



2G-3G Sunset Guidelines

Version 1.0

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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.

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	3 rd 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

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:

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

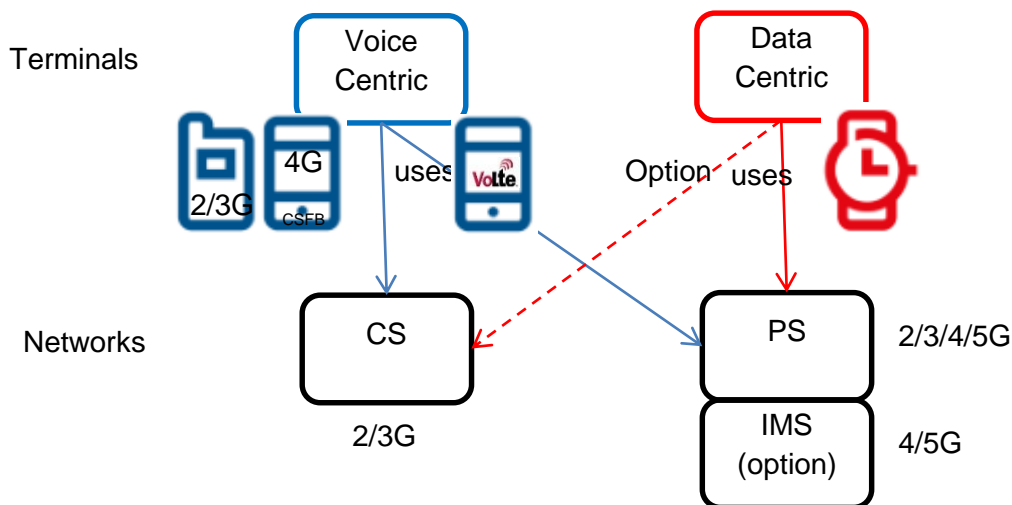


Figure 1 voice/data centric devices

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 SMS over SGs, 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 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).

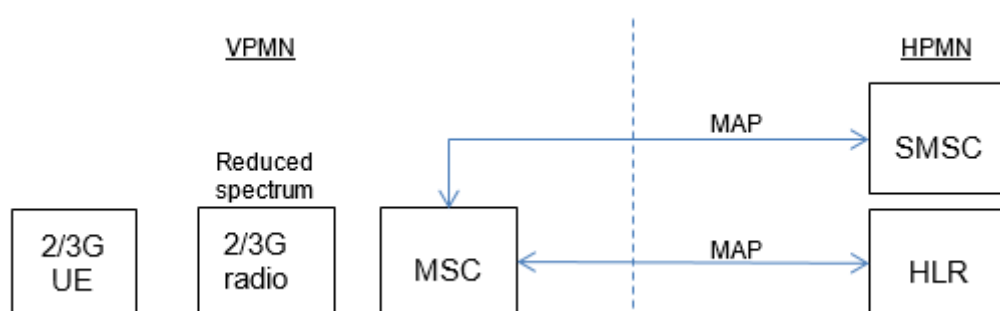


Figure 2: Limited 2/3G radio network

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.

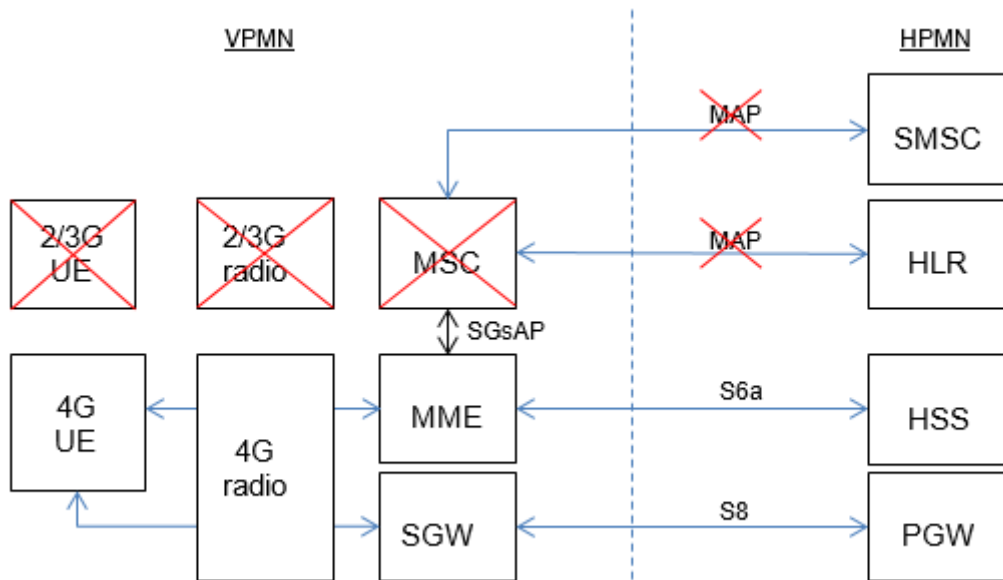


Figure 3: Full removal of 2/3G

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.

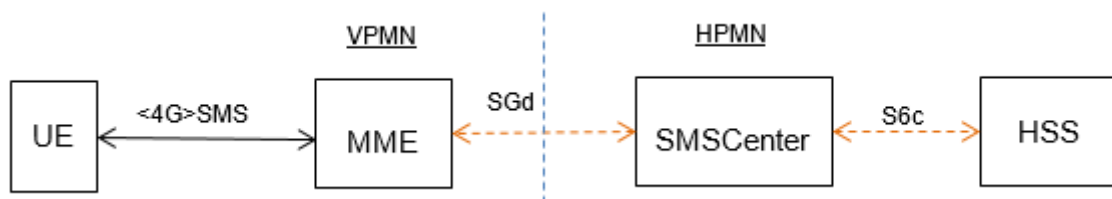


Figure 4: SMS over Diameter interfaces

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.

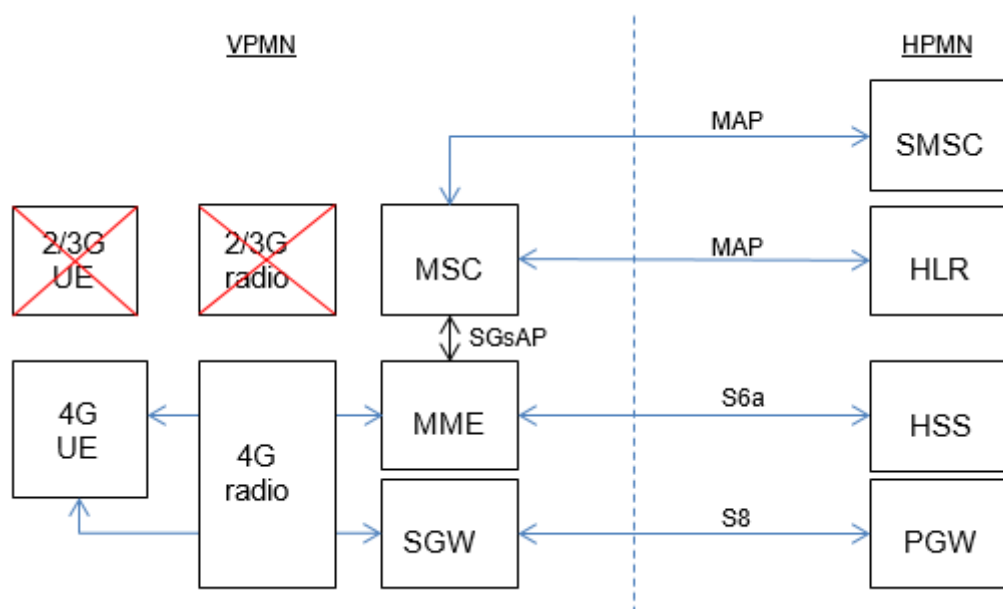


Figure 5: Partial removal of 2/3G

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

3. Visited IMS Voice only network
4. 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.

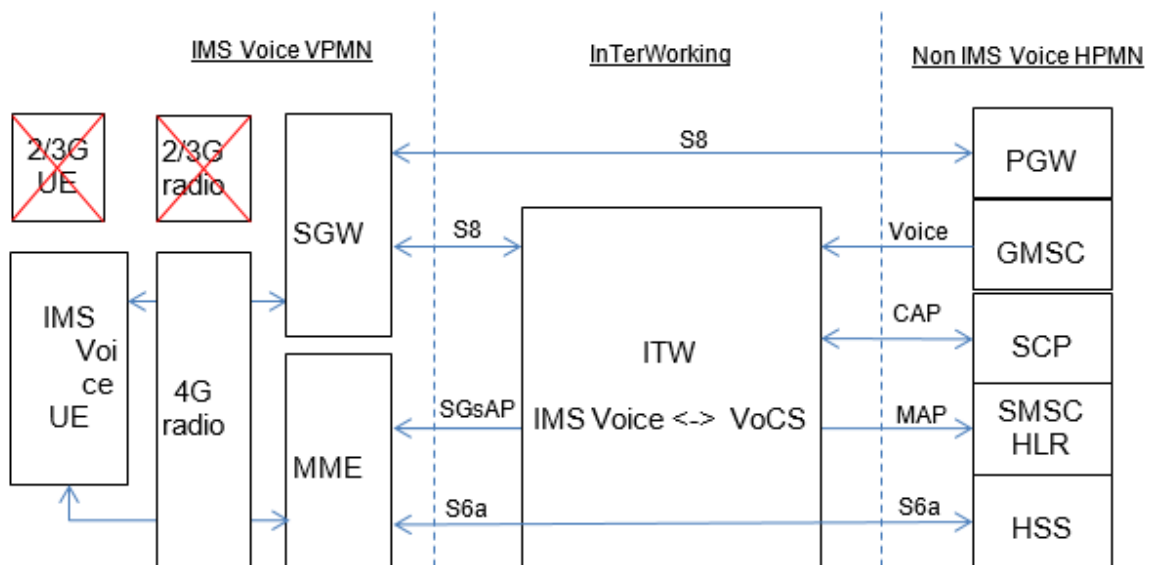


Figure 6: ITW architecture (IMS Voice VPMN <-> non IMS Voice HPMN)

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 could be adapted to define more precisely the 2/3G sunset scenario selected by the visited network:

1. ID 2 (Network): define 2/3G closure dates for scenario 1 (full removal) and 2 (partial removal)
2. ID 20 (LTE): VPMN support for SGd interface to support SMS using Diameter for scenario 1 (full removal)

The following information could be added (underlined in the text):

NETWORK

Section ID: 2 (Mandatory, Repeating)

Planned closure of 2G or 3G Network	Date
< network type 2g or 3G>	<planned date>

Note: *Different scenarios to remove 2/3G, are defined in NG.121*

- *Partial: Radio network removed, but MSC operational*
- *Full: Radio network and MSC removed*

LTE ROAMING INFORMATION

Section ID: 20 (Optional)

SMS ITW

SMS Delivery mechanism

SMS over IP	[Yes/No]
SMS over NAS (<u>SGs</u>) - via <u>SS7</u>	[Yes/No]
<u>SMS over NAS (SGd) - via Diameter</u>	[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).

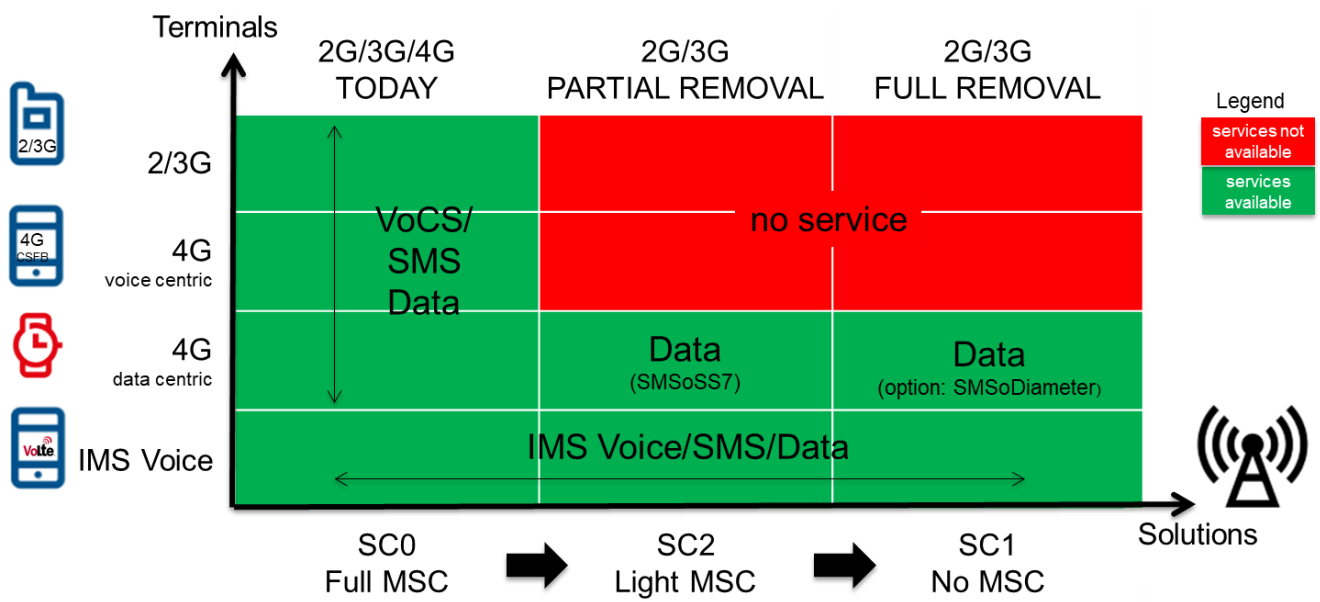


Figure 7 Service availability

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)

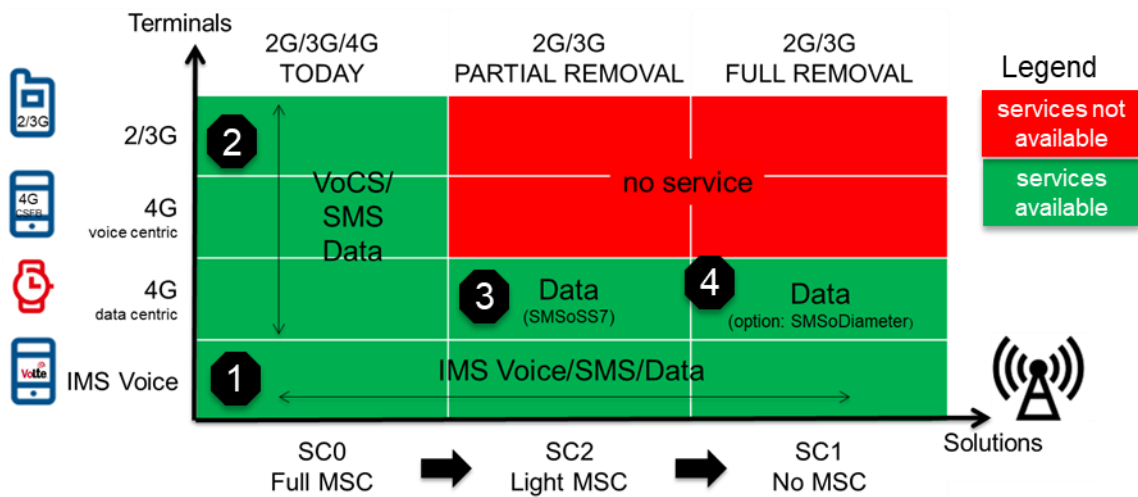


Figure 8 Recommendations

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.

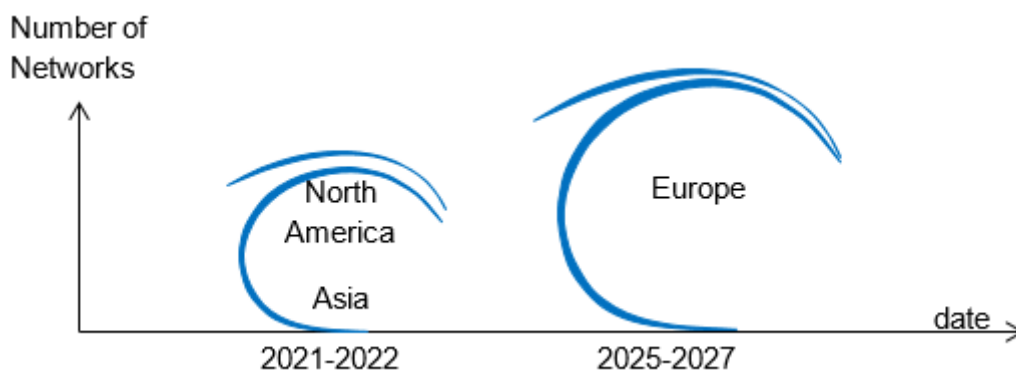


Figure 9: CS shutdown trends per continent

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.

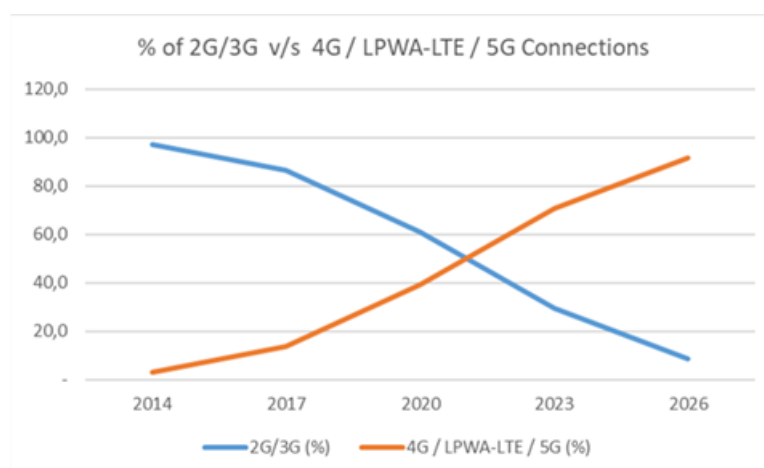


Figure 10: 2/3G vs 4/5G connections for Mobile IoT

Annex B Document Management

B.1 Document History

Version	Date	Brief Description of Change	Approval Authority	Editor / Company
1.0	03 June 2021	Initial version	TG	Marc Balon (Orange) Walter Zielinski (Huawei)

Other Information

Type	Description
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