicator (EMCN3) (octet 4, bit 1)** NOT CHECKED. **Interworking without N26 Interface Indicator (IWK N26) (octet 3, bit 7):** NOT CHECKED.

Annex A (informative): 5GS network feature support information element

Table A-1: 5GS network feature support information element (from ETSI TS 124 501 [7], Table 9.11.3.5.1)

IMS voice over PS session over 3GPP access indicator (IMS-VoPS-3GPP) (octet 3, bit 1) This bit indicates the support of IMS voice over PS session over 3GPP access (see note 1). Bit **1** 0 IMS voice over PS session not supported over 3GPP access 1 IMS voice over PS session supported over 3GPP access IMS voice over PS session over non-3GPP access indicator (IMS-VoPS-N3GPP) (octet 3, bit 2) This bit indicates the support of IMS voice over PS session over non-3GPP access. Bit **2** 0 IMS voice over PS session not supported over non-3GPP access 1 IMS voice over PS session supported over non-3GPP access Emergency service support indicator for 3GPP access (EMC) (octet 3, bit 3 and bit 4) These bits indicate the support of emergency services in 5GS for 3GPP access (see note 1). Bits **4 3** 0 0 Emergency services not supported 0 1 Emergency services supported in NR connected to 5GCN only 1 0 Emergency services supported in E-UTRA connected to 5GCN only 1 1 Emergency services supported in NR connected to 5GCN and E-UTRA connected to 5GCN Emergency services fallback indicator for 3GPP access (EMF) (octet 3, bit 5 and bit 6) These bits indicate the support of emergency services fallback for 3GPP access (see note 1). Bits **6 5** 0 0 Emergency services fallback not supported 0 1 Emergency services fallback supported in NR connected to 5GCN only 1 0 Emergency services fallback supported in E-UTRA connected to 5GCN only 1 1 Emergency services fallback supported in NR connected to 5GCN and E-UTRA connected to 5GCN **Interworking without N26 interface indicator (IWK N26) (octet 3, bit 7)** This bit indicates whether interworking without N26 interface is supported. Bit **7** 0 Interworking without N26 interface not supported 1 Interworking without N26 interface supported **MPS indicator (MPSI) (octet 3, bit 8)** This bit indicates the validity of MPS. Bit **8** 0 Access identity 1 not valid 1 Access identity 1 valid Emergency service support for non-3GPP access indicator (EMCN3) (octet 4, bit 1) This bit indicates the support of emergency services in 5GS for non-3GPP access. Bit (see note 2) **1** 0 Emergency services not supported over non-3GPP access 1 Emergency services supported over non-3GPP access

MCS indicator (MCSI) (octet 4, bit 2)
This bit indicates the validity of MCS.

Bit	
2	
0	Access identity 2 not valid
1	Access identity 2 valid

Restriction on enhanced coverage (RestrictEC) (octet 4, bit 3 and bit 4)
These bits indicate enhanced coverage restricted information.
In WB-N1 mode these bits are set as follows:

Bits		
3	**4**	
0	0	Both CE mode A and CE mode B are not restricted
0	1	Both CE mode A and CE mode B are restricted
1	0	CE mode B is restricted
1	1	Reserved

In NB-N1 mode these bits are set as follows

Bits		
3	**4**	
0	0	Use of enhanced coverage is not restricted
0	1	Use of enhanced coverage is restricted
1	0	Reserved
1	1	Reserved

Control plane CIoT 5GS optimization (5G-CP CIoT) (octet 4, bit 5)
This bit indicates the capability for control plane CIoT 5GS optimization.

Bit	
5	
0	Control plane CIoT 5GS optimization not supported
1	Control plane CIoT 5GS optimization supported

N3 data transfer (N3 data) (octet 4, bit 6)
This bit indicates the capability for N3 data transfer.

Bit	
6	
0	N3 data transfer supported
1	N3 data transfer not supported

IP header compression for control plane CIoT 5GS optimization (5G-IPHC-CP CIoT) (octet 4, bit 7)
This bit indicates the capability for IP header compression for control plane CIoT 5GS optimization.

Bit	
7	
0	IP header compression for control plane CIoT 5GS optimization not supported
1	IP header compression for control plane CIoT 5GS optimization supported

User plane CIoT 5GS optimization (5G-UP CIoT) (octet 4, bit 8)
This bit indicates the capability for user plane CIoT 5GS optimization.

Bit	
8	
0	User plane CIoT 5GS optimization not supported
1	User plane CIoT 5GS optimization supported

Location Services indicator in 5GC (5G-LCS) (octet 6, bit 1)

Bit	
1	
0	Location services via 5GC not supported
1	Location services via 5GC supported

ATSSS support indicator (ATS-IND) (octet 5, bit 2)
This bit indicates the network support for ATSSS.

Bit	
2	
0	ATSSS not supported
1	ATSSS supported

Ethernet header compression for control plane CIoT 5GS optimization (5G-EHC-CP CIoT) (octet 5, bit 3). This bit indicates the capability for Ethernet header compression for control plane CIoT 5GS optimization. Bit **3** 0 Ethernet header compression for control plane CIoT 5GS optimization not supported. 1 Ethernet header compression for control plane CIoT 5GS optimization supported. Bits 4 to 8 in octet 5 are spare and shall be coded as zero.	
NOTE 1: For a registration procedure over non-3GPP access, bit 1 of octet 3 and bits 3 to 6 of octet 3 are ignored. NOTE 2: For a registration procedure over 3GPP access, bit 1 of octet 4 is ignored.	

Annex B (informative): 5GMM capability information element

Table B-1: 5GMM capability information element (from ETSI TS 124 501 [7], Table 9.11.3.1.1)

EPC NAS supported (S1 mode) (octet 3, bit 1)
S1 mode not supported
S1 mode supported

LTE Positioning Protocol (LPP) capability (octet 3, bit 3)
LPP in N1 mode not supported
LPP in N1 mode supported (see ETSI TS 136 355 [31])

Restriction on use of enhanced coverage support (RestrictEC) (octet 3, bit 4)
This bit indicates the capability to support restriction on use of enhanced coverage.
Restriction on use of enhanced coverage not supported
Restriction on use of enhanced coverage supported

Control plane CIoT 5GS optimization (5G-CP CIoT) (octet 3, bit 5)
This bit indicates the capability for control plane CIoT 5GS optimization.
Control plane CIoT 5GS optimization not supported
Control plane CIoT 5GS optimization supported

N3 data transfer (N3 data) (octet 3, bit 6)
This bit indicates the capability for N3 data transfer.
N3 data transfer supported
N3 data transfer not supported

IP header compression for control plane CIoT 5GS optimization (5G-IPHC-CP CIoT) (octet 3, bit 7)
This bit indicates the capability for IP header compression for control plane CIoT 5GS optimization.
IP header compression for control plane CIoT 5GS optimization not supported
IP header compression for control plane CIoT 5GS optimization supported

Service Gap Control (SGC) (octet 3, bit 8)
service gap control not supported
service gap control supported

User plane CIoT 5GS optimization (5G-UP CIoT) (octet 4, bit 2)
This bit indicates the capability for user plane CIoT 5GS optimization.
User plane CIoT 5GS optimization not supported
User plane CIoT 5GS optimization supported

V2X capability (V2X) (octet 4, bit 3)
This bit indicates the capability for V2X, as specified in ETSI TS 124 587 [32].
Bit

V2X not supported
V2X supported

V2X communication over E-UTRA-PC5 capability (V2XCEPC5) (octet 4, bit 4)
This bit indicates the capability for V2X communication over E-UTRA-PC5, as specified in ETSI TS 124 587 [32].
Bit

Annex C (informative): IMS - Parameters information element [from ETSI TS 138 331]

Table C-1: IMS -Parameters information element

```
-- ASN1START
-- TAG-IMS-PARAMETERS-START

IMS-Parameters::=          SEQUENCE {
    ims-ParametersCommon       IMS-ParametersCommon                 OPTIONAL,
    ims-ParametersFRX-Diff     IMS-ParametersFRX-Diff               OPTIONAL,
    ...
}

IMS-Parameters-v1700::=    SEQUENCE {
    ims-ParametersFR2-2-r17    IMS-ParametersFR2-2-r17              OPTIONAL
}

IMS-ParametersCommon::=    SEQUENCE {
    voiceOverEUTRA-5GC                  ENUMERATED {supported}               OPTIONAL,
    ...,
    [[
    voiceOverSCG-BearerEUTRA-5GC        ENUMERATED {supported}               OPTIONAL
    ]],
    [[
    voiceFallbackIndicationEPS-r16       ENUMERATED {supported}                   OPTIONAL
    ]]
}

IMS-ParametersFRX-Diff::= SEQUENCE {
    voiceOverNR                ENUMERATED {supported}               OPTIONAL,
    ...
}

IMS-ParametersFR2-2-r17::= SEQUENCE {
    voiceOverNR-r17             ENUMERATED {supported}              OPTIONAL,
    ...
}

-- TAG-IMS-PARAMETERS-STOP
-- ASN1STOP
```

Annex D (informative): Bibliography

Recommendation ITU-T T.38 (11-2015): "Procedures for real-time Group 3 facsimile communication over IP networks".

Recommendation ITU-T G.711 (1988): "Pulse code modulation (PCM) of voice frequencies".

Recommendation ITU-T V.152 (09/10): "Procedures for supporting voice-band data over IP networks".

History

Document history		
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