2G-3G Sunset Guidelines
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1 Introduction

1.1 Overview

This document aims to provide guidelines related to 2/3G sunset.

1.2 Scope

This document aims to provide guidelines on the existing 2/3G services like voice, sms and data. The 2/3G sunset is a VPMN topic, with a potential high impact on the roaming services.

WA.01 [27] describes the best practises to close 2/3G networks with a business approach.

Several scenarios will be analysed, based on how the network terminates the 2/3G service/features. Different classes of UE will be studied, and specially for voice centric and data centric devices.

2/3G shutdown figures are presented in annex A.

The expected behaviour of legacy UEs with different capabilities in a post sun-set era is presented in Annex B.

1.3 Drivers

Mobile operators are announcing 2/3G sunset, in order to

1. reuse radio frequencies for 4/5G deployments
2. decrease maintenance cost by reducing the number of radio networks

This document intends to clarify the different scenarios.

Home Networks want to know Network capabilities in Visited Networks, so that:

1. Home Networks knows which operator to steer on for which kind of users (terminal based)
2. Do not lose business together e.g. buy-sell relations

1.4 Definition of Terms

Term	Description
3GPP	3rd Generation Partnership Project
CS	Circuit Switched
CSFB	Circuit Switched FallBack
EPC	Evolved Packet Core
EPS	Evolved Packet System (Core)
E-UTRAN	Evolved Universal Terrestrial Radio Access Network
GMSC	Gateway MSC
GPRS	General Packet Radio Service
GTP	GPRS Tunneling Protocol
HLR	Home Location Register
HP(L)MN	Home Public (Land) Mobile Network
HSS	Home Subscriber Server
IMS	P (Internet Protocol) Multimedia Subsystem
IMSI	International Mobile Subscriber Identity
IoT	Internet of Thing
ITW	InTerWorking
LTE	Long Term Evolution (Radio)
MAP	Mobile Application Part (protocol)
MIoT	Mobile Internet of Thing
MME	Mobility Management Entity
MSC	Mobile services Switching Centre
MTC	Mobile Terminating Call
M2M	Machine to Machine
NAS	Non Access Stratum
NE	Network Element
PGW	PDN (Packet Data Network) Gateway
PLMN	Public Land Mobile Network
PRD	Permanent Reference Document
RAN	Radio Access Network
SGW	Serving Gateway
SRVCC	Single Radio Voice Call Continuity
UE	User Equipment
VoCS	Voice over Circuit Switched
VP(L)MN	Visited Public (Land) Mobile Network
WAS	Wholesale Agreements and Solutions Group

1.5 Document Cross-References

Ref	Document Number	Title
1	GSMA PRD IR.88	LTE and EPC Roaming Guidelines
2	GSMA PRD NG.111	SMS Evolution
3	GSMA PRD NG.119	Emergency communication for roamers
4	3GPP TS 29.274	"Evolved General Packet Radio Service (GPRS) Tunneling Protocol for Control plane (GTPv2-C); Stage 3"
5	3GPP TS 29.281	"General Packet Radio System (GPRS) Tunneling Protocol User Plane (GTPv1-U)"
6	3GPP TS 23.272	Circuit Switched (CS) fallback in Evolved Packet System (EPS); Stage 2 (SGsAP)
7	GSMA PRD IR.65	IMS Roaming & Interworking Guidelines
8	ETSI TR 103 140	Mobile Standards Group (MSG);eCall for VoIP (V1.1.1) - (2014-04).
9	3GPP TS 23.167	IP Multimedia Subsystem (IMS) emergency sessions
10	GSMA PRD IR.21	Roaming Database, Structure and Updating Procedures
11	GSMA PRD IR.92	IMS Profile for Voice and SMS
12	3GPP TS 23.002	Network architecture
13	3GPP TS 23.204	Support of Short Message Service (SMS) over generic 3GPP Internet Protocol (IP) access; Stage
14	3GPP TS 23.228	IP Multimedia Subsystem (IMS); Stage 2
15	3GPP TS 23.272	Circuit Switched (CS) fallback in Evolved Packet System (EPS); Stage 2
16	3GPP TS 24.008	Mobile radio interface Layer 3 specification; Core network protocols; Stage 3
17	3GPP TS 24.229	IP multimedia call control protocol based on Session Initiation Protocol (SIP) and Session Description Protocol (SDP); Stage 3
18	3GPP TS 24.301	Non-Access-Stratum (NAS) protocol for Evolved Packet System (EPS); Stage 3
19	3GPP TS 29.002	Mobile Application Part (MAP) specification
20	3GPP TS 29.078	Customised Applications for Mobile network Enhanced Logic (CAMEL) Phase X; CAMEL Application Part (CAP) specification
21	3GPP TS 32.240	Telecommunication management; Charging management; Charging architecture and principles
22	3GPP TS 33.127	Lawful Interception (LI) architecture and functions
23	3GPP TS 33.203	3G security; Access security for IP-based services
24	3GPP TS 23.292	IP Multimedia Subsystem (IMS) centralized services; Stage 2
25	3GPP TS 29.118	Mobility Management Entity (MME) - Visitor Location Register (VLR) SGs interface specification
26	3GPP TS 29.061	Interworking between the Public Land Mobile Network (PLMN) supporting packet based services and Packet Data Networks (PDN)

27	GSMA PRD WA.01	Best Practises for Roaming Technology Life Cycle
28	3GPP TS 23.221	3rd Generation Partnership Project; Technical Specification Group Services and System Aspects; Architectural requirements
29	GSMA PRD IR.25	VoLTE Roaming testing
30	GSMA PRD TS.32	Technical Adaptation of Devices through Late Customisation
31	3GPP TS 23.167	IP Multimedia Subsystem (IMS) emergency sessions
32	3GPP TS 23.221	Architectural requirements
33	3GPP TS 24.301	Non-Access-Stratum (NAS) protocol for Evolved Packet System (EPS); Stage 3

2 Challenges

The major challenges (regulation, device, and network) for the industry related to 2/3G sunset are listed hereafter:

Regulation:

1. Regulator's permission: get regulators' support to shut down 2/3G
2. eCall migration toward IMS Voice

Device:

1. 4G Entry level phone: promote entry level phone industry
2. IMS Voice phone: recommend industry to enable IMS Voice by default
3. Migrate 2/3G M2M to 4G MIoT (LTE-M and NB-IoT) by promoting the migration of legacy 2/3G use case to 4G

Network:

1. Develop IMS Voice in the home network, including postpaid and prepaid offers
2. Promote IMS Voice roaming
3. SIM replacement to offer 4G SIM card, or promote SIM replacement solution
4. Define network sunset initiation criteria: how to make 2G or 3G phase out decision based on the situation of 2/3G network, revenue, user, expenditure and 4G network readiness
5. Migrating 2/3G users to LTE by identifying the user category and develop the migration policy (2G user with no data requirement, 2G user with less data requirement, 2/3G user with 4G phone), offer different promotion
6. Spectrum refarming (partial or full)

3 Current services

This section will provide the current status of the existing 2/3G services and 4G data services for voice or data centric UE. If 2/3G network is no more available, roaming services (voice, SMS and data) could be significantly impacted.

3.1 Attachment

The core network is from a functional point of view divided into a PS Domain, IM Subsystem and a CS Domain. Any deployment of the IM subsystem requires a PS domain.

The following network configurations shall be allowed:

1. networks which provide the functionality of CS Domain and PS Domain (and optionally IM Subsystem)
2. networks which only provide the functionality of the PS Domain (and optionally IM Subsystem)

The following terminal configurations shall be allowed:

3. terminals which are able to access both to the CS Domain and PS Domain (and optionally IM Subsystem) – typically voice centric UE
4. terminals which prefer to access to the PS Domain (and optionally IM Subsystem) – typically data centric UE

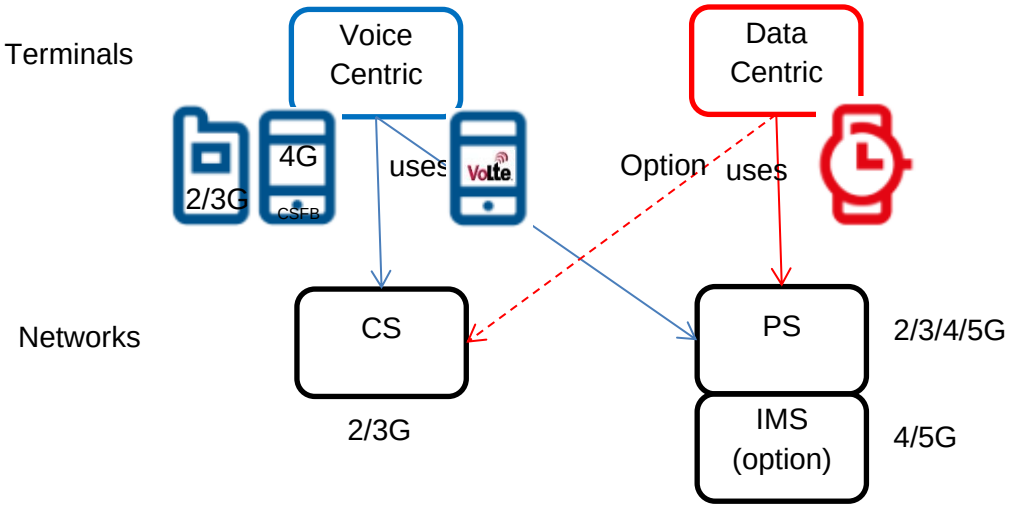

Figure 1 voice/data centric devices

Voice centric UEs are implementing today a combined EPS/IMSI attachment to 2/3G and 4G, using the MME connection and relying on CSFB for voice. If combined attachment is not possible, the voice centric UE (using CSFB) will try to select another network (see Annex A.2 and A.3 of 3GPP 23.221 [28].

Data centric UE are not obliged to attach on 2/3G and 4G using combined attach, but a lot of Data centric UE are still using combined attach in order to benefit from SMSoSGs, reusing SS7 networks for SMS.

2/3G sunset will have a huge impact on roaming services:

1. voice centric terminal: voice service is not available if roaming IMS Voice is not opened
2. data centric terminal: higher possibility of losing voice and SMS services

3.2 Voice calls

Voice calls are based on CSFB using 2/3G networks, for mobile originating and terminating calls.

Voice calls could be controlled with Camel protocol.

Emergency call is also carried by CSFB (see ref GSMA PRD NG.119 [3]).

3.3 SMS

SMS are based on SGs interface, reusing 2/3G MSC, for mobile originating and terminating SMS.

3.4 Data sessions

Data sessions could be carried on:

1. 2/3G data session using GTP v0/1
2. 4G data session using GTP v2

3.5 eCalls (certain regions)

Finally, eCall (emergency service for cars) is also based on CS.

In the event of a crash, an eCall-equipped vehicle will automatically trigger an emergency call, which sends information on the accident, including location, to the emergency services. Studies have shown that eCall cuts emergency services response time by 50% in the rural areas and 60% in urban areas.

For example, in EU, all new vehicle models type approved from 31st March 2018 are equipped with eCall, using Circuit-switches services on 2/3G networks. eCall exists also in IMS version, which could be deployed to replace the CS version.

4 Consideration for using IMS Voice roaming

4.1 IMS Voice for voice centric devices

IMS Voice roaming is the target scenario for all Voice centric devices (see IR.88 [1] / IR.65 [7] / IR.92 [11]).

IMS Voice roaming needs to have:

1. HPMN is IMS Voice compliant
2. UE is IMS Voice compliant: IMS Voice roaming requires UE to be typically configured for IMS Voice roaming, i.e. being IMS Voice capable as such is not enough. There are some devices out there that are per default "IMS Voice roaming enabled" but they are minority
3. VPMN is IMS Voice compliant, supporting voice, emergency and sms (and optionally some additional functions such legal interception
4. IMS Voice roaming is opened commercially

4.2 eCalls (certain regions)

eCall exists also in IMS version, and actions have to be taken to migrate from CS eCall modems (see NG.119 [3]).

The analysis on how eCall can most appropriately evolve to address LTE is being finalised. ETSI created a special taskforce on the migration of eCall transport, which has issued a technical report on eCall for VoIP ETSI TR 103 140 [8].

This report provides recommendations on the road forward for standardisation, as well as different migration possibilities. Standardisation activities within 3GPP to support eCall features are defined in 3GPP TS23.167 [9].

The critical issue is the deployment of IMS eCall modem in the car and deployment of IMS core solution enabling IMS eCall. Every delay on introduction of IMS eCall will potentially delay the 2/3G shutdown planning.

5 Architectural consideration for EPC and CS domains

Several architectures could be deployed when removing 2/3G networks in the VPMN:

1. Sc0: Limited 2/3G radio network: keep a minimal set of 2/3G radio frequencies to support some legacy devices
2. Sc1: Full 2/3G removal: removing all components, including access and core networks
3. Sc2: Partial 2/3G removal: removing only the access network part.

5.1 Limited 2/3G radio network

One scenario could be to close partially the 2/3G radio network with a reduced spectrum in order to cover some legacy devices, especially for emergency services, eCall, M2M and some inbound roamers (using 2/3G devices and also 4G devices using CSFB).

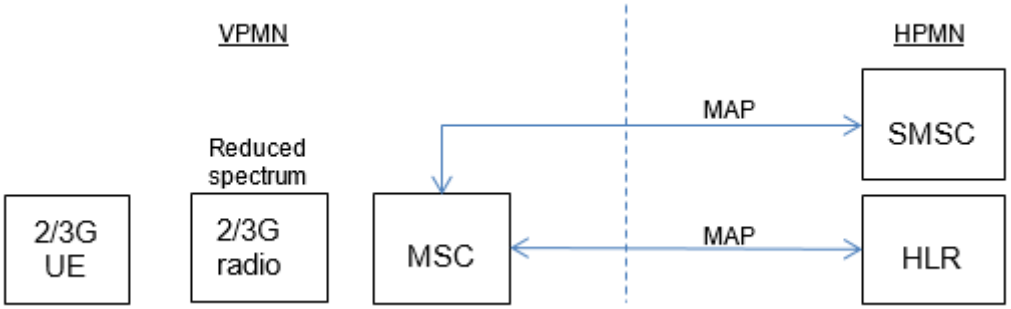

Figure 2: Limited 2/3G radio network

Some base stations could operate GSM and another technology (3G, 4G or even 5G) simultaneously by partitioning a common radio band". These technologies would potentially reduce technical constraints to continue providing a GSM service.

The need of this limited 2/3G scenario will reduce progressively with the decrease of 2/3G terminals:

1. 2/3G M2M machines will migrate to 4G/5G MIoT devices, reducing also the power consumption
2. eCall terminals will migrate to IMS eCall
3. 2/3G roamers will progressively disappear, using 4G/5G smartphones

At network level, 2/3G networks will be very costly to maintain while 4/5G networks will reduce spectrum/energy consumption.

An optional scenario is to maintain only one 2/3G network per country in order to support legacy users and associated services (emergency, eCall, M2M). National roaming could be used to provide this legacy 2/3G network to all the users of the country, and even to inbound roamers.

5.2 Full 2/3G removal

In such scenario, 2G and 3G roaming agreements are completely removed. The 2/3G access and core networks are eliminated.

The architecture is then fully based on a 4G roaming agreements, including potentially IMS Voice roaming agreement. In such scenario, 2/3/4G UE (voice centric, non-IMS Voice) have no access to the roaming services for voice, SMS and data. Only IMS Voice UE will have roaming access, if the HPMN has IMS Voice roaming agreement with the VPMN.

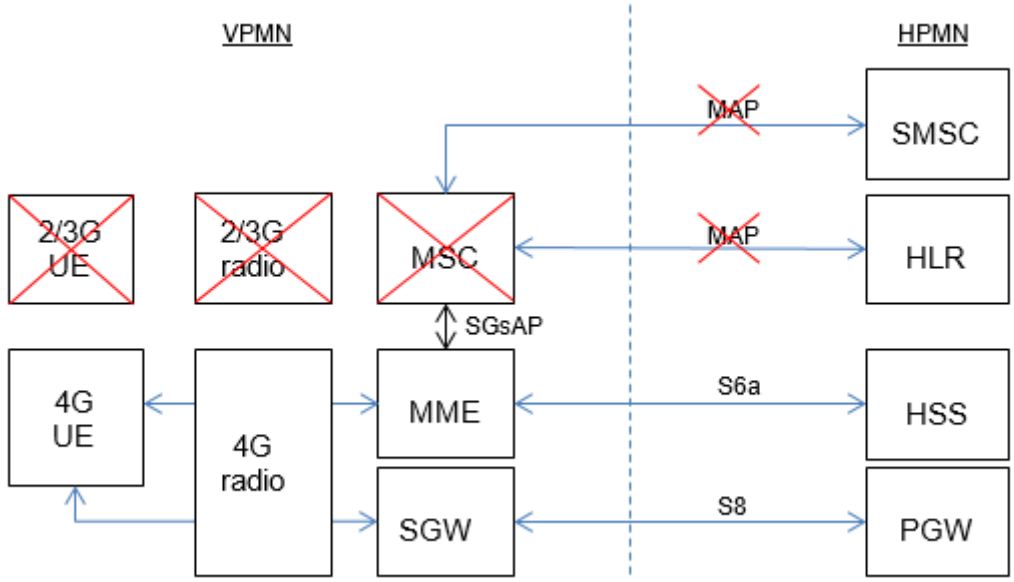

Figure 3: Full removal of 2/3G

In those only IMS Voice networks, there is no more support for SMS over SGsAP, and also no more support for SRVCC.

For data centric devices, full removal of 2/3G scenario could have an impact on SMS services, using today SMS via SGs (using SS7 networks), unless SMS over IP, i.e. via IMS, is used.

For M2M/MIoT devices, the following picture describes the option to use SMS over Diameter via SGd (see also NG.111 [2]). SGd Diameter interface will require also the deployment of signature (defined in DESS) in order to manage anti-spoofing.

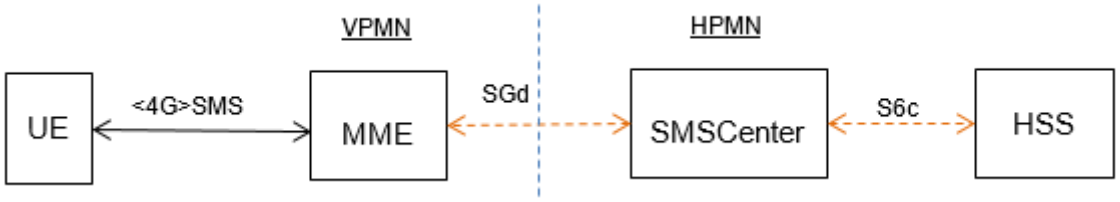

Figure 4: SMS over Diameter interfaces

5.3 Partial 2/3G removal

In such scenario, 2G and 3G roaming agreements are partially active.

The 2/3G access networks are removed, but core network (MSC) will remain in the VPMN.

As shown in the figure hereafter, the remaining MSC in the VPMN (without 2/3G radio access) will be able to manage the dual attachment for data centric devices, exactly like if 2/3G radio is still present. 4G data centric UE are still able to send/receive SMS (via SGs) and use 4G data connection.

4G voice centric UE (no IMS Voice) will not remain attached: combined attach will be accepted, indicating SMS only (no CS voice), and 4G voice centric UE will search for another network as such UE will always prioritize selecting the voice capable network.

IMS Voice roaming agreements will provide voice service for IMS Voice users from IMS Voice HPMN.

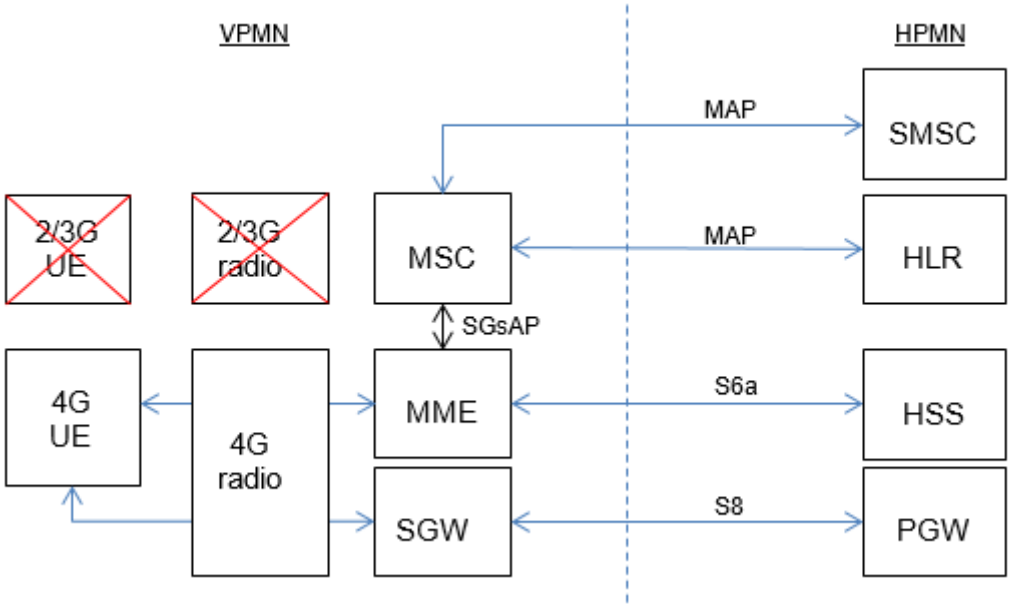

Figure 5: Partial removal of 2/3G

5.4 Data sessions

Migration of 2/3G data to 4G data will imply GTP V0/1 removal (only GTP v2 is available in 4G)

The S8 interface (GTP based) uses GTP version 1 for the User plane, and GTP version 2 for the Control plane. Nodes supporting the S8-GTP based interface are compliant to 3GPP TS 29.274 [4] Release 8 or later, and 3GPP TS 29.281 [5] Release 8 or later. Accordingly, fallback to GTP version 0 is no longer supported; this has significance if hybrid networks containing legacy nodes are sharing infrastructure.

6 Potential InTerWorking Architecture

Another scenario could be based on an InTerWorking (ITW) function between

1. Visited IMS Voice only network
2. Home non IMS Voice network, but LTE roaming is opened
   The basic idea is to implement between the visited and the home an ITW managing GTP, SIP, Diameter, MAP and CAP. ITW is not defined in 3GPP specifications, but is built on top of standardised 3GPP interfaces while it is not assumed that all procedures required on one side of the interface can be fully mapped on another interface interworked via ITW.

Existing 2/3G voice roaming agreements (MAP, CAP) and 4G data roaming agreements (S6a, GTP) are used to implement 4G IMS Voice roaming

UEs supporting voice and SMS over IMS compliant to GSMA PRD IR.92 [11] can be supported, while UEs relying on CS voice cannot be used.

The ITW function could be implemented by the VPMN, or by a 3rd party such an IPX provider. If ITW is implemented in 3rd party, some interfaces, e.g. SGs, usually used within the PLMN is exposed to external network from VPMN's perspective, and security aspect needs to be considered.

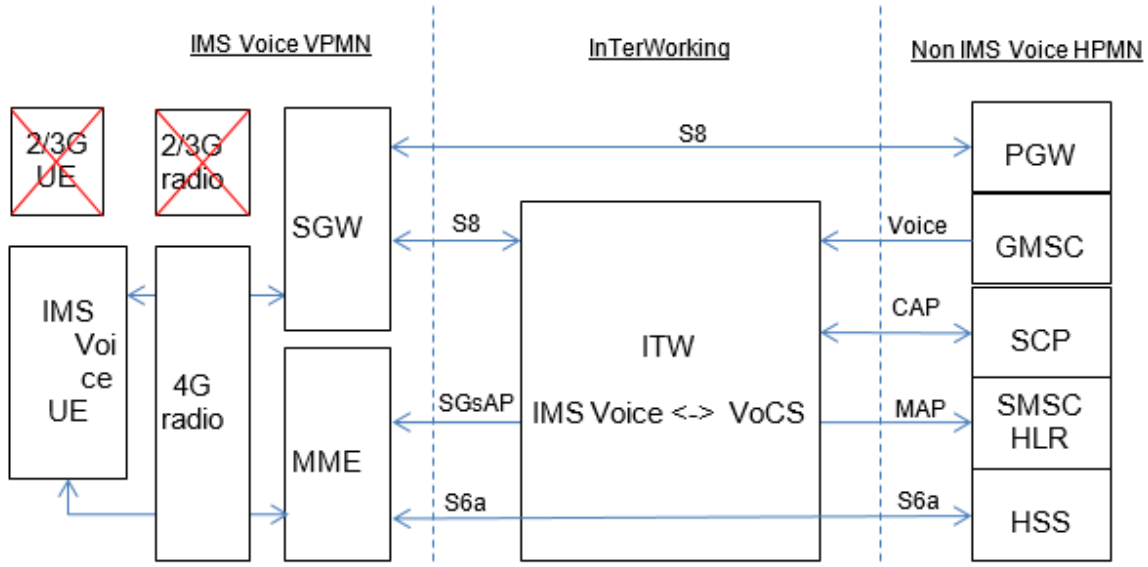

Figure 6: ITW architecture (IMS Voice VPMN <-> non IMS Voice HPMN)

7 Other roaming considerations

7.1 Roaming Agreements

2/3G roaming agreement will be closed progressively in the world, and it will be very important that visited network notifies clearly the home networks about the selected scenario to terminate the 2/3G agreement.

IR.21 [10] defines the network configuration parameter.

The following sections can be adjusted to more precisely define the 2/3G sunset scenario chosen by the visited network (IR.21 release 17):"

1. Network: define 2G or 3G closure dates in the Service status and planned closure table
2. SMS Roaming Information VPMN support for SGd interface to support SMS over NAS using Diameter

NETWORK

Service Status and Planned Closure and availability (Radio network)

Roaming Services supported as VPMN	**Support (Y/N)**	**Planned closure date**	**Planned availability date**
2G			
3G			
4G			
MIoT-LTE-M			
MIoT-NB-IOT			
VoLTE			
5G-NR			

SMS Roaming Information
Section ID: 29 (Conditional)

SMS ITW-as VPLMN	
SMS Delivery mechanism	
SMS over IP	[Yes/No]
SMS over NAS via SS7	[Yes/No]
SMS over NAS via Diameter	[Yes/No]
SMS over NAS via HTTPs	[Yes/No]

8 Conclusions

8.1 Pros/Cons

This section will provide a list of Pros/Cons for the different scenarios:

Sc	Title	Pros	Cons
Sc0	Limited 2/3G radio network	All services for 2/3G devices, especially for some segment (emergency, M2M, roaming)	Does not allow to shutdown 2/3G radio (even if spectrum is limited)
Sc1	Full 2/3G removal	The target scenario enables cost saving and radio frequencies reuse for 4 or 5G	No more services for 4G devices (CS Voice, not supporting IMS)
Sc2	Partial 2/3G removal (MSC left)	Still Data/SMS services for 4G devices (data centric) Easy to implement (keeping MSC)	MSC perpetuity no more service for 4G devices (CS Voice, not supporting IMS) inducing potential customer complaints Cedes voice as a product to OTT and other players
Sc3	ITW	Enable potentially IMS Voice for all IMS Voice devices, even if home is CS Voice	Reduce the motivation of Home Network to implement IMS Voice in Home and Roaming Complex implementation due to the protocol interworking No 3GPP specifications on the protocol interworking and not all procedures for the CS roaming cannot be ensured UE must be IMS Voice compliant, while HPMN is CS Voice Additional device testing may be required between the visited network and UE from other networks

8.2 Services

The figure hereafter describes table of the services (voice, SMS, data) for different terminals and solutions (available services are in green, while unavailable services are in red):

1. 2G/3G terminals are served only by 2/3G networks
2. 4G voice centric terminals (without IMS Voice) do not work after 2/3G network shutdown (Sc1 or 2)
3. 4G data centric terminals will continue to work for Data service; SMS will be provided via SS7 in sc2 and optionally via Diameter in sc1
4. IMS Voice terminals will enable Data and Voice/SMS service (if VoLTE roaming agreement is opened) after 2/3G network shutdown (Sc1 or 2).

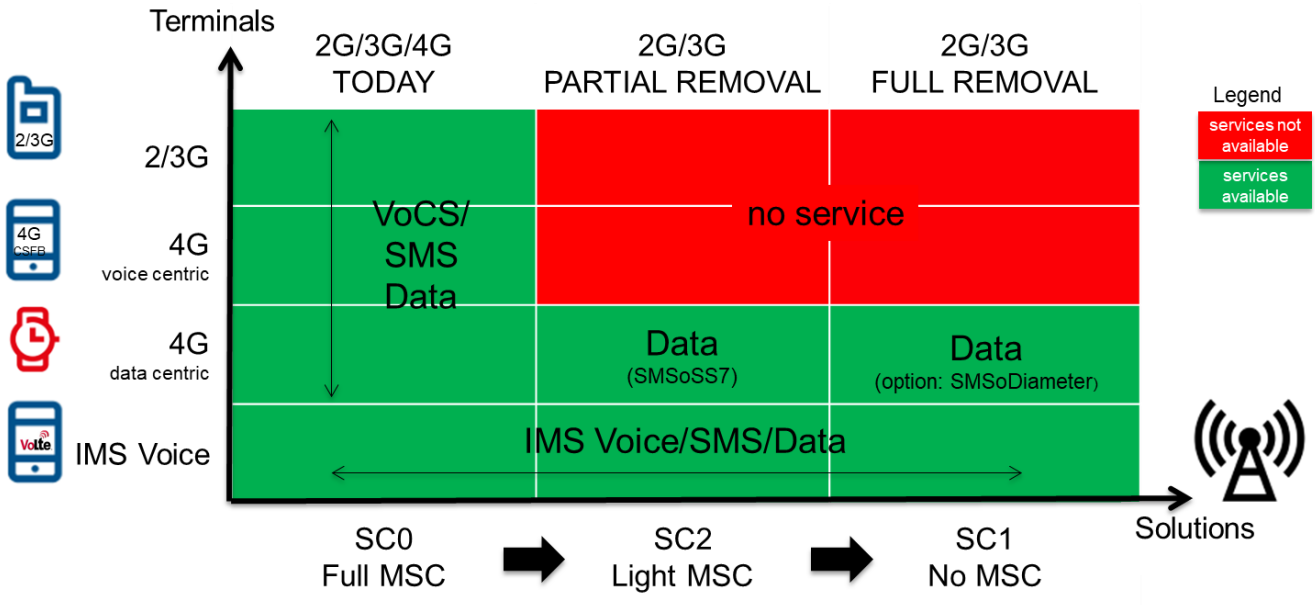

Figure 7Service availability

After 2/3G full removal (scenario 1), the following services will be provided:

- 4G Voice centric UE needs to support IMS Voice roaming, using
  - IMS Voice
  - Emergency IMS Voice
  - SMSoIMS
  - data 4G

- 4G Data centric UE needs to support SMS and data using
  - SMSoNAS (Diameter)
  - data 4G

8.3 Recommendations

Based on the Pros/Cons section, and on the services to be provided to different terminals, the following recommendations could be proposed:

1. HPLMN to open IMS Voice in Home and HPLMN/VPLMN to open IMS Voice Roaming (target architecture)
2. HPLMN to inform 2/3G users of 2/3G sunset (specially M2M) based on VPLMN information provided in IR.21 (user's education)
3. VPLMN to keep MSC to maintain sms/data for 4G (data centric) devices (partial removal scenario)
4. VPLMN/HPLMN to open SMSoDiameter to maintain SMS for 4G objects (full removal scenario)

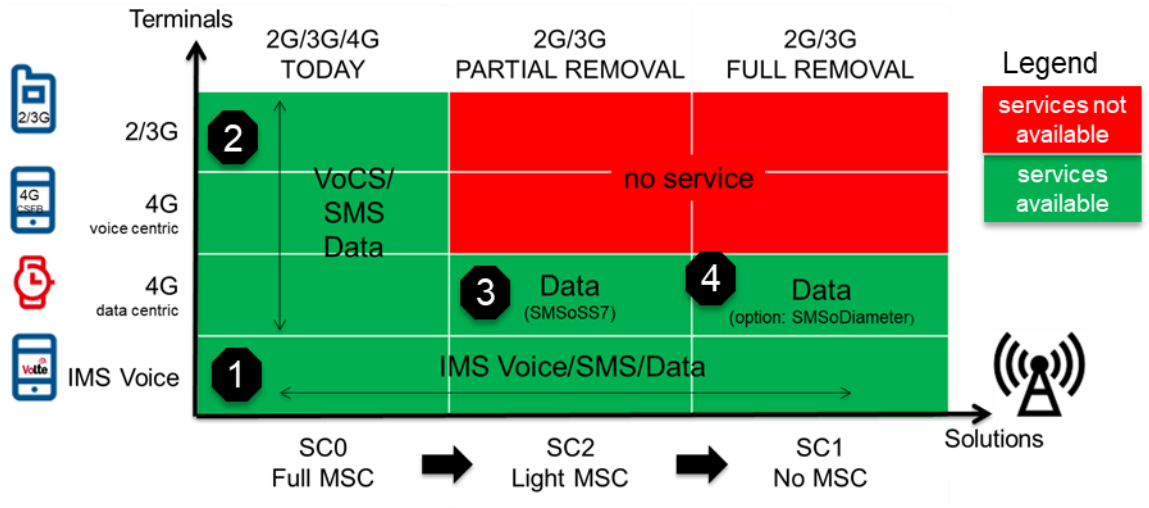

Figure 8 Recommendations

Additionally, based on the Pros/Cons, ITW scenario described in section 6 is considered as too complex solution. GSMA concluded that it will not develop further ITW architecture for roaming from non-IMS Voice to IMS Voice networks.

8.4 Further studies

USSD support for the different scenarios (depending of USSI and Ut/XCAP support)

Annex A 2/3G shutdown reports

A.1 2/3G network closure report

This section will contain some figures showing 2/3G shutdown planned in the next years, based on the 2020 WAS report of 2/3G closure. This report is only based on announced closures, and only 5% of the market declares publically Full Circuit-Switched closure before 2026.

The major milestones for Full Circuit-Switched closure are 2021-2022 starting in North America and Asia, and 2025-2027 starting in Europe.

Note: Asia, Oceania and North America are first decommissioning 2G while Europe is starting first with 3G.

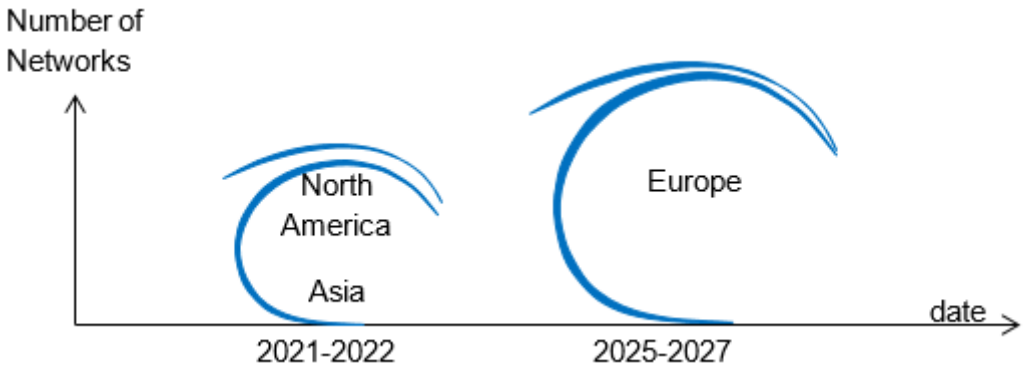

Figure 9: CS shutdown trends per continent

A.2 Mobile IoT report

The figure hereafter (Based on ABI Research, April 2020) shows also the 2/3G shutdown forecasts in the Mobile IoT ecosystem.

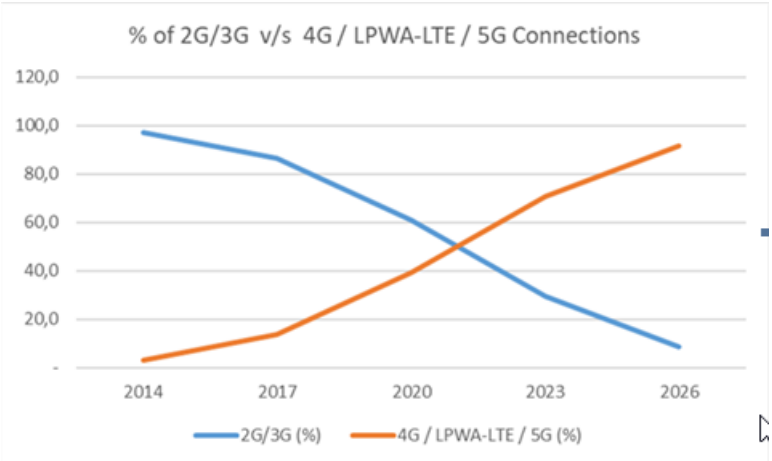

Figure 10: 2/3G vs 4/5G connections for Mobile IoT

Annex B Expected Legacy Device Behaviour in post 2G/3G Sunset Networks

B.1 Introduction

This annex clarifies how legacy UEs with different capabilities are expected to behave in networks that have executed the 2G/3G sunset.

In the context of this annex, a legacy UE is defined as exhibiting the capabilities outlined in annex B.2.1, B.2.2 and B.2.4.

B.2 Terminology & Definitions

B.2.1 User Equipment – General Capabilities

Within this document, only UEs that support LTE radio access technology (i.e. 4G) are considered. Unless otherwise specified, it is assumed that the UE also supports CS Radio Access Technology (i.e. 2G and 3G) and that by default the UE is voice capable.

UEs that are not voice capable (e.g. LTE-M devices) are out of scope in this annex.

B.2.2 Voice Capability

Two types of voice capable UEs are defined:

- **CS-only Voice capable UE**: A UE that supports voice service only in the CS domain.
- **IMS Voice capable UE**: A UE that supports Voice over IMS. It is assumed that the IMS Voice capable UE is also CS voice capable. Such a UE is assumed to be compliant to GSMA PRD IR.92 [11].

B.2.3 UE “Centricity”

A UE can be configured as voice centric or data centric (see 3GPP TS 23.221 [32] and 3GPP TS 24.301 [33]). A voice centric UE shall attempt to register on a network that supports voice service.

NOTE: The configuration of UE as voice centric or data centric is generally not under the control of the user or the operator.

B.2.4 UE Types

Based on B.2.2 and B.2.3, Table 1 defines a number of UE-Types in the context of this annex based on their capabilities relating to CS Voice support, IMS Voice support, 4G Data support, SMSoIP support, SMSoNAS support and UE Usage Type (“Centricity”).

UE Types	Capabilities					
	CS Voice	IMS Voice	4G Data	SMSoIP	SMSoNAS	UE Usage Type
Type 1	Yes	No	Yes	No	N/A	Voice Centric
Type 2	Yes	No	Yes	No	N/A	Data Centric
Type 3A (Note 1)	Yes	Yes	Yes	Yes	Yes	Voice Centric
Type 3B (Note 2)	Yes	Yes	Yes	Yes	Yes	Voice Centric
Type 4A (Note 1)	Yes	Yes	Yes	Yes	Yes	Data Centric
Type 4B (Note 2)	Yes	Yes	Yes	Yes	Yes	Data Centric

Notes:

1. The device supports both SMSoNAS and SMSoIP but shall use SMSoIP (via IMS configuration data parameter "SMS Over IP Networks Indication" – see GSMA PRD TS.32 [30]).
2. The device supports both SMSoNAS and SMSoIP but shall use SMSoNAS (via IMS configuration data parameter "SMS Over IP Networks Indication" – see GSMA PRD TS.32 [30]).

Table 1 – UE Types Definitions

B.2.5 Network Types & Assumptions

All Networks are assumed to:-

- Have no 2G/3G RAN (i.e., sunset has occurred),
- Have a 4G RAN (LTE) and core network (EPC),
- Support IMS Voice (VoLTE),
- Support IMS / PS Emergency Call.

Table 2 defines the applicable Network Types based on their SMS capabilities:

Network Types	SMS Capabilities		
	SMSoIP Support	SMSoNAS Support via SGs	SMSoNAS Support via SGd
Type A (Note 1)	Yes	No	No
Type B (Note 2)	No	No	Yes
Type C (Note 3)	No	Yes (Note 4)	No (Note 4)

Notes:

1. This is a 4G only network.
2. This is a 4G only network which supports the DIAMETER SGd interface (see 3GPP TS 23.272 [15]) to support SMSoNAS.
3. This is a 4G network which also provides some legacy CS core functionality to enable support of the SGs interface to support SMSoNAS.
4. It is possible to replace the SGs interface with the SGd interface, but this is internal to the Network and transparent to the UE. In this scenario, a Type C network would/can evolve into a Type B network.

Table 2– Network Types Definitions

It is noted that the UE may initially be unaware of the Network Type (in particular in the roaming scenario) although the UE may be able to infer the network type based on the signaling exchange at network attachment (see annex B.3).

B.2.6 UE Modes of Operation

When a UE is attached for EPS services it shall operate in one of the following modes of operation (see 3GPP TS 24.301 [18]):

- PS mode 1: UE only registered to EPS; UE is voice centric.
- PS mode 2: UE only registered to EPS; UE is data centric.
- CS/PS mode 1: UE registers to both EPS and non-EPS services; UE is voice centric.
- CS/PS mode 2: UE registers to both EPS and non-EPS services; UE is data centric.

NOTE: A UE in CS/PS mode 1 or CS/PS mode 2 is only possible on a Type B or Type C network since support of SMSoNAS (either via SGs or SGd) is required for the combined attach.

B.2.7 IMS Voice Capability

The terminology “IMS voice not available” indicates one of the following conditions (see 3GPP TS 24.301 [18]):

a) the UE is not configured to use IMS;

b) the UE is not configured to use IMS voice, i.e. when the voice domain preference for E-UTRAN, as defined in 3GPP TS 23.167 [31], indicates that voice communication services are allowed to be invoked only over the CS domain;
c) the UE is configured to use IMS voice, but the network indicates in the ATTACH ACCEPT message or the TRACKING AREA UPDATE ACCEPT message that IMS voice over PS sessions are not supported; or
d) the UE is configured to use IMS voice, the network indicates in the ATTACH ACCEPT message or the TRACKING AREA UPDATE ACCEPT message that IMS voice over PS sessions are supported, but the upper layers:
    - provide no indication that the UE is available for voice call in the IMS within a manufacturer determined period of time; or
    - indicate that the UE is not available for voice calls in the IMS.
e) the UE is in limited service state (i.e. with an IMSI that cannot be authenticated by the Network, or is without an IMSI).

NOTE 1: Condition a) may occur when the UE does not have an IMS stack or when the IMS stack has been disabled due to local policy implemented on the device (e.g., on encountering an untrusted network with which 1:1 testing has not been performed to prove interoperability).

NOTE 2: Condition c) may occur when the UE is roaming on a network that does not have a VoLTE roaming agreement with the UE's subscriber Home Network

NOTE 3: Condition d) may occur for example when IMS registration has failed multiple times.

B.3 Network Attachment Types & Responses

Table 3 provides a legend for combinations for all combinations of the UE Types and Network types described in B.2.4 and B.2.5 for the NAS Attach Request and NAS Attach Accept messages as described in 3GPP TS 24.301 [18] .

Network Type / UE Type	**Network Type A**	**Network Type B**	**Network Type C**
UE Type 1	See Table 4	See Table 5	See Table 5
UE Type 2	See Table 6	See Table 7	See Table 7
UE Type 3A	See Table 8	See Table 8	See Table 8
UE Type 3B	See Table 9	See Table 9	See Table 9
UE Type 4A	See Table 10	See Table 11	See Table 11
UE Type 4B	See Table 12	See Table 13	See Table 13

Table 3 – Index of Network and UE Type Combinations

NAS Attach Request Parameters

Attach Type	**Voice Domain Preference**	**UE Usage Type**	**Additional Update Type**
Combined EPS/IMSI	CS Only	Voice Centric	N/A
NAS Attach Accept Parameters			
Response Type	**EMM Cause**	**Additional Update Response**	**VOPS Indicator**	**EMC_BS**
EPS Only	#18 (CS Domain not available)	N/A	N/A	N/A
Only 4G data service available. UE will move away from this network and seek another network with CS voice service.				

Table 4– Type 1 UE and Type A Network

NAS Attach Request Parameters			
Attach Type	**Voice Domain Preference**	**UE Usage Type**	**Additional Update Type**
Combined EPS/IMSI	CS Only	Voice Centric	N/A
NAS Attach Accept Parameters			
Response Type	**EMM Cause**	**Additional Update Response**	**VOPS Indicator**	**EMC_BS**
Combined EPS/IMSI	#18 (CS Domain not available)	SMS Only	N/A	N/A
Only 4G data service and SMS available. UE will move away from this network and seek another with CS voice service				

Table 5– Type 1 UE and Type B/C Network

NAS Attach Request Parameters			
Attach Type	**Voice Domain Preference**	**UE Usage Type**	**Additional Update Type**

Combined EPS/IMSI	CS Only	Data Centric	N/A	
NAS Attach Accept Parameters				
Response Type	**EMM Cause**	**Additional Update Response**	**VOPS Indicator**	**EMC_BS**
EPS Only	#18 (CS Domain not available)	N/A	N/A	N/A
Only 4G data service available. UE will stay on EUTRAN for data and look for a CS network when call is initiated.				

Table 6– Type 2 UE and Type A Network

NAS Attach Request Parameters			
Attach Type	**Voice Domain Preference**	**UE Usage Type**	**Additional Update Type**
Combined EPS/IMSI	CS Only	Data Centric	N/A
NAS Attach Accept Parameters			
Response Type	**EMM Cause**	**Additional Update Response**	**VOPS Indicator**	**EMC_BS**
Combined EPS/IMSI	#18 (CS Domain not available)	SMS Only	N/A	N/A
Only 4G data service and SMS available. UE will stay on EUTRAN for data and SMS and look for CS network when call is initiated.				

Table 7– Type 2 UE and Type B/C Network

NAS Attach Request Parameters			
Attach Type	**Voice Domain Preference**	**UE Usage Type**	**Additional Update Type**
EPS Only	PS Preferred, CS Secondary	Voice Centric	N/A

NAS Attach Accept Parameters				
Response Type	**EMM Cause**	**Additional Update Response**	**VOPS Indicator**	**EMC_BS**
EPS Only	N/A	N/A	Dependent on VoLTE Roaming agreement	Yes
4G data, voice and SMS services available.				

Table 8– Type 3A UE and Type A/B/C Network

NAS Attach Request Parameters			
Attach Type	**Voice Domain Preference**	**UE Usage Type**	**Additional Update Type**
EPS Only	PS Preferred, CS Secondary	Voice Centric	N/A
NAS Attach Accept Parameters			
Response Type	**EMM Cause**	**Additional Update Response**	**VOPS Indicator**	**EMC_BS**
EPS Only	N/A	N/A	Dependent on VoLTE Roaming agreement	Yes
4G data, voice and SMS services available.				

Table 9– Type 3B UE and Type A/B/C Network

NAS Attach Request Parameters			
Attach Type	**Voice Domain Preference**	**UE Usage Type**	**Additional Update Type**
Combined EPS/IMSI	PS Preferred, CS Secondary	Data Centric	SMS Only
NAS Attach Accept Parameters			

Response Type	**EMM Cause**	**Additional Update Response**	**VOPS Indicator**	**EMC_BS**
EPS Only	N/A	N/A	Dependent on VoLTE Roaming agreement	Yes
4G data and voice services available. No SMS service.				

Table 10– Type 4A UE and Type A Network

NAS Attach Request Parameters			
Attach Type	**Voice Domain Preference**	**UE Usage Type**	**Additional Update Type**
Combined EPS/IMSI	PS Preferred, CS Secondary	Data Centric	SMS Only
NAS Attach Accept Parameters			

Response Type	**EMM Cause**	**Additional Update Response**	**VOPS Indicator**	**EMC_BS**
Combined EPS/IMSI	#18 (CS Domain not available)	SMS Only	Dependent on VoLTE Roaming agreement	Yes
4G data, voice and SMS services available.				

Table 11– Type 4A UE and Type B/C Network

NAS Attach Request Parameters			
Attach Type	**Voice Domain Preference**	**UE Usage Type**	**Additional Update Type**
Combined EPS/IMSI	PS Preferred, CS Secondary	Data Centric	N/A
NAS Attach Accept Parameters			

Response Type	EMM Cause	Additional Update Response	VOPS Indicator	EMC_BS
EPS Only	N/A	N/A	Dependent on VoLTE Roaming agreement	Yes
4G data and voice services available. No SMS service.				

Table 12– Type 4B UE and Type A Network

NAS Attach Request Parameters			
Attach Type	**Voice Domain Preference**	**UE Usage Type**	**Additional Update Type**
Combined EPS/IMSI	PS Preferred, CS Secondary	Data Centric	N/A

NAS Attach Accept Parameters				
Response Type	**EMM Cause**	**Additional Update Response**	**VOPS Indicator**	**EMC_BS**
Combined EPS/IMSI	#18 (CS Domain not available)	SMS Only	Dependent on VoLTE Roaming agreement	Yes
4G data, voice and SMS services available.				

Table 13– Type 4B UE and Type B/C Network

NOTE 1: Unless the network responds indicating SMS-only, a successful combined attach response is assumed to indicate to the UE that voice service is available in the serving PLMN.

NOTE 2: Even if the MME has responded indicating no support for SMS, SMSoIP may be available to UEs that are configured to use SMSoIP.

B.4 Emergency Call Aspects

CS only devices will not be able to make emergency calls in a post 2G/3G Sunset network. Devices that support IMS should follow existing standard behaviour to find a suitable network and setup an emergency call in home and roaming scenarios. Retry attempts should follow standard behaviour. This is summarised in the Table 14.

UE Types	Network Types		
	Type A	**Type B**	**Type C**
Type 1 / 2	Emergency Call Not possible		
Type 3A / 3B / 4A / 4B	Follow 3GPP 23.167 [31] annex H.5 & H.6		

Table 14 – Emergency Call Behaviour in 4G-only Networks

B.5 High Level UE Expected Behaviours

The following expected UE behaviours are defined:-

- A Type 1 UE (CS-only voice capable) is expected to attach to a network that does not support voice service if no other network is available (i.e., UE should conform to behaviour specified in 3GPP TS 24.301 [18] section 4.5).

- A Type 3 and Type 4 UE (IMS voice capable) is expected to attempt to set up an IMS emergency session even if voice service is not supported due to IMS voice not being available (see B.2.7) if the Network supports IMS Emergency call based on one or both of i) Emergency Support on SIB1, and ii) EMC_BS indication in the NAS Attach Accept. The Network can reject the Emergency IMS Registration but indicate that "anonymous emergency call" is allowed. The UE is expected to support “anonymous emergency call”.

- A Type 3 and Type 4 UE is expected to preferentially use voice over IMS for voice service regardless of the voice preference setting for all network types. This is dependent on the Network indicating that “IMSVOPS = 1” in the NAS Attach Accept message. In the event of “IMSVOPS = 0” being signalled from the Network:-
    - A Type 3 UE is expected to seek to find a voice capable network for a pre-determined period as described in 3GPP TS 23.167 [31] annex H.5 and H.6.
    - A Type 4 UE is expected to attach to the network and not provide a voice service.

Annex C Document Management

C.1 Document History

Version	Date	Brief Description of Change	Approval Authority	Editor / Company
1.0	03 June 2021	Initial version	NG	Marc Balon (Orange) Walter Zielinski (Huawei)
2.0	06 February 2024	CR 1002 (2G/3G sunset requirements)	NG#18	Wayne Cutler (GSMA)
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Your comments or suggestions & questions are always welcome.