White Paper

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SMS for IoT after 2G/3G Shutdown

Ensuring SMS service continuity for IoT on LTE

This is a whitepaper of the GSMA 5G IoT Community

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Executive Summary

The ongoing retirement of 2G/3G networks could have a major impact on the availability of SMS for Internet of Things (IoT) customers worldwide. This is due to the standard SMS delivery solution's dependence on the legacy 2G/3G infrastructure.

SMS is widely used by IoT applications for interactions between user equipment and the network. There are two main groups of applications. Firstly, SMS as a shoulder tap mechanism for IoT application developers to trigger specific events on their end-device application. Secondly SMS as an over-the-air (OTA) mechanism for mobile operators to remotely update SIM or eUICC profiles.

On LTE networks, SMS messages to and from IoT devices are primarily transmitted via the NAS (non-access stratum) protocol, as most of these devices can't employ the IP multimedia subsystem (IMS). SMS over NAS currently relies on the SGs interface between the MME (mobility management entity) and the MSC (mobile switching centre), as well as the SS7 MAP protocol between roaming partners, both of which are at risk of disappearing after the shutdown of 2G/3G.

An alternative to this SGs interface is the direct SGd interface between the MME and the SMS-centre, which uses the Diameter protocol. Unfortunately, according to the IR.21 database, this interface is currently not exposed by most operators as a roaming interface.

Therefore, all mobile operators need to take steps to ensure that SMS service continuity in roaming for IoT over LTE will be preserved over the coming years, both for their own IoT customers and the customers of their roaming partners. These steps primarily consist of the following:

- All operators planning a 2G/3G shutdown should continue to expose at least one SMS over NAS interface towards their roaming partners to guarantee SMS support for all inbound roaming IoT customers. This may be achieved either by preserving their existing SMS over MAP infrastructure or by implementing 4G-native SMS over the SGd interface.
- All operators already planning a full 2G/3G shutdown (i.e. including the retirement of their SS7 infrastructure) should:
  - inform all their roaming partners of the impact on SMS support for inbound roaming.
  - Provide these partners with sufficient lead time for them to jointly plan and carry out the new SMS /service integration using the Diameter protocol.
- All operators should also update their IR.21 document and urgently notify the GSMA of:
  - Partial 2G/3G closure date (local 2G connectivity no longer available)
  - Full 2G/3G closure date (SMS over MAP no longer available)
  - Target date for SGd interface support
- Irrespective of their own 2G/3G network shutdown plan, all operators should ascertain their roaming partners' plans for 2G/3G shutdowns and the implications for SMS roaming.
- All operators should involve their roaming teams as early as possible in their own internal SMS architecture evolution plans.

Objectives of this white paper

Produced by the GSMA 5G IoT Community for mobile operators and their partners, this white paper considers how to ensure the Internet of Things can continue to harness SMS after the shutdown of 2G and 3G networks. In particular, the paper is designed to:

- Alert all mobile operators to the often-overlooked consequences of switching off the 2G and 3G networks on SMS service
- Urge all mobile operators to consider taking action to avoid the SMS service being terminated, which could have consequences for millions of IoT users in their country,
- Describe all available options to ensure SMS service continuity in roaming for IoT in LTE (resp. NB-IoT & LTE-M) after the shutdown of 2G and 3G by a mobile operator.
- Point to GSMA-recommended solutions for providing a longer-term SMS service in a cost-effective way,
- Recommend possible transition scenarios and optionally propose standard communication and procedures between roaming partners.

Abbreviations

Term	Description
3GPP	3rd Generation Partnership Project
APN	Access point name
CDR	Call data record
DCM	Data communications module
EDGE	Enhanced data rates for GSM evolution
EoL	End-of-life
eUICC	Embedded universal integrated circuit card
E-UTRAN	Evolved UMTS terrestrial radio access network
EF	Elementary file
GPRS	General Packet Radio Service
GSM	Global System Mobile
GSMA	GSM Association
HHPLMN	Higher priority PLMN search period
HLR	Home location register
IoT	Internet of Things
IP	Internet protocol
IP-SM-GW	IP short message gateway
IPX	Internetwork packet exchange
IMS	IP multimedia subsystem
LTE	Long-Term Evolution
LTE-M	Long-Term Evolution - Machine Type Communications
MAP	Mobile application part
MME	Mobility management entity
MSC	Mobile switching centre
MSISDN	Mobile station international subscriber directory number

Term	Description
MT	Mobile terminating SMS
NAS	Non-access stratum
NAT	Network address translation
NB-IoT	Narrowband IoT
OEM	Original equipment manufacturer
OPLMNwACT	Operator-controlled PLMN selector with access technology
OTA	Over-the-air SMS
PDN	Packet data network
PLMN	Public land mobile network
PSM	Power saving mode
SGsAP	SGs application protocol
SIM	Subscriber identity module
SIP	Session initiation protocol
SMS	Short message service
SMSC	SMS centre
SS7	Signalling System 7
STP	Service transfer point
UDP	User datagram protocol
UE	User equipment
UIO	Unit in operation
UMTS	Universal Mobile Telecommunications System
TCP	Transmission control protocol
TCU	Telematics control unit
VLR	Visited location register
VoLTE	Voice over LTE

Why is SMS still critical for IoT?

Exemplary use case scenarios

Since the very beginning of LTE about 15 years ago, SMS has been used in a wide range of IoT applications to interact between the user equipment and the network. Those applications can be grouped in two main categories, serving two very distinct purposes:

1. SMS as a shoulder tap mechanism for IoT application developers to trigger specific events on their end-device application.
2. SMS as an over-the-air mechanism for mobile operators to remotely update SIM or eUICC profiles.

SMS as shoulder tap mechanism

SMS for connected car

In the early years of the adoption of mobile connectivity in vehicles, several automotive manufacturers opted to use SMS for communication to some essential on-board applications. Still in use today, these applications continue to provide essential functionality to vehicle users.

The primary role of SMS in this scenario consists of a shoulder tap mechanism that enables the automotive back-end servers to reach the on-board connectivity modules in the vehicles and trigger a reaction from the embedded applications. In-car functions relying on this shoulder tap mechanism range from remote climate control, remote door lock/unlock or remote status confirmation of usage-based insurance activation, service flag setting and many more.

In some instances, a unique tap is assigned to each data communications module (DCM) function, allowing the onboard application to directly trigger the required function (e.g. remote control, service flag update, etc.). The corresponding DCM then connects to the OEM's telematics centre and downloads the detailed instructions to be executed.

Unlike many other IoT-connected devices, automotive vehicles have a long lifecycle. Passenger cars in Europe have an average lifetime of around 11 years and commercial vehicles remain in use for even longer than that. Therefore, it is unlikely that these vehicles, with their embedded SMS connectivity, will be out of circulation before the 2G and 3G sunset.

SMS for smart metering

Many smart meters deployed in Europe are dependent on MT SMS as a shoulder tap mechanism and for sending of remote control instructions. Operators indicate that more than 10 million devices are dependent on SMS for this service in the UK and EU.

SMS for IoT applications with multimode modules

Even after the introduction of a new generation of networks allowing permanent connectivity with the end-device, many IoT application developers have continued to use SMS as a shoulder tap mechanism.

This is particularly the case for IoT solutions implemented using multimode modules and relying on 2G/3G as a fallback technology in areas or countries whether the primary access technology isn't locally available. Examples of such solutions include tracking applications that may at any point in time connect either to a 2G or an LTE network, and therefore use SMS to trigger the device to perform on-demand actions, such as providing a location update to a back-end server and customer's mobile application.

Although alternatives exist when communicating over a packet-switch network, such as LTE or its LPWA variant LTE-M (discussed later in this chapter). Customers don't implement these alternatives due to the complexity of having to deal with technology-specific communication mechanisms and logics.

Over-the-air SMS applications

SMS for remote SIM updates

Over-the-air (OTA) remote SIM update is a well-established mechanism for the maintenance of configuration files and applications on SIM cards. OTA SMS messages are, for example, used by mobile operators to remotely access SIM-cards and update elementary files (EF) configured on those SIMs.

One key application for OTA SMS is the update of the EF_OPLMNwACT file of the SIM card, often referred to as the "Preferred Partner List", which is employed by the user equipment to prioritise which networks to attach to following a network scan. This mechanism ensures that networks that are technically and commercially available for roaming at the equipment's location will be prioritised over other networks towards which an attach request would be likely to fail.

The associated SIM-based steering of roaming mechanism is essential for mobile operators to provide customers with an optimal experience while roaming outside their home network. Combined with other steering mechanisms, such as signalling steering, it ensures efficient operation of a roaming device, while minimising the underlying roaming signalling overhead.

SMS for eUICC profiles remote management

In several markets, such as the automotive sector, eUICCs are used in end-devices to enable advanced connectivity and remote management of network services via SMS and other OTA technologies. Automakers embed eUICCs in vehicles to allow seamless switching between network providers, enabling various connected services without requiring a physical SIM change. This capability is particularly important as vehicles often travel across borders, needing different network coverage in different regions.

With eUICCs, car makers can offer services, such as subscription management: Through SMS and OTA updates, car makers can remotely manage SIM profiles on the eUICC. For instance, if a driver moves to a new country, the car's network profile can switch to a local provider automatically, ensuring continuous connectivity.

Impact of SMS discontinuation on IoT services

Implications for connected car services

The discontinuance of the SMS service would have a very specific implication for connected road vehicles. Some manufacturers have already assessed the cost of replacing the relevant applications and on-board connectivity modules in their vehicles and concluded that the cost will be prohibitive. As well as the cost of physically recalling millions of vehicles, there is the cost of tracking them down after several ownership changes and taking them out of production to be retrofitted.

Various automakers have made the following points about the in-car functionalities dependant on the SMS service and for which the discontinuance of the service will have a major impact:

— The data communications module (DCM) and/or telematics control unit (TCU) in the connected vehicle must receive an SMS shoulder tap to change the service subscription status. This SMS shoulder tap is required to switch from dormant to awake mode.
— All remote-control functions (such as remote climate control, remote door lock/unlock, remote status confirmation, usage-based insurance activation, service flag setting, etc.) will become unavailable in the case of SMS service discontinuation. If an automotive OEM is unable to provide remote control functionality for the duration promised to the customer at the time of vehicle purchase, the result will be customer dissatisfaction.
— Other mobile applications that work in conjunction with connected vehicles will no longer be available, as a SMS shoulder tap is required to activate those mobile apps.

One automaker estimates that more than five million of its connected vehicles operating in Europe will be affected by the 2G/3G sunset. Other OEMs are undoubtedly facing similar situations, and the number of affected connected vehicles could be approximately 30 million in Europe.

Given this scenario, some automakers are willing to work with the relevant mobile operators to ensure that there will be an SMS delivery mechanism after the sunset of 2G and 3G networks. The two industries could together avoid the possibility of reduced functionality, which could have safety implications in countries where a 2G/3G sunset takes place without consideration of how the SMS service can be provided going forward.

Implications for smart metering

The loss of SMS would have a significant impact on the ability for national power and gas grid operators to manage demand and supply. Without a shoulder tap mechanism, meter readings cannot be collected and energy billing cannot take place. New mechanisms, such as time-of-day tariffs for green energy, would not function.

Implications for remote SIM updates

As discussed earlier, OTA remote SIM update is a well-established mechanism for maintenance of configuration files and applications on SIM cards. With the removal of SMS, these functions will no longer be executable, resulting in poorer performance of connectivity services and an inability to ensure SIMs will continue to meet operating and security requirements.

For instance, SMS service discontinuation in roaming would prevent mobile operators from updating any elementary files of their SIMs and, in particular, the EF_OPLMNwACT file.

Unfortunately, the Preferred Partner List contained in this EF_OPLMNwACT file is limited in size and can therefore only provide steering rules limited to specific geographical areas (using a finite combinations of PLMNIDs with access technology types). Furthermore, this list is never set in stone and must from time to time be updated to take into account new roaming partner networks or steering requirements.

As a result, the inability to send OTA SMS for roaming would lead to the Preferred Partner List not being updated according to the actual location of the SIM or the latest steering rules of the network operators, preventing the user equipment from knowing the current preferred partner networks at its location.

In addition, the steering of roaming logic implemented in the SIM could easily become out-of-sync with other steering of roaming mechanisms, such as signalling steering. In a worst-case scenario, a roaming network that is no longer available for roaming (e.g. for technical or for commercial reasons) could not be removed from the Preferred Partner List. As a result, SIM cards in the associated country would continue favouring this network over all other local networks, generating multiple and unnecessary random-access procedures and update-location requests.

This would be particularly the case with SIM-cards configured with a short periodic rescan value (stored in the HHPLMN entry of the SIM) or with devices being regularly power-cycled by the IoT application, as this power-cycle would generally erase the Forbidden PLMN and Forbidden Tracking Area lists on the SIM and lead to recurring failed attempts to attach to a roaming-restricted network.

Alternatives to SMS and associated limitations

SMS alternatives

Persistent IP connectivity as communication bearer

While SMS was first commercially introduced in circuit-switched GSM networks to enable person-to-person communication via short text messages, it also became the first medium enabling IoT customers to establish a data communication with a mobile IoT device and exchange information with a backend application.

Later, the introduction of 2G's GPRS and EDGE networks followed by 3G's UMTS networks opened the way for a much more efficient bilateral data communication using native IP packets over the associated packet-switched infrastructures. 4G's E-UTRAN and LTE networks further enhanced the performance and reliability of mobile IP communication, thereby fulfilling the requirements of all modern IoT applications.

Eventually, the ability for the customer to establish a persistent IP socket communication channel between their equipment and their backend server promised to render SMS as a communication bearer obsolete and comparatively inefficient.

Paging as shoulder tap mechanism

Having a persistent IP communication channel available for downlink data delivery promised to also make SMS as a shoulder tap mechanism superfluous, as customers no longer need to care about the device activity status:

- Devices in idle mode can be automatically switched back to connected mode by sending a downlink data packet that automatically triggers a paging procedure towards the UE in the radio network.
- For devices temporarily sent into sleep mode (using the eDRX extended discontinuous reception mode) or deep-sleep mode (using the PSM power-saving mode), downlink data packets can be buffered in the access network and a paging message initiated as soon as the UE returns to an idle or connected mode at the end of the eDRX or PSM cycle.

This latter procedure can be compared with the 2G's message waiting indicator set in the VLR, informing the SMS-centre about the availability of the UE for SMS-MT delivery.

Limitations of available alternatives

Despite the technological developments highlighted above, many IoT applications continue utilising SMS to communicate with mobile devices, even when they use LTE as their primary communication bearer.
The main reasons why IoT applications still rely on this legacy technology are summarised in the table below:

BACKGROUND SITUATION	DRIVER OF SMS USAGE
– Application code was originally designed to run over 2G networks and was subsequently ported to 3G/4G with the same application logic.	– Limited cost and effort with minimum application redesign activity during porting from 2G/3G to 4G/LTE-M.
– Customer uses multimode modules and 2G as a fall back technology when 4G/LTE-M isn't available.	– SMS as the only solution available to reach the UE when connected over 2G.
– Customer uses a public APN with network address translation (NAT) and public/private port mapping.	– SMS is the only solution available to reach the UE after port mapping has been deleted (usually after seconds or minutes of inactivity over UDP or TCP).
– Customer uses MSISDN in their backend application as key identifier to identify and reach individual UEs.	– No need to maintain large IP address to UE mapping tables.
– An active PDN connection may get torn down due to an unexpected event (e.g. cell, base station, packet gateway or server outage), disrupting the UE availability in downlink.	– Implementation effort required to monitor the availability of the PDN connection to achieve the same reachability performance in downlink as with SMS.
– In a roaming situation, an active IP (transport) session may get prematurely terminated by an IPX firewall idle timer (due to UE inactivity).	– No implementation effort to implement session keep-alive mechanisms.

Technical Solutions and Scenarios

How does SMS service for IoT work in LTE?

This section briefly outlines the solutions available today to provide SMS services with LTE and highlights the main benefits and drawbacks of each solution.

(Readers looking for a comprehensive description of the technical architecture and associated implementation solutions are advised to download the GSMA Document NG.111 “SMS Evolution” from the GSMA Networks Group.)

SMS over MAP – the legacy SMS over NAS protocol

The SMS service’s original implementation solution in 4G is a hybrid solution that combines:

- A 4G-native SMS over non-access stratum (SMS over NAS) communication between UE and the 4G’s mobility management entity (MME).
- A transfer to the 2G core network and MAP/SS7 network via the SGsAP interface between the 4G’s MME and the 2G’s MSC.
- From there, the SMS messages follow the 2G legacy MAP/SS7 implementation between the MSC/VLR, HLR and SMS-centre.

When LTE was first introduced, this standardised solution exhibited limited complexity and implementation costs and efforts, enabling network operators to piggyback on the existing 2G infrastructure and protocols.

This implementation solution, however, requires the continued availability of key elements and functions of the SS7 network and associated interfaces in the 2G core network, in particular the visited location register (VLR) and service transfer point (STP).

Unfortunately, these network elements are now obvious candidates for retirement after the shutdown of the 2G/3G networks and many equipment vendors have already announced the end-of-life of their associated product lines.

SMS over Diameter – The 4G-native SMS over NAS alternative

With the introduction of 4G, an alternative SMS over NAS solution was standardised that solely relied on Diameter-based interfaces in the core network rather than on legacy MAP interfaces.

With this solution, a direct communication path is created between the MME and the SMS-centre within the 4G network, allowing UE to continue using the

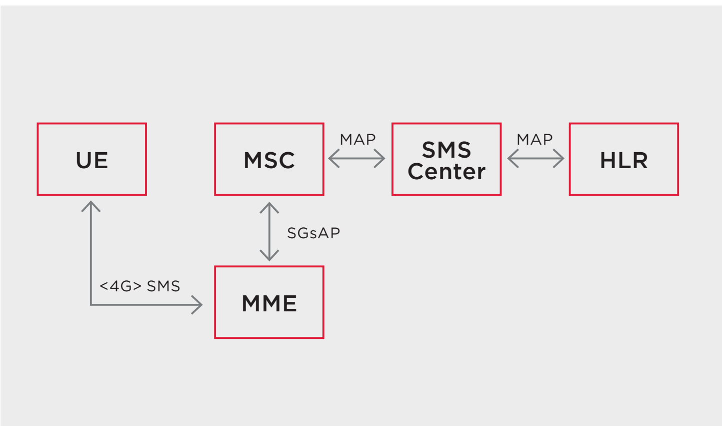

Figure 1, SMA over SGsAP unterfaces

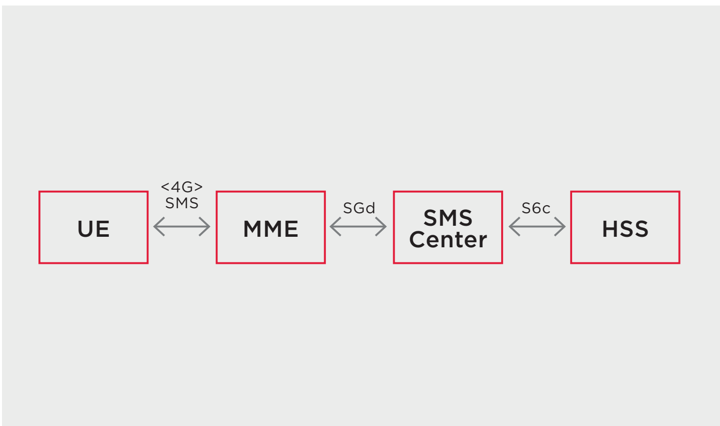

Figure 2, SMS over Diameter interfaces legacy SMS over NAS protocol towards the MME, while not having to rely on the availability of an SS7 infrastructure in the background.

Unfortunately, few, if any, operators have implemented and exposed the associated interfaces based on the Diameter protocol (SGd, S6c, see above) towards their roaming partners. As a result, SMS over NAS still relies on the availability in both the visited and the home PLMN networks of legacy MSC/VLR, STP and HLR functions for SMS to work when roaming.

SMS over IMS – The 4G-native SIP-based SMS protocol

With the introduction of the IP multimedia subsystem (IMS), operators implemented a fully native 4G solution based on the Diameter protocol that allows SMS messages to be exchanged end-to-end in 4G via the IMS.

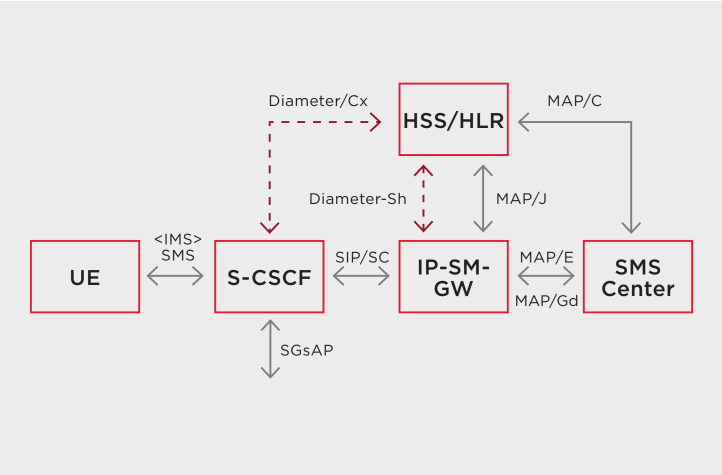

Figure 3, SMS over IMS interfaces (MAP)

With this solution, services no longer require the availability of legacy 2G network functions and SMS messages can be exchanged end-to-end on 4G between the UE and the SMS-centre.

However, one key prerequisite for this solution is the implementation of an IMS SIP stack in the UE as well as the provisioning of an IMS-capable offering in the network. Unfortunately both prerequisites involve significant software and licence costs, on both the UE and network sides. Most IoT devices in the field and their associated offerings today do not satisfy those requirements.

SMS shoulder tap use cases therefore cannot be realised with this protocol since mobile-terminating SMS sent via IMS cannot trigger an IP session for the UE to retrieve the downlink message over IP.

2G/3G shutdown scenarios and handling options

Shutdown scenarios and their impact on SMS continuity

In document NG.121 "2G-3G Sunset Guidelines" from the GSMA Networks Group, three different shutdown scenarios are identified. As shown in the table below, only one of those scenarios has a direct impact on SMS continuity for IoT in LTE.

Due to the dismantling of the 2G core infrastructure. including MSC/VLR and STP functions, in Scenario 1, SMS messages can no longer be exchanged using SMS over NAS, rendering all IoT devices without IMS stack unable to use this service.

It is therefore critical for any operator planning to execute a full shutdown scenario in the near future to understand the impact on SMS support in LTE. As there could be consequences for themselves, their customers and their roaming partners' customers roaming onto the 4G network. These operators need to evaluate how to preserve SMS service continuity in LTE for IoT customers.

SCENARIO	DESCRIPTION	IMPACT ON SMS OVER NAS
Sc0: Limited 2G/3G removal	– Shutdown of parts of the 2G/3G radio network only, keeping reduced spectrum for some legacy devices.	No impact
Sc1: Full 2G/3G removal	– Full shutdown of the 2G/3G network, including radio, access and core network functions.	High impact
Sc2: Partial 2G/3G removal	– Shutdown of the complete 2G/3G radio network, while preserving key core network components and functions (incl. MSC/VLR and STP).	No impact

SMS continuity options after full 2G/3G shutdown

The benefits and drawbacks of the three implementation options (as described in this chapter) to provide SMS service in LTE for IoT devices can be summarised as follows:

Pros and cons of each SMS implementation options

SMS PROTOCOL	ADVANTAGES	DRAWBACKS
SMS over MAP	– Existing and common protocol for 2G/3G/4G/LTE-M – Supported by all SMS-capable IoT modules	– Requires further operation of 2G core functions (MSC/VLR, STP, HLR) with associated platforms running EoL – No interoperability with 5G possible
SMS over IMS	– 4G-native, no dependence to 2G/3G – Common protocol for all VoLTE-capable modules – Already in use by most mass-market consumer mobile phones.	– Not supported by the majority of IoT modules – Requires IMS infrastructure, VoLTE-capable offering and associated network feature activation (e.g. IMS APN) – Requires VoLTE roaming agreement – No support for SMS shoulder tap use case
SMS over Diameter	– 4G native, no dependence to 2G/3G – No additional network element required (direct MME-SMSC communication) – Support for SMS shoulder tap scenario – Future-proof SMS solution in 5G	– Requires interface integration effort between roaming partners (SGd between MME and SMSC, S6c between SMSC and HSS) – Billing solution required for wholesale billing due to missing CDR generation in MME in the visited PLMN.

As indicated in the table, the option “SMS over IMS” does not guarantee SMS continuity in roaming for all IoT devices. This leaves mobile operators with the following two SMS over NAS implementation options:

1. SMS over SGs
2. SMS over SGd

Option 1: Maintenance of the SMS over SGs and MAP/SS7 interface

Although this option seems to be in contradiction with the scope of scenario Sc1, operators may be able to preserve this SMS routing option without operating a full-featured 2G/3G core infrastructure, only keeping the required functions for SMS support within a slimmed-down version of the MSC/VLR, STP and HLR components.

With this solution, operators will be able to continue supporting SMS in their LTE networks for their own as well as for (inbound) roaming partners’ IoT customers.

However, for outbound roaming scenarios, the SMS service will still require the support of the same components by the roaming partner. Should a roaming partner decide to discontinue their own SMS support via SGs and SS7, a migration to the alternative SMS over NAS option (SMS over SGd, see below) will eventually be required to support SMS outbound roaming towards these partners.

Note: As described in the §6.2.2. of the NG.111 } document, an intermediate option exists that involves externalising the implementation of a **MAP/Diameter inter-working function** as an alternative to a straight SGd implementation in the 4G access network. This intermediary option is not described in more detail in this whitepaper, as it is not currently perceived as a mainstream solution. However, operators are invited to consult section §6.2.2. of the NG.111 document for a detailed description of the benefits, drawbacks and limitations of this intermediate option.

Option 2: Implementation of the new SMS over SGd and Diameter interface

This solution guarantees by design, full native SMS support in LTE for IoT devices and, as indicated in the table above, is a future-proof solution in case of SMS interoperability support with 5G networks.

For inbound roaming scenarios, however, based on the same principle described in option 1 for outbound roaming, a SMS service when roaming will require the support of the same Diameter-based interface by the roaming partner. Should a roaming partner not implement SMS support via a Diameter-based interface (SGd/S6c), SMS inbound roaming will not be available to the IoT customers of those partners.

Eventually, operators planning to implement this option will need to carefully assess the implication on their billing and charging capability for SMS-MO messages and the potential need for additional development effort with their local network vendors.

Recommendations

The ongoing retirement of 2G/3G networks worldwide has the potential to cause a major impact on SMS service availability in LTE for IoT customers worldwide. As explained in this document, this is due to the standard SMS delivery solution's dependence on the legacy 2G/3G infrastructure.

Therefore, all mobile operators should take steps to ensure that SMS service continuity for IoT over LTE will be preserved over the coming years, both for their own IoT customers and the customers of their roaming partners.

Those steps primarily consist of the following:

- All operators planning a 2G/3G shutdown should ensure that they continue to expose at least one SMS over NAS interface to guarantee SMS support for all IoT customers. This may be achieved either by preserving their existing SMS over MAP infrastructure or by implementing and exposing 4G-native SMS over the SGd interface.
- All operators already planning a full 2G/3G shutdown (i.e. including the retirement of their SS7 infrastructure) should in particular:
  - inform all their roaming partners of the impact on SMS support for inbound roaming.
  - Provide these partners with sufficient lead time for them to jointly plan and carry out the new SMS service integration using the Diameter protocol.
- All operators should also update their IR.21 document and provide as early as possible information to the GSMA about:
  - Partial 2G/3G closure date (local 2G connectivity no longer available)
  - Full 2G/3G closure date (SMS over MAP no longer available)
  - Support target date for SMS over the SGd interface
- All operators, irrespective of their own 2G/3G network shutdown plan, should actively seek information from their roaming partners regarding those partners' 2G/3G shutdown plan and the implication for SMS roaming.
- All operators should involve their roaming teams as early as possible in their own internal SMS architecture evolution plans.

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