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Technical Report

3rd Generation Partnership Project;

Technical Specification Group Services and System Aspects;

Study on system enablers for devices having multiple Universal Subscriber Identity Modules (USIM)

(Release 17)

** 

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# Foreword

This Technical Report has been produced by the 3rd Generation Partnership Project (3GPP).

The contents of the present document are subject to continuing work within the TSG and may change following formal TSG approval. Should the TSG modify the contents of the present document, it will be re-released by the TSG with an identifying change of release date and an increase in version number as follows:

Version x.y.z

where:

x the first digit:

1 presented to TSG for information;

2 presented to TSG for approval;

3 or greater indicates TSG approved document under change control.

y the second digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.

z the third digit is incremented when editorial only changes have been incorporated in the document.

# 1 Scope

Editor's note: This clause will describe the scope for this study item.

With the growing usage of Multi-USIM devices in the market 3GPP is considering system enhancements that would allow better support of such devices.

This study item will address the objectives listed in the WID (SP-190248).

# 2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non‑specific.

- For a specific reference, subsequent revisions do not apply.

- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.

[1] 3GPP TR 21.905: "Vocabulary for 3GPP Specifications".

[2] 3GPP TS 36.304: "Evolved Universal Terrestrial Radio Access (E-UTRA); User Equipment (UE) procedures in idle mode".

[3] 3GPP TS 38.304: "NR; User Equipment (UE) procedures in idle mode".

[4] 3GPP TS 23.501: "System Architecture for the 5G System; Stage 2".

[5] 3GPP TS 22.101: "3rd Generation Partnership Project; Technical Specification Group Services and Systems Aspects; Service aspects; Service principles".

[6] 3GPP TS 23.502: "Procedures for the 5G System (5GS)".

[7] 3GPP TS 23.401: "General Packet Radio Service (GPRS) enhancements for Evolved Universal Terrestrial Radio Access Network (E-UTRAN) access".

[8] 3GPP TS 36.331: "Evolved Universal Terrestrial Radio Access (E-UTRA); Radio Resource Control (RRC); Protocol specification".

[9] 3GPP TS 38.331: "NR; Radio Resource Control (RRC); Protocol specification".

[10] 3GPP TS 23.402: "Architecture enhancements for non-3GPP accesses".

[11] 3GPP TS 23.292: "IP Multimedia Subsystem (IMS) Centralized Services; Stage 2".

[12] 3GPP TS 33.501: "Security architecture and procedures for 5G System".

[13] IETF RFC 5626: " Managing Client-Initiated Connections in the Session Initiation Protocol (SIP)".

# 3 Definitions, symbols and abbreviations

## 3.1 Definitions

For the purposes of the present document, the terms and definitions given in TR 21.905 [1] and the following apply. A term defined in the present document takes precedence over the definition of the same term, if any, in TR 21.905 [1].

Definition format (Normal)

**<defined term>:** <definition>.

**example:** text used to clarify abstract rules by applying them literally.

## 3.2 Symbols

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

Symbol format (EW)

<symbol> <Explanation>

## 3.3 Abbreviations

For the purposes of the present document, the abbreviations given in TR 21.905 [1] and the following apply.   
An abbreviation defined in the present document takes precedence over the definition of the same abbreviation, if any, in TR 21.905 [1].

Abbreviation format (EW)

<ACRONYM> <Explanation>

# 4 Architectural Requirements and Assumptions

## 4.1 Architectural Requirements

The following architectural requirements apply:

- The 3GPP system shall treat each registration from the USIMs of a Multi-USIM devices independently.

- Each registered USIM in a Multi-USIM device shall be associated with a dedicated IMEI/PEI.

- GSM, UMTS are out of scope.

- End-user's determination on whether to have on-going service and/or incoming service is controlled by user.

- An Emergency call related to one USIM for a multi-USIM device shall not be interrupted by the system autonomously without the calling or called party initiating the interruption, i.e. emergency calls related to one USIM shall not be interrupted autonomously by the system due to services for another USIM.

- Solutions shall build on the 5G System architectural principles as in TS 23.501 [4], including flexibility and modularity for newly introduced functionalities.

## 4.2 Architectural Assumptions

The following architectural assumptions apply:

- The study shall focus on Dual-USIM devices, the expectation being that the enablers for Dual-USIM devices will also apply to Multi-USIM devices.

- The study shall consider all of the following cases:

- UE connected over 3GPP Access with EPS on one USIM and 5GS on the other USIM.

- UE connected over 3GPP Access with EPS on both USIMs.

- UE connected over 3GPP Access with 5GS on both USIMs.

NOTE 1: The use of "3GPP Access" above is related to issues that can occur due to concurrent transmission and/or reception in Multi-USIM device via two or more 3GPP RATs.

- Specific to Dual-USIM devices the study shall focus on Single Rx / Single Tx UEs and Dual Rx / Single Tx UEs.

NOTE 2: Dual Rx allows the Dual-USIM device to simultaneously receive traffic from two networks. Single Rx allows the Dual-USIM device to receive traffic from one network at one time. Single Tx allows the Dual-USIM device to transmit traffic to one network at one time.

- The Multi-USIM device shall handle Emergency calls using TS 22.101 [5] clause 10.9 as a basis.

- The problem statement is common to 5GS and EPS, but the solutions for 5GS and EPS need not be the same.

- The system enablers for Multi-USIM devices are expected to apply for the cases where the multiple USIMs are owned by the same or by different MNOs.

NOTE 3: While the solutions developed as part of this study might also be applicable to DR-mode (single USIM) interworking between 5GS and EPS, 5GS-EPS interworking use cases with DR-mode (single USIM) are considered outside the scope of this study.

- The solutions shall not require network coordination for the case where the multiple USIMs in the Multi-USIM device are served by different serving networks.

- A multi-USIM device with different USIMs may be camping with all USIMs on the same serving network RAN node, or it may be camping on different serving networks RAN nodes.

- For a multi-USIM device, the solutions may require in-device co-ordination between the UEs represented by each USIM within the multi-USIM device. The mechanism for in-device co-ordination shall be left for the multi-USIM device implementation.

- MUSIM features requiring new UE-network interactions are optional, hence the UE may use MUSIM features requiring new UE-network interactions in one PLMN when it has learnt that this PLMN supports these MUSIM features.

# 5 Key Issues

## 5.1 Key Issue 1: Handling of Mobile Terminated service with Multi-USIM device

### 5.1.1 Description

Consider a Multi-USIM device that has concurrent registrations over 3GPP RAT associated with multiple USIMs.

While actively communicating with the system associated with one USIM ("current system"), the Multi-USIM device may need to perform some activity (e.g. listen to paging, respond to paging, perform mobility update etc.) in the other system(s). While the Multi-USIM device communicates with another system, there may be interruption to the ongoing services in the current system.

The present key issue shall study:

- How to handle the MT service for a Multi-USIM device with the aim of avoiding any unnecessary interruptions of the service in the current system and saving system resources.

- How to prevent the other system, which triggered the paging message, from performing undesirable operations (e.g. wasting resources, reaching misleading assumption of reachability, etc.).

- Solutions shall be studied for both EPS and 5GS. For 5GS, the solutions shall consider the cases where the Multi-USIM device in the current system is in either IDLE state or RRC Inactive state.

## 5.2 Key Issue 2: Enabling Paging Reception for Multi-USIM Device

### 5.2.1 Description

Paging Occasions (POs) are calculated based on the UE identifier i.e. IMSI and 5G-S-TMSI for EPS and 5GS, respectively. The formulae for determination of the POs are specified in TS 36.304 [2] and TS 38.304 [3] for E-UTRA and NR, respectively.

Multi-USIM device that is unable to simultaneously monitor paging on all 3GPP RATs and systems in which it is in Idle state or RRC\_Inactive state (for 5GS) needs to make a choice of the paging channel(s) to monitor which can lead to unsuccessful paging on the other paging channel(s). In some cases the UE identifier values associated with the different USIMs can lead to systematic collisions which may result in corresponding missed pages. The present key issue shall study:

- How the system can enable operation when the paging associated with the 3GPP RATs and systems in which the Multi-USIM device is in Idle state or RRC\_Inactive state (for 5GS) overlap in time?

NOTE 1: The exact timing of paging on the radio interface is managed by RAN, therefore coordination with the RAN Groups will be necessary.

- Whether and how the network needs to be aware of specific UE communication constraints (e.g. Single Rx) in order to enable the Multi-USIM device to receive paging for each of the registered USIMs?

The solutions for enabling receiving paging for each of the registered USIMs in 5GS and EPS may not be based on the same principles.

NOTE 2: For this key issue, coordination with RAN WGs is needed for final solution decision. No E-UTRA radio interface impact is expected in RAN WGs.

## 5.3 Key Issue 3: Coordinated leaving for Multi-USIM device

### 5.3.1 Description

Consider a Multi-USIM device that has concurrent registrations associated with several USIMs. While actively communicating with the system associated with one USIM (the "current system"), the Multi-USIM device determines that it needs to perform some activity in the system associated with another USIM (e.g. respond to a page, or perform mobility update).

Today, in the absence of any procedure for notifying the network the Multi-USIM device may autonomously leave or release the RRC connection with the current system. This is likely to be interpreted as an error case by the current system and has the potential to distort the statistics in the current system, and misguide the algorithms that rely on them. Moreover, during the Multi-USIM device's absence from the current system, if the UE cannot receive downlink data or process the paging from the current system, it may result in waste of resources. The present key issue shall study:

- How to enable a Multi-USIM device to leave the current 3GPP system in coordination with the network while avoiding wasting the network resource during the leave.

- How the network handles MT data or MT control-plane activity occurring when Multi-USIM device has left?

NOTE 1: Any privacy implications of implicitly indicating to the MNO owning one USIM that the UE is also using another USIM (potentially owned by another MNO) will be studied by SA WG3.

NOTE 2: For this key issue, coordination with RAN WGs WGs is needed for final solution decision. No E-UTRA radio interface impact is expected in RAN WGs.

## 5.4 Key Issue 4: Emergency handling of MUSIM UE

### 5.4.1 General Description

TS 22.101 [5] defines the necessary requirements for and handling of Emergency services for a MUSIM UE. As a result, the present TR need not address Emergency services.

NOTE: Whether changes to Stage 2 TS are needed will be addressed in the potential normative phase.

## 5.X Key Issue X: <Key Issue Title>

### 5.X.1 Description

Editor's note: This clause provides a short description of the key issue.

# 6 Solutions

Editor's note: This clause is intended to document the agreed architecture solutions. Each solution should clearly describe which of the key issues it covers and how.

## 6.0 Mapping Solutions to Key Issues

Table 6.0-1: Mapping of Solutions to Key Issues

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Key Issues | | | |
| Solutions | 1 | 2 | 3 | 4 |
| 1 | X |  |  |  |
| 2 | X |  |  |  |
| 3 | X |  |  |  |
| 4 |  |  | X |  |
| 5 |  |  | X |  |
| 6 |  |  | X |  |
| 7 | X | X |  |  |
| 8 | X |  |  |  |
| 9 | X |  |  |  |
| 10 | X |  |  |  |
| 11 | X |  |  |  |
| 12 | X | X |  |  |
| 13 | X |  |  |  |
| 14 |  | X |  |  |
| 15 |  | X |  |  |
| 16 |  | X |  |  |
| 17 |  | X |  |  |
| 18 |  | X |  |  |
| 19 |  | X |  |  |
| 20 |  | X |  |  |
| 21 |  | X |  |  |
| 22 |  |  | X |  |
|  |  |  |  |  |

## 6.1 Solution #1: Handling of MT service with Paging Cause

### 6.1.1 Introduction

The solution applies to Key Issue #1 "Handling of MT service".

The solution applies to both 5GS (UE in either CM\_IDLE or RRC\_Inactive state) and EPS (UE in CM\_IDLE state only).

### 6.1.2 Functional Description

The solution is based on a Paging Cause that is delivered to the UE as part of the [Uu] Paging message.

NOTE 1: The granularity of the paging information in the Paging Cause will be coordinated with SA WG1 input, if needed.

NOTE 2: Based on the Paging Cause and the service preferences configured by the user or a pre-configured logic specific to the Multi-USIM device, the Multi-USIM device that is actively engaged in communication associated with another USIM can decide whether to present the mobile terminated service that triggered the paging to the user. Alternatively, the Multi-USIM device can systematically present the mobile terminated service that triggered the paging to the user, in which case it is up to the user to decide whether to respond to the paging request.

NOTE y: In this release, only the operator managed services, e.g. IMS voice, is considered to be indicated in paging cause and only standardized values are used for the Paging Cause. This does not preclude the use of a specific Paging Cause value for “Other” services.

For a UE in CM\_IDLE state:

- For MT user plane traffic as part of the Network Triggered Service Request procedure, and if Paging Policy Differentiation (PPD) applies, the SMF determines Paging Policy Indicator (PPI) and optionally determines a Paging Cause value based on the DSCP received from the UPF. The SMF includes the Paging Cause, along with the PPI, the ARP and the 5QI of the corresponding QoS Flow, in the N11 message sent to the AMF. The AMF uses this information to derive a paging strategy and sends paging messages to NG-RAN over N2. The AMF shall forward the Paging Cause in the PAGING message to NG-RAN if it was received from the SMF.

Editor’s note: Whether exposing the Paging Cause in clear poses as security issue will be determined by SA WG3.

NOTE: It will be determined whether the Paging Cause can be used only for UEs that have requested MUSIM assistance or unconditionally.

- For MT control plane traffic (e.g. MT SMS over NAS, or NAS signaling) the AMF derives the paging strategy and Paging Cause based on the type of MT control plane traffic and forwards the Paging Cause in the PAGING message to NG-RAN.

For a UE in RRC\_Inactive state:

- For MT user plane traffic the SMF instructs the UPF to detect the DSCP in the TOS (IPv4) / TC (IPv6) value in the IP header of the DL PDU and to transfer the corresponding PPI and optionally the Paging Cause in the CN tunnel header (by using a FAR with the PPI and Paging Cause value). The NG-RAN can then utilize the PPI received in the CN tunnel header of an incoming DL PDU in order to apply the corresponding paging policy for the case the UE needs to be paged when in RRC Inactive state. If the Paging Cause was included in the CN tunnel header of an incoming DL PDU the NG-RAN forwards the Paging Cause to the UE for the case the UE needs to be paged when in RRC Inactive state.

NOTE 3: The Paging Cause is included in the CN tunnel header in all data packets.

- Alternatively, the NG-RAN determines the Paging Cause based on specific 5QI (i.e. 5QI=1 or 5) of the QoS flows for the downlink data packet.

Editor's note: Since all the IMS signalling is transmitted in specific QoS Flow, it is FFS whether specific 5QI value can be used to determine the paging cause for voice service.

Editor's note: It is FFS whether there is a need to support the Paging Cause for UE in RRC\_Inactive. There is a dependency with the key issue on "coordinated leaving".

- For MT control plane traffic (e.g. MT SMS over NAS, or NAS signaling) the AMF derives the Paging Cause based on the type of MT control plane traffic and forwards the Paging Cause in the DOWNLINK NAS TRANSPORT message to NG-RAN.

The solution can also be used in EPS with the following changes:

- It applies to UE in CM\_IDLE only.

- AMF, SMF and UPF in the description above are replaced with MME, SGW-C and SGW-U, respectively.

### 6.1.3 Procedures

#### 6.1.3.1 Handling of MT service with Paging Cause for UE in CM\_Idle in 5GS

The solution has impact on the Network Triggered Service Request procedure in TS 23.502 [6] clause 4.2.3.3. The changes relative to the existing procedure are indicated in bold underlined text. Only the impacted steps are shown.



Figure 6.1.3.1-1: Network Triggered Service Request (based on TS 23.502 [6] Figure 4.2.3.3-1)

*2c. The UPF forwards the downlink data packets towards the SMF if the SMF instructed the UPF to do so (i.e. the SMF will buffer the data packets).*

*- If the Paging Policy Differentiation feature is supported by the SMF and if the PDU Session type is IP, the SMF determines the Paging Policy Indicator* ***and optionally a Paging Cause*** *based on the DSCP in TOS (IPv4) / TC (IPv6) value from the IP header of the received downlink data packet and identifies the corresponding QoS Flow from the QFI of the received DL data packet.*

*3a. [Conditional] SMF to AMF: Namf\_Communication\_N1N2MessageTransfer (SUPI, PDU Session ID, N1 SM container (SM message), N2 SM information (QFI(s), QoS profile(s), CN N3 Tunnel Info, S-NSSAI), Area of validity for N2 SM information, ARP, Paging Policy Indicator,* ***Paging Cause****, 5QI, N1N2TransferFailure Notification Target Address, Extended Buffering support), or NF to AMF: Namf\_Communication\_N1N2MessageTransfer (SUPI, N1 message).*

*[…]*

*When supporting Paging Policy Differentiation, the SMF determines the Paging Policy Indicator* ***and may also determine a Paging Cause*** *related to the downlink data that has been received from the UPF or triggered the Data Notification message, based on the DSCP as described in TS 23.501 [4] clause 5.4.3, and indicates the Paging Policy Indicator* ***and the Paging Cause*** *in the Namf\_Communication\_N1N2MessageTransfer.*

*4b. [Conditional] If the UE is in CM-IDLE state in 3GPP access and the PDU Session ID received from the SMF in step 3a has been associated with 3GPP access and based on local policy the AMF decides to notify the UE through 3GPP access even when UE is in CM-CONNECTED state for non-3GPP access, the AMF may send a Paging message to NG-RAN node(s) via 3GPP access* ***including the Paging Cause****.*

*4c. If the UE is simultaneously registered over 3GPP and non-3GPP accesses in the same PLMN, and the UE is in CM-CONNECTED state for non-3GPP access and in CM-IDLE for 3GPP access,* ***the AMF may decide to send the NAS Notification message containing the 3GPP Access Type to the UE over non-3GPP access including the Paging Cause****.*

*4d. If the UE is simultaneously registered over 3GPP and non-3GPP accesses in the same PLMN, and the UE is in CM-CONNECTED state for non-3GPP access and in CM-IDLE for 3GPP access* ***and if the UE decides to not accept the incoming service the UE shall respond with NAS Notification response message over the non-3GPP access to indicate the same to the network.***

*6. The UE may choose to respond to paging or NAS notification message based on paging cause value by executing service request procedure.*

#### 6.1.3.2 Handling of MT service with Paging Cause in RRC\_Inactive mode

Figure 6.1.3.2-1is the call flow of handling of MT service with Paging Cause in RRC\_Inactive mode.



Figure 6.1.3.2-1 Handling of MT service with Paging Cause in RRC\_Inactive mode

1. NG-RAN receives the DL data (control plane data and/or user plane data) in RRC\_Inactive mode. If handling of MT service with Paging Cause is supported by NG-RAN, NG-RAN determines the Paging Cause based on the Paging Cause field included in the CN tunnel header of an incoming DL PDU. Alternatively, the NG-RAN determines the Paging Cause based on specific 5QI (i.e. 5QI=1 or 5) of the QoS flows for the downlink data packet.

Editor's note: Since all the IMS signalling is transmited in specific QoS Flow, it is FFS whether specific 5QI value can be used to determine the paging cause for voice service.

NG-RAN sends the paging message with the Paging Cause.

#### 6.1.3.3 Handling of MT service with Paging Cause in EPS

Figure 6.1.3.3-1 is handling of MT service with Paging Cause in EPS.



Figure 6.1.3.3-1: Handling of MT service with Paging Cause in EPS

1. If the handling of MT service with Paging Cause is supported by Serving GW, Serving GW determines the Paging Cause based on DSCP in TOS (IPv4)/TC (IPv6) value from the IP header of the downlink data packet. Alternatively, if the Serving GW supports the Paging Policy Differentiation feature, then the Serving GW unconditionally, for each bearer and for each packet of PDN type IPv4, IPv6 or IPv4v6 that triggers a Downlink Data Notification, sends the DSCP in TOS (IPv4) / TC (IPv6) information received in the IP payload of the GTP-U packet from the PDN GW in the Paging Policy Indication in the Downlink Data Notification.

2. SGW includes the Paging Cause in the DDN message sent from SGW to MME. If the Paging Cause is not received, but the Paging Policy Indication is received, the MME determines the Paging Cause taking the configuration for that HPLMN and/or APN and/or QCI into account.

For mobile terminating signalling and SMS over NAS, the MME determines an appropriate Paging Cause.

3. MME sends S1 paging message by including the Paging Cause information.

4. RAN sends the paging message with Paging Cause.

### 6.1.4 Impacts on services, entities and interfaces

For 5G:

AF:

**-** P-CSCFsets the DSCP value in the IP header to indicate the traffic type.

SMF:

- optionally, determines Paging Cause based on DSCP value from IP header and HPLMN/APN/QCI configuration and includes the Paging Cause in DDN sent to AMF.

AMF:

- determines the Paging Cause for NAS SMS and MT control plane traffic. For user plane traffic the AMF either receives the Paging Cause from the SMF or determines a Paging Cause based on HPLMN/DNN/5QI configuration (e.g. 5QI=1 or 5) received from the SMF.

- sends the N2 paging signalling with Paging Cause.

NG-RAN:

- sends the paging message with Paging Cause.

- in RRC\_Inactive mode, NG-RAN determines the Paging Cause based on the Paging Cause field included in the CN tunnel header of an incoming DL PDU. Alternatively, the NG-RAN determines the Paging Cause based on specific 5QI (i.e. 5QI=1 or 5) of the QoS flows for the downlink data packet.

UE:

- receives paging message with the Paging Cause information.

For EPS:

SGW

- optionally, determines Paging Cause based on DSCP value from IP header and HPLMN/APN/QCI configuration and includes the Paging Cause in DDN sent to MME. Alternatively implements existing, optional, Paging Policy Differentiation feature.

MME

- determines the Paging Cause for NAS SMS and MT control plane traffic. For user plane traffic the MME either receives the Paging Cause from the SGW or alternatively, determines a Paging Cause based on HPLMN/APN/QCI configuration (e.g. QCI=1 or 5) received in DNN.

- sends the S1 paging signalling with Paging Cause.

eNB

- sends the paging message with Paging Cause.

UE

- receives paging message with the Paging Cause information.

## 

## 6.2 Solution #2: Negotiated Short Period Absence

### 6.2.1 Introduction

This is a solution for Key Issue 1 Handling of Mobile Terminated service with Multi-USIM device. This solution avoids any unaware interruptions of the service in the current system, saves system resources, and prevents the other system, which triggered the Paging, from performing undesirable operations on the UE/the other USIM.

This solution is applicable to any UE that needs assistance to perform operations on another network while connected to another.

### 6.2.2 Functional Description

This solution provides a mechanism to enable paging response for one USIM when there are on-going services in the other USIMs for MUSIM UE.

The MUSIM UE negotiates a single short period of absence from the serving RAN (USIM1) of current system. During the negotiated single short period of absence, service specific data packets are transferred that allow a determination of which service is preferred.

The negotiated single short period absence may also cover other IDLE/INACTIVE mode MO "light" signalling such as TAU/RAU and RNAU on USIM B.

During the negotiated short period of absence, the UE may be in RRC\_INACTIVE state on the network the absence has been negotiated with. MT traffic during the absence maybe delayed or discard based on, e.g. the QoS requirements for the MT data. The duration of the negotiated short absence may be the same length. If the UE returns before the the period of absence expires, the UE signals to network when it returns. If the UE does not return at the end of the negotiated absence, then the network that the absence was negotiated with assumes the UE has an ongoing service with the other network.

The solution to negotiate an absence may be used by E-UTRA or NR.

Editor's note: Confirmation from RAN WG2 is needed whether negotiated short period absence for E-UTRA is in scope.

Editor's note: the detailed negotiation of the short period and an early return request should be discussed and determined by RAN WGs and requires their feedback.

### 6.2.3 Procedures

#### 6.2.3.1 Responding to Paging

The overall procedure below shows different examples of the UE selecting a network, leaving the non-selected network and using or continuing to use the selected network. Figure 6.2.3.1-1 shows the example of the UE determining to continue with Network A, and the changing to Network B.



Figure 6.2.3.1-1: Selecting Network A or Network B

0. UE is in CM\_CONNECTED with Network A and is monitoring paging in Network B.

1. The UE is paged by Network B.

2. The UE negotiates a one-off single short period of absence with Network A’s RAN to allow the UE to respond to paging from Network B.

RAN WGs will determine the details of the procedure used for absence negotiation between UE and RAN, and the RRC state in network A.

3. The UE responds to the paging from Network B. During the response to paging the UE and Network B exchange service specific data packets which allow the choice of service. After receiving the service specific packets the UE starts its determination of which network to use.

4. The UE determines which network service to use, either, continue with Network A or use the services of Network B.

Editor’s Note: The service level interaction with Network B when determining which service is preferred are FFS.

5. [Conditional] If the UE determines to continue to use Network A, then optionally in order to avoid wasting resources and to be able to return to Network A before the end of the negotiated absence the UE can use the solution to KI#3 to leave Network B and continue with its connection in Network A.

6. If the UE determines to continue using Network A, then the UE continues with Network A services and monitor the paging from Network B, matching the preconditions in Step 0.

If the UE determines to use Network B then the preconditions in Step 0 are met but with the roles of Network A and Network B reversed. When the Network A detects that the UE does not return at the end of the negotiated absence, then Network A determines that the UE chose to continue with the service on Network B (i.e. an implicit signalling coordinated leave occurred). The Network A RRC connection is autonomously released by RAN and the UE (i.e. without signalling over the Uu interface).

### 6.2.4 Impacts on services, entities and interfaces

**UE:**

- Request and use short period absence on the air interface (RAN only impact).

**RAN:**

- Assignment and use of short period absence on the air interface (RAN only impact).

**5GC:**

- None.

## 

## 6.3 Solution #3: Busy indication as a paging response

### 6.3.1 Introduction

This solution relates the KI#1 and proposes a solution how to handle MT service in case that the MultiSIM device judge the ongoing connection in the other system more important. Assuming that, multi-USIM devices can efficiently perform some activity (e.g. listen to paging, respond to paging, perform mobility update etc.) in a system while communicating in another system, how this is done is not part of this solution. Responding to the page is important for the network, since it would allow the network to save paging resources as a result of not escalating the page across a larger area. This solution proposes a solution allowing the UE to send a busy indication to the network as a response to a page.

### 6.3.2 Functional Description

This solution addresses KI#1 and assumes that solutions for KI#3 will be selected. The solution is described as a MultiSIM device with two USIM A and B. That corresponds to two UEs, UE A and UE B. The following principles are used:

- The procedure "Busy indication as a paging response" with network B is based on the periodic absence time with network A. The periodic absence time should be short enough and acceptable for the ongoing service associated with UE A in the multi-USIM device.

NOTE: The time spent for the procedure "Busy indication as a paging response" should be estimated to see whether the periodic absence time is enough to perform the procedure "Busy indication as a paging response".

- When the UE A is in RRC\_CONNECTED it may use implementation specific method to achieve a periodic absence in system A or it may request a periodic absence time in RAN serving the UE A. The absence time requested coincides to when UE B (which is in RRC-IDLE or RRC-Inactive) monitors paging occasions. During the absence time, UE A is still in RRC-CONNECTED, but does not need to e.g. monitor the control channel to detect whether downlink data is scheduled for delivery.

- If UE B identity is not part of the paging message, UE B can go back to sleep.

- If the UE B identity is part of the paging message, the MultiSIM device may need to decide which communication is most important (UE A or UE B). This decision can be done based on implementation in the device and may take into account e.g. an already ongoing high priority communication for UE A and/or if the UE B receives Network Assistance Information when paged and other information.

Editor's note: Whether a solution for providing Network Assistance Information when the UE is paged will be concluded later during this study.

- If, at this moment, it is not possible to setup the communication for UE B service, UE B instead sends a NAS message to the network that it is currently busy, e.g. a new cause value "busy" in the Service Request. The RAN node forwards the NAS Service Request including the busy indication to the AMF using a N2 message.

- When the AMF receives the cause value "busy", it can stop paging the UE B and the corresponding paging escalation.

- In case the UE B was in RRC-Inactive, then the RAN node will not need to forward the busy indication to the AMF.

- The network may store the MT traffic until UE B connects.

### 6.3.3 Procedures

The procedure below assumes that UE A can pause the RRC-connection in a periodic manner allowing UE B to perform page monitoring.



Figure 6.3.3-1: Procedure for the UE to send a busy indication as a paging response

0. A multi-USIM device with two USIM has the following states; UE A (USIM A) is in connected mode and UE B (USIM B) is in idle mode. UE A may have negotiated a periodic absence time allowing the MultiSIM device to perform activities related to other USIMs.

1. UE A enters a periodic absence time that allows UE B to monitor a scheduled paging occasion and send a busy response.

2. The AMF serving the UE B sends a N2 paging request message to RAN B

3. RAN B page UE B

4. UE B receives the page i.e. decodes the paging message and the associated Network Assistance Information. The device evaluates which connection is more important. The decision is based on implementation in the device and may take into account the Network Assistance Information, what type of ongoing communication and other information.

a. The MultiSIM device decides that UE B communication is more important and decides to leave UE A connection according to solutions selected for KI#3. This is not shown in this procedure.

b. The device decides that the UE A connection is more important and steps 5 to 8 follow.

5. UE B performs Random Access procedure and sends a NAS Service Request towards the AMF with the new cause value "busy" which indicates that the UE has received the paging message but is not able to setup the communication for UE B service. After sending the NAS Service Request, the UE B locally release the RRC connection. The UE A can return to the connection.

NOTE: It is assumed that the UE can decode the paging message and respond with the busy indication within a short time. The assumption is based on that the preparation phase before performing the Random Access has already been done when monitoring the paging occasion, and the time to execute msg1 to msg5 in the Random Access Procedure is less than 100ms.

6. RAN B forwards the NAS Service Request message to the AMF

7. The AMF, based on the cause value "busy" in the Service Request, stops paging the UE B and informs the network node that triggered the Network Triggered Service Request procedure that the UE is not reachable.

### 6.3.4 Impacts on services, entities and interfaces

UE:

- Support sending a busy indication.

AMF:

- Support receiving a busy indication as a response to the N2 paging request message sent to RAN.

NOTE: The response could either be in the Service Request cause value or in the N2 message, depending on potential RAN enhancements.

RAN:

- None, if the Release/Suspend/Resume methods are reused for pausing the connection for UE A and if the busy indication is sent as NAS service request cause value.

- Optionally: If RAN decides to enhance the operation, then possible enhancement may be developed:

- It is up to RAN1 and RAN2 to consider whether and how a UE may request to pause an existing RRC connection e.g. similar to measurement gaps for making inter-frequency and inter-RAT measurements. The gap should be a short as possible to minimise the interruption of UE A connection.

- It is up to RAN2 to consider whether the busy indication should be included in the RRC Connection Establishment request cause value.

- New busy indication received in RRC message shall be forwarded in the N2 message to the AMF.

SMF:

- none.

UPF:

- none.

## 

## 6.4 Solution #4: Local leaving

### 6.4.1 Introduction

This solution relates the KI#3 Coordinated leaving for Multi-USIM device. A local leaving mechanism is proposed to avoid network resource waste and to ensure synchronization between the UE and the network. The resource is local released on UE side and network side triggered by UE with with a specific indication for local leaving.

### 6.4.2 Functional Description

This solution provides a mechanism for the UE to indicate the network at NAS that the multi-USIM device is switching from the current system to another system, and thus the resources for this UE shall be released. The indication is provided by the UE in UL NAS TRANSPORT (5GS) / UPLINK GENERIC NAS TRANSPORT (EPS). This mechanism applies to both EPS and 5GS.

- After sending the indication, the UE locally releases the RRC connection and enters into RRC\_IDLE state and CM\_IDLE / ECM\_IDLE state.

- Upon receipt of the indication from the UE, the AMF (5GC) or MME (EPC) triggers the AN Release procedure (5GS) or S1 Release procedure (EPS) with a specific cause value in the N2 UE Release Context Command (5GS) or S1-AP:S1 UE Context Release Command (EPS) sent to RAN.

- Upon receipt of the specific cause value, RAN triggers the local release of the RRC connection and notifies the AMF (5GC) or MME (EPC).

- The AMF (5GC) or MME (EPC) proceeds with the residual steps of AN Release Procedure (5GS) or S1 Release procedure (EPS) as specified in TS 23.501 [4] (5GC) and TS 23.401 [7] (EPC).

NOTE: The mechanism above ensures no handshake between the UE and the network is required, thus minimizing the time required for the UE to switch to the other system from the moment the UE decides to leave the current system.

This solution also provides a mechanism for the UE to negotiate the local leaving configuration with the network in advance. When the UE indicates local leaving to the network, both the network and the UE performs local release RRC connection or local suspend the RRC connection based on the local leaving configuration. When the local leaving is negotiated via RRC signalling, the mechanism applies to 5GS with NR access.

### 6.4.3 Procedures

#### 6.4.3.1 Procedure for local release based on the UE leaving indicated via NAS message



Figure 6.4.3.1-1: local Release triggered via NAS

1. The UE determines to leave the current system.

2. Subject to network support, the UE sends an UL NAS TRANSPORT message (5GS) or UPLINK GENERIC NAS TRANSPORT (EPS) with a local leaving indication to the network.

Editor's note: How network support is indicated to the UE is FFS.

3. After sending the local leaving indication to the network, the UE locally releases RRC connection and enters RRC\_IDLE state, CM-IDLE/ECM-IDLE state as specified in TS 36.331 [8] clause 5.3.9 (LTE) or TS 38.331 [9] clause 5.3.9 (NR).

Editor's note: It is FFS whether the UE needs to maintain a timer after sending the release request indication to initiate local RRC release.

4. Upon receipt of the local leaving indication, the AMF/MME sends an N2 UE Release Context Command (5GS) or an S1-AP:S1 UE Context Release Command (EPS) with a specific cause value to RAN.

5. Upon receipt of the specific cause value RAN initiates local resource release.6. After the resources are released, RAN sends an N2 UE Release Context Complete (5GS) or an S1-AP:S1 UE Context Release Complete (EPS) to the AMF/MME.

7. [Optional] The AMF/MME may send an N2 message (5GS) or a Modify Bearer Request (EPS) with a specific cause value to the SMF/PGW which decides the handling of PDU sessions/PDN connections accordingly.

Editor's note: AS support for the above is subject to RAN WG confirmation.

#### 6.4.3.2 Procedure for Local leaving negotiation with RAN



Figure 6.4.3.2-1: Local leaving negotiation with RAN

1. When the UE detects it is in MUSIM, it triggers the local leaving configuration negotiation with the RAN in advance, in order to support the possible leaving subsequently. The UE indicates the local leaving configuration request to the RAN via RRC message.

2a-2b. The RAN determines whether the UE should locally release or suspend the RRC connection when the UE requests leaving. According to operator policy, the RAN responses the local leaving configuration to the UE, indicating either local release or locally suspend when the UE leaves the network. For local suspend, the RAN additionally provides the suspend configuration to the UE as well. The local leaving configuration is stored in the UE context in the RAN. During UE mobility in connected more, the UE context is forwarded from the source RAN to the target RAN. The target RAN can decide whether update the local leaving configuration (e.g. suspend configuration) to the UE based on local leaving configuration in the UE context and operator policy at the RAN side.

#### 6.4.3.3 Procedure for local leaving indicated via RRC message



Figure 6.4.3.3-1: local leaving

1. The UE decides to immediate leave the network (e.g. due to the more preferred service at another network and the service is not delay tolerant).
2. The UE notifies the local leaving to the RAN. After sending the local leaving indication, the UE turns into RRC\_IDLE or RRC\_INACTIVE according to the local leaving configuration received before, as defined in clause 6.4.3.1.
3. Upon reception of the local leaving indication, based on the local leaving configuration, the RAN also local release or suspend the UE’s RRC connection as shown in 3a and 3b respectively.

### 6.4.4 Impacts on services, entities and interfaces

Impact for local release based on the UE leaving indicated via NAS message

UE:

- Support sending a *release request* indication at NAS and initiating local RRC release accordingly.

AMF:

- Support receiving a *release request* indication at NAS from the UE and triggering the necessary resource release procedures (i.e. AN Release procedure and S1 Release procedure) with a specific cause value in the N2 and S1 messages.

RAN:

- Support locally releasing the RRC connections with the UE upon receipt of the N2 and S1 messages from the AMF and MME in the AN Release and S1 Release procedures.

SMF:

- none

UPF:

- none

Editor's note: The indication from the UE can trigger different PDU Session handlings in the core network, but the main point of this solution is to trigger AN/S1 Release. It is FFS the impacts to the core network entities based on different PDU Session/PDN connection handlings.

Impact for local release based on the UE leaving indicated via RRC message

UE

* Triggers the local leaving configuration negotiation with the RAN.
* Locally release RRC connection or locally suspend the RRC connection based on the local leaving configuration, after sending the local leaving indication to the network via RRC message.

RAN:

* Provision local leaving configuration to the UE.
* Locally release RRC connection or locally suspend the RRC connection based on the local leaving configuration, upon reception of the local leaving indication from the UE via RRC message.

## 6.5 Solution #5: Graceful leaving and resumption solutions

### 6.5.1 Introduction

The solutions address the key issue 3: Coordinated leaving for multi-USIM device.

The solution aims to cover the following use cases for various durations of the UE "leaving" the system:

- The UE leaves for short time duration, e.g. a 100-500 ms, in order to send/receive an SMS in the target system, e.g. perform periodic registration/TAU or check the caller identity of incoming call;

- The UE leaves for long time duration, e.g. a couple of minutes, in order to make a call in the target system.

Editor's note: the short time duration range value is FFS and need to be synchronized with RAN group and CT1

One design principle of the solution is to minimize the signalling needed for coordinated leaving (including leaving and return) and to minimize the service interruption in the source system.

The solution applies to both 5GS and EPS.

### 6.5.2 Functional Description

For the single receiver multi-USIM device, if USIM1 is registered in 3GPP system (e.g. PLMN 1), and decides to establish connection for USIM 2 in 3GPP system (e.g. PLMN 2), either for a short stay (e.g. responding a MT service paging) or possibly a long stay in PLMN 2, the UE(USIM1) informs the PLMN 1 that UE(USIM1) is leaving and PLMN 1 may suspend certain DL services for UE(USIM1).

The UE/USIM(s) of the multi-USIM device first registered in PLMN(s) separately.

The leaving procedure can either be initiated at NAS level or at AS level. The UE(USIM) may provide MUSIM Release assistance Information (MUSIM-RAI) to the network to assist the network for MT service delivery.

The detailed handling of MT service in the current system after leaving procedure is described in the procedures in clause 6.5.3 below.

After UE/USIM2 ended the service in PLMN 2, or received notification (e.g. Paging or NAS level notification) indicating there is a MT service with higher priority in PLMN 1, the device resumes the service for UE/USIM 1 in PLMN 1.

NOTE: how device will receive MT service notification from PLMN1, is based on the outcome of the KI 1 and KI 2.

The service resumption procedure can also be done at the NAS level or at AS level. It can be the normal existing resumption procedures (e.g. NAS service request or RRC resume).

The solution can be used for both LTE and 5G.

### 6.5.3 Procedures

#### 6.5.3.0 General

NAS procedures are documented in clause 6.5.3.1 (leaving) and 6.5.3.2 (resumption).

AS procedures are documented in clause 6.5.3.3 (leaving) and 6.5.3.4 (resumption).

The UE may determine whether to apply for short leaving (AS or NAS procedure to suspend the RRC connection) or long leaving (AS or NAS procedure to move to CM-IDLE mode). The decision may take into account the service type (either provided to UE in paging request, NAS notification, or realized by UE for MO service) at the target PLMN, and based on the supported or preferred capabilities exchanged between UE/USIM and network.

Editor's note: It's FFS if both NAS and AS level solution is needed or only one level solution is needed. The messages and details used in the flow is also FFS.

After the procedures for leaving, the UE/USIM may end up in either CM-IDLE mode or RRC Inactive mode.

#### 6.5.3.1 NAS Leaving procedure

##### 6.5.3.1.1 NAS Leaving procedure in 5GS

Figure 6.5.3.1.1-1 is the call flow of NAS Leaving procedure in 5GS in CM-CONNECTED mode.



Figure 6.5.3.1.1-1: NAS Leaving procedure in 5GS

1. UE sends NAS Service request to AMF indicating the cause of release. The UE also optionally provides the release assistance info for MUSIM (MUSIM-RAI), which includes the following:

- PDU sessions, services or both that the UE want network to trigger (or not trigger) MT service delivery indication (the services indicated by the UE is corresponding to the services related to paging causes in solution 1). The UE may also indicate to the network that no MT data shall be delivered at all (e.g. due to specific service in another network and can’t answer paging request).

- The time period expected by the UE that will be away from this serving network.

Editor's note: It's FFS how UE sets a proper value of expected time period.

2. AMF may respond with NAS Service Accept message. The N2 Message may also indicate the connection release.

If AMF does not have information to provide to UE, the Service Accept is optional. The AMF may either use UE context release towards RAN to move UE to IDLE mode directly or UE context modification towards RAN with release assistance info and RAN decides to move UE to RRC Inactive, RRC\_idle or Suspend mode as in TS 23.502 clause 4.8.1.

The UE may conclude the NAS procedure based on the indication from low layer when RRC connection release is released if no NAS response message is received.

Editor’s Note: It’s FFS if RRC layer need to have specific indication to NAS that there is no NAS response message.

3. RAN delivers the NAS message and releases the RRC connection with UE.

In case of UE context modification with release indication, RAN decides if UE moves to RRC Inactive mode, Suspend mode or RRC\_Idle mode based on the policy at RAN and release assistance info if available.

If RAN decides to move UE to RRC inactive mode, the RAN handles the MT service as indicated in step 2 of clause 6.5.3.3.1 RRC leaving procedure in 5GS, and step 4-7 below is not performed.

4. Based on local policy and MUSIM-RAI provided by UE/USIM in step 1 and decision from RAN side in step 3 (i.e. UE is moved to Suspend mode or RRC\_IDLE), AMF sends N11 message to SMF indicating the possible N3 tunnel release and also includes the MT data handling info. The MT data handling info shall include the following:

- PDU sessions on 3GPP access that may release the N3 tunnels;

- The possible MT data handling information (either discard/block or normal MT service delivery handling for certain PDU sessions/services, and optionally an applicable time period).

5. Based on the MT data handling info, policy from PCF, DNN/S-NSSAI info in the subscription or local configuration (e.g. operator may determine that certain services/PDU sessions will trigger MT service delivery), the SMF decides how to handle the PDU sessions and informs relevant UPFs.

For example, for PDU session 1, the SMF1 may decides to discard/block the DL data transmission and send N4 Session Modification request message to UPF1 with data handling instruction information.

6. Based on the received data handling instruction information, UPF1 keeps the PDU session context but discard/block the DL data. The UPF1 send a response message to SMF 1.

7. The SMF1 sends response message back to AMF.

For a different PDU session, the SMF2 may decide to discard/block the DL data for certain period. After this period, DL data shall trigger the UPF request for the N3 tunnel setup as normal when there is no N3 tunnel.

The AMF does not trigger paging to the UE and discard/block any NAS data for the UE if MUSIM-RAI indicates no MT data delivery at all.

##### 6.5.3.1.2 NAS Leaving procedure in EPS

Figure 6.5.3.1.2-1 is the call flow of NAS leaving procedure in EPS.



Figure 6.5.3.1.2-1: NAS leaving procedure in EPS

1. UE sends NAS Extended Service request to MME indicating the cause of release. The UE also optionally provides the MUSIM-RAI which includes the following:

- PDN connections or services that the UE want network to trigger (or not trigger) MT service delivery indication (the services indicated by the UE is corresponding to the services related to paging causes in solution 1). The UE may also indicate to the network that no MT data shall be delivered at all (e.g. due to specific service in another network and can’t answer paging request).

- The time period expected by the UE that will be away from this serving network.

Editor's note: It's FFS how UE sets a proper value of expected time period.

2. MME may respond with NAS Service Accept message. MME also indicate the connection release in the S1 message.

The MME may either use UE context release towards RAN to move UE to IDLE mode directly or UE context modification towards RAN with release assistance info, and RAN decides to move UE to RRC\_Idle or Suspend mode as in TS 23.401 clause 5.3.4A as optional procedure.

The UE may conclude the NAS procedure based on the indication from low layer when RRC connection release is released if no NAS response message is received.

3. RAN delivers the NAS message and releases the RRC connection with UE.

In case of UE context modification with release indication, RAN decides if UE moves to RRC\_Suspend mode or RRC idle mode based on the policy of the RAN and release assistance info if available. Step 4 to Step 7 are the same as step 4 to step 7 in clause 6.5.3.1.1 with following differences:

MME replaces the role of SMF.

#### 6.5.3.2 NAS Resumption procedure

##### 6.5.3.2.1 NAS Resumption procedure in 5GS

Figure 6.5.3.2.1-1 is the call flow of NAS resumption procedure in 5GS.



Figure 6.5.3.2.1-1: NAS Resumption procedure in 5GS

1. UE sends the NAS Service Request or Registration Request message to AMF.

2. AMF sends N11 message to SMF for different PDU sessions/Services indicating the return to normal MT service handling.

3. SMF sends the indication to UPF. UPF data handling becomes normal (e.g. DL data will trigger N3 tunnel setup request if there is no N3 tunnel for the PDU session).

4. SMF sends the response message to AMF.

5. AMF sends the NAS accept message to UE. The AMF may also provide normal periodic mobility info to UE, if the UE was provided with adjusted periodic mobility info in previous leaving procedure.

##### 6.5.3.2.2 NAS resumption procedure in EPS

Figure 6.5.3.3.2-1 is the call flow of NAS resumption procedure in EPS.



Figure 6.5.3.2.2-1: NAS resumption procedure in EPS

1. UE sends the NAS Extended Service Request or TAU Request message to MME.

2. MME sends S11 message to SGW for different PDN connections/services indicating the return to normal MT service handling.

3. SGW sends S5/S8 message to PGW with return indication. PGW data handling change to normal handling.

4. SGW sends the response message to MME.

5. MME sends the NAS service or TAU accept message to UE. The MME may also provide normal periodic mobility info to UE, if the UE was provided with adjusted periodic mobility info in previous leaving procedure.

#### 6.5.3.3 RRC leaving procedure

##### 6.5.3.3.1 RRC leaving procedure in 5GS

Figure 6.5.3.2.1-1 is the call flow of RRC Leaving procedure in 5GS.



Figure 6.5.3.3.1-1: RRC leaving procedure in 5GS

1. UE sends RRC request to RAN indicating the cause of release. The UE also optionally provides the MUSIM-RAI, which includes the following, e.g.:

- PDU sessions or services that the UE wants network to trigger (or not trigger) MT service delivery.

- The time period expected by the UE that will be away from this serving network.

2. Based on the MUSIM-RAI from UE, RAN can either decides to move to RRC-Inactive state or to RRC Idle state. RAN sends RRC message to UE to release the RRC connection. In case of RRC-Inactive, RAN may also pre-configure a pause timer e.g. based on local policy/configuration for the UE/USIM and blocks the DL data transmission without paging UE if there are following DL data received except services/PDU sessions that UE indicated not to trigger MT delivery in step 1, or other services (e.g. for control signalling or important services determined using Paging Policy Indication) based on operator policy. The UE/USIM may locally transfer to RRC-Idle state if the received timer expires and it's not able to resume the connection. The RAN considers the UE leaves current network normally based on the cause of release received in step 1.

3. If pause timer activated in step 2 expires, and if RAN does not receive a resume request from the UE, RAN sends a N2 request message to AMF including the release assistance info if CN needs to handle MT data, and UE state in network enters either CM-IDLE or suspend state as in TS 23.502 clause 4.8.1. The UE/USIM also enters CM-IDLE/RRC\_Idle or Suspended state, according to the RRC release message in step2.

In case of moving UE to RRC Idle state and consequently to CM-Idle, RAN sends to the AMF UE context release indication. In case of moving UE to suspend state, RAN sends to the AMF the UE context suspend request. RAN provides also the release assistance info to the AMF.

4-7: similar to 6.5.3.1.1 step 4-7 with the following differences: AMF receives the MUSIM-RAI from N2 interface instead of NAS message. The MT data handling info provided by AMF to SMF may include the following:

- PDU sessions on 3GPP access that may release the N3 tunnels;

- The possible MT data handling information (either discard/block or normal MT service delivery handling for certain applicable time period).

##### 6.5.3.3.2 RRC leaving procedure in EPS

Figure 6.5.3.2.2-1 is the call flow of RRC Leaving procedure in EPS.



Figure 6.5.3.3.2-1: RRC leaving procedure in EPS

1. UE sends RRC request to RAN indicating the cause of release. The UE also optionally provides the release assistance info which includes the following, e.g.:

- PDU sessions or services that the UE want network to trigger (or not trigger) MT service delivery.

- The time period expected by the UE that will be away from this serving network.

NOTE: The RRC message may differ depending on the current RRC status.

2. Based on the release assistance info from UE, RAN can either decides to move to Suspend state or to RRC-Idle state. RAN sends RRC message to UE to release the RRC connection. In case of Suspend, RAN may also pre-configure a pause timer for the UE e.g. based on local policy/configuration. The UE may locally transfer to RRC-Idle state if the received timer expires and it's not able to resume the connection. The RAN considers the UE leaves current network normally based on the cause of release received in step 1.

3. If pause timer activated in step 2 expires, and if RAN does not receive a resume request from the UE, RAN release AS context and move the UE to RRC-Idle. The UE/USIM also release AS context and enters CM-IDLE mode, according to the RRC release message in step2.

RAN sends UE context release indication and provide the release assistance info to the MME.

4-7: similar to 6.5.3.1.2 step 4-7 with the following differences: MME receives the release assistance info from S1-C interface instead of NAS message.

#### 6.5.3.4 RRC Resumption procedure

##### 6.5.3.4.1 RRC Resumption procedure in 5GS



Figure 6.5.3.4.1-1: RRC Resumption procedure in 5GS

1. If the UE is in RRC-Inactive state, the UE/USIM sends RRC Request message (e.g. including resume indication) to RAN.

If the UE has transferred to CM-Idle state (e.g. due to expired pause timer), the UE performs NAS Resumption procedure as described in clause 6.5.3.2.

2. If the pause timer which is described in step 2 in Figure 6.5.3.3.1-1 is activated and not expired, step 2 to step 4 are skipped. Otherwise, RAN sends N2 request message to AMF to indicate the returning to CM-Connected mode and normal MT service handling.

3. AMF performs the step 2-4 similar to clause 6.5.3.2.1.

4. AMF sends N2 response message to RAN. CN tunnel info may be provided to RAN.

5. RAN sends RRC response message to UE/USIM.

##### 6.5.3.4.2 RRC Resumption procedure in EPS



Figure 6.5.3.4.2-1: RRC resumption procedure in EPS

1. UE sends RRC Request message to RAN. The UE may include return indication if leaving procedure was performed previously and new periodic mobility info has been received.

2. RAN sends S1 Request message to MME to indicate the returning to CM-Connected mode and normal MT service handling.

3. MME performs the step 2-4 similar to clause 6.5.3.2.2.

4. MME sends S1 response message to RAN. CN tunnel info may be provided to RAN.

5. RAN sends RRC response message to UE/USIM.

RAN may provide normal RNA provide periodic RNA info, if suspend is applied afterwards.

### 6.5.4 Impacts on services, entities and interfaces

**SMF:**

- decides how to handle the PDU session after receiving the MT data handling info, based on release assistance information from UE, in N11 message.

- initiates MT data handling instruction to UPF.

- receiving return indication and initiate normal MT data handling instruction to UPF.

**UPF:**

- block the DL data transmission according to SMF's request.

**AMF/MME:**

- receives the Release assistance info from UE through NAS message or from RAN through N2 message.

- provides NAS response to UE.

- provides MT data handling info, based on release assistance info from UE, to SMF.- If AMF does not have information to provide to UE, the Service Accept is optional

**NG-RAN:**

- Supports UE initiated RRC leaving procedure with release assistance info according to clause 6.5.3.3.

- Provides release assistance info the AMF.

- Sends RRC response message to UE.

**UE:**

- Supports NAS leaving procedure with release assistance info.

- Supports RRC leaving procedure with release assistance info.

- Supports NAS Resumption procedure.

- Supports RRC Resumption procedure.

- The UE may conclude the NAS procedure based on the indication from low layer when RRC connection release is released if no NAS response message is received.

## 6.6 Solution #6: UE leave and return

### 6.6.1 Introduction

This solution addresses the Key Issue 3: Coordinated leaving for multi-USIM device.

### 6.6.2 Functional Description

The solution can be applied for both EPS and 5GS.

A multi-SIM device with 1Tx/1Rx or 1Tx/2Rx may not communicate with two networks simultaneously. Hence the multi-SIM device will leave the current 3GPP system if it turns to communicate with another network. In order to notify the current system the UE leave, it is proposed the Multi-USIM device to initiate the leave to the current network and give up the ongoing service associated with the current network. Then the NG-RAN can decide to release or suspend the connection.

After leaving, the MT CP/UP data for the Multi-USIM device may continue to arrive or be generated at the network side. There can be two options to handle subsequent data after leaving:

1. The network does not page the UE for a certain short period of time that is up to network implementation.

If the UE state becomes CM-IDLE after the UE initiated leave, then the AMF does not page the UE for a certain short period and the CN buffers the mobile terminated data using the existing procedures. If the UE returns within the period then any buffered data is delivered, no data is lost and no network resource is wasted. If there is buffered data and if the UE does not return within the period then the network pages the UE to deliver the buffered data. If the UE does not respond to paging then the procedure is the same as the existing paging failure procedures, i.e. data may be lost and some network resources are wasted.

If the UE state becomes CM-CONNECTED with RRC inactive after the UE initiated leave then the procedure is the same except it is NG-RAN that initiates the paging and not the CN. If the UE does not respond to paging then the existing procedure defined in TS 23.501 [4] clause 5.3.3.2.5 for RAN paging failure is performed.

2. After the UE initiated leave the UE is not paged (either by the CN or RAN). Some user data for the UE may be buffered depending upon the network implementation. The potential buffered data will be delivered when the UE returns to RRC-CONNECTED using any UE initiated procedure, e.g. Service Request, Registration procedure or RAN based RRC resume procedure and the can resume paging after the UE subsequently returns to either CM-IDLE or RRC-Inactive. The network resource wastage can be entirely avoided however the UE is not reachable.

NOTE: How to handle the MT service from the network may also be based on the outcome of the KI 1.

### 6.6.3 Procedures

#### 6.6.3.1 UE initiated leave and return procedure

**< UE initiated leave procedure >**



Figure 6.6.3.1-1: UE initiated leave procedure

1. If a UE in connected mode would like to leave a 5GS network, the UE provides in the RRC message the indication for leaving. Upon reception of the indication, based on UE context and operator policy, the NG RAN suspends or releases the UE connection, as shown as step2a, step2b.

2a. RRC Release with suspend operation as defined in TS 38.331 [9]. It is up to RAN's implementation to handle the current MT data, e.g. discarding the current data. Subsequently, RAN paging may not be triggered fora certain period that is up to RAN implementation. Alternatively, RAN paging may not be triggered until the UE initiates resume procedure.

2b. NG-RAN initiated connection release as defined in Figure 4.2.6 AN Release procedure in TS 23.502 [6], including N2 release and N3 resource release, with the modification that NG-RAN provides in N2 UE Context Release Request message the indication for UE coordinated leaving to AMF in step1. It is up to operator policy to trigger RRC release response ahead of or later than N2/N3 release. During this procedure, it is UPF's implementation to handle the current MT data, e.g. discarding the current data. Subsequently, CN paging may not be triggered fora certain period that is up to network implementation. Alternatively, CN paging may not be triggered until the UE contacts the network.

**< UE initiated return procedure >**

When the multi-USIM device decides to return to the network, the multi-USIM device initiates the return by using the existing procedure, either via RRC resume procedure or via RRC setup procedure, corresponding to step2a (i.e. RRC suspend), step2b (i.e. RRC Release) in the leave procedure respectively.

### 6.6.4 Impacts on services, entities and interfaces

**NG RAN**

- Upon reception of the indication for leaving, decide to suspend or release the UE by using the existing procedure, based on operator policy and UE context.

- Send a cause to indicate release is a result of coordinated leave.

**UE**

- Send an indication for leaving.

**AMF**

- Option1: Don’t page the UE after UE initiated leave for a certain preconfigured short period; if there is buffered data and if the UE does not return within the period then the network pages the UE to deliver the buffered data

- Option2: Don’t page the UE after UE initiated leave until the UE returns.

## 6.7 Solution #7: Push Notification

### 6.7.1 Introduction

The solution applies to Key Issue #1 "Handling of MT service" and Key Issue #2 "Enabling Paging Reception".

The solution applies to both 5GS and EPS.

The solution relies on Push Notification that is delivered via the Internet.

The solution applies to Single Rx Multi-USIM devices only.

### 6.7.2 Functional Description

Depicted in Figure 6.7.2-1 is a Dual-USIM device that is simultaneously registered to 5GS/EPS A (system A) and 5GS/EPS B (system B).



Figure 6.7.2-1: Simultaneous paging from AMF A (or MME A) in system A and system B

Upon registration to the network associated with USIM A the UE indicates to the network (AMF) that it wants to register for paging events, e.g. because it is unable to monitor the paging channel during an active communication via the network associated with USIM B or would like to avoid creating reception gaps.

If the network (AMF) acknowledges the UE request, it indicates to the UE the address (e.g. IP address or FQDN) of a 5GC network function, referred to as Paging Server A, that has a service-based interface in 5GC (N99 in reference point representation in Figure 6.7.2-1) and is also accessible via the Internet. The AMF also provides a credential and an identity for the UE which enables the UE to register for paging events at Paging Server A via the Internet. The UE next registers with Paging Server A (e.g. using an HTTPS connection) via Internet access provided by the network associated with USIM B. This is illustrated in Figure 6.7.2-1 for the case where both systems are 5GS, but the same principle applies if either or both systems are EPS.

Editor’s note: The security aspects of the communication between UE and Paging Server, including the details for the assignment of UE identity and credential which enable the UE to establish a secure connection with the Paging Server via the Internet, as well as any privacy issues, will be addressed by SA WG3.

Similarly, upon connecting to the network associated with USIM B the UE obtains the address of a Paging Server B and registers for paging events at Paging Server B via Internet access provided by the network associated with USIM A.

NOTE 1: There is no business relationship between system A and system B in this solution. UE registers with Paging Server A using the Internet access of system B, and vice versa.

While connected to the network associated with USIM A the UE keeps an established connection with Paging Server B via the Internet.

Similarly, while connected to the network associated with USIM B the UE keeps an established connection with Paging Server A via the Internet.

When the UE needs to be paged for MT service in system A, the SMF (or MME) in system A initiates the direct paging in system A (refer to red dashed line in Figure 6.7.2-1) and after some delay (the value of which depends on configured paging strategy in the AMF) it also sends a Push Notification via Paging Server A (refer to the blue dash-dotted line in Figure 6.7.2-1). The following cases may arise:

1. UE was engaged in active communication via system B; in this case the UE will not be able to listen to the Uu paging in system A, but it will receive the Push Notification from Paging Server A via its Internet connection on system B. Upon reception of the Push Notification the UE decides whether it should suspend the communication in system B and respond to the Uu paging in system A.

2. UE was in Idle state in both system A and system B. The UE will be paged sequentially: initially in system A only and after some delay also via its Internet connection in system B with the Push Notification. In system B, a DL packet for the UE is received, that triggers "normal" paging, which can be successful or unsuccessful, independently from the fact that the UE has responded in system A or not. If unsuccessful, the Push Notification packet is dropped by system B.

NOTE 1a: The solution is not applicable when extended buffering is used.

The Push Notification content is equivalent to the content of the Uu Paging message. As a minimum it includes an indication of the service type that triggered the paging and an identifier that non-ambiguously points to the USIM in the Multi-USIM device for which the paging is intended.

NOTE 2: The Push Notification in the UE is expected to be handled in an IP application client that is able to communicate with the 3GPP layers in the UE (cf. similar to the IMS client). The details of the IP application client handling the Push Notifications is implementation dependent and is outside the scope of this study. The registration for paging events is expected to be performed by the same IP application client.

### 6.7.3 Procedures

Depicted in Figure 6.7.3-1 is the call flow for the case where UE A and UE B are in Idle and Connected state, respectively, when a downlink user plane packet (e.g. SIP INVITE) arrives at UPF A.



Figure 6.7.3-1: Push Notification: UE A in Idle; UE B in Connected

1. User plane packet (e.g. SIP INVITE) arrives at the UPF in system A.

2-4. AMF pages the UE.

5. In absence of UE A response during preconfigured time Tnr (e.g. Tnr<T3513) the AMF triggers sending of a Push Notification via the Internet using PS A (Paging Server A).

6-7. The Push Notification is delivered to UE B as user plane data.

8. If the multi-USIM device determines that it shall respond to the paging in system A, UE B sends back a Push Notification ACK to PS A via the Internet.

9-11. The Push Notification ACK is eventually delivered to the AMF which may “encourage” it to continue the paging of UE A (e.g. reinitiate paging upon expiry of timer T3513) to allow the multi-USIM device to perform coordinated leaving on UE B and respond to paging on UE A.

12. UE A responds to paging and receives the SIP INVITE in the user plane



Figure 6.7.3-2: Push Notification: UE A in Idle; UE B in Idle

1-6. Same as in Figure 6.7.3-1.

7. Given that UE B is in Idle state the Push Notification is buffered at the UPF in system B.

8-10. UE B is paged.

11. UE B responds to paging and receives the Push Notification in the user plane.

12-13. The multi-USIM device determines that it is unable to receive the paging in system A (e.g. UE A is out of coverage in system A) and sends back a Push Notification NAK to PS A via the Internet to stop unnecessary paging of UE A in system A.

NOTE 1: This call flow assumes that UE A is unable to receive paging in system A (e.g. UE A is out of coverage in system A) which seems to be the most likely cause for UE A’s lack of response to paging. However, if the multi-USIM device determines that UE A is able to detect the paging in system A, then UE B responds with a Push Notification ACK and the rest of the call flow is the same as steps 8-12 in Figure 6.7.3-1.

14-15. Upon reception of the Push Notification NAK, the AMF of system A abandons paging of UE A.



Figure 6.7.3-3: Push Notification: “Reverse” Push Notification and loop avoidance

1-10. Same as in Figure 6.7.3-2.

11. In absence of UE B’s response to the paging during preconfigured time Tnr (e.g. Tnr<T3513) the AMF of system B triggers sending of a Push Notification via the Internet (“reverse” Push Notification) using PS B.

NOTE 2: The “forward” Push Notification is perceived by system B as “ordinary” MT Internet data. As a configuration choice, system B can be configured to not trigger a Push Notification for “ordinary” MT Internet data, which obviates the need for a solution to the loop avoidance problem. The rest of the call flow assumes that a Push Notification is always sent, including for “ordinary” MT Internet data.

The execution of the subsequent steps depends on the status of system A when the “reverse” Push Notification reaches system A.

12. UE A has responded to the paging in system A. The “reverse” Push Notification is delivered to UE A in the user plane. By inspecting the Push Notification the multi-USIM device determines that this notification is for lower or equal priority traffic and determines to not respond to the paging of UE B in system B. UE A nevertheless should send a Push Notification NAK to stop the paging of UE B in system B as soon as possible.

13. System A is still in a process of paging UE A when the “reverse” Push Notification is received. UE A does not respond within a pre-configured time interval Ttot (e.g. Ttot=T3513), which leads system A to abandon the paging. The original user plane data that trigger the paging (e.g. SIP INVITE) as well as the queued “reverse” Push Notification, are both dropped by the UPF of system A.

14. System A has already stopped paging UE A when the “reverse” Push Notification is received. To avoid triggering new Push Notification, system A is configured with a guard timer Tgua that is armed at the end of the unsuccessful paging of UE A (step 14a). Any “ordinary” MT data received before the Tgua timer expires is considered as spurious data.

NOTE 3: The guard timer Tgua can be used in any of the UPF, SMF, AMF or PS. If configured in UPF, SMF or AMF, the spurious data does not trigger any paging in system A (steps 14e, 14f anf 14g are skipped, and possibly steps 14c, 14d can be skipped). However, to minimize the impact on the existing system, figure 6.7.3-3 illustrates the case where the Tgua timer is configured in the PS. For any Trigger Push Notification message received by PS before the Tgua timer has expired (step 14f), the PS does not send a Push Notification via the Internet and instead immediately responds to the AMF with a Push Notification NAK message (step 14g).

### 6.7.4 Impacts on services, entities and interfaces

**Paging Server:**

- new functionality in 5GC that maintains a secure connection with the UE via the Internet, and that is used for sending Paging Notifications.

**AMF:**

- handles UE request for Push Notification via the Paging Server.

- triggers sending of Push Notification to the UE via the Paging Server.

**UE:**

- requests and receives information from the AMF for being paged with Push Notifications.

- establishes and maintains a secure connection with the Paging Server, that is used for receiving Push Notifications.

- handles Push Notification received via the Internet.

## 

## 6.8 Solution #8: MT Service Notification through N3IWF

### 6.8.1 Introduction

The solutions mainly address the key issue 1: Handling of Mobile Terminated service with Multi-USIM device.

### 6.8.2 Functional Description

For the single receiver multi-USIM device, if USIM 1 is registered in 3GPP system (e.g. PLMN 1), and USIM 2 is also registered in 3GPP system (e.g. PLMN 2), it will be ideal if multi-USIM device only needs to monitor one system, i.e. a single PLMN. This can be achieved by the following mechanism:

1. Both USIMs initial register independently first as defined in TS 23.501 [4] and TS 23.502 [6].

2. If the multi-USIM device decides to monitor MT services on one system (e.g. PLMN 1), the USIM 2 triggers a NAS message (e.g. registration request with a specific indicator) to N3IWF/AMF in PLMN 2 indicating that UE is currently reachable for NAS notification through N3IWF for the PDU sessions previously established on 3GPP access of the PLMN2. This NAS message for registration with PLMN2 is sent through user plane tunnel to N3IWF in PLMN2 via a PDU Session established in PLMN 1 using the mechanism introduced in "access PLMN through a SNPN network" in TS 23.501 [4] clause 5.30.

3. When MT service is triggered in PLMN 2, the AMF in PLMN 2 realizes that the UE is reachable through N3IWF and a NAS notification with MT service information shall be sent to UE, i.e. eliminating need for paging in 3GPP access.



Figure 6.8.2-1: Non-roaming Solution architecture

NOTE: The UE selects the N3IWF in the PLMN2 where the serving AMF#2 is located.

In case of both USIMs are roaming, if the UE decides to receive V-PLMN2 related NAS notification for USIM2 via V-PLMN1, the user plane of the PDU session that carries NAS signalling between UE and N3IWF in V-PLMN2 is either via V-PLMN1 in case the UE/USIM1 in V-PLMN 1 using local breakout PDU session, or via H-PLMN1 in case the UE/USIM 1 in V-PLMN1 using home routed PDU session.

 Figure 6.8.2-2. Roaming Solution architecture

### 6.8.3 Procedures

#### 6.8.3.1 NAS Indication procedure and NAS Notification procedure through N3IWF

Figure 6.8.3.1-1 shows the call flow of NAS Indication and Notification procedure in 5GS through N3IWF. By NAS Indication through N3IWF, the network can also eliminate the paging in 3GPP access triggered by MT service and the existing NAS notification procedure can be applied.

Figure 6.8.3.1-1: NAS Indication procedure in 5GS

0a. The multi-USIM device registers in PLMN1 using USIM1 and establishes PDU sessions.

0b. The multi-USIM device registers in PLMN2 using USIM2 and establishes PDU sessions.

In case of USIM2 is also registered directly in non-3GPP access of PLMN2, NAS notification for MT service can be delivered as in described in TS 23.502 clause 4.2.3.3.

NOTE 1: There may be further details shall be addressed during normative phase on handling of the existing N3GPP PDU sessions, if UE still prefers to perform this solution.

1. Through the UP established in PLMN1 (either 3GPP or N3GPP access), the UE performs registration procedure including NAS Indication (or using existing mobility registration) using USIM2 through N3IWF2 towards PLMN2 again (e.g. It's similar to access PLMN through a SNPN network in TS 23.501 [4] clause 5.30 and Annex D, clause D.3). The UE may provide the following info through NAS message:

- Indication for AMF in PLMN 2 that UE/USIM2 is not reachable through 3GPP access in PLMN 2 and optionally with a time period. However, the UE is reachable for NAS notification through N3IWF as long as the UE is in CM-CONNECTED mode through N3IWF.

- MUSIM Release Assistance information (MUSIM- RAI) that the UE/USIM2 indicates which PDU sessions/services in the PLMN 2 shall trigger (or not trigger) MT service delivery.

Editor's note: Further clarifications on how UE determines the time period and MUSIM- RAI are FFS. For example, are they determined based on the set of active services on USIM1? Does this information need to be updated to PLMN2 whenever there is a change in the set of active services on USIM1?.

Editor's note: the details of the NAS procedures are FFS.

Editor's note: the details and its related charging aspect of the PDU session that provides UP in PLMN 1 is FFS.

2 Based on the received information in step 1, local policy or subscription information, the AMF-2 shall release N2 connections if there is any. Furthermore, based on Release assistance information in step 2, the AMF-2 provides MT handling info to SMF2 that indicates:

- PDU sessions on 3GPP access that shall release the N3 tunnels.

- The possible MT data handling information (either discard/block or normal MT service delivery handling for certain PDU sessions/services, and optionally an applicable time period).

3. Based on the MT data handling info, policy from PCF, DNN/S-NSSAI info in the subscription or local configuration, the SMF-2 decides how to handle the PDU session and informs relevant UPFs.

4. SMF-2 responses to AMF-2. AMF-2 shall mark that any future MT service request for the USIM2 shall be notified to UE through N3IWF. The AMF-2 sends also a NAS accept message to inform UE the request for notification via N3IWF has been accepted. The UE shall not trigger PDU session establishment via N3IWF in this particular case (i.e. connection establishment via N3IWF is only for NAS signaling communication).

5. When DL data arrives into UPF-2, the MT data handling policy decided in step 4 applies. In case MT service shall be delivered to UE, the UPF-2/SMF-2 perform the normal steps as no N3 tunnel exists (see details in clause 4.2.3.3 Network triggered Service Request procedure in TS 23.502 [6]).

6. The SMF-2 sends Namf\_Communicaiton\_N1N2MessageTransfer () to establish the N3 tunnel on 3GPP access.

7. The AMF-2 notifies the UE/USIM2 with NAS notification, including the MT service info and intended access type, through N3IWF2 as AMF-2 marked the UE in step 4.

NOTE: The NAS notification message is handled as downlink traffic in user plane in PLMN 1.

8. Based on the info received in NAS notification, if the UE decides to move to PLMN2, the UE shall perform NAS Service Request procedure through 3GPP access toward PLMN2.

If the UE decides to stay in PLMN1, the UE sends NAS Notification Response message to AMF#2 through the user plane in PLMN1.

### 6.8.4 Impacts on services, entities and interfaces

**SMF:**

- Support of MT data handling info from AMF, and

- decides how to handle the PDU session after receiving the MT data handling info, based on release assistance information from UE, in N11 message.

- initiates MT data handling instruction to UPF

- receiving return indication and initiate normal MT data handling instruction to UPF

**AMF:**

- Handles the NAS procedures from N3IWF and mark the UE/PDU sessions for future MT service notification delivery.

- forwards MT data handling info, based on the release assistance info from UE, to SMF.

- using NAS notification instead of paging based on previous marking in case of MT service delivery.

**UE:**

- Deactivation of paging reception in idle mode in a PLMN and support N3IWF access to a PLMN via 3GPP access of another PLMN and related procedures for NAS notification

- Supports indication of MUSIM MT assistance info to the network (i.e. activation) and release of such indication (i.e. deactivation).

## 

## 6.9 Solution #9: Handling of MT IMS voice service with different Paging Cause

### 6.9.1 Introduction

The solution is an incremental solution based on solution #1 and applies to Key Issue #1 "Handling of MT service".

### 6.9.2 Functional Description

In addition to solution #1, it is proposed to add the following procedures:

For IMS voice call, UE can provide a preferred list and / or a non-preferred list which includes the list of MSISDNs or tel/sip URIs of the MT caller to the Telephone Application server via Ut interface which is specified in TS 24.623.. It is based on operator’s decision that only support one of these two lists or support both of the lists. When the MT call is received, TAS will check if the MSISDN or tel/sip URI of the MT caller is in the preferred list or non-preferred list and TAS will set different DSCP value for different list. SMF and RAN will derive different paging cause based on different DSCP value. For non-roaming case, the P-CSCF will not set the DSCP value in the IP header if the DSCP value is already marked as specific values. In roaming case, if the DSCP value is already marked as specific value, the V-P-CSCF may map the received DSCP value based on roaming agreement.

UE is configured how to handle the paging with the specific paging cause, for example, reject the non-preferred voice all or only accept the preferred voice call.

Editor’s Note: it is FFS whether this solution can work if there is no guarantee the DSCP cannot change between TAS and UPF in transport networks outside operators control between TAS in HPLMN and the P-CSCF in VPLMN. Impact on IPX especially is to be considered in roaming case and any requirement on NG.113 by GSMA shall be specified.

### 6.9.3 Procedures

Editor's note: This clause describes high-level procedures and information flows for the solution.

### 6.9.4 Impacts on services, entities and interfaces

UE:

- provides a preferred list and or a non-preferred list of MSISDN or tel/sip URI to TAS via Ut interface in TS 24.623.

For IMS

* TASreceives preferred and / or non-preferred list of MSISDNs or tel/sip URI from the UE and marks accordingly the DSCP header of the SIP INVITE

P-CSCF:

* not (re-)set the DSCP value in the IP header to indicate the traffic type if it comes already marked as specific values in non-roaming case.
* Mapping the received specific DSCP values based on roaming agreement in roaming case.

## 6.10 Solution #10: Network based paging filtering

### 6.10.1 Introduction

The solution applies to Key Issue #1 “Mechanism for handling of MT service”.

The solution applies to both 5GS (UE in either CM\_IDLE or RRC\_Inactive state) over 3GPP access and EPS (UE in CM\_IDLE state).

### 6.10.2 Functional Description

The solution proposes that the network corresponding to USIM-1 sends paging for USIM-1 only if Paging Filtering Rules in the network allows to page the UE.

To achieve this, a UE provides the Paging Filtering Rules in the MUSIM Assistance Information in Registration or Service Request message to the nework either over 3GPP access or non-3GPP access. The AMF only triggers paging over 3GPP access for the MT services allowed by the Paging Filtering Rules. This information may be updated by a further Registration or Service Request message when the UE needs not such filtering, or user settings or preferences change. This filter is passed to the RAN for the UE in RRC inactive state, and the filtering is based on classification performed at the UPF for user plane e.g. PPI value in the CN tunnel header of the DL PDU. For example, the UE may want to receive paging related with voice service only, or data only, or disable SMS.

NOTE 1: Standardized values are to be used for the identification of services in the Paging Filtering Rules. So it should be PLMN independent.

The Paging Filtering Rules in the MUSIM assistance information in the Registration or Service Request may also block entirely the paging. If so, the information sent to the network is filtering all services as not eligible for paging.

Editor's note: The granularity of Paging Filtering Rule the UE provides to the network is FFS.

NOTE 2: The Paging Filtering Rules can be based on user settings, e.g. the user can make a configuration for which services are to be subject to paging per USIM. The user settings and preferences can also be triggered when certain applications are started in a MUSIM device, to make the behaviour dynamic and not just based on static configuration.

The AMF provides the Paging Filtering Rules to the RAN so that the RAN can decide whether to send paging to the UE of user plane services when the UE is in RRC Inactive state (the paging for control plane services is controlled at the AMF at all times). The service causing the paging is determined by the AMF or RAN by reusing the mechanism of PPD feature.

- In case of CM-IDLE state, the UPF sends the DSCP in TOS of IP header towards the SMF and the SMF will determine whether to send notification to AMF. If so, the SMF includes the PPI, the ARP and the 5QI of the corresponding QoS Flow. The AMF determines which service caused paging based on the PPI, ARP and 5QI.

- In case of RRC-Inactive state, the UPF adds the PPI value in CN tunnel header of a DL PDU and RAN determines which service caused paging based on the PPI, ARP and 5QI.

Editor's note: It is FFS whether Packet Filters can be used for Paging Filtering Rules, which requires the UPF to classify the DL packets based on DPI.

### 6.10.3 Procedures

#### 6.10.3.1 CM-IDLE in 5GS



Figure 6.10.3.1-1. Paging filtering based paging delivery in CM-IDLE state

0. The UE can be in CM-CONNECTED or CM-IDLE or CM-CONNECTED with RRC Inactive state.

1. The UE sends Registration or Service Request message with MUSIM Assistance Information with Paging Filtering Rules over 3GPP access or non-3GPP access, which indicates list of services the UE wants to be notified. The UE may request to update the existing Paging Filtering Rules by sending Registration or Service Request procedure.

NOTE 1: This step can be combined with NAS level solution for KI#3: Coordinated leaving for Multi-USIM device. For example, the UE can send Service Request message with Paging Filtering Rules and Leave indication at the same time.

2. The AMF stores the MUSIM Assistance Information with Paging Filtering Rules and sends Registration or Service Accept message to the UE. The AMF may send the MUSIM Assistance Information with Paging Filtering Rules to the NG-RAN and the NG-RAN stores the Paging Filtering Rules. The MUSIM Assistance Information sent to the NG-RAN includes only user plane services rules. The AMF updates the RAN with fresh MUSIM Assistance Information with Paging Filtering Rules whenever they change compared to the ones stored at the AMF. The Paging Filtering Rules may lift any paging filtering or stop completely paging also, as an option. The Registration accept contains information (e.g. by network capability or including MUSIM assistance information) whether the network supports MUSIM.

NOTE 2: The Paging Filtering Rules sent to the NG-RAN is used when a UE is in RRC-Inactive as described in clause 6.x.3.2.

3. The NG-RAN forwards to the UE the Registration or Service Accept.

4. Assume that the UE is in CM-IDLE state over 3GPP access.

5. The SMF triggers Namf\_Communication\_N1N2MessageTransfer to activate user plane and includes ARP, PPI and 5QI.

6. Based on the ARP, PPI and 5QI, the AMF determines which service caused paging and decides whether to send paging considering the Paging Filtering Rules received in step 1.

NOTE 3: It is up to UE implementation to decide with what frequency and under what circumstances it sends Paging Filtering Rules. The network can either accept or reject the request. It is expected the UE would not change the rules very frequently.

Editor's note: In which condition the UE updates Paging Filtering Rule is FFS.

#### 6.10.3.2 RRC-Inactive in 5GS



Figure 6.10.3.2-1. Prioritized Service List based paging delivery in RRC-Inactive state

0. The UE can be in CM-CONNECTED or CM-IDLE or CM-CONNECTED with RRC Inactive state.

1. The UE context including MUSIM Assistance Information with Paging Filtering Rules is provided to the RAN after the UE performs Registration or Service Request procedure as described in steps 1~3 in clause 6.X.3.1.

2. Assume that the UE is in RRC\_Inactive state.

3. The UPF sends DL PDU to the NG-RAN including PPI value in the CN tunnel header of the DL PDU.

4. Based on the ARP, PPI and 5QI, the NG-RAN determines which service caused paging and decides whether to send paging considering the MUSIM Assistance Information with Paging Filtering Rules received in step 1.

#### 6.10.3.4 Paging delivery in EPS

The same mechanism in CM-IDLE state in 5GS also applies to EPS.

### 6.10.4 Impacts on services, entities and interfaces

For 5GS:

- UE:

- provide MUSIM Assistance Information with Paging Filtering Rules in the Registration or Service Request message over 3GPP access or non-3GPP access

- AMF:

- decides whether to send Paging message based on Paging Filtering Rules

- provides MUSIM Assistance Information with Paging Filtering Rules in applicable N2 messages

- RAN:

- decides whether to send Paging message based on Paging Filtering Rules

For EPS:

- UE:

- provide MUSIM Assistance Information with Paging Filtering Rules in the Attach or TAU or Service Request message

- MME:

- decides whether to send Paging message based on Paging Filtering Rules

- provide MUSIM Assistance Information with Paging Filtering Rules in the S1-AP messages

## 6.11 Solution #11: Operator-defined upper bound timer for paging response

### 6.11.1 Introduction

This is a solution complementing any other solution to KI#1 that allows a UE user to decide whether it is interested in accepting a paging. This solution allows the operator to have a deterministic behaviour from the UEs registered with the PLMN which are acting as MULTI-USIM devices by providing them with an upper bound timer for paging response, whereby the network either will receive a service request indicating the paging was accepted and the UE is establishing connectivity with the network, or the UE indicates it is not interested in the MT service and therefore indicates to complete the paging procedure without establishing UE connectivity with the network,.

### 6.11.2 Functional Description

When a UE registers and indicates (e.g. in MUSIM Assistance Information) that is behaving as Multi-USIM device, then the Network provides in a registration response message or, in 5GS, at any time in a UE configuration update message an Upper Bound Timer for paging response specifying that the UE shall provide a response to paging (if paging message is received) within the time indicated by the timer. This way, even if the user missed the request for input from the UE so the UE can be instructed to respond to paging, the UE can autonomously complete the paging procedure one way or another by the time indicated by the network. The network indicates a timer smaller than the time the network gives up paging the UE.

### 6.11.3 Procedures

#### 6.11.3.1

For a MUSIM capable UE, the UE configuration in 5GS (similar concepts in EPS apply by changing registration messages to the equivalent in EPS) can happen at Registration or by means of a UE configuration Update procedure at any time. See figures 6.11.3.1-1 and 6.11.3.1-2



Figure 6.11.3.1-1: Configuration of the timer in the UE during a registration procedure



Figure 6.11.3.1-2: Configuration of the timer in the UE during a registration procedure

Once the UE is configured with the timer, then if the UE is being paged and the user does not provide input to the UE when prompted to assess whether the user intends to accept the MT service, when the timer configured in the UE elapses the UE completes autonomously the Paging procedure as shown in figure 6.11.3.1-3.



Figure 6.11.3.1-3: User does not provide input to the UE in time and the UE autonomously completes the paging procedure

1. The UE receives a paging message
2. the UPPER BOUND TIMER FOR PAGING RESPONSE.
3. The UE is waiting for a decision from the User
4. The UPPER BOUND TIMER FOR PAGING RESPONSE elapses

5-7. The paging is rejected by the UE with a cause code indicating the rejection was due to expiration of the UPPER BOUND TIMER FOR PAGING RESPONSE.

### 6.11.4 Impacts on existing entities and interfaces

UE: support of the timer configuration, storage and processing using the procedures indicated above

AMF, MME: support the support of the timer configuration, and the procedures indicated above

RAN: only impacted by the handling of a message indicating the UE intends to not respond to paging (maybe along the lines of solution #3.)

## 6.12 Solution #12: Push Notification via SMS

### 6.12.1 Introduction

The solution applies to Key Issue #1 "Handling of MT service" and Key Issue #2 "Enabling Paging Reception".

The solution applies to both 5GS and EPS.

The solution relies on Push Notification that is delivered via the SMS.

The solution applies to Single Rx Multi-USIM devices only.

### 6.12.2 Functional Description

Depicted in Figure 6.12.2-1 is a Dual-USIM device that is simultaneously registered to 5GS/EPS A (PLMN A) and 5GS/EPS B (PLMN B).



Figure 6.12.2-1: Simultaneous paging from AMF (or MME) in PLMN A and PLMN B

Upon registration to the network associated with USIM A (associated with PLMN A) the UE indicates to the network (AMF) that it wants to register for paging events, e.g. because it is unable to monitor the paging channel during an active communication via the network associated with USIM B (associated with PLMN B) or would like to avoid creating reception gaps. During the registration, the UE also provides MSISDN of USIM B so that the paging event is sent to the provided MSISDN.

NOTE 1: The MSISDN of the other PLMN can be preconfigured as a part of subscription data via pre-configuration. Instead of using MSISDN, GPSI can be used.

If the network (AMF) acknowledges the UE request, the AMF provides a credential for the UE which enables the security validation of paging information in SMS. This is illustrated in Figure 6.12.2-1 for the case where both PLMNs are 5GS, but the same principle applies if either or both PLMN are EPS.

NOTE 2: The USIM credential can be reused to validate SMS. The details will be addressed by SA WG3.

Similarly, upon connecting to the network associated with USIM B the UE provides MSISDN of USIM A and receives credential for security validation of paging information.

NOTE 3: There is no business relationship between PLMN A and PLMN B in this solution. However, the explicit indication of MSISDN of USIM B to be used for SMS notifications by PLMN A explicitly indicates the identity of PLMN B to PLMN A.

NOTE 4: The SMS for paging may impact the billing charges between the two PLMNs in inter-operator billing settlement.

When the UE needs to be paged for MT service in PLMN A, the SMF (or MME) in PLMN A initiates the direct paging in PLMN A (refer to red dashed line in Figure 6.12.2-1) and after some delay (the value of which depends on configured paging strategy in the AMF) it provides MSISDN of USIM B and SMS payload contains Push Notification to SMS-SC via NEF (or SCEF). The AMF may provide validity time of the paging information. When the SMS-SC generates SMS message, it uses new TP-PID value to indicate that the SMS message is used for transfering paging information and optionally set TP Validity Period as a validity time provided by the AMF. The following cases may arise:

1. UE was engaged in active communication via PLMN B; in this case the UE will not be able to listen to the Uu paging in PLMN A, but it will receive the Push Notification from PLMN A via SMS. Upon reception of the Push Notification the UE decides whether it should suspend the communication in PLMN B and respond to the Uu paging in PLMN A.

2. UE was in Idle state in both PLMN A and PLMN B. The UE will be paged sequentially: initially in PLMN A only and after some delay also via SMS with the Push Notification. In PLMN B, a DL packet for the UE is received, that triggers "normal" paging, which can be successful or unsuccessful, independently from the fact that the UE has responded in PLMN A or not.

Editor's note: How to prevent loops if system B uses SMS-over-IP is FFS (i.e. how to avoid that the Push Notification perceived as U-plane data by system B triggers a Push Notification towards system A).

The Push Notification in SMS content is equivalent to the content of the Uu Paging message. As a minimum it includes an indication of the service type that triggered the paging and an identifier that non-ambiguously points to the USIM in the Multi-USIM device for which the paging is intended.

### 6.12.3 Procedures

6.12.3.1 5GS Procedure



**Figure 6.12.3.1-1: Push Notification via SMS procedure in 5GS**

1. The UE registers to PLMN B with USIM\_B.

2. The UE sends Registration Request to PLMN A with USIM\_A. In the request message, the UE includes Multi SIM indication and MSISDN of USIM\_B to indicate that the UE wants to receive Push Notification via SMS.

3. If the AMF allows to send Push Notification via SMS, the AMF includes Multi SIM indication to notify that the Push Notification via SMS will be performed.

4. When there is downlink data, the SMF requests to setup user plane resources by triggering Namf\_Communication\_N1N2MessageTransfer service.

5. The AMF may send Paging request to the RAN. The AMF also triggers Nnef\_Trigger\_Delivery request to send Push Notification via SMS to the UE. The AMF provides MSISDN of USIM\_B and Push Notification. The Push Notification includes Service Type that triggered Push Notification and PLMN identity. In addition, the AMF may provide validity time of the Push Notification message.

6. The NEF sends Submit Trigger message to the SMS-SC. The NEF relays Push Notification, MSISDN of USIM\_B and validity time received from the AMF.

7. The SMS-SC response to the NEF.

8. The NEF response to the AMF.

9. The SMS-SC generates SMS message which contains Push Notification. If SMS-SC receives validity time, it sets Validity-Period of the SMS message with the received validity time. The SMS-SC sends the generated SMS message to the UE by using the received MSISDN of USIM\_B.

10. When the UE receives the Push Notification via SMS the UE may send SMS Delivery Report according to the configuration of SMS-SC. In this case, the UE may include Push Notification response. The Push Notification response may indicate that the UE will not respond to the paging.

Editor’s note: If UE (USIM\_B) determines to not respond to paging or if UE (USIM\_A) is unable to respond (e.g. out of coverage) it is FFS whether the UE sends a NACK towards PLMN A.

11. The SMS-SC sends the Message Delivery Report to the NEF to notify that the SMS is delivered. If the UE sends Push Notification response, the SMS-SC includes the Push Notification response in the message.

12. The NEF triggers Nnef\_Trigger\_Delivery Notify service to notify that the SMS is delivered. If the NEF receives Push Notification response, it is sent to the AMF. Based on the received information, the AMF knows that whether the UE received Push Notification and whether the UE will respond to the Push Notification.

13. The UE decides whether to receive service in PLMN A considering validity time of the SMS message, Service Type that triggered Push Notification, ongoing services in PLMN B, time stamp of SMS message, etc. If the UE decides to receive service in PLMN A, the UE sends Service Request message to PLMN A with USM\_A.

6.12.3.2 EPS Procedure



**Figure 6.12.3.2-1: Push Notification via SMS procedure in EPS**

1. The UE attaches to PLMN B with USIM\_B.

2. The UE sends Attach / TAU Request to PLMN A with USIM\_A. In the request message, the UE includes Multi SIM indication and MSISDN of USIM\_B to indicate that the UE wants to receive Push Notification via SMS.

3. If the MME allows to send Push Notification via SMS, the MME includes Multi SIM indication to notify that the Push Notification via SMS will be performed.

4. When there is downlink data, the S-GW sends Downlink Data Notification to the MME.

5. The MME may send Paging request to the RAN. The MME also sends Device Trigger request to send Push Notification via SMS to the UE. The MME provides MSISDN of USIM\_B and Push Notification. The Push Notification includes Service Type that triggered Push Notification and PLMN identity. In addition, the MME may provide validity time of the Push Notification message.

6. The SCEF sends Submit Trigger message to the SMS-SC. The SCEF relays Push Notification, MSISDN of USIM\_B and validity time received from the MME.

7. The SMS-SC response to the SCEF.

8. The SCEF response to the MME.

9. The SMS-SC generates SMS message which contains Push Notification. If SMS-SC receives validity time, it sets Validity-Period of the SMS message with the received validity time. The SMS-SC sends the generated SMS message to the UE by using the received MSISDN of USIM\_B.

10. When the UE receives the Push Notification via SMS the UE may send SMS Delivery Report according to the configuration of SMS-SC. In this case, the UE may include Push Notification response. The Push Notification response may indicate that the UE will not respond to the paging.

11. The SMS-SC sends the Message Delivery Report to the SCEF to notify that the SMS is delivered. If the UE sends Push Notification response, the SMS-SC includes the Push Notification response in the message.

12. The SCEF sends Device Trigger Report to notify that the SMS is delivered. If the NEF receives Push Notification response, it is sent to the MME. Based on the received information, the MME knows that whether the UE received Push Notification and whether the UE will respond to the Push Notification.

13. The UE decides whether to receive service in PLMN A considering validity time of the SMS message, Service Type that triggered Push Notification, ongoing services in PLMN B, time stamp of SMS message, etc. If the UE decides to receive service in PLMN A, the UE sends Service Request message to PLMN A with USM\_A.

### 6.12.4 Impacts on services, entities and interfaces

**AMF:**

- handles UE request for Push Notification via SMS.

- requests to send Push Notification via SMS to the SMS-SC via NEF (or SCEF)

**UE:**

- requests and receives information from the AMF for being paged with Push Notifications via SMS.

- handles Push Notification received via SMS.

**NEF:**

- requests to the SMS-SC to send SMS contains Push Notification.

## 6.13 Solution #13: MT service via ePDG/N3IWF

### 6.13.1 Introduction

This solution addresses Key Issue #1: Handling of Mobile Terminated service with Multi-USIM device.

This solution can be used to receive MT IP services (e.g., IMS voice and SMS) on a PLMN via its ePDG or N3IWF, while being connected to another PLMN over 3GPP access.

This solution applies to both 5GS and EPS.

This solution applies to Single Tx Multi-USIM devices with either Single or Dual Rx.

### 6.13.2 Functional Description

This solution allows the UE to access an operator’s IP services (e.g., IMS voice and SMS) on a PLMN without requiring the UE to be connected to the PLMN over 3GPP access. The mechanism works as follows.

1. The UE decides which PLMN to connect over 3GPP access (say PLMN1). The UE then ceases to monitor the other PLMN (PLMN2) over 3GPP access.
2. In order to receive IP service with PLMN2, the UE establishes SIP connectivity via the ePDG/N3IWF of PLMN2 using the user plane connectivity offered by PLMN1.
3. When MT IMS service is triggered in PLMN2, the UE may use one of two possible options. In one option (Alternative A), the UE will switch to PLMN2 to receive IP service. In another option (Alternative B), if PLMN1 allows, the ePDG/N3IWF in PLMN2 uses the user plane connectivity with PLMN1 to establish IP service.



Figure 6.13.2-1: Solution architecture illustrating IMS services

### 6.13.3 Procedures

Figure 6.13.3-1 provides a call flow of the UE selecting one of the PLMNs for 3GPP access, and establishing a connection with the ePDG/N3IWF of the other PLMN to access IP services.



Figure 6.13.3-1: Information flow

NOTE: For the purpose of making the diagram simpler the P-CSCF and S-CSCF have been collapsed into one entity. No changes are made to the IMS architecture.

1a, 1b. The multi-USIM device registers with USIM2 in PLMN2.

2A. In Alternative A, the UE, using USIM2, performs an IMS REGISTRATION with contact address IP1, Registration ID = 1 (e.g. RFC 5626 [13]) over IMS well known DNN/APN.

3A. The CSCF2 performs a third party registration with the SCC AS.

NOTE 1: SCC AS is described in TS 23.292 [11]. Only the Terminating Access Domain Selection (T-ADS) is required.

2B. In Alternative B, in 5GS, the UE may enter MICO mode if allowed, or deregister with PLMN2. In EPS, the UE detaches from PLMN2.

NOTE 2: The UE is assumed to be aware that PLMN1 supports ePDG/N3IWF connectivity to PLMN2. Otherwise, step 2B is performed after step 5.

4. The UE then ceases to monitor PLMN2 over 3GPP access.

5a. The multi-USIM device registers with USIM1 in PLMN1. It attempts to determine if the network supports establishment of user plane connectivity to an ePDG/N3IWF.

5b. The UE may receive an indication from the AMF or MME of PLMN1 about whether it supports establishment of user plane connectivity to an ePDG/N3IWF of the same or different network.

NOTE 3: For example, the UE could attempt to establish a PDU session (5GS) or PDN connection (EPS) to the ePDG using a specific DNN / APN. This would be agreed at an SLA level between operators.

NOTE 4: If the network does not support user plane connectivity to an ePDG/N3IWF, then the UE can only use Alternative A.

6. The multi-USIM creates a secure connection to the N3IWF2 or ePDG using USIM2 using a PDU session that allows access to N3IWF2 or ePDG2 in PLMN2. The IP address used is the one provided by PLMN1, say IP2. The N3IWF2 or ePDG2 is selected using the configuration data associated with USIM2.

NOTE 5: This procedure uses non-3GPP access procedures as defined in TS 23.502 [6] clause 4.12 or TS 23.402 [10]. The PDU session over which the secure connection is established over could be internet access.

7. The UE using USIM2 performs an IMS REGISTRATION using the connection that was established as step 6 with contact address IP2. For:

- Alternative A, this IMS registration contains an indication that it is 2nd IMS REGISTRATION and is related to a MUSIM capable UE; or

- Alternative B, this IMS registration contains an indication that it is 1st IMS REGISTRATION (e.g. Registration ID =1).

NOTE 6: The inclusion of an indication that the IMS REGISTRATION is related to a MUSIM capable UE can be left to Stage 3.

8. The CSCF2 receives an IMS session INVITE for Public User Identity associated with USIM2. The CSCF2 sends the IMS INVITE to the SCC AS. The SCC AS chooses the contact address (IP2) associated with the IMS REGISTRATION. For Alternative A, it includes in the SIP INVITE an indication that the 2nd IMS REGISTRATION should be chosen.

9. The CSCF2 receives the SIP INVITE from the SCC AS, and sends the INVITE to the UE via the ePDG2/N3IWF2 access that was set-up in step 6.

10A. In Alternative A, if the UE determines that it wants to accept the IMS session, then the UE sends a redirect message back to the SCC AS to inform the SCC AS to choose the contact address associated with 1st IMS REGISTRATION.

11A. The UE ceases monitoring PLMN2 over 3GPP, and tunes / moves back to PLMN 2, and establishes user plane resources.

12A.The CSCF2 send the message in step 10A to SCC AS. The SCC AS receives the message in step 12A, determines that there is another IMS REGISTRATION that can be used to establish the session and sends the SIP INVITE to CSCF2 to use the 1st IMS REGISTRATION.

13A. The UE and CSCF2 establish a SIP connection.

10B. In Alternative B, the UE and network will establish user plane resources over PLMN1 to support IMS media traffic via ePDG2/N3IWF2.

11B. The UE and CSCF2 establish a SIP connection.

Editor's note: SA5 will need to be involved if any IMS user and control plane traffic is sent over a PDU session that is carrying data traffic.

### 6.13.4 Impacts on services, entities and interfaces

UE:

- Inquires the AMF/MME for ePDG connectivity, decides which network to connect over 3GPP, and requests user plane resources for ePDG connectivity

- Supports indication of MUSIM IMS REGISTRATION

- Supports providing alternative contact address.

SCC AS

- Supports receiving indication MUSIM related IMS REGISTRATION and using it for subsequent selection of MT service.

## 6.14 Solution #14: Paging collision avoidance by changing NAS parameters

### 6.14.1 Introduction

The solution applies to Key Issue #2 “Enabling Paging Reception”.

The solution is defined for the 5GS, but can be applied to scenarios where the UE is connected to multiple 5GS systems or a mix of 5GS and EPS systems.

The solution relies on the following principles:

- When the UE is assigned a new 5G-GUTI in the Registration Accept message, the UE determines whether the new 5G-GUTI creates collisions with the paging in the other mobile system(s) to which it is registered.

- If a collision is detected upon reception of the Registration Accept, the UE indicates in the Registration Complete message that it would like to receive another 5G-GUTI and includes information to assist the AMF for assignment of the new 5G-GUTI. The assistance information can be in the format of a UE\_ID that provides the best timing of the paging.

- UE\_ID format for E-UTRA/NR is 10bits and for NB-IoT it is 12bits as defined in TS 36.304 [2] and TS 38.304 [3].

- For perfectly overlapping POs (same serving RAN) then the UE\_ID is equal to 5G-S-TMSI (of the other USIM) mod 1024.

- For non-overlapping POs than the UE\_ID should not be equal to 5G-S-TMSI (of other USIM) mod 1024.

- The network subsequently triggers the UE Configuration Update procedure to assign a new 5G-GUTI.

- Additionally, if a collision is detected outside of any ongoing NAS procedure, the UE initiates the Registration Update procedure indicating that it would like to receive another 5G-GUTI and includes information, as mentioned above, to assist the AMF for assignment of the new 5G-GUTI.

The same approach is used when the new 5G-GUTI is assigned via the UE Configuration Update procedure.

### 6.14.2 Functional Description

According to TS 36.304 [2] and TS 38.304 [3] the following is the formula for calculating Paging Frame (PF) and Paging Occasions (POs):

*The PF and PO for paging are determined by the following formulae:*

*SFN for the PF is determined by:*

*(SFN + PF\_offset) mod T = (T div N)\*(****UE\_ID*** *mod N)*

*Index (i\_s), indicating the index of the PO is determined by:*

*i\_s = floor (****UE\_ID****/N) mod Ns*

Where UE\_ID is:

UE\_ID: IMSI mod 1024 (in the EPS)

UE\_ID: 5G-S-TMSI mod 1024 (in the 5GS)

As implied by the mod 1024 operaton in the UE\_ID, the POs are determined only by the last 10 bits of the IMSI (EPS) or last 10 bits of the 5G-S-TMSI (5GS).

Regarding the DRX paprameter ("T" in the equation), it can be one of the following:

- Cell-level DRX (a DRX value pre-configured at the base station and sent to all UEs in a cell through broadcast messages).

- UE-level DRX (for the calculation of PF and PO by the UE in RRC\_IDLE state, the DRX is sent by the core network MME/AMF to the base station, and the base station further transmits the DRX to the UE).

- RAN-level DRX (for the calculation of PF and PO by the UE in RRC\_INACTIVE state, the DRX is also sent by the core network to the base station, and the base station further transmits the DRX to the UE).

Consider the case where a Dual-USIM device is connected to two systems that are synchronized at SFN level for the sake of the argument. Whenever the last 10 bits of the UE\_ID in the two systems to which the UE is registered are the same, there will be a full paging collision (meaning that a single Rx UE will systematically miss the pages in the other system). Even when the last 10 bits of the UE\_ID in the two systems do not match fully and/or if the two systems are not synchornized at SFN level, there can be combinations of UE\_ID that will lead to partial overlap of the POs, which can still lead to degraded performance in terms of paging detection.

It should be noted that the paging occasions in EPS are calculated based on a permanent subscription identifier (IMSI), which means that in the unfortunate case where the IMSIs associated with the two USIM cards are matching in the last 10 bits, the paging collisions will be systematic. This also means that any solution for paging collision avoidance, once activated, will be definitive.

In contrast, the paging occasions in 5GS are calculated based on a temporary identifier (5G-S-TMSI) which can be reassigned over time. The frequency of 5G-S-TMSI reassignment today is left to the operator. Given that the 5G-S-TMSI is used to prevent identity-based tracking, in the extreme case the network can decide to assign a new 5G-S-TMSI every time the UE performs a Mobility Registration procedure. Due to the frequent 5G-S-TMSI reassignment in one or the other system, the possibility for paging collisions can arise at any time.

The last two paragraphs considered the cases where the UE is simultaneously registered to two EPSs or two 5GSs. It is also possible for the UE to be simultaneously registered in EPS (with USIM1) and in 5GS (with USIM2). In this case the paging occasions in EPS will be based on the permanent identifier (IMSI), whereas the paging occasions in 5GS will be based on a temporary identifier (5G-S-TMSI). In this case, too, the possibility for paging collisions can dynamically arise at any time, similar to the case where UE is registered to two 5GSs.

### 6.14.3 Procedures



Figure 6.14.3-1 Paging collision avoidance

1. The Multi-USIM device registers to network-A and network-B respectively. During the registration procedure if the UE desires to have network assistance for collision avoidance (e.g. because the use has activated more than one USIM) the UE indicates Multi-USIM capabilities support and the networks indicate whether they support paging collision avoidance by changing of NAS parameters.

2. The Multi-USIM UE calculates Paging Occasion and it determines whether Paging Collision can happen.

3. If the Multi-USIM UE determines that Paging Collision can happen, the Multi-USIM UE next selects a registered network supporting UE request for change of NAS parameters (e.g., network-B) and performs a Mobility Registration Update on that network. The Registration Request includes a new UE ID request indication and includes information to assist the AMF for assignment of the new 5G-GUTI, e.g. requested UE-ID value or range. The assistance information can be in the format of UE\_ID that provides the best timing of the paging.

4. The AMF allocates a new 5G-GUTI for the Multi-USIM device in the Registration Accept. When the AMF allocates the new 5G-GUTI, the AMF shall consider the assistance information provided by the UE. AMF should not allocate a new 5G-GUTI which does not fulfill the assistance information The AMF may also change the DRX parameters.

5. Upon receiving the new 5G-GUTI, the Multi-USIM UE re-calculates the Paging Occasion for network-B.

NOTE: This procedure is defined for 5GS only. It can also be used in mixed scenarios (i.e. when the UE is connected to both EPS and 5GS), but is always executed only on the 5GS side.

If the UE determines that paging collision can happen upon reception of a new 5G-TMSI in the Registration Accept message, the UE may immediately include a new UE ID request indication in the Registration Complete message including information to assist the AMF for assignment of the new 5G-GUTI. The assistance information can be in the format of UE\_ID that provides the best timing of the paging. The network subsequently triggers the UE Configuration Update procedure to assign a new 5G-GUTI.

### 6.14.4 Impacts on existing entities and interfaces

**AMF:**

- handles UE request for assignment of a new 5G-GUTI, using assistance information provided by the UE.

**UE:**

- determines whether the newly assigned 5G-GUTI creates PO collisions and requests another 5G-GUTI and provides assistance information to the AMF.

## 6.15 Solution #15: Paging collision avoidance by using Alternative UE\_ID in paging procedure.

### 6.15.1 Introduction

The solution applies to Key Issue #2 “Enabling Paging Reception”.

The solution is described for the 5GS but can also be applied to the EPS. The solution is suitable for all scenarios, i.e. where the UE is connected to multiple 5GS systems, a mix of 5GS and EPS systems, or only multiple EPS systems.

The solution relies on the following principles:

- When a UE detects non-optimal paging timing e.g. collision or increased power consumption, the UE may in the Registration Request message indicate that it would like to use the included Alternative UE\_ID solely to determine PF/PO. The Alternative UE\_ID has the same format as the UE\_ID defined in TS 36.304 [2] and TS 38.304 [3].

NOTE: The indication and/or the Alternative UE\_ID may be included in a MUSIM Assistance Information container as there may be other information sent not in scope of this particular solution, but for other solutions.

- The UE\_ID format for E-UTRA/NR is 10bits and for NB-IoT it is 12bits as defined in TS 36.304 [2] and TS 38.304 [3].

- The AMF subsequently confirms the proposed Alternative UE\_ID in the Registration Accept message.

- The AMF includes the Alternative UE\_ID, to be used solely for PF/PO computation, in the N2 paging message when paging the UE, but the other ID(s) i.e 5G-S-TMSI, S-TMSI and/or IMSI used in the paging message is still included.

- RAN uses the Alternative UE\_ID to determine the next PF/PO and pages the UE. In this case the RAN does not derive the UE\_ID from the IMSI or 5G-S-TMSI.

- The Alternative UE\_ID is used for all subsequent PF/PO computations until the UE either revokes it by not including it in a subsequent registration (e.g. due to mobility or periodic) or provides another Alternative UE\_ID for paging in a registration message. The change should not take effect until the request has been confirmed by the AMF.

- This solution, in order to avoid uneven distribution of PO/PFs across devices, assumes that the UE provides a non conflicting Alternative ID which may be:

1. randomized, or

2. a function of the UE\_ID related to the other USIM since this other USIM UE\_ID is in turn assumed to have some built-in randomization.

### 6.15.2 Functional Description

According to TS 36.304 [2] and TS 38.304 [3] the following is the formula for calculating Paging Frame (PF) and Paging Occasions (POs):

*The PF and PO for paging are determined by the following formulae:*

*SFN for the PF is determined by:*

*(SFN + PF\_offset) mod T = (T div N)\*(****UE\_ID*** *mod N)*

*Index (i\_s), indicating the index of the PO is determined by:*

*i\_s = floor (****UE\_ID****/N) mod Ns*

Where UE\_ID is:

UE\_ID: IMSI mod 1024 (in the EPS)

UE\_ID: 5G-S-TMSI mod 1024 (in the 5GS)

As implied by the mod 1024 operaton in the UE\_ID, the POs are determined only by the last 10 bits of the IMSI (EPS) or last 10 bits of the 5G-S-TMSI (5GS).

Regarding the DRX parameter ("T" in the equation),

- Cell-level DRX (DRX pre-configured at a base station is sent to all UEs in a cell through broadcast messages).

- UE-level DRX (for the calculation of PF and PO by the UE in the RRC\_IDLE state, the DRX is sent by the core network MME/AMF to the base station, and the base station is further transmitted the DRX to the UE).

- RAN-level DRX (for the calculation of PF and PO by the UE in the RRC\_INACTIVE state, the DRX is also sent by the core network to the base station, and the base station further transmits the DRX to the UE).

Consider the case where a Dual-USIM device is connected to two systems that are synchronized at SFN level for the sake of the argument. Whenever the last 10 bits of the UE\_ID in the two systems to which the UE is registered are the same, there will be a full paging collision (meaning that a single Rx UE will systematically miss the pages in the other system). Even when the last 10 bits of the UE\_ID in the two systems do not match fully and/or if the two systems are not synchornized at SFN level, there can be combinations of UE\_ID that will lead to partial overlap of the POs, which can still lead to degraded performance in terms of paging detection.

It should be noted that the paging occasions in EPS are calculated based on a permanent subscription identifier (IMSI), which means that in the unfortunate case where the IMSIs associated with the two USIM cards are matching in the last 10 bits, the paging collisions will be systematic. To resolve the systematic collition this solution relies on the use of an Alternative UE\_ID that is not derived from the IMSI.

In contrast, the paging occasions in 5GS are calculated based on a temporary identifier (5G-S-TMSI) which can be reassigned over time. The frequency of 5G-S-TMSI reassignment today is left to the operator. Given that the 5G-S-TMSI is used to prevent identity-based tracking, in the extreme case the network can decide to assign a new 5G-S-TMSI every time the UE performs a Mobility Registration procedure. Due to the frequent 5G-S-TMSI reassignment in one or the other system, the possibility for paging collisions can arise at any time. To resolve the paging collition this solution relies on the use of an Alternative UE\_ID that is not derived from the 5G-S-TMSI.

The last two paragraphs considered the cases where the UE is simultaneously registered to two EPSs or two 5GSs. It is also possible for the UE to be simultaneously registered in EPS (with USIM1) and in 5GS (with USIM2). In this case the paging occasions in EPS will be based on the permanent identifier (IMSI), whereas the paging occasions in 5GS will be based on a temporary identifier (5G-S-TMSI). In this case, too, the possibility for paging collisions can dynamically arise at any time, similar to the case where UE is registered to two 5GSs. To resolve the paging collition this solution relies on the use of an Alternative UE\_ID that is not derived from the either IMSI or 5G-S-TMSI.

### 6.15.3 Procedures

#### 6.15.3.1 Registration including Alternative UE\_ID



Figure 6.15.3.1-1 Paging collision avoidance

1. The Multi-USIM device registers to network-A and network-B respectively, during the registration procedure, the UE may indicate MUSIM capabilities and networks indicate whether to support UE request for change of UE\_ID.

2. The Multi-USIM UE calculates Paging Occasion and determines whether Paging Collision would happen. In this flow the UE has determined that paging collision would happen.

3. The Multi-USIM UE selects a registered network supporting UE request for change of UE\_ID (e.g., network-B) and performs a Mobility Registration Update on that network. The Registration Request includes an Alternative UE\_ID to assist the AMF.

4. The AMF confirms it has accepted the proposed Alternative UE\_ID in the Registration Accept message and stores the Alternative UE-ID in the UE context for use for paging. The AMF also provides the Alternative UE\_ID to the RAN if the RAN supports RRC-Inactive.

5. Upon receiving the confirmation that an Alternative UE\_ID shall be used to determine PF/PO, the Multi-USIM UE re-calculates the Paging Occasion for network-B.

#### 6.15.3.2 Paging with Alternative UE\_ID



Figure 6.15.3.2-1: Procedure for paging with Alternative UE\_ID.

1. UE B register on system B according to TS 23.502 [6] clause 4.2.2.2.2 and adds an Alternative UE\_ID in the registration request. The AMF assigns a 5G-S-TMSI to the UE and acknowledge the request to use the Alternative UE\_ID for paging.
2. Either AMF A or AMF B or both send an N2 paging request message to RAN.
   * 1. AMF A sends the paging message to RAN A that includes the paging ID (5G-S-TMSI) and other information elements needed by the RAN to page the UE A
     2. AMF B sends the paging message to RAN B that includes the paging ID (5G-S-TMSI), Alternative UE\_ID and other information elements needed by the RAN to page the UE B.
3. The RAN calculates the next PF/PO based on the information received in the N2 message.
   * 1. RAN A calculate the next PF/PO based on 5G-S-TMSI according the TS 36.304 [2] or TS 38.304 [3]
     2. RAN B calculate the next PF/PO using the Alternative UE\_ID as the UE\_ID in the algorithm specified in TS 36.304 [2] or TS 38.304 [3]. The paging ID in the paging message is still 5G-S-TMSI.

NOTE: If the RAN A and RAN B is the same node, it may happen that the PF/PO is the same for both UE A and UE B. In that case the UE may monitor two paging records (out of maximum transmitted 16) that includes 5G-S-TMSI (UE A) and 5G-S-TMSI (UE B)

1. The UE(s) reads the paging message(s). In case the UE(s) were registered in systems same system or the systems share the RAN, it may happen that the both UEs 5G-S-TMSI are in the same paging message as two independent paging records.
2. The UE(s) responds to the page(s).

### 6.15.4 Impacts on existing entities and interfaces

**AMF/MME:**

- Handle the UE request for use of an Alternative UE\_ID.

- Store the Alternative UE\_ID in the UE context if one is received from the UE.

- Support including Alternative UE\_ID in the paging request message sent to RAN and using the Alternative UE\_ID to calculate the timing of when to page the UE

- Send the Alternative UE\_ID to the RAN if one is received from the UE (only for AMF).

**UE:**

- Support sending and request of using an Alternative UE\_ID to the AMF/MME and using the Alternative UE\_ID to calculate the timing of PF/PO

**RAN:**

- Support receiving an Alternative UE\_ID in the paging request message and use this in order to determine next PF/PO for paging the UE

- Store the Alternative UE\_ID in the UE context if received from AMF

6.16 Solution #16: Resolving paging occasion conflict in EPS using offset to the IMSI

6.16.1 Introduction

This solution addresses KI# 2

As stated in Key Issue 2, “Paging Occasions (POs) are calculated based on the UE identifier i.e. IMSI and 5G-S-TMSI for EPS and 5GS, respectively”.

For the situation that a MUSIM device is experiencing repeated clashes of POs, other solutions may have proposed that the UE causes the 5G-S-TMSI to be reallocated to a value that avoids PO clashes. Those solutions obviously do not solve the case of a PO clash between multiple EPS SIMs.

For this EPS situation, it is proposed that the UE and MME negotiate an offset to the UE Identity Index Value(s) (c.f. “IMSI mod 1024”) used in the S1-AP Paging message.

Guidance from RAN WG 2 would be useful in determining the useful values of the offset.

A small number of different offset values may be needed to permit 3 and 4 SIM devices to avoid paging clashes.

6.16.2 Functional Description

During the Attach procedure, the MME indicates support (or not) for this feature.

When an EPS UE detects a systematic clash of Paging Occasions between its EPS SIMs, one of the EPS UEs in the MUSIM device sends a TA Update Request (to one of the supporting MMEs) including a new parameter suggesting an “offset value”. The value of the “offset value” (e.g. {1, 3, 5, 7, 11…}) might depend upon how many of the EPS SIMs in a 3/4/5 SIM device are experiencing PO clashes, and, whether a particular offset value would create a different PO clash.

The MME allocates an “offset value” to the UE in the TAU Accept. The UE then starts to use this “offset value” to calculate its Paging Occasion.

After the TAU Complete is received, the MME adds the “offset value” to the value it would have otherwise sent in the UE Identity Index Value field sent in the S1-AP paging message.

NOTE: If the TAU Complete is lost, normal stage 3 procedures apply, e.g. the MME pages with both old and new S-TMSIs using (respectively) the old and new “offset value”.

**Extract from TS 36.413 (S1-AP)**:

#### *9.2.3.10 UE Identity Index value*

*The UE Identity Index value IE is used by the eNB to calculate the Paging Frame TS 36.304 [20].*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| *IE/Group Name* | *Presence* | *Range* | *IE type and reference* | *Semantics description* |
| *UE Identity Index Value* | *M* |  | *BIT STRING (SIZE(10))* | *Coded as specified in TS 36.304 [20].* |

*\*\* end of extract from TS 36.413 \*\**

A **potential update to TS 36.304** section 7.1 “Discontinuous Reception for paging” is **shown** below

*- UE\_ID:*

*If the UE supports E-UTRA connected to 5GC and NAS indicated to use 5GC for the selected cell:*

*5G-S-TMSI mod 1024, if P-RNTI is monitored on PDCCH.*

*else*

***MUSIM Offset +*** *IMSI****)*** *mod 1024, if P-RNTI is monitored on PDCCH.*

***(MUSIM Offset +*** *IMSI****)*** *mod 4096, if P-RNTI is monitored on NPDCCH.*

***(MUSIM Offset +*** *IMSI****)*** *mod 16384, if P-RNTI is monitored on MPDCCH or if P-RNTI is monitored on NPDCCH and the UE supports paging on a non-anchor carrier, and if paging configuration for non-anchor carrier is provided in system information.*

6.16.3 Procedures

These are described above.

6.16.4 Impacts on existing entities and interfaces

UE:

- determine Offset Value based on number of active SIMs, their IMSIs, and the cell configurations;

- support signalling for Offset Value in Attach/TAU Request/Accept

- support modified Paging Occasion calculation based on Offset Value

RAN implementation: none.

- update of TS 36.304 (UE Idle mode spec) likely to be required.

MME/AMF:

- support signalling for Offset Value in Attach/TAU Request/Accept and abnormal case of loss of TAU Complete

- support modified “IMSI mod 1024” calculation based on Offset Value

- non-volatile storage of the Offset Value

S/PGW: none

HSS: none

6.17 Solution #17: Resolving paging conflict using MUSIM Assistance Information.

6.17.1 Introduction

This solution addresses KI# 2

The Assumption underlying this solution are the following:

1. The UE is aware it has >1 USIM active. By active we define a USIM that is related to a SUPI or IMSI registered with a PLMN.
2. The UE is aware of potential paging occasion conflict and can take action to remedy to such conflicts or make sure the impact of resources waste is minimised. There is no need for network side detection of such conflicts.
3. We cannot assume any two USIMs are served by the same PLMN nor same nodes (AMFs or SMFs) inside the PLMN if both are registered in the same PLMN. This may also be impossible even if the USIMs register with the same PLMN as AMF for one USIM may be on a different Slice Set than other USIMs. In other words, the network is not assumed to spend any effort to initiate actions on behalf of MUSIM UEs or derive that a UE is using multiple USIMs based on network side intelligence. It is only the UE responsibility to provide any assistance to the network to improve the system behaviour when it is using multiple USIMs.

Based on the above assumptions, the following considerations can be made:

1) The UE detects whether it is single USIM or MUSIM at any point in time

2) When the UE detects it is MUSIM, it can inform the PLMN for each USIM and indicate to the network MUSIM assistance information in RM/MM messages

3) When the UE detects it transitions back to single USIM, it can indicate this to the PLMN of the remaining USIM by RM/MM message not including MUSIM information. This needs not be instantaneous and may wait till next RM/MM event.

4) When a MUSIM UE detects potential of paging conflict, it can indicate to one PLMN of one USIM (or, in >2 USIMs case, to all applicable PLMNs) assistance information to avoid paging conflict, e.g. a Replacement UE\_ID for paging occasion computation.

5) The MUSIM Assistance Information may include the number of USIMs that are currently active so the PLMN may tune its paging strategy according to this information (e.g. the number of paging attempts from CN and/or RAN could be modified based on this information). The MUSIM-related information should be orthogonal to any existing paging strategy as it is meant to modify it, hence it should be provided to the system in a well identified MUSIM Assistance INFO. This MUSIM Assistance INFO can be provided to the RAN so the RAN adapts the way it pages the UE accordingly. This can be provided to the RAN via N2 in connected mode 9to enable RRC inactive paging strategies) or when a paging message is sent to the RAN via S1 or N2.

6.17.2 Functional Description

When a UE detects it is operating as MUSIM UE (i.e. it has active registrations with >1 USIM) , it provides indication to the PLMNs it registered with that it is a MUSIM UE.

The indication may be based on inclusion in the Registration Request, Attach or TAU or service request messages of MUSIM Assistance Information.

If the UE becomes single USIM because only one registered USIM is left, when the UE registers with this USIM again in the related PLMN but it does not provide any indication it is MUSIM UE (i.e. it does not include any assistance information). This registration may not need to wait for the next periodic or mobility related registration trigger.

When the AMF or MME receive assistance information, they store it in the UE context.

When some of the information is relevant for RRC Inactive state, then the assistance information may be provided to the RAN in PLMNs that support RRC-INACTIVE, when the UE context is configured in the RAN. The MUSIM assistance information may also be provided to the RAN in the N2 Paging message to trigger related behaviour in the RAN for Paging.

The assistance information may include:

1. indication of the number or USIMs so the network may tune its paging strategy as it may e.g. modify the number of paging attempts based on its own policies. It may include indications of periodicity for UE reachability also (e.g. in terms of DRX cycles during which the UE can be reached (or periodicity etc, i.e., with reference to SFN DRX cycle zero is the first from the SFN=0 etc.).

2. Indication of a Replacement UE\_ID for paging or any other information RAN WGs may decide is relevant to modify the timing for PF/PO to avoid overlapping POs across USIMs. If this is a Replacement UE\_ID, this is used in the RAN to compute the PF and PO for the UE. The page message itself is still related to the UE\_ID the UE has obtained from the CN, but the Replacement ID is just used for paging PF/PO computation. Then there are no overlapping PF/PO across USIMs, then this information is not present. When the UE has provided a Replacement PF/PO, this is kept until this would create an overlapping PF/PO for the USIM, in which case the UE updates the network by e.g. omitting the information or by suggesting an alternate Replacement UE\_ID. This Replacement UE\_ID is passed to the RAN in the N2 Paging message for Idle mode, or to the RAN in the UE Context for storage when the UE is RRC-Inactive.

6.17.3 Procedures

#### 6.17.3.1 Providing MUSIM assistance information to the CN

This procedure in figure 6.17.3.1-1 is described using the 5GS but it equally applies to EPS.

The UE provides the MUSIM assistance information in registration procedure and a supporting network acknowledges the reception of the MUSIM assistance information. Figure 6.x.3.1-1 describes in a very high-level manner the procedure. This procedure can be executed at any time whenever the UE needs to update the network with relevant MUSIM Assistance Information. If the UE is RRC connected with the other USIM in the same or another PLMN, this message procedure first requires creating a long enough gap in the RAN serving the other USIM.

When the UE does not need any more MUSIM Assistance information to be sent to the RAN, it registers without it.



Figure 6.17.3.1-1: Providing MUSIM assistance information to a PLMN in Registration messages

1. The UE includes MUSIM Assistance Information in a Registration Request Message (tor provide or update MUSIM assistance information) or a Service Request message (e.g. if the UE needs to update the MUSIM assistance information in the CN) for one USIM.

2. The AMF takes action based on the MUSIM assistance information and stores it in the UE context. The AMF may provide or update, if and as applicable, to the RAN the assistance information relevant to the RAN by N2 message. The RAN stores Assistance Information that applies and retains it when the UE moves to RRC inactive. The MUSIM Assistance Information also passed to the RAN in N2 Paging messages when MT services apply when a UE is in CM-IDLE mode.

3. The AMF acknowledges support of MUSIM assistance information at Registration Accept.

#### 6.17.3.2 Paging

Figure 6.17.3.2-1 is the call flow of Paging collision avoidance procedure.

UE has provided MUSIM assistance information to the AMF as it needs the AMF to perform paging collision avoidance and AMF has accepted the MUSIM assistance information.

AMF will indicate to the UE that the paging collision avoidance procedure is requested by indicating MUSIM assistance information to the RAN.

The AMF includes the paging collision avoidance indication along with N2 paging message to RAN. RAN can decide the mechanism on how to avoid paging collision based on the received MUSIM assistance information.



Figure 6.17.3.1-1: Paging collision avoidance procedure with MUSIM assistance Information

#### 6.17.3.2 Stopping paging on one PLMN

Figure 6.17.3.2-2 shows the UE can request the RAN and CN to stop paging upon receiving a paging message by responding with a SR that includes a stop paging indication. This indication to stop paging installs a (potentially temporary) match all paging filter in the UE context in AMF and SMF that blocks DL paging. To lift this condition the UE must update the MUSIM Assistance Information by a registration procedure (see 6.17.3.1) including indication to either resume the earlier paging filter or a new paging filter or no paging filter. If the UE is RRC connected with the other USIM in the same or another PLMN, this message procedure first requires creating a long enough gap in the RAN serving the other USIM.



Figure 6.17.3.2-2: UE cause the network to stop paging

Note that the RAN immediately releases the connection when it receives the Stop Paging indication in RRC MSG 5. The AMF does not establish any user plane when the MUSIM assistance Information includes Stop Paging indication.

A PLMN may also be provisioned with a timer that lifts the effects of a stop paging indication, or the UE can provide a UE specific timer if this is used to indicate the intention of the UE to return within the specific time.

6.17.4 Impacts on existing entities and interfaces

UE: support of the MUSIM Assistance Information and procedures as specified above

RAN: calculation of PF/PO based on MUSIM Assistance Information, support of Service request specific cause code indicating stop paging

MME/AMF: support of storing and resending MUSIM Assistance Information to the RAN (in N2/S1 messages as applicable. PF/PO calculation, provision of MUSIM Assistance Information, .

SMF/UPF: classification in Classes of Service and filtering per UE according to the paging filters provided in the MUSIM Assistance Information, Classification and Marking in DL for UEs for which filtering applies in RRC inactive mode.

## 6.18 Solution #18: Sending paging on consecutive POs for Multi-USIM UE

### 6.18.1 Introduction

This solution is for Key Issue 2: Enabling Paging Reception for Multi-USIM Device. If Paging Occasions (POs) on more than one RATs overlap in time, the Single Rx MUSIM UE only monitors paging on one RAT, which may lead to unsuccessful paging reception on the other RATs. The solution reuses the existing procedures to address this key issue.

### 6.18.2 Functional Description

The UE alternates paging monitoring on RATs that overlap in time and RAN repeats paging on several consecutive POs. As one of the POs will be monitored by the UE, the paging will be received.

To avoid unnecessary waste of network resources, the first paging attempt on a single PO may not be repeated. If the UE does not respond to the first paging attempt, which may indicate the overlap occurred, then a second paging attempt is made and the paging is repeated on two consecutive POs.

For a UE in RRC\_Idle state, the MME/AMF sends the first attempt of paging with existing Paging Attempt IE within the PAGING message set to ‘1’ to RAN. The RAN pages the UE. If the MME/AMF does not receive respond from the UE, the MME/AMF sends the second attempt of paging with Paging Attempt Count set to ‘2’ to RAN. The RAN pages the UE on consecutive POs.

For a UE in RRC\_inactive state, the serving RAN node sends the first attempt of paging with Paging Attempt Count set to ‘1’ to the RAN nodes within RNA. The RAN nodes within RNA pages the UE without repetition. If the UE does not respond, the serving RAN node sends the second attempt of paging to with Paging Attempt Count set to ‘2’ to the RAN nodes within RNA. The RAN nodes within RNA page the UE on consecutive POs.

The AMF does not differentiate between whether consecutive POs needs to be used when paging a UE. RAN WGs may determine applicability to the UE being paged. This for instance can be based on reusing the UE radio capabilities for paging information the UE provides to the network.

### 6.18.3 Procedures

No additional procedures or procedural changes are required for this solution. It is assumed the RAN adapts its paging behaviour based on UE radio capabilities for paging information the UE provides to the network. It is also assumed the AMF/MME indicate the paging attempt number to the RAN.

### 6.18.4 Impacts on services, entities and interfaces

UE:

* Alternately monitors paging on the overlapped RATs. Provided MUSIM related information in UE radio capabilities for paging.

RAN:

* Send paging on UE’s consecutive POs if the UE does not respond paging after the first attempt of paging

Network:

* send to the RAN the paging attempt number.

## 6.19 Solution #19: UE solution to address overlapping PO

### 6.19.1 Introduction

This solution relates to KI#2 Enabling Paging Reception for Multi-USIM Device. The solution proposes a UE-only approach to handle PO collisions, while not preventing PO collisions to occur.

This solution is based on the observation that, although particular combinations of UE IDs and system parameters used to derive POs can lead to systematic PO collisions, these combinations are neither systematic nor permanent due to 5G‑GUTI re-allocation. When PO collisions occur, the UE can minimize the impact thereof.

### 6.19.2 Functional Description

The solution consists simply in introducing the following requirements:

- A MUSIM device shall be able to identify whether or not PO collisions can occur between the USIMs

- A MUSIM device that has identified PO collisions can occur between the USIMs, shall be able to use UE implementation means to minimize page loss due to collision taking into account paging repetition (for example by selecting the order in which USIMs are operated for paging reception e.g. using a round-robin approach).

### 6.19.3 Procedures

No new procedure is needed.

### 6.19.4 Impacts on existing entities and interfaces

UE:

- Identifying whether collisions can occur.

- USIM selection for paging reception, while ensuring paging reception opportunity for all USIMs

AMF:

* none

RAN:

* none

SMF:

* none

UPF:

- none

## 6.20 Solution #20: Triggering MRU upon PO collision detection

### 6.20.1 Introduction

This solution relates to KI#2 Enabling Paging Reception for Multi-USIM Device. The solution proposes the UE to trigger a Mobility Registration Update when a collision risk is detected by the UE, which prompts the AMF to assign a new 5G-GUTI to the UE.

### 6.20.2 Functional Description

The solution consists in the following:

- A MUSIM device shall be able to identify whether or not PO collisions can occur between the USIMs

- A MUSIM device that has identified PO collisions can occur between the USIMs, initiates a Mobility Registration Update from one USIM’s PLMN indicating the need for a new 5G-GUTI.

Editor’s Note: It is FFS whether a specific indication need to be provided by the UE in the Registration Request message or an existing indication can be reused.

- The AMF assigns a new 5G-GUTI to the UE in the Registration Accept message sent back to the UE, as per existing specification (see 3GPP TS 33.501 [12] clause 6.12.3).

### 6.20.3 Procedures

The figure below illustrates the proposal above.



Figure 6.20.3-1 MRU trigger upon PO collision risk detection

Upon registration the UE is informed the network supports higher paging repetition request.

1. Upon the UE detecting paging collisions will occur between USIMs, the UE initiates a Registration Update procedure in one of the colliding USIMs requesting a new 5G-GUTI from the network.

2. The network returns a Registration Accept to the UE including a new 5G-GUTI.

### 6.20.4 Impacts on existing entities and interfaces

UE:

- Identifying whether paging collisions can occur between USIMs

- Selection of the USIM for which to request a new 5G-GUTI and setting the corresponding indication in the Registration Request message.

AMF:

* Detecting the indication from the UE in the Registration Request message and, as per existing specification, returning a new 5G-GUTI in the Registration Accept message to the UE

RAN:

* none

SMF:

* none

UPF:

- none

## 6.21 Solution #21: Scheduling gap for Multi-SIM UE

### 6.21.1 Introduction

This solution addresses the key issue #2: Enabling Paging Reception for Multi-USIM Device.

### 6.21.2 Functional Description

For the multi-USIM UE, if USIM A is in connected mode and USIM B is in idle or RRC\_INACTIVE mode, then the UE should be able to maintain RRC connection in USIM A but may also be required to tune to USIM B periodically to listen to paging. While the UE is absent from the network where USIM A is camped, if the UE can not receive DL data, it may result in waste of resources and degrade USIM A connected mode performance, e.g. the RAN node for USIM A may determine USIM A has lost the traffic and reduce the scheduling rate.

A proposed solution is to negotiate the “scheduling gap” on USIM A for UE to tune away to USIM B in order to listen to paging and then return to USIM B. Since the tune away for listening paging is happened periodically, the “scheduling gap” negotiated between UE and RAN is applied periodically.

USIM A negotiate the “scheduling gap” with the served RAN node so the UE can tune away from USIM A to perform the USIM B procedures. It is up to RAN2 to decide the procedure that used to negotiate the “scheduling gap” between RAN node and the UE.

But if UE needs to transmit MO data or receives MT data on USIM B, the core network that served for USIM A should be informed, the details should be discussed in Key issue 3.

### 6.21.3 Procedures

The access stratum procedure that the UE and served RAN node create a “scheduling gap” is defined by RAN2.

### 6.21.4 Impacts on existing entities and interfaces

UE

- sends the “scheduling gap” to the served UE in AS signalling. The procedure is decided by RAN.

## 6.22 Solution #22: AS-triggered coordinated leaving

### 6.22.1 Introduction

This solution is a simplified variant of Solution #5 to remove unnecessary flexibility and complexity.

### 6.22.2 Functional Description

The solution consists of the following:

- The UE triggers RRC Leaving including *Release Assistance Indication* (incl. piggybacking of NAS indication of PDU Sessions (not) requiring MT delivery indication) in the RRC Connection release request message.

- Unlike Solution #5, the UE does not select between short or long leave. No absence duration is provided by the UE to the network as this is not accurately predictable by the UE.

- The UE-triggered RRC connection release procedure is controlled by a UE RRC timer started when sending the above *Release Assistance Indication* in the RRC Connection release request message, and at expiry of which the UE proceeds with local RRC connection release (the UE RRC timer value is specified such as to minimize any potential negative impact to user experience) if no response (i.e. RRC Connection suspend/release) is received from the network.

- Upon receiving the RRC Connection release request from the UE, the network explicitly releases or suspends the RRC connection. An RRC inactive timer is started (as per Solution #5) at the expiry of which local RRC release takes place in the UE and in the network (AN/S1 release proceeds) if the UE has not otherwise resumed the RRC connection.

### 6.22.3 Procedures

Procedures are analogous to what is described in Solution #5, but with the simplifications outlined above.

### 6.22.4 Impacts on existing entities and interfaces

UE:

- RRC leaving procedure with (NAS) release assistance info

- NAS and RRC resumption

AMF:

- Reception of (NAS) release assistance info from RAN over N2

- Provides MT data handling info, based on (NAS) release assistance info to the SMF

SMF:

- decides how to handle the PDU session after receiving the MT data handling info from the AMF

- initiates MT data handling instruction to UPF

- receiving return indication and initiate normal MT data handling instruction to UPF

UPF:

- Block the DL data transmission according to SMF's request

RAN:

- UE-initiated RRC leaving procedure with (NAS) release assistance info.

- Provides release assistance info the AMF.

* RRC response message to UE

## 6.X Solution #X: <Solution Title>

### 6.X.1 Introduction

Editor's note: This clause lists the key issue(s) addressed by this solution.

### 6.X.2 Functional Description

Editor's note: This clause outlines solution principles and documents any assumptions made.

### 6.X.3 Procedures

Editor's note: This clause describes high-level procedures and information flows for the solution.

### 6.X.4 Impacts on services, entities and interfaces

Editor's note: This clause describes impacts to existing entities and interfaces.

# 7 Evaluation

Editor's note: This clause will provide a general evaluation of the solutions.

# 8 Conclusions

Editor's note: This clause will capture conclusions from the study.

Annex A:  
Change history

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Change history** | | | | | | | |
| **Date** | **Meeting** | **TDoc** | **CR** | **Rev** | **Cat** | **Subject/Comment** | **New version** |
| 2019-10 | SA2#135 | S2-1910542 |  |  |  | Skeleton agreed at SA2#135 | 0.0.0 |
| 2019-10 | SA2#135 |  |  |  |  | S2-1910542 (skeleton), S2-1910685; S2-1910815; S2-1910687; S2-1910785; S2-1910465; S2-1910816; S2-1910468; S2-1910817; S2-1910818 | 0.1.0 |
| 2019-12 | SA2#136 |  |  |  |  | S2-1912402; S2-1912740; S2-1912689; S2-1912690, S2-1912741; S2-1912692 | 0.2.0 |
| 2020-01 | SA2#136AH |  |  |  |  | S2-2001353, S2-2001642rev1 (S2-2001723), S2-2001672, S2-2001637rev6 (S2-2001719), S2-2001638rev2 (S2-2001720), S2-2001640rev3 (S2-2001721), S2-2001641rev3 (S2-2001722) | 0.3.0 |
| 2020-06 | SA2#139-E |  |  |  |  | S2-2004709; S2-2004710; S2-2004519; S2-2003675; S2-2004520; S2-2004588; S2-2004049; S2-2004589; S2-2003764; S2-2004590; S2-2004599; S2-2004600; S2-2004591; S2-2004218; S2-2004601; S2-2004592; S2-2004050; S2-2004593; S2-2004711; S2-2004595; S2-2004596; S2-2004602; S2-2004597; S2-2004598; S2-2004712; | 0.4.0 |