CEPT ECC
Electronic Communications Committee

ECC Report 274

Regulatory Analysis of Over-The-Air Provisioning of SIM profiles including its impact on Number Portability

approved 20 December 2018

0 EXECUTIVE SUMMARY

ECC Report 212 [1] identified the need for greater flexibility in how Mobile Network Codes (MNCs) are assigned and used. As business models continue to evolve, the need for greater flexibility and adaptation of regulatory rules is becoming increasingly apparent and, to this end, the ECC adopted ECC Recommendation 17(02) [2] which provides harmonised assignment and management principles for E.212 MNCs.

In the Machine-To-Machine (M2M) communications sphere, devices using public mobile networks need a Subscriber Identity Module (SIM) card for network authentication and communication. However, providing SIM cards for M2M devices is a different supply chain challenge. In the consumer market sphere (including Person-To-Person (P2P) communications) using conventional SIM cards, if a subscriber wishes to switch operator it is a simple matter of approaching a new operator for a new SIM card that can then be inserted into the subscriber's device. With M2M, a subscriber may have hundreds, thousands or millions of devices installed over a wide geographical area (possibly across borders). Replacing SIM cards is therefore economically and logistically unrealistic which introduces a risk of "operator lock-in". Furthermore, because certain M2M devices may be installed in environments where they are exposed to extreme conditions (cold, heat, dust, vibration etc.), the SIM cards are generally embedded into devices and cannot be easily replaced. In certain cases consumer devices may also include SIMs embedded into devices (e.g. tablets, smartphones, wearables, etc.) and therefore the challenge of switching operator without a physical SIM card replacement is also relevant in the consumer market.

From a competition perspective, this is a concern for policy makers. The principles of competition and customer choice must be preserved in the M2M market and consumer market as is with traditional P2P forms of electronic communications. ECC Report 212 [1] identifies both administrative/operational and technical means to achieve this. The administrative approaches involve the assignment of MNCs directly to large M2M-users or to consortia of M2M-users.

The alternative to an administrative/operational solution (with reference to E.212) is a technical solution where the International Mobile Subscriber Identity (IMSI) number can be provisioned remotely over-the-air, a solution which is beneficial for both facilitating switching of service providers and initial device provisioning. In 2013, the GSMA released a first version of its specification for an embedded Universal Integrated Circuit Card (eUICC) that provides the capability of managing subscriptions remotely in the M2M communications sphere thereby allowing embedded eUICCs to be reprogrammed. This was followed up in 2017 by another specification for the consumer market.

This Report examines the high-level aspects of the architectures defined in the GSMA specifications and considers the implications for the role of E.164 numbers and the relevance of Number Portability (NP) in the M2M and consumer markets.

Chapter 2 of this Report provides information on the identifiers affected by the remote provisioning ecosystem and the standards specifying their structure and use. This chapter also introduces a new identifier called the Embedded Universal Integrated Circuit Card Identifier (EID) as defined in the GSMA Remote Provisioning Specification.

Chapter 3 provides a high level description of the over-the-air provisioning ecosystem and describes the stakeholders in the remote provisioning supply chain both for the GSMA’s M2M specification and consumer specification. A comparison of the different approaches is also given.

Chapter 4 looks at issues related to E.164 numbers and Number Portability (NP) for a number of different switching scenarios. For M2M applications the E.164 number is normally not visible and sometimes only used for billing and operational purposes. This suggests that the reasons for keeping the E.164 number when changing operator are rather limited. A similar situation also exists for certain consumer market scenarios where the relevance of NP is also considered negligible. Nevertheless, NP remains an end-user right and needs to be considered in this context.

Chapter 5 analyses and compares different switching approaches and regulatory implications when an E.164 number is changed or retained and also if assigned to the end-user. The assignment of E.212 numbering resources is also considered in the analysis.

Chapter 6 provides guidance on how existing regulation is applicable to the change of service providers in the remote provisioning ecosystem, and how the regulation can be improved in order to encompass the possibilities that M2M services and remote provisioning represent.

Chapter 7 draws conclusions following consideration of the implications for and the relevance of NP in the M2M and consumer markets and, as a consequence, the impact on the current regulatory framework on switching and NP. These conclusions are:

- The eligibility criteria defined in ITU Recommendation E.118 should be reviewed and the relationship between the EID defined in the GSMA specification and the IIN should be clarified. At time of publication, Recommendation E.118 is under review by ITU-T Study Group 2;
- CEPT administrations should take into account that new functions are introduced into the ecosystem with the introduction of remote provisioning. The subscription manager function needs to be performed by an entity that treats all market players equally in order to avoid barriers to entry among mobile service providers and operator lock-in of the end-user (and M2M-user) or of MVNOs;
- CEPT administrations should review their NP processes to include potential scenarios identified in this Report and to verify the possible necessity of data exchange between donor and recipient operators, like the fact the eUICC has to be updated remotely;
- It should be noted that the procedure for changing service provider could be similar whether the E.164 number is being changed or retained;
- Furthermore, existing processes need to be reviewed, and potentially new processes introduced, in order to ensure that:
  - The update of NP databases and the remote update of the eUICC, in the case that NP data is also needed for the service, are synchronised. The use of any characteristic or feature (e.g. SIM-locking) that may prevent or limit synchronisation should be carefully evaluated and possibly avoided;
  - Current methods of ensuring that end-users (and M2M-users) are not switched to another provider against their will should be re-evaluated with the introduction of remote provisioning also taking into account M2M services;
  - Methods of communications with end-users during the switching process need to be evaluated as, for example with M2M, an SMS to a device can no longer be considered as a means of communication with the M2M-user.

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LIST OF ABBREVIATIONS

Abbreviation	Explanation
CEPT	European Conference of Postal and Telecommunications Administrations
CI	Certificate Issuer
DM	Device Manufacturer
ECC	Electronic Communications Committee
EECC	European Electronic Communications Code which entered into force on 20 December 2018.
EID	Embedded Universal Integrated Circuit Card Identifier
ETS	European Telecommunication Standard
ETSI	European Telecommunications Standards Institute
eUICC	Embedded Universal Integrated Circuit Card
EUM	eUICC Manufacturer
GSMA	Global System for Mobile Communications Association or GSM Association
HLR	Home Location Register
HSS	Home Subscriber Server
IAIN	Individual Account Identification Number
ICCID	Integrated Circuit Card IDentifier
IIN	Issuer Identifier Number
IMSI	International Mobile Subscriber Identity
IoT	Internet of Things
ISO/IEC	International Organization for Standardization / International Electrotechnical Commission
ITU-T	International Telecommunication Union - Telecommunication Standardization Sector
LDS	Local Discovery Service
LPA	Local Profile Assistant
LPD	Local Profile Download
LUI	Local User Interface
M2M	Machine-to-Machine
MCC	Mobile Country Code
MNC	Mobile Network Code
MNO	Mobile Network Operator
MNP	Mobile Number Portability
MSIN	Mobile Subscription Identification Number

Abbreviation	Explanation
MVNO	Mobile Virtual Network Operator
NP	Number Portability
NRA	National Regulatory Authority
OA	Operating Agency
OTA	Over-The-Air
P2P	Person-to-Person
QR Code	Quick Response Code
RSP	Remote SIM Provision
SIM	Subscriber Identity Module
SM	Subscription Manager
SMS	Short Message Service
SM-DP	Subscription Manager - Data Preparation
SM-DS	Subscription Manager - Discovery Service
SM-SR	Subscription Manager - Secure Routing
TC-SCP	Technical Committee - Smart Card Platform
TS	Technical Specification
UICC	Universal Integrated Circuit Card
USD	Universal Service Directive

1 INTRODUCTION

ECC Report 212 [1] identified the need for greater flexibility in how MNCs are assigned and used. As business models continue to evolve, the need for greater flexibility and adaptation of regulatory rules is becoming increasingly apparent and, to this end, the ECC adopted ECC Recommendation 17(02) [2] which provides harmonised assignment and management principles for E.212 MNCs.

M2M is a communication technology where information can be transferred between devices and applications in an automated way with little or no human interaction. In the M2M and consumer communications sphere, devices using public mobile networks need a SIM card for network authentication and communication. The SIM contains a unique number sequence called an International Mobile Subscriber Identity (IMSI) and an encryption key which are used to identify and authenticate the subscriber when the device attaches to the network. SIM cards are secure by design and only MNOs (and in later years MVNOs) were assigned MNCs to generate IMSI numbering ranges. Therefore, MNOs had a lot of discretion in developing the mobile communications ecosystem from the outset.

Providing SIM cards for M2M devices is a different supply chain challenge. In the consumer market sphere (including P2P communications) using conventional SIM cards, if a subscriber wishes to switch operator it is a simple matter of approaching a new operator for a new SIM card that can then be inserted into the subscriber's device. With M2M, a subscriber may have hundreds, thousands or millions of devices installed over a wide geographical area (possibly across borders). Replacing SIM cards is therefore economically and logistically unrealistic which introduces a risk of "operator lock-in". Furthermore, because certain M2M devices may be installed in environments where they are exposed to extreme conditions (cold, heat, dust, vibration etc.), the SIM cards are generally embedded into devices and cannot be easily replaced. In certain cases consumer devices (e.g. smartphones, tablets, wearables, etc.) may also include SIMs embedded into devices and therefore the challenge of switching operator without a physical SIM card replacement is also relevant in the consumer market.

From a competition perspective, this is a concern for policy makers. The principles of competition and customer choice must be preserved in the M2M and consumer markets as is with traditional P2P forms of electronic communications. ECC Report 212 identifies both administrative/operational and technical means to achieve this. The administrative approaches involve the assignment of MNCs directly to large M2M-users or to consortia of M2M-users.

The alternative to an administrative/operational solution (with reference to E.212) is a technical solution where the IMSI number can be provisioned Over-The-Air (OTA) remotely. For the purposes of this Report, OTA is a technology used to communicate remotely with, download applications to and manage an eUICC using a radio access network. OTA is also referred to as remote provisioning in this document. In 2013, the GSMA released a first version of its specification for an embedded Universal Integrated Circuit Card (eUICC) that provides the capability of managing subscriptions remotely in the M2M communications sphere thereby allowing embedded eUICCs to be reprogrammed. This was followed up in 2017 by another specification for the consumer market.

This Report examines the high-level aspects of the architectures defined in the GSMA specifications for the M2M [3][4] and consumer [5][6] markets. It also considers the implications for the role of E.164 numbers and the relevance of NP in the M2M and consumer markets and, as a consequence, the impact on the current regulatory framework on facilitating a change of provider and NP.

2 IDENTIFIERS USED ON SIMS

A SIM card is configured with two key identifiers:

- The Primary Account Number (PAN) is the Integrated Circuit Card Identifier (ICCID), based on ITU-T Recommendation E.118 [7], identifying the physical SIM card and the SIM card issuer; and
- The International Mobile Subscription Identity (IMSI), based on ITU-T Recommendation E.212 [8], identifying the subscription of the service.

With traditional SIM cards, the ICCID identifies the physical hardware and it is possible to have multiple profiles in one SIM card which have different IMSIs. This is illustrated on the left hand side of Figure 1 below. With the eUICC, the GSMA specification introduces a new identifier called the Embedded Universal Integrated Circuit Card IDentifier (EID). The EID identifies the physical hardware and therefore the ICCID is no longer used for this purpose. The ICCID is now associated with a SIM profile that is stored logically on the eUICC. This is illustrated on the right hand side of figure 1 below. Each logical SIM profile is identified by a unique ICCID and IMSI.

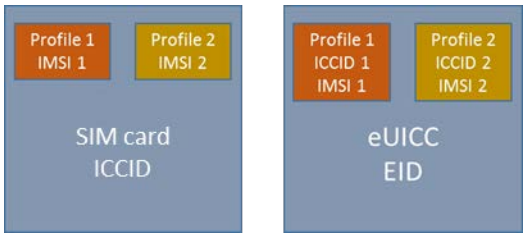


Figure 1: Identifiers in the traditional SIM and the eUICC

2.1 INTEGRATED CIRCUIT CARD IDENTIFIER (ICCID)

A SIM card contains a unique serial number known as the ICCID. This is the identifier of the physical SIM card and the SIM card issuer. The ICCID is stored on, and usually printed on, the SIM card as illustrated in Figure 2 below:

Figure 2: Example of ICCID printed on SIM card
(Source: Android Stack Exchange)

The ICCID is already used by mobile operators in their information systems for managing SIMs. In order to ensure backward compatibility, this identifier has been kept in the GSMA specification and is applied individually to every single operator profile installed on a eUICC.

The ICCID is defined by ITU-T Recommendation E.118 as the PAN. An ICCID contains a maximum of 19 digits1 that includes, besides other information, an identification of the country (Country Code) of the issuer of the SIM card, the Issuer Identifier Number (IIN) and the Individual Account Identification Number of the SIM Card (IAIN). The format is shown in Figure 3 below:

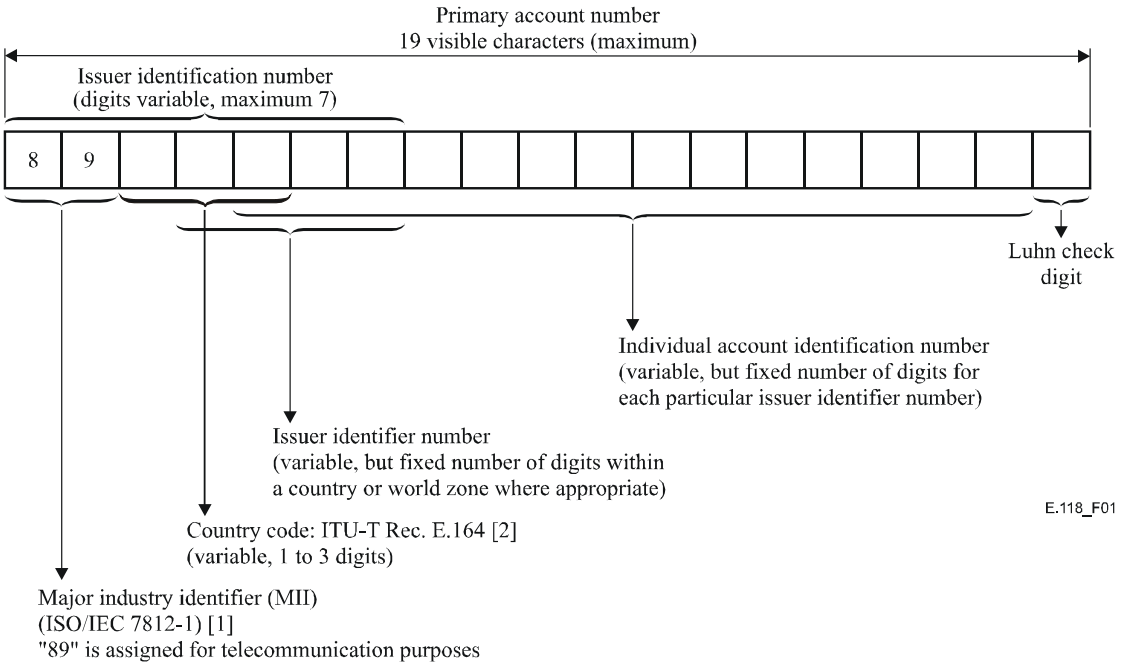


Figure 3: Format of the Primary account number in the SIM (Source: ITU-T Rec. E.118)

ITU Recommendation E.118 [7] states that the assignment of specific IINs should be the responsibility of a country or group of countries as appropriate. These numbers should only be assigned to Operating Agencies (OAs) (i.e. operators) with the agreement of their national numbering plan administrator. These IINs are normally used to distinguish between multiple operators who issue cards within a single country. The Director of the Telecommunications Standardisation Bureau (TSB) of the ITU-T is responsible for the registration and/or cancellation of IINs for operators/MVNOs that have been assigned at the national level by the national numbering plan administrator. Furthermore, in the event of technical or operational difficulties in registration an IIN, the Director of the TSB should consult the Chairman of ITU-T Study Group 2. In practice, the operators apply for an IIN with the national numbering plan administrator and complete a registration form contained in Recommendation E.118 (also available on ITU web site2) that then the national numbering plan administrator sends to the ITU TSB.

In most of the cases, the operators are SIM card issuers. These operators request SIM card manufacturers to program the ICCID on the SIM and, normally, to print it on the SIM card. It should be noted that this identifier is used in some porting processes to validate the NP request (e.g. for anonymous or pre-paid subscriptions).

ITU-T Recommendation E.118 is based on the International Organization for Standardization (ISO/IEC) 7812-1 standard [9]. In January 2017, this standard was amended and the length of the Issuer identification number was increased from 6 to 8 digits. As it can be seen in Figure 3 above, the present ITU-T Recommendation E.118 has defined a maximum length of 7 digits for the Issuer identification number. At time of publication, Recommendation E.118 is under review by ITU-T Study Group 2.

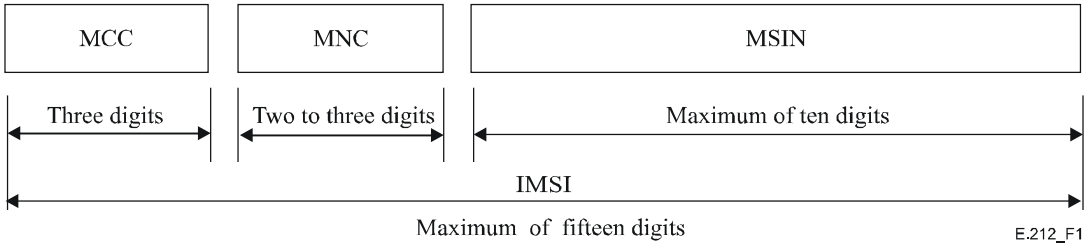
1 This is defined in ITU-T Recommendation E.118 and ETSI ETS-300-608. ETS-300-608 also specifies that network operators who are already issuing Phase 1 SIM cards with an identification number length of 20 digits may retain this length in the future.

2 http://www.itu.int/en/ITU-T/inr/forms/Pages/iin.aspx

As mentioned in the introduction to this chapter, the ICCID is used to identify a profile on an eUICC. There may be more than one profile provisioned on a eUICC but only one profile can be active at any given time.

2.2 INTERNATIONAL MOBILE SUBSCRIBER IDENTITY (IMSI)

The IMSI is the most important identifier in the process of registration of devices on mobile networks. It identifies the country (MCC – Mobile Country Code) and the network (MNC – Mobile Network Code). It is based on this identifier that, when a terminal initiates a registration request, a profile of the subscription is selected. Figure 4 below describes the structure of the IMSI:



MCC Mobile Country Code
MNC Mobile Network Code
MSIN Mobile Subscription Identification Number
IMSI International Mobile Subscription Identity

Figure 4: Format of the IMSI
(Source: ITU-T Rec. E.212)

According to ITU-T Recommendation E.212 [8], the MCC is 3 digits in length and identifies a country, a group of countries (region) or identifies shared resources (e.g. under the shared MCC range 90x). The Director of TSB may assign more than one MCC to a country. If a country requests more than one MCC the rules for this assignment of an extra MCC are included in Annex C of the recommendation. MCCs in the 90x range are non-geographic MCCs (country-agnostic) and are administered by the Director of TSB in accordance with Annex A of the recommendation.

The MNC is 2 or 3 digits in length and the resource is administered by the respective national numbering plan administrator. In CEPT countries MNCs are 2 digits in length, while MNCs with 3 digits are mainly used in Central and North America. Annex B of the recommendation contains the principles for the assignment of MNCs within geographic MCCs.

The MNC, in combination with the MCC, provides sufficient information to identify the home network. In the case of switching service providers over-the-air, this information and other parameters related to the subscription are changed to reflect the details of the new service provider.

2.3 EMBEDDED UNIVERSAL INTEGRATED CIRCUIT CARD IDENTIFIER (EID)

The EID uniquely identifies the eUICC and is defined in the GSMA Remote Provisioning Architecture for Embedded UICC - Technical Specification [4] and ETSI TS 103 383 [10]. This identifier is set by the eUICC manufacturer and the present specification foresees that it does not change during the operational life of the eUICC. In the M2M scenario, the EID is used as a key by a function called the Subscription Manager - Secure Routing (SM-SR) to identify eUICCs in its database [4]. EID for consumer market is used inter-alia for the discovery service [5][6]. The EID shall be protected from unauthorised modification.

The EID consists of 32 digits as shown in Figure 5 below:

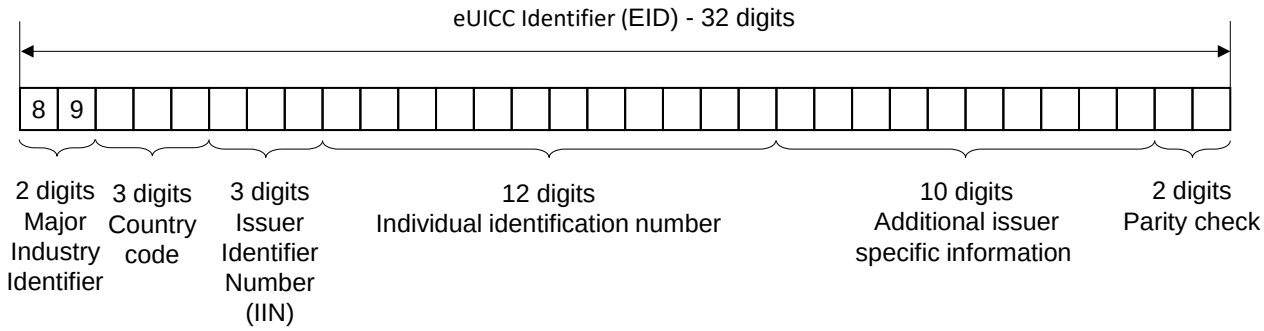


Figure 5: Format of EID [4]

The GSMA Remote Provisioning Architecture for eUICC - Technical Specification [4] [5] [6] specifies that the IIN shall be assigned based on what is specified in ITU-T Recommendation E.118. At time of publication, Recommendation E.118 is under review by ITU-T Study Group 2.

It is specified that the M2M device manufacturer shall ensure that there is a method for the owner of the device or the service provider to access the EID [3] while the consumer device manufacturer shall ensure that there is a means for the end-user to obtain the EID through the device software [5].

For the EID, all the fields have a fixed length. If the value contained in any of these fields has a length of fewer digits than the field's maximum length, then the value is prefixed (or left-padded) with zeros. The EID is a key identifier in the remote provisioning architecture for M2M [4] and consumer [5] markets, since this identifier is used to address the eUICC on which the various profiles are stored. The ICCID and IMSI identifiers are contained in the subscription profiles and can be changed during the operational life of the eUICC.

2.4 E.164 NUMBERS

An E.164 number is associated with the IMSI but is not stored on the SIM itself. The E.164 number is associated with the subscription in the HLR/HSS. The role of the E.164 numbers is discussed in detail in Chapter 4 in the context of NP.

3 HIGH LEVEL DESCRIPTION OF THE OVER-THE-AIR PROVISIONING ECOSYSTEM

3.1 DESCRIPTION OF THE STAKEHOLDERS IN THE REMOTE PROVISIONING SUPPLY CHAIN

The GSMA has published two separate remote provisioning specifications for two different target markets:

- the Machine-to-Machine (M2M) market; and
- the Consumer market.

Table 1 below provides an overview of the different roles and functions in the remote provisioning ecosystem and this is followed by a more detailed description in the subsequent sections. One entity can perform several different roles. The information in Table 1 is mainly compiled from the GSMA specifications for M2M [3][4] and consumer [5][6] markets.

Table 1: Description of the Stakeholders in the Remote Provisioning Supply Chain

Stakeholder	Description
eUICC Manufacturer (EUM)	The EUM is responsible for the initial cryptographic configuration and security of the eUICC. The eUICCs are delivered to other parties (e.g. DM)
Device Manufacturer (DM)	The DM produces the terminal equipment (e.g. mobile phones, smartphones, tablets, wearables). Within the consumer market, the DM is responsible for the implementation of any Local Profile Assistant (LPA) elements that reside on the device. It is also responsible for the implementation of any application that resides on the primary device allowing User Interface access to the companion device.
Certificate Issuer (CI)	The CI issues certificates for remote SIM provisioning entities and acts as a trusted third party for the purpose of authenticating the entities of the system. It communicates also with the various Subscription Manager modules (SM-SR, SM-DP. SM-DP+ and SM-DS).
Connectivity Provider	The connectivity provider provides an electronic communications service which consists in the conveyance of signals in order to provide and/or use a service for exchange of information.
M2M Service Provider	The M2M service provider enters into a contract with the M2M-user for the provision of an M2M service that allows the exchange of information between devices/platforms.
M2M-User	The M2M-user purchases an M2M service from an M2M service provider and incorporates it into his own product/equipment, e.g. car manufacturers or electricity supply providers.
End-User	The user of the services related to the enabled profile.

3.2 MACHINE-TO-MACHINE

In case of M2M services, the defined general architecture is illustrated in Figure 6 below. For detailed information on the GSMA's Embedded eUICC Remote Provisioning Architecture, consult the GSMA specification [1].

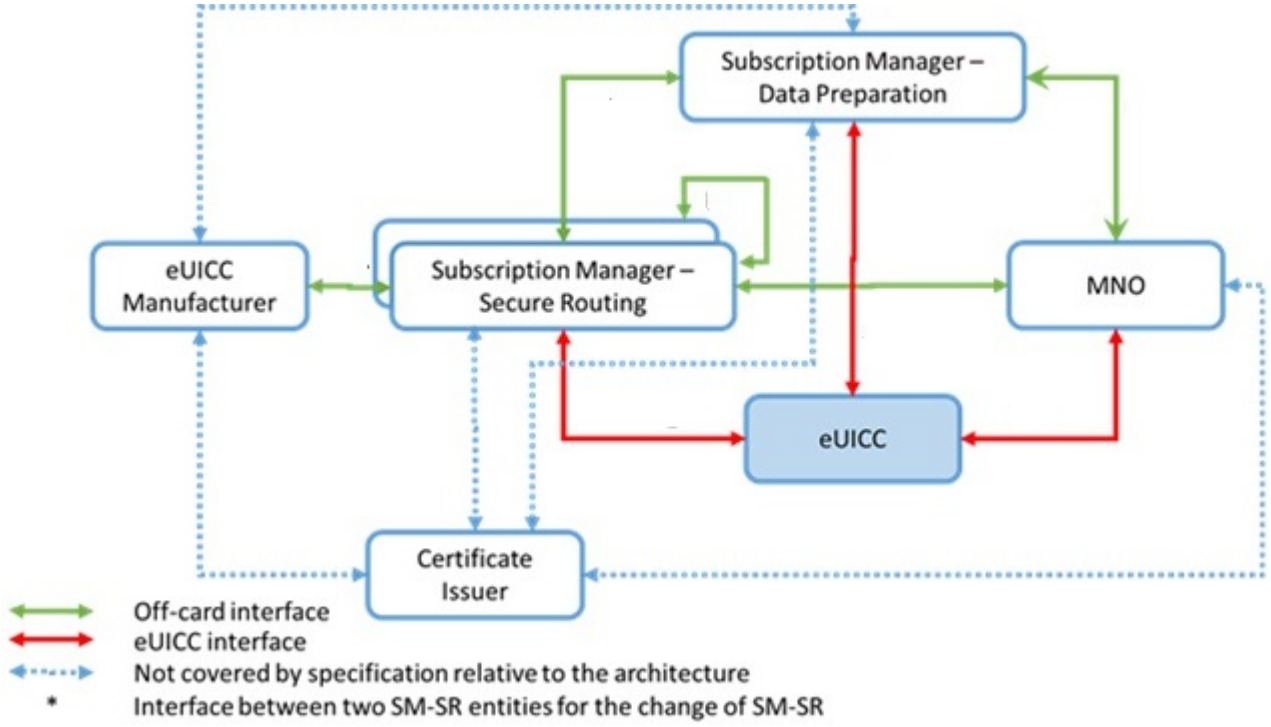


Figure 6: eUICC Remote Provisioning System
(Source: GSMA Embedded eUICC Remote Provisioning Architecture)

The Subscription Manager - Secure Routing (SM-SR) performs the following activities: load, enable, disable and delete profiles on the eUICC. The SM-SR manages the eUICC in accordance with the MNO's (operators) requests and secures the communications link between the eUICC and Subscription Manager - Data Preparation (SM-DP) for the delivery of operator profiles. The SM-DP is responsible for preparing, storing and protecting operator profiles (including the operator credentials) establishing a secure and authenticated channel to the eUICC to download and install profiles onto the eUICC [11].

3.3 CONSUMER

Several stakeholders are involved in the remote provisioning process. Currently, with the standard provision of SIM cards and subscription profiles, some of the stakeholders have a similar role to those performed by the Certificate Issuer (CI), the eUICC Manufacturer (EUM) and the service provider. The Subscription Manager - Data Preparation+ (SM-DP+) is a new and important function for the remote provisioning of subscription profiles.

In this process the end-user can perform several actions related with the provisioning of the eUICC. In the past the only action associated with switching was the physical replacement of the SIM card by the end-user.

In order to facilitate a better understanding of the process, Figure 7 below provides details of the different stakeholders involved.

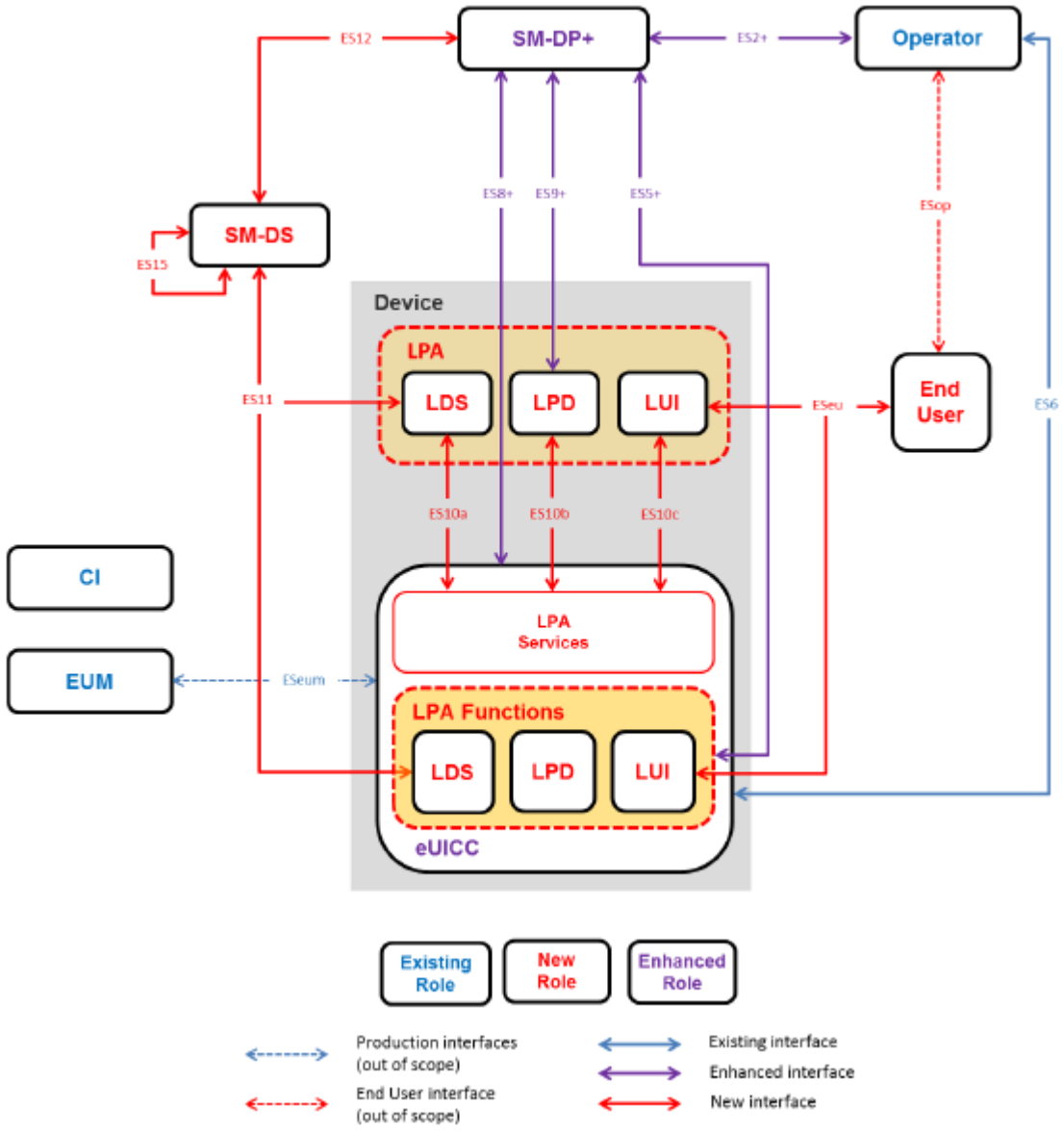


Figure 7: Remote eUICC Provisioning System Architecture (Source: based on the GSMA RSP Architecture)

3.3.1 Subscription Manager - Data Preparation + (SM-DP+)

The SM-DP+ is a new function in the remote provisioning ecosystem. In fact, this functionality has two main roles:

- To prepare the profiles to be securely provisioned on the eUICC;
- To perform functions which directly manage the profiles in the eUICC.

3.3.2 Subscription Manager - Discovery Service (SM-DS)

The SM-DS function is to be notified by the SM-DP+ if there is any information intended for a specific eUICC. Once the eUICC's (or device's) Local Discovery Service (LDS) query for a notification to the SM-DS is confirmed, the same SM-DS uses the eUICC's EID to communicate the corresponding SM-DP+ address.

The introduction of the SM-DS makes it possible to download a profile on a eUICC without necessitating either the provision of a quick response (QR) code (containing a set of information such as SM-DP+ address,

etc.) by the mobile service provider to the end-user or the pre-configuration of the eUICC with a default SM-DP+ address.

3.3.3 Local Profile Assistant (LPA)

The Local Profile Assistant is also a new function in the remote provisioning ecosystem. It is a module included in the device and/or eUICC which provides three main functions:

- Local Profile Download (LPD) - This plays a proxy role for the efficient download of a profile package. This function will depend on network, device and eUICC capabilities;
- Local User Interface (LUI) - This function allows local profile management on the device by the end-user. The user intent has to be enforced as required.
- Local Discovery Service (LDS) - Retrieves the SM-DP+ address from the SM-DS which is then utilised by the LPA to locate the SM-DP+ for profile downloading.

3.3.4 Local profile management procedures

Several procedures are specified for controlling the profile management procedures. The following list gives examples of some procedures that may be activated by the end-user:

- Profile download with activation code;
- Add (download) profile with activation code and by operator push;
- Enable profile;
- Disable profile;
- Delete profile.

3.4 COMPARISON OF M2M AND CONSUMER APPROACHES

Two different approaches to how profiles are managed are defined in the GSMA's specifications. In the M2M specification [4] the profile is “pushed” and there is no local profile management by the M2M device. Mechanisms have been defined that guarantee that a profile (provisioning or operational) is always available.

In the consumer specification [5] extra functionality will be required to allow the user to browse possible Electronic Communications Service Provider (and their individual packages) and select a package that suits them. Each of these packages would have a different profile so the user would be effectively “pulling” the profile.

When considering other aspects, there are various commonalities between the GSMA's specifications for M2M and consumer markets. In accordance with each specification, an eUICC can contain one or more profiles. Only one profile shall be enabled at any point in time. Enabling a profile requires the agreement of the relevant MNO.

In the case of the architecture for both M2M and consumer markets, two types of profiles are specified: a provisioning profile (only one in each eUICC) and an operational profile. In the M2M market, the provisioning profile can be used only to provide transport capability for eUICC management and profile management between the eUICC and an SM-SR while in the consumer market, the provisioning profile allows connectivity to a mobile network solely for the purpose of profile provisioning. An operational profile may be also used as a provisioning profile.

The EID uniquely identifies the eUICC, while an ICCID identifies a single profile on the eUICC. As an eUICC can contain multiple profiles, multiple ICCIDs may also be present in a single eUICC.

4 SWITCHING THE OPERATOR - E.164 NUMBER ISSUES

4.1 VALUE OF MAINTAINING E.164 NUMBER

NP was introduced for voice telephony as changing telephone number was seen as a major barrier to competition due to the inconvenience and extra costs involved (reprinting business cards, letters, avoiding hassle by correspondents, lost calls etc.). NP has proven over the years to be a key competition enabler and is well known to users, especially those who attach a high value to retaining their existing E.164 number while changing operator. NP is a cost burden on the industry but, to a large extent in most countries, the costs are largely independent of the volume of numbers ported.

For M2M-applications the E.164 number is normally not visible and sometimes only used for billing and operational purposes. This suggests that the reasons for keeping the E.164 number when changing operator are rather limited. On the other hand NP is a well-established process.

Nevertheless, in the context of the consumer market, NP will continue to be fundamental to facilitate competition. Also there could be a difference depending on the type of terminal and/or type of application that uses the E.164 number. For smartphones with an eUICC, maintaining E.164 numbers is important when the end-user changes service provider, but with tablets, laptops or dongles with eUICCs, this type of facility may only add value if there are applications where the E.164 numbers are used (e.g. for voice or SMS services).

One also needs to take into consideration that number portability would not be possible if numbering resources (e.g. E.164, E.212 etc.) of the recipient operator and donor operator do not pertain to a single country. Amongst other reasons every country has its own numbering format and adopts a different porting process.

In M2M communications the E.164 number may not have relevance for the M2M-user as M2M communications are automated and mainly data-only. Therefore in most cases when an M2M-user wishes to switch service provider, the associated E.164 numbers will also be changed without any impact on its operations. The introduction of OTA technology will enable the remote provisioning of IMSIs and the porting of the E.164 numbers becomes a matter of implementation of the M2M solution.

In this chapter we focus on scenarios where the E.164 number is retained.

4.2 SWITCHING SIM CARD PHYSICALLY WHILE RETAINING THE E.164 NUMBER

With the introduction of NP, it is possible for an end-user to retain the E.164 number while changing operator. Nevertheless, the process for changing the operator is that the end-user has to physically change the SIM card in the device. This is a simple process and a small burden for users who have fewer devices within their reach, e.g. mobile phones and tablets. However, and as already described in Chapter 1, physically changing the SIM card in the M2M and consumer sector can be cost-intensive and burdensome. It can create a lock-in effect where in reality it is not possible to physically change the SIM card and therefore not possible to change the operator.

4.3 REMOTELY PROVISIONING THE EUICC WHILE RETAINING THE E.164 NUMBER

Updating the eUICC remotely using OTA technology means that the physical replacement of SIM cards is no longer necessary. However, the impact of remote provisioning on NP-processes needs to be assessed. For example, in some countries the ICCID is used in the validation phase of the NP process for numbers used for pre-paid services. More specifically, the subscriber communicates the part of the ICCID that is printed on the SIM card to the recipient operator, who includes this code on the NP request that is sent to the donor operator. Then the donor operator checks this code for validating the NP request. This process has the purpose of ensuring that the customer requesting the port is in the physical possession of the SIM card

associated with the number for which the port is requested. In case the device has an eUICC, an analysis inside the single process could be useful to confirm the use of ICCID or to consider another method of validation, e.g., by providing the EID and ICCID with any porting request.

After the NP validation process is concluded, the donor operator will receive an "NP-Execute" message or its equivalent. In some countries, the donor operator will then deactivate the user's service and send the "NP-Ready" message or its equivalent to the recipient operator. An "NP-Broadcast" message or its equivalent will then be sent to all operators so that they can update their routing tables. In other countries, the donor operator will deactivate the user's number a few hours after the "NP-Ready" message or its equivalent is sent to the recipient operator in order to allow time for other network operators to update their database after receiving the "NP-Broadcast" message or its equivalent. The user will notice that service is no longer available and must then replace the existing SIM card with the new SIM card provided by the recipient operator.

In case the update is done using OTA technology, the profile should be downloaded on the eUICC as an operational profile. This new profile is initially disabled. The download could be done as soon as the NP has been positively validated. The activation of the new operational profile downloaded needs to be synchronised with the update of the NP databases. In fact, if the activation is not synchronised, the user will no longer have service. If a call is routed to the recipient operator while the SIM profile is still registered with the donor operator the connection will not be successful. Conversely, if the eUICC has been updated and the NP database has not been updated, the SIM should register in the recipient network while the call is addressed towards the donor network and, again, the call cannot be completed.

This implies that the SIM card profile update process must start when the "NP-Ready" message or its equivalent is received from the donor operator and the "NP-Broadcast" message or its equivalent must be synchronised with the SIM card profile update process.

In the context of the GSMA's remote provisioning architecture for M2M and consumer markets, the SM-SR and SM-DP+ respectively have to update the profile. The SM-SR or SM-DP+ may be an entity that is not authorised to provide an electronic communications service. Therefore, careful consideration should be given to possible obligations on entities performing this function to notify the CEPT Administration of their activities. If the CEPT Administration is not aware of the SM-SR's or SM-DP+'s activities it may be impossible to guarantee that NP will be completed within the specified timeframe.

At the end of the subscription for service using a ported number, the recipient operator must initiate a return (disconnect) process, which is a NP process in the opposite direction. The result of the return process is that the routing information which corresponds to the recipient operator should be deleted from the NP database and the number should then be made available for re-assignment normally by the original number range holder. This process starts at the date of the end of the subscription and is finalised at the end of a pre-defined quarantine period.

Disabling or deleting the profile from the eUICC at the end of subscription is not a critical requirement for synchronisation between the number return process and the OTA provisioning process. However, as a best practice, the return process should be initiated at the same time as the MNO requires the eUICC profile to be disabled or deleted.

5 ANALYSIS OF DIFFERENT SWITCHING SCENARIOS[3]

This section analyses and compares different switching approaches and regulatory implications when an E.164 number is changed or retained and also if assigned to the M2M-user in countries where this is possible. The assignment of E.212 numbering resources is also considered in the analysis.

Moreover, it is to be pointed out that in case of changing the service provider, modifying both E.212 and E.164 numbering resources, it could happen that the new E.212 and E.164 numbering resources are of a country different from the original one. It should also be noted that switching may be possible across national borders whereas number portability is mainly a national matter.

The different scenarios are shown in Table 2 below and discussed in the subsequent sections:

Table 2: Analysis of the Different Switching Scenarios

E.164 number assigned from CEPT Administration to:	E.212 number assigned from CEPT Administration to:	E.164 number is	Scenario
Operator	Operator	retained	A: See section 5.1
Operator	Operator	changed	B: See section 5.2
Operator	M2M-user	retained	C*: The change of operator that handles E.164 numbers implies a change of profile. There are doubts about the feasibility of scenarios where the E.164 numbers are assigned to the operator and the M2M-user has its own IMSI numbers and consequently on the fact that this scenario may have an actual applicability.
Operator	M2M-user	changed	D*: The change of operator that handles E.164 numbers implies a change of profile. There are doubts about the feasibility of scenarios where the E.164 numbers are assigned to the operator and the M2M-user has its own IMSI numbers and consequently on the fact that this scenario may have an actual applicability.
M2M-user	Operator	retained	E*: See section 5.3
M2M-user	Operator	changed	F*: Not applicable as the E.164 numbers are already assigned to the M2M-user.
M2M-user	M2M-user	retained	G*: See section 5.4

[3] These scenarios are described for illustrative purposes and do not imply that they are possible from a legal point of view.

E.164 number assigned from CEPT Administration to:	E.212 number assigned from CEPT Administration to:	E.164 number is	Scenario
M2M-user	M2M-user	changed	H*: Not applicable as the E.164 numbers are already assigned to the M2M-user.
*Scenarios C to H are only applicable in countries where E.164 or E.212 numbering resources can be assigned directly to M2M-users by national numbering administrations.			

5.1 SCENARIO A: SWITCHING OPERATOR WHILE RETAINING THE E.164 NUMBER WHERE THE E.164 NUMBER RANGE WAS ASSIGNED TO AN OPERATOR

In case the update of the eUICC is done remotely using OTA technology, no operation should be done from the end-user at the moment in which the switching is performed. The update of the SIM profile should be done when the NP databases are updated. In the case of GSMA solution, the entity which activates the new SIM profiles is the SM-SR for the M2M solution and the SM-DP+ (or locally updated) for the consumer solution. Consequently, in switching the operator while retaining the E.164 number, the actions of SM-SR and SM-DP+ must be synchronised with the NP process. If the update of profiles is not done in a synchronised way the end-user may have no service availability.

5.2 SCENARIO B: SWITCHING OPERATOR WHILE CHANGING THE E.164 NUMBER WHERE THE E.164 NUMBER RANGE WAS ASSIGNED TO AN OPERATOR

In this case, the update of NP databases may not be necessary but this does not mean that a definition of a process is not required when switching service providers. If CEPT administrations have to guarantee the right of M2M-users to change the service provider, some rules are necessary. In order to guarantee that this process is accomplished in a given time period and in a synchronised way (i.e. all the updates done in a short time slot), the definition of a process by the CEPT administrations (similar to the NP process), which provides details on relevant responsibilities and service level agreements to the entities involved, could be appropriate.

It should be noted that some countries have defined an optional process in the case of NP for business end-users interested in porting a large amount of numbers in a synchronised way. A first step could be to review these processes and possibly give some suggestions. For remote provisioning, the presence of such a process may limit the out of service period that may occur when a change of operator is executed. Also in case of changing the operator and changing the E.164 number, the donor operator has to update its HLR/HSS cancelling the IMSI contained in the old profile and the recipient operator has to update its HLR/HSS activating the IMSI contained in the new profile.

5.3 SCENARIO E: SWITCHING OPERATORS OF A M2M-USER WHERE THE E.164 NUMBER RANGE WAS ASSIGNED TO THE M2M-USER AND THE E.212 RESOURCES WERE ASSIGNED TO THE OPERATOR

In this situation, when the M2M-user wants to change the operator offering the connectivity service, the profiles of its eUICCs have to be updated for this scenario. The situation is similar to the present one when a MVNO with its own E.164 numbers wants to change the underlying MNO that provides a radio access network for service provision to its customers, except that the IMSIs can be changed remotely. This process is typically not regulated and the involved parties have to agree how to proceed.

Considering that the M2M-user has its own E.164 numbers, these will be maintained, while the IMSI number will change.

There is the necessity to change the way traffic is routed to these E.164 numbers. There are two possibilities:

- The routing tables of all operators are updated with the E.164 number block assigned to the M2M-user with details of the network in which this number block has been provisioned; and
- The E.164 number block is included in the NP database and a NP routing number is assigned. If the M2M-user already has its own NP routing number assigned then the NP process is not necessary (since the number should already be included in the NP database). All operators routing tables must be configured to route calls to these numbers.

The previous activities have to be coordinated with the update of SIM profiles in order to minimise the out of service period.

5.4 SCENARIO G: SWITCHING THE OPERATOR OF A M2M-USER WHERE THE E.164 NUMBER RANGE AND THE E.212 RESOURCES WERE ASSIGNED TO THE M2M-USER

In this case, there is no need to update the SIM profiles for this scenario. However, changes need to be made on the network side to register the SIM profiles with the new operator so that calls, messages and signalling are routed correctly. If the registration of the SIM is not performed directly from the M2M-user and there is a need of changing who performs the SIM registration the registration key needs to be transferred. Otherwise an update of the SIM profiles is needed.

6 IMPACT OF OTA ON THE REGULATION OF NUMBER PORTABILITY AND CHANGE OF SERVICE PROVIDER

This chapter provides guidance on how existing regulation is applicable to the change of service providers in the remote provisioning ecosystem, and how the regulation can be improved in order to encompass the possibilities that M2M services and remote provisioning represent.

The existing provision in the Universal Service Directive (USD) regarding change of provider states that all subscribers with numbers from national numbering plans who so request can retain their numbers when changing provider. A subscriber is defined as a party to a contract with a provider of publicly available electronic communications services for the supply of such services. The existing regulation does not explicitly take into account the development of M2M services and the different stakeholders involved in the M2M scenario compared to the consumer scenario. In a M2M scenario, the subscriber of a number used for M2M communication is typically not the end-user while in consumer market scenarios the subscriber is more likely to be also the end-user. Nor does the existing regulation outline any kind of technology to use (i.e. physical change of SIM cards, OTA provisioning etc.) when changing provider or porting a number.

In the European Electronic Communications Code (EECC), the term "subscriber" has been replaced by the term "end-user". Even if the new term may have some unintended consequences in the consumer market (e.g. employer/employee relationship) the term end-user seems to take into account the different stakeholders in some M2M scenarios and one of the recitals also states that "[…] the right to port the number should be attributed to the end-user who has the relevant (pre- or post-paid) contract with the provider […]". In the EECC, M2M is directly mentioned in the definition of an electronic communications service, which is defined as a "service normally provided for remuneration via electronic communications networks, which encompasses […] services consisting wholly or mainly in the conveyance of signals such as transmission services used for the provision of machine-to-machine services […]". At least the connectivity service underlying an M2M service represents an electronic communications service whereas the M2M service or the product sold by an M2M-user might not qualify as an electronic communications service.

In the EECC the term "user" is described as a "legal entity or natural person using or requesting a publicly available electronic communications service". The term "end-user" is described as a "user not providing public communications networks or publicly available electronic communications services". Taking into account the description of the different stakeholders in a M2M environment in chapter 3 in this Report the "user" corresponds to the "M2M-user". The M2M-user that purchases a connectivity service from a M2M service provider and incorporates it into a product and sells the product to an end-user does not necessarily imply that the M2M-user becomes a provider of an electronic communications service.

As such, the M2M-user would in principle be entitled to request its numbers to be ported in case of changing the M2M service provider. However, the question is whether there is an actual need of porting the E.164 number in the M2M context as it is in the P2P context. The possibility for subscribers to continue using a specific telephone number when changing service provider, is a key facilitator of subscriber choice and effective competition. These objectives are obvious in the context of P2P communication where there can be a lot of value in keeping a certain number while changing service provider. In an M2M context the value in keeping a certain number while changing M2M service provider may not be as clear as in the P2P sphere. In a M2M scenario change of service provider would be relevant for the M2M-user who purchases or subscribes to a M2M connectivity service and incorporates it into a product. A similar situation also exists for certain consumer market scenarios where the relevance of NP may also be considered negligible (e.g. wearables).

The original EECC proposal explicitly stated that Member States should promote OTA provisioning, where technically feasible, to facilitate switching of providers of electronic communications networks or services by end-users other than consumers, in particular providers and users of M2M services. In the European Parliament's proposal for trilogue discussions the scope was expanded to also promote OTA provisioning for consumer markets and this has also been reflected in the final version of the EECC. OTA provisioning of SIM cards, if implemented in the consumer market, will make it possible to change provider within a very short timeframe. The porting timers could be revised in order to reflect this.

The scope of the EECC for change of provider and NP is limited to change of provider of Internet access services and NP from one service provider to another. A more general adjustment of the proposed provision could be considered in order to encompass the change of SIM profiles as described in this Report. The right to change provider and NP should also entail the right to change the SIM profile in case of changing the connectivity service provider, since today it is crucial that the SIM can be continuously used in case of changing the service provider (including in the M2M and in the consumer scenarios). In case of updating a large amount of SIMs, the main interest of the end-user is not the time to start the process of updating, but that this is done in a synchronised way. To be out of service and having some SIMs handled from one operator and others from another operator are far from ideal situations for an enterprise. In fact, if such situations occur, the enterprise may be called to handle complaints. A process that verifies the situation of all involved SIMs could reach a better quality of service from the end-user point of view.

Another aspect to be analysed is that the possible subjects that manage the update of the SIM cards without physically changing them should comply with processes defined by the CEPT administration and they should report their operations to the CEPT administration, even if they are not authorised subjects (i.e. not authorised to provide electronic communication services or networks). Without this rule it may be difficult to have a full control of the process for allowing the change of the provider.

Another suggestion concerns exemptions from the general rule of maintaining the E.164 number while changing service provider. For services using geographic numbers and numbers for land mobile services, it is difficult to see any valid reasons for exemptions from the rule. However, the need to switch providers will most likely increase for M2M and consumer markets. For such services, there may be situations where maintaining the E.164 number while changing service provider is neither necessary nor convenient. Therefore there should be a possibility for CEPT administrations to make exemptions from NP obligations to assignees for specific numbering ranges.

A further consideration regards the possible situation in which end-users are switched to another provider against their will. In fact, until now for mobile services, active collaboration with the end-user in switching the provider is needed for physically changing the SIM card. With remote provisioning, this operation is no longer necessary. Theoretically, a switching of the end-user to another provider against their will and without knowledge of the end-user may occur. The USD foresees that "Competent national authorities shall also take into account, where necessary, measures ensuring that subscribers are protected throughout the switching process and are not switched to another provider against their will". The EECC also states that "National regulatory authorities shall also take appropriate measures ensuring that end-users are adequately informed and protected throughout the switching and porting processes and are not switched to another provider against their will". In defining adjustment of the MNP for allowing OTA technology to be used avoiding possible problem, a method to check the client should be analysed and possibly introduced. A possible solution may be an exchange of SMS with the end-user to register their intent to switch. Moreover, considering that the switching of the operator may be of a SIM used for IoT/M2M service, where the end-user does not read the received SMS, the process should consider the possibility to indicate an alternative method to communicate with the end-user (e.g. another mobile number for exchange SMS, e-mail etc.).

7 CONCLUSION

Until recently, changing the operator required a physical replacement of the SIM card. In the M2M sphere, a subscriber may have hundreds, thousands or millions of devices installed over a wide geographical area (possibly across borders). Furthermore, because certain M2M devices may be installed in environments where they are exposed to extreme conditions (cold, heat, dust, vibration etc.), the SIM cards are generally embedded into devices and cannot be easily replaced. Replacing the SIM cards is therefore economically and logistically unrealistic which introduces a risk of "operator lock-in". In certain cases consumer devices (e.g. smartphones, tablets, wearables, etc.) may also include SIMs embedded into devices and therefore the challenge of switching operator without a physical SIM card replacement is also relevant in the consumer market. The introduction of the eUICC will allow the IMSI and operator profile to be changed remotely using OTA technology. Therefore, the physical replacement of the SIM card may no longer be necessary.

This Report examines the high-level aspects of the architectures defined in the GSMA specifications and considers the implications for the role of E.164 numbers and the relevance of Number Portability (NP) in the M2M and consumer markets and, as a consequence, the impact on the current regulatory framework on switching and NP. The Report concludes that:

- The eligibility criteria defined in ITU Recommendation E.118 should be reviewed and the relationship between the EID defined in the GSMA specification and the IIN should be clarified. At time of publication, Recommendation E.118 is under review by ITU-T Study Group 2;
- CEPT administrations should take into account that new functions are introduced into the ecosystem with the introduction of remote provisioning. The subscription manager function needs to be performed by an entity that treats all market players equally in order to avoid barriers to entry among mobile service providers and operator lock-in of the end-user (and M2M-user) or of MVNOs;
- CEPT administrations should review their NP processes to include potential scenarios identified in this Report and to verify the possible necessity of data exchange between donor and recipient operators, like the fact the eUICC has to be updated remotely;
- It should be noted that the procedure for changing service provider could be similar whether the E.164 number is being changed or retained;
- Furthermore, existing processes need to be reviewed, and potentially new processes introduced, in order to ensure that:
  - The update of NP databases and the remote update of the eUICC, in the case that NP data is also needed for the service, are synchronised. The use of any characteristic or feature (e.g. SIM-locking) that may prevent or limit synchronisation should be carefully evaluated and possibly avoided;
  - Current methods of ensuring that end-users (and M2M-users) are not switched to another provider against their will should be re-evaluated with the introduction of remote provisioning also taking into account M2M services;
  - Methods of communications with end-users during the switching process need to be evaluated as, for example with M2M, an SMS to a device can no longer be considered as a means of communication with the M2M-user.

ANNEX 1: LIST OF REFERENCES

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