3GPP TSG-RAN WG2 Meeting #112e R2-20xxxxx

Online, 2-13 November 2020

**Agenda item: X.X.X**

**Source: vivo**

**Title: [DRAFT] E-mail discussion: [Post111-e][917][Multi-SIM] Multi-Sim (vivo)**

**WID: LTE\_NR\_MUSIM-Core**

**Document for: Discussion and Decision**

# 1 Introduction

This document aims to collect views from companies for the following email discussion agreed during RAN2#111e:

* [Post111-e][917][Multi-SIM] Multi-Sim (vivo)

Reply LS prep. Identify Topics that need conclusion and that can benefit from pre-discussion in order to produce replies to LS from SA2. For each such topic, with reasonable ambition level, identify main proposals on the table and their main characteristic (in preparation for discussion and potential decisions at next meeting), aim to have a reply LS at next meeting with at least partial responses.

Scope: WI Scope clarification a first step: Clarify use cases for each objective and collect opinions on priority/urgency when applicable (in preparation to agree clarifications and agree necessary use cases/scope to proceed with the work next time, e.g. for switching notification).

 Intended Outcome: Report

 Deadline: Tuesday 13 OCT 0700 UTC

# 2 Discussion

## 2.1 SA2 LS related questions

### 2.1.1 Paging collision

Multi-USIM UE with single Rx cannot simultaneously monitor paging on more than one 3GPP networks (in this paper UE with two USIMs will be considered as a typical example for multi-USIM UE). If the paging occasions (POs) of the two USIMs overlap in time, paging reception collision occurs. The UE needs to select one of the networks to monitor when the UE is in RRC\_Idle or RRC\_Inactive in both networks, which may lead to paging missing on the other network. The paging reception collision may periodically occur at the UE, having an impact on the user experience. SA2 has discussed potential solutions that may address the paging reception collision issue and asks RAN2 to assess the feasibility and effectiveness of the following paging collision solutions [1].

|  |
| --- |
| *-* ***Option 1****: UE -requested 5G-GUTI reassignment for one USIM using the Mobility Registration Update. However, it should be noted the 5G-GUTI is systematically reassigned by the network during the Mobility Registration Update procedure (as of Rel-15) requires. Proposed for 5GS only.**-* ***Option 2:*** *Changes related to the UE\_ID (UE Identity Index) that is used for calculation of PF/PO only:**-* ***Option 2a*** *Calculation of PF/PO by using an Alternative UE\_ID I. The UE ID sent in the paging message is not impacted by this Alternative ID that is only used for PO/PF calculations Proposed for both EPS and 5GS.**-* ***Option 2b*** *Calculation of PF/PO by using a UE\_ID which is derived from IMSI+offset value. The offset value is negotiated between UE and MME. Proposed for EPS only.* *-* ***Option 2c*** *Calculation of PF/PO based on MUSIM Assistance Information which can carry either a paging policy selector in RAN or an Alternative ID (like in the solution above) or a pattern of availability (e.g. specific SFN Slots/ DRX cycles).**-* ***Option 3*** *Repeating paging in the RAN on consecutive POs. for MUSIM devices.**-* ***Option 4*** *UE Implementation-based solution to address overlapping POs (like today)**-* ***Option 5*** *Access Stratum-based solution with scheduling gap.*Q8: SA2 would like to ask RAN2 whether these approaches are all feasible and effective for paging reception when paging collisions are detected in 5GS and in EPS respectively. |

The above **Option5 (***Access Stratum-based solution with scheduling gap***)** is not used to address the paging collision issue and will be discussed in section 2.1.2.1, hence we focus on the **option 1** to **option 4** in this section. Companies are invited to comment on whether these approaches are all feasible and effective for paging reception when paging reception collision is detected.

**Question 1 (Q8 in [1]): When paging collision is detected, is the approach Option 1 (*UE-requested 5G-GUTI reassignment*) feasible and effective for the UE to solve the paging collision issue in 5GS?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Feasible (Comments)** | **Effective (Comments)** |
| OPPO | Yes  | Maybe. We think it is possible that the new 5G-GUTI can solve the paging collision issue. But we also agree that the new 5G-GUTI does not work. It is up to AMF and available 5G-GUTIs to ensue the new 5G-GUTI works. |
| Lenovo, MotM | Not for RAN2 to conclude | Yes, SA2 has asked our view on this but RAN2 does not expertise in the 5G identities. So, we can’t say what the repercussions will be or how much acceptable this may be to operators. What happens if the reassigned GUTI does not work as well?If SA2 intends to ask RAN2 if it is feasible to release the RRC Connection and initiate afresh establishment of RRC Connection (to initiate a new Service Request/ TAU), it is feasible from RAN2 pespective. But then again, it is operator network configuration whether to reassign GUTI every time, as we understand. If a UE changes Idle-Connected every minute, the AMF may be configured to not change the GUTI every time, but say every upon each 10th SR. Furthermore, the mobile registration update is associated with only idle mode rather than both idle and inactive modes. We need to pusue one single solution to cover both CN paging and RAN paging. If the inactive state is considered, the inactive UE has to transit to idle mode then perform mobile registration update.  |
| Vodafone | Making “paging collision” an extra trigger for a non-periodic registration update is feasible. | The analysis in Vodafone’s R2-2006540 is transferrable to 5GC-NR and shows that this approach will work “by chance” in most cases (as the new GUTI is randomly selected).  |

Summary: TBD

**Question 2 (Q8 in [1]): When paging collision is detected, is the approach Option 2a (*Calculation of PF/PO by using an Alternative UE\_ID*) feasible and effective for the UE to solve the paging collision issue in EPS and 5GS respectively?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Feasible (Comments)** | **Effective (Comments)** |
| OPPO | Yes  | Maybe. The same reason as Qustion 1.We cannot see the essential difference between the option 1 and option 2a. We prefer option 1 due to no spec impact. |
| Lenovo, MotM | Yes | Depends on how the Alternative UE\_ID is calculated, derived or signalled. What ensures that the new Alternative UE\_ID will not lead to any further collisions? These are details that needs to be delved into to judge effectiveness. |
| Vodafone | Making “paging collision” an extra trigger for a non-periodic registration update is feasible. | The analysis in Vodafone’s R2-2006540 is transferrable to 5GC-NR and shows that this approach should work.  |

Summary: TBD

**Question 3 (Q8 in [1]): When paging collision is detected, is the approach Option** **2b (*Calculation of PF/PO by using a UE\_ID which is derived from IMSI+offset value*) feasible and effective for the UE to solve the paging collision issue in EPS?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Feasible (Comments)** | **Effective (Comments)** |
| OPPO | Yes. | Maybe. The same reason as Qustion 1.We cannot see the essential difference between the option 1 and option 2a/2b. We prefer option 1 due to no spec impact. |
| Lenovo, MotM | Yes | Same answer as above (for offset).  |
| Vodafone | We believe that this approach is feasible and has no impact on RAN implementation.Further reasoning and analysis of potential offset values is provided in R2-2006540. | The analysis of offset values in R2-2006540 shows that this method can be effective. |

Summary: TBD

**Question 4 (Q8 in [1]): When paging collision is detected, is the approach Option 2c (*Calculation of PF/PO based on MUSIM Assistance Information*) feasible and effective for the UE to solve the paging collision issue in EPS and 5GS respectively?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Feasible (Comments)** | **Effective (Comments)** |
| OPPO | Not necessary. | We think the network will ensure the new configuration will solve the paging collision issue.Furthermore, we also think the paging collision is a low possibility issue. |
| Lenovo, MotM | Maybe | Again, when and how’s this done – what’s the full solution?Is it about adding a pre-agreed/ configured offset on the PF/ PO calculated as in legacy? UE decides on which USIM it needs assistance and requests network’s assistance upon discovering collision (receiving a GUTI upon Registration). |
| Vodafone | Making “paging collision” an extra trigger for a non-periodic registration update is feasible. | Solution not reviewed yet. |

Summary: TBD

**Question 5 (Q8 in [1]): When paging collision is detected, is the approach Option 3 (*Repeating paging in the RAN on consecutive POs*) feasible and effective for the UE to solve paging collision issue in EPS and 5GS respectively?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Feasible (Comments)** | **Effective (Comments)** |
| OPPO | YesIt is already supported in R16 NR-U.It can be resued. | Yes |
| Lenovo, MotM | Maybe | Uncertain about “consecutive”: It depends on UE’s radio situation in two different radios, willingness of the operator to expend so much more resources as the paging propogation of a higher repeated paging can be very costly, switching time for the Rx etc. A more static and away POs (i.e. not just extended) in two systems can be more reliable. From that perspective, not CONSECUTIVE POs but rather POs shifted by an offset could be foolproof, allowing the UE to finish in the first system, retune and still have sufficient opportunities in receiving Paging in the second system. |
| Vodafone | This is NOT a feasible solution.Note: In at least EPC, paging repetition is a core network feature not a RAN feature.Repeating the paging locally in the RAN can significantly waste paging resources as there is a good chance that the UE has responded to the first page in a different cell.The CN normally retransmits soon after the DRX interval has expired. Hence, for a first ‘collided’ page sent on Paging Occasion N, the page retransmission is likely to be sent on paging occasion N+2, and so a mobile that alternates between the two networks will miss both pages! | This is NOT an effective solution. |

Summary: TBD

**Question 6 (Q8 in [1]): When paging collision is detected, is the approach Option 4 (*UE Implementation-based approach*) feasible and effective for the UE to solve the paging collision issue in EPS and 5GS respectively?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Feasible (Comments)** | **Effective (Comments)** |
| OPPO | Yes  | Yes we also think the paging collision is a low possibility issue. |
| Lenovo, MotM | Effective to reduce the paging collision possibility/unfeasible to avoid the paging collision | As our immediate (SIB24) example experience has demonstrated, UE implementation are not always sane, even after clear specification. According to TR2376, UE implementation only minimizes the impact from the issue. There is no UE implementation solution to avoid the PO collision. |
| Vodafone | This is likely to have the same disadvantages as mentioned in our answer to question 5. | This is likely to have the same disadvantages as mentioned in our answer to question 5. |

Summary: TBD

In the LS [1], SA2 asks RAN2 and RAN3 to take the above solutions into consideration. In addition, SA2 asks RAN2 to provide feedback including proposals from RAN that SA2 may have not yet considered. Hence:

**Question 7 (Q9 in [1]): Companies are invited to provide other solutions (if any), in 5GS and EPS respectively, for paging reception collision if any, with comments on the feasible and effective for paging reception.**

* **Option X**

|  |  |  |
| --- | --- | --- |
| **Company** | **Option** | **Comments** |
|  |  |  |
|  |  |  |

Summary: TBD

Some companies, in SA2, believe that the RAN plenary decision on “No E-UTRA impact” restriction is only related to layers RRC and below. Other companies believe that the restriction also includes no impact on S1\_AP and NG\_AP. It would be helpful for SA2 to get the correct definition of the WI restriction from RAN WGs. Thus, companies are invited to express their view on the WI scope related to paging collision with regard to “No E-UTRA impact” restriction [1].

**Question 8 (Q10 in [1]): Do companies understand that the “No E-UTRA impact” restriction applies to?**

1. **Only RRC layer and below**
2. **S1\_AP, NG\_AP, RRC layer and below**

|  |  |  |
| --- | --- | --- |
| **Company** | **Option** | **Comments** |
| OPPO | b) | “No E-UTRA impact” means no impact on LTE RAN node, including the impact from air interface and also other interface, e.g. S1 and NG interfaces. |
| Vodafone | A | E-UTRA relates to the radio interface not the S1-AP signaling.Vodafone does not accept that changes to the NAS parameters used in the PO/PF calculation in TS 36.304 constitute a change to E-UTRA. |
| Lenovo, MotM | b) | ‘No E-UTRA impact’ means no change for the Uu, S1 and NG interface. |

Summary: TBD

### 2.1.2 UE switching/leaving

#### 2.1.2.1 Scheduling gap for paging reception

SA2 has discussed scheduling gap solution described as follows in TR 23.761.

|  |
| --- |
| *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 happens 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.* |

About Question 8 in LS [1], one option is mentioned:

|  |
| --- |
| *-* ***Option 5*** *Access Stratum-based solution with scheduling gap.*Q8: SA2 would like to ask RAN2 whether these approaches are all feasible and effective for paging reception when paging collisions are detected in 5GS and in EPS respectively.  |

Based on RAN WI objective, it can be considered as switching notification case, from RAN2 point of view, rather than paging collision; because UE is in RRC\_Connected state in network A. Hence, the rapporteur invites companies to provide their views on the following **scheduling gap** question.

**Question 9 (Q8 in [1]): When paging reception in one network collision with data transmission in another network is detected, is the approach of *Access Stratum-based solution*** ***with scheduling gap* feasible and effective for the UE to solve the paging reception issue in 5GS and EPS respectively?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Feasible (Comments)** | **Effective (Comments)** |
| OPPO | Yes, but it may be not necessary. | The UE will monitor the paging, receive the updated systeminformantion and perfrom measurement and cell reselection.We think will need to switch to USIM-B for the above cases, e.g. pagin reception, SI reception and measurement and cell reselection.We agree the gap works. But we also think the UE can use automous gap, and UE idle period to perfrom the above cases. |
| Lenovo, MotM | Yes | Using scheduling gap or away time for receiving paging is useful for a single Rx UE. This avoids or minimizes potential degradation of user experience with regards to the first system by allowing the control on the network side. |
| Vodafone  | Yes, but this is not a solution only a work around  | Further work and investigation is required to better undersand how this technique would work  |

#### 2.1.2.2 UE busy indication

SA2 has agreed on the scenario where a multi-USIM device, having an ongoing communication in network A while received a paging message in network B by using a negotiated periodic absence time, evaluates the ongoing communication in network A is more important and may switch to network B to indicate that the UE has received the paging but cannot set up the communication. After notifying the “busy” situation to network B, UE would return to Network A.

SA2 expects RAN2 to address the following points: *What is the expected time (in ms) required for UE to send a (NAS) Busy Indication for Network A and whether a scheduling gap would be needed?* [1]

For the convenience of the expected timing estimation, the procedure for sending a busy indication in TR 23.761 is shown in Figure 1, for more details please see Appendix A.



Figure 1: send a busy indication as a paging response

Moreover, according to TR 37.910, TR 36.912, TS 36/38.331, the assumptions of the referred components for time estimation for sending a NAS busy indication in NR and LTE are also shown in Table 1.

Table 1 Assumption for sending a NAS busy indication

|  |  |  |  |
| --- | --- | --- | --- |
| Step | Description | Latency in NR [ms] | Latency in LTE [ms] |
| 1 | Monitoring PO and decoding the paging message | 4 | 4 |
| 2 | Delay due to RACH scheduling period | Depend on the PRACH configuration [6.3.3, TS 38211] | 2.5 on average  |
| 3 | Transmission of RACH Preamble | Length of the preamble according to the PRACH format [6, 38211] | 1 |
| 4 | Preamble detection and processing in RAN | Tproc,2 (assuming d2,1=0)  | 2 |
| 5 | Transmission of RA response | the length of 1 slot  | 1 |
| 6 | UE Processing Delay (decoding of scheduling grant, timing alignment, and C-RNTI assignment + L1 encoding of RRC Connection Setup Request) | *N*T,1*+N*T,2*+*0.5ms [8.3, TS 38213] | 4 |
| 7 | Transmission of RRC Connection Setup Request | the length of 1 slot  | 1 |
| 8 | Processing delay in RAN (L2 and RRC) | 3 | 3 |
| 9 | Transmission of RRC Connection Setup | the length of 1 slot  | 1 |
| 10 | Processing delay in UE of RRC Connection Setup including grant reception | 10 | 15 |
| 11 | Transmission of RRC Connection Setup complete (including NAS Service Request) | the length of 1 slot  | 1 |
| 12 | Processing delay in RAN (Uu –> S1-C/NG-C) | 4 | 4 |
| 13 | S1-C/NG-C Transfer delay | T  | T |
| 14 | MME/AMF Processing Delay | 15  | 15 |
| 15 | S1-C/NG-C Transfer delay | T  | T |
| 16 | Processing delay in RAN (S1-C/NG-C –> Uu) | 4  | 4 |
| 17 | Transmission of RRC Connection Release | the length of 1 slot  | 1 |
| NOTE: 1. in step 4, Tproc,2 is used only for evaluation. RAN processing delay may vary depending on the implementation.
2. in step 8, the delays due to inside-gNB/eNB or inter-gNB/eNB communication are not included. Such delays may exist depending on deployment.
 |

Based on the above information, companies are invited to provide their views on the below question.

**Question 10a (Q4 in [1]): What is the expected time (in ms) required for UE to send a (NAS) busy indication to Network B?**

|  |  |  |  |
| --- | --- | --- | --- |
| **Company** | **For LTE** | **For NR** | **Comments** |
| OPPO | We think the busy indication is only for “MO-signalling” purpose, so we think maybe we don’t need a long period gap, we can use the TDM gap pattern to send busy indication in order not to impact the service as much as possible. | We think the busy indication is only for “MO-signalling” purpose, so we think maybe we don’t need a long period gap, we can use the TDM gap pattern to send busy indication in order not to impact the service as much as possible. | For idle mode UE in USIM-B, we think a NAS busy indication will be tanferred to he AMF.For RRC\_INACTIVE mode UE in USIM-B, we think a RRC busy indication will be transferred to the anchor RAN.Proposal: we can remobve the “(NAS)” wording from the above sentence. |
| Lenovo, MotM | Till message 11, assuming the service request is part of NAS SR | Till message 11, assuming the service request is part of NAS SR |  |
| Vodafone  | Variable depending on how the network and the UE react end-to-end  | Variable depending on how the network and the UE react end-to-end | This latency is very much dependent on the implementation and the network behaviou/ latencies for both 5G and the LTE cases, we would required indicative lower and upper bound of the expected delay in responding  |

Summary: TBD

And SA2 also asked SA2 whether a scheduling gap is needed or not. Based on TR 23.761, the scheduling gap is negotiated in network A for the UE to monitor the paging occasion and send the busy indication in network B. Companies are invited to provide their views on the below questions.

**Question 10b (Q4 in [1]): Would a scheduling gap be needed for network A to enable the UE to monitor the paging occasion and send the busy indication in network B?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Comments** |
| OPPO | Yes  | We think the busy indication is only for “MO-signalling” purpose, so we think maybe we don’t need a long period gap, we can use the TDM gap pattern to send busy indication in order not to impact the service as much as possible. |
| Lenovo, MotM | Yes | For a single Rx UE, scheduling gap is needed for both activities.For a two Rx UE, scheduling gap is needed for sending Busy indication. |
| Vodafone  | Yes  | the thing to note here is that this scheduling gap has to occue between the Paging Occasions of Network A to monitor Network B |

Summary: TBD

Potentially, in response to the paging message, it can be possible that UE sends the busy indication in RRC Msg3 without RRC connection. For RRC inactive UE, the security is activated when sending the RRC connection resume request message, thus the UE can include the busy indication in the RRC connection resume request message. The network can release the UE as a response. However, the security cannot be guaranteed for RRC idle state UE if the busy indication is included in the Msg3 without RRC connection. Companies are invited to provide their views on the below question.

**Question 11 (Q5 in [1]): Is it feasible (and secure) that the busy indication is sent as an RRC message instead (no NAS message to the CN) i.e. as an RRC response to paging without requiring an RRC connection?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Comments** |
| OPPO | Yes  | For idle mode UE in USIM-B, we think a NAS busy indication will be tanferred to he AMF.For RRC\_INACTIVE mode UE in USIM-B, we think a RRC busy indication will be transferred to the anchor RAN. |
| Lenovo, MotM | Yes | For RRC\_Inactive UE it works as the proponent described. The remaining question will be if RAN2 would prefer a unified solution for RRC Inactive and RRC Idle UEs. |
| Vodafone  | Yes  | Agree with above:In idle mode,, the busy indication to be sent over NASand in inactive state , the busy message sent over RRC however we are open to hear other options if it is practical  |

Summary: TBD

#### 2.1.2.3 UE switching/leaving and returning

In the LS [1], there are the below assumptions about the RRC-based leaving and returning:

|  |
| --- |
| *- Leaving is always triggered by the UE with an RRC request to the network. The UE leaves either upon explicit acknowledgement by the network, or by a given time if no (RRC-level) acknowledgement is received from the network.**- The UE may be released to either RRC Inactive or RRC Idle based on available information (e.g. Assistance information, configuration).**- The UE uses the above to perform a MO procedure (e.g. periodic mobility registration, keep-alive message, sending (NAS) busy indication, etc.) or a MT procedure (e.g. pick-up an SMS, inspect a MT service invite, respond to a network-initiated C-plane procedure, etc.) in the other network.* *NOTE 1: In addition to the above assumptions, there is a proposal that if the UE does not return for a time period, the UE autonomously enters RRC Idle from RRC Inactive, and RAN also autonomously moves the UE RRC state into RRC Idle from RRC Inactive.* |

Companies are invited to express their view on the following questions:

**Question 12 (Q6 in [1]): Is it feasible to define an RRC-based switching/leaving and returning procedure in 5GS/NR?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Comments** |
| OPPO | No  | No matter the UE is released to RRC\_IDLE or RRC\_INACTIVE after switching, the AMF should be inlvoved. So we think the common solution should be defined, the NAS based switching is enough. |
| Lenovo, MotM | Yes | We assume here that RAN is in control of the UE’s state changes and it keeps the CN informed.Regarding SA2’s note 1 “*if the UE does not return for a time period, the UE autonomously enters RRC Idle from RRC Inactive, and RAN also autonomously moves the UE RRC state into RRC Idle from RRC Inactive*”, we think that this behaviour is feasible. Such procedure provides efficient use of the radio resources, i.e. controlled transition from RRC-Inactive to RRC-Idle without explicit signaling. |
| Vodafone  | too early to comment  | Further work and invstigation is required to make a definite decision on this feature  |

Summary: TBD

#### 2.1.2.4 LTE/5GC related

The RAN2 WI scope on UE switching is described as:

|  |
| --- |
| Specify mechanism for UE to notify Network A of its switch from Network A (for MUSIM purpose) [RAN2]:* + RAT Concurrency: Network A is NR. Network B can either be LTE or NR.
	+ Applicable UE architecture: Single-Rx/Single-Tx, Dual-Rx/Single-Tx
 |

SA2 asks RAN2 to clarify the WI scope on whether changes to 5GS/E-UTRA (Option 5, i.e. LTE eNB connected to 5GC) to support RRC-based switching is part of RAN Work Item. Companies are invited to express their view on UE switching to 5GS/E-UTRA (Option 5) to support RRC-based switching.

**Question 13 (Q7 in [1]): Do you agree that changes to 5GS/E-UTRA (Option 5) to support RRC-based switching is part of RAN Work Item?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Comments** |
| OPPO | No  | No matter the UE is released to RRC\_IDLE or RRC\_INACTIVE after switching, the AMF should be inlvoved. So we think the common solution should be defined, the NAS based switching is enough. |
| Lenovo, MotM | Yes |  |

Summary: TBD

### 2.1.3 Paging Cause

SA2 has discussed to introduce paging cause in the paging message. Based on the paging cause, one UE can determine whether to interrupt the ongoing service on the other network and respond to the paging. The introduced paging cause avoids the UE to respond to the paging triggered by service with low priority, thus minimizing the impact on the ongoing service in the other network. More details about the paging cause solutions in TR 23.761 can be found in Appendix B.

In SA2 LS [1], RAN2 is asked about the feasibility of paging cause on Uu interface for EPS and 5GS respectively, and the overhead of sending a paging cause in paging message on Uu.

There are some extension fields in both LTE/NR paging message which can be used for paging causes. The Rel-16 extension has been added to the paging record (*accessType, mt-EDT*) by a parallel list [31]. The parallel list approach was adopted as it introduces lower overhead. If we follow the same extension solution for paging cause, an example of parallel list *PagingRecordList-v17xy* in LTE is the following:

***Paging* message**

-- ASN1START

Paging ::= SEQUENCE {

 pagingRecordList PagingRecordList OPTIONAL, -- Need ON

 systemInfoModification ENUMERATED {true} OPTIONAL, -- Need ON

 etws-Indication ENUMERATED {true} OPTIONAL, -- Need ON

 nonCriticalExtension Paging-v890-IEs OPTIONAL

}

*… omit part …*

Paging-v1610-IEs ::= SEQUENCE {

 pagingRecordList-v1610 PagingRecordList-v1610 OPTIONAL, -- Need ON

 uac-ParamModification-r16 ENUMERATED {true} OPTIONAL, -- Need ON

 nonCriticalExtension Paging-v17xy-IEs OPTIONAL

}

Paging-v17xy-IEs ::= SEQUENCE {

 pagingRecordList-v17xy PagingRecordList-v17xy OPTIONAL, -- Need ON

 nonCriticalExtension SEQUENCE {} OPTIONAL

}

PagingRecordList ::= SEQUENCE (SIZE (1..maxPageRec)) OF PagingRecord

PagingRecordList-v1610 ::= SEQUENCE (SIZE (1..maxPageRec)) OF PagingRecord-v1610

PagingRecordList-v17xy ::= SEQUENCE (SIZE (1..maxPageRec)) OF PagingRecord-v17xy

PagingRecord ::= SEQUENCE {

 ue-Identity PagingUE-Identity,

 cn-Domain ENUMERATED {ps, cs},

 ...

}

PagingRecord-v1610 ::= SEQUENCE {

 accessType-r16 ENUMERATED {non3GPP} OPTIONAL, -- Need ON

 mt-EDT-r16 ENUMERATED {true} OPTIONAL -- Need ON

}

PagingRecord-v17xy ::= SEQUENCE {

 pagingCause-r17 ENUMERATED { voice, spare1, spare2, spare3, spare4, spare5, spare6, spare7} OPTIONAL -- Need ON

}

*… omit part …*

-- ASN1STOP

Similarly, the below ASN.1 text is an example of NR paging message change, which creates a parallel list *PagingRecordList-v17xy* to include paging causes.

***Paging* message**

-- ASN1START

-- TAG-PAGING-START

Paging ::= SEQUENCE {

 pagingRecordList PagingRecordList OPTIONAL, -- Need N

 lateNonCriticalExtension OCTET STRING OPTIONAL,

 nonCriticalExtension Paging-v17xy-IEs OPTIONAL

}

Paging-v17xy-IEs ::= SEQUENCE {

 pagingRecordList-v17xy PagingRecordList-v17xy OPTIONAL, -- Need N

 nonCriticalExtension SEQUENCE {} OPTIONAL

}

PagingRecordList ::= SEQUENCE (SIZE(1..maxNrofPageRec)) OF PagingRecord

PagingRecordList-v17xy ::= SEQUENCE (SIZE(1..maxNrofPageRec)) OF PagingRecord-v17xy

PagingRecord ::= SEQUENCE {

 ue-Identity PagingUE-Identity,

 accessType ENUMERATED {non3GPP} OPTIONAL, -- Need N

 ...

}

PagingRecord-v17xy ::= SEQUENCE {

 pagingCause-r17 ENUMERATED {voice, spare1, spare2, spare3, spare4, spare5, spare6, spare7} OPTIONAL -- Need N

}

PagingUE-Identity ::= CHOICE {

 ng-5G-S-TMSI NG-5G-S-TMSI,

 fullI-RNTI I-RNTI-Value,

 ...

}

-- TAG-PAGING-STOP

-- ASN1STOP

After adding the paging causes via the above parallel list approach for NR and E-UTRA, the overhead per UE includes encoding of ASN.1 preamble (i.e. used to indicate whether *pagingCause* is included for the intended UE) and paging cause, which is mainly decided by the number of potential paging causes (i.e. the length of *pagingCause*).

As a result, the increased overhead per UE can be calculated as below:

Overhead\_per\_UE <N bits>= preamble <1 bit> + Paging\_cause\_encoding<M bits>

Where M is given by the following formula:

$$M=⌈ log\_{2}number\\_of\\_paging cause ⌉$$

Typically, if 8 paging causes are defined, the paging cause encoding will occupy 3 bits, and the increased overhead is 4 bits per UE.

**Observation 1: The overhead of paging cause is (1+**$⌈ log\_{2}number\\_of\\_paging cause ⌉$**) bits per UE in E-UTRA and NR, if parallel list, the extension solution adopted in R16 E-UTRA paging message, is applied for introducing paging causes**.

Now, SA2 asks RAN2 to discuss the following points:

**Question 14 (Q1 in [1]): Do companies think it is feasible to have paging cause on Uu for EPS and 5GS, and do companies agree with the analysis in Observation 1? If not, please provide alternatives.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Overhead** |
| OPPO |  | we think it is too early to discuss the paging cause issue. It should be up to SA2 decision.For the first email discussion, it is also too early to discuss the ASN.1 issue. |
| Lenovo, MotM | Yes | The direction for overhead calculation is correct. |
| Vodafone  | too early to make a decision  | Further work and investigation is required |

Summary: TBD

Furthermore, SA2 also asks whether the introduced paging cause (e.g. 3-4bits) per UE in the paging message would reduce the number of paging records that could be included in a single paging message, and if so by what magnitude (for NR and E-UTRA).

The current NR paging message size is ~210 bytes when 32 paging records are included. Supposing 3-bit paging cause is defined, the increased overhead per UE is 4 bits. Moreover, extra 7 bits are introduced for *Paging-v17xy-IEs extension.* The total message size is ~227 bytes. A maximum TBS size of 3000 bits for PDSCH carrying paging records [30] is enough to cover the new NR paging message.

The current E-UTRA paging message size, based on TS 36.331-g11, is ~140 bytes (assume UE ID is using *ng-5G-S-TMSI*) when 16 paging records are included. Supposing 3-bit paging cause is defined, the overhead per UE is 4 bits. Moreover, extra 6bits are introduced for *Paging-v17xy-IEs extension*. The total message size is ~149 bytes. As specified in TS 36.213, sec 7.1.7.2, the network has space to decide the suitable MCS (range [0,9]) and  to support the new E-UTRA paging message.

Based on the above discussion, companies are invited to express their view on the following questions.

**Question 15 (Q2 in [1]): If the paging cause (e.g. 3-4bits per UE) is added into the paging message, will the number of paging records that could be included in a single paging message be reduced? If yes, by what magnitude (for NR and E-UTRA, respectively)?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Comments** |
| OPPO |  | we think it is too early to discuss the paging cause issue. It should be up to SA2 decision.For the first email discussion, it is also too early to discuss the ASN.1 issue. |
| Lenovo, MotM | Yes on paper | Yes, assuming the size of the Paging message may not exceed the full size in rel. 16, there can be a maximum of 30 records included instead of 32. This may not be a problem in most cases. But if there are real problems in field when 32 Paging records are ‘often’ required to be included, a Paging extension may be desirable especially if something more than just paging cause needs to be included.RAN1 may also need to be asked to see if there are implications on shrinking of Paging coverage if the Paging message size is increased by around 5%. |

Summary: TBD

**Question 16 (Q3 in [1]): Please indicate how the paging cause is expected to be supported in RAN nodes (for NR and E-UTRA)?**

1. **Option A: Per PLMN**
2. **Option B: Per TA**
3. **Option C: Per Ran Node**
4. **Option D: Per Cell**
5. **Option E: Other**

|  |  |  |
| --- | --- | --- |
| **Company** | **Option** | **Comments** |
| OPPO | Option A | we think it is too early to discuss the paging cause issue. It should be up to SA2 decision. |
| Lenovo, MotM | Option A | From the UE perspective it is better to assume that the support (or not support) for Paging cause is PLMN wide. |

Summary: TBD

## 2.2 RAN2 WI use cases (objectives) priority

As described in the WID [32], RAN2 WI has three main objectives. Different use cases of each WI objective may be addressed with a different priority. And the urgency and priority among different WI objectives may also not be the same. Thus, we would like to invite companies to, first, express their view on the priority of different objectives and corresponding use cases, where relevant.

For the WI third objective (paging cause) issue, RAN2 can wait SA2 progress.

For the WI first objective (paging collision) issue, as described in WID so far, there is only one scenario, thus the rapporteur thinks RAN2 can directly decide on its necessity and priority in this WI.

**Question 17: With what priority (Low L, Medium M, High H) paging collision issue should be addressed in this WI?**

|  |  |  |
| --- | --- | --- |
| **Company** | **L/M/H** | **Comments** |
| OPPO | M | 1. We think some solutions without spec impact can be considered for paging collision issue.
2. We also think the paging collision is a low possibility issue.
 |
| Lenovo, MotM | M | It is low probability issue but needs standardized solution. |
| Vodafone | H | as number of dual sim decices are increasing and the user and the network is faced with ‘real’ collision regularly, we would urge to tackle this issue as the primary focus of this work.Only one scenario has been mentioned but this alone has a huge impact on the network and we should not make light of this problem just because there is only one scenario !  |

Summary: TBD

For the WI second objective, SA2 has discussed switching scenarios from Network A and also sent an LS to RAN2 [1]. UE may switch from network A for some activities on network B such as paging reception, measurements performing in network B.

UE switching from network A scenarios can be classified as follows:

* Single-Rx or Dual-Rx/Single-Tx:
	+ **Scenario 1**: short time switching, such as paging reception, measurements, TAU, RNAU, MO SMS [3, 4, 5, 6, 11, 15, 16, 19, 20, 22, 24, 28]
	+ **Scenario 2**: Long-time switching, such as VoLTE/VoNR voice call [3, 5, 6, 9, 13, 15, 16, 19, 20, 21, 26, 28]
* Dual-Rx /Single-Tx:
	+ **Scenario 3:** UE in RRC CONNECTED state in network A and needs to switch to network B and hence change its RX capability in NW A [3, 4, 9]
* Dual-Rx /Dual-Tx:
	+ **Scenario 4**: UE in RRC CONNECTED state in network A and needs to switch (part capability) to network B and hence change its Tx capability in NW A, such as dual connectivity [23, 25]

NOTE 1: Single Rx allows MUSIM UE to receive traffic from only one network at one time, Dual Rx allows MUSIM UE to simultaneously receive traffic from two networks. Single Tx allows MUSIM UE to transmit traffic to one network at one time, dual Tx allows MUSIM UE to simultaneously Transmit traffic to two networks. (The terms Single Rx/Tx and Dual Rx/Tx do not refer to a device type. A single UE may, as an example, uses Dual Tx in some cases but Single Tx in other cases)

Companies are invited to express their view on the priorities (Low L, Medium M, High H) of the above UE switching scenarios considered in the WI scope.

**Question 18: With what priority should scenario 1 (short time switching, such as paging reception, measurements, TAU, RNAU, MO SMS) be considered in this WI?**

|  |  |  |
| --- | --- | --- |
| **Company** | **L/M/H** | **Comments** |
| OPPO | H | The basic actions should be perfrom to ensure the USIM-B can work normally. |
| Lenovo, MotM | H | This are very fundamental problem statements.  |
| Vodafone  | H  |  |

Summary: TBD

**Question 19: With what priority should scenario 2 (Long-time switching, such as VoLTE/VoNR voice call) be considered in this WI?**

|  |  |  |
| --- | --- | --- |
| **Company** | **L/M/H** | **Comments** |
| OPPO | H | We agree the voice ervice should be ensured in network B.But we are not sure whether long time swithing or TDM based switching are used. |
| Lenovo, MotM | H | This is fundamental problem as well; without this properly working the whole effort will go waste.  |
| Vodafone  | H  |  |

Summary: TBD

**Question 20: With what priority should scenario 3 (UE in RRC CONNECTED state in network A and needs to switch to network B and hence change its RX capability in NW A) be considered in this WI?**

|  |  |  |
| --- | --- | --- |
| **Company** | **L/M/H** | **Comments** |
| OPPO | H | We can wait for progress of R17 red-cap WI because there is similar performance reduction due to reduced Rx.  |
| Lenovo, MotM | H | This is important for single Rx UE.  |
| Vodafone  | H  |  |

Summary: TBD

**Question 21: With what priority should scenario 4 (UE in RRC CONNECTED state in network A and needs to switch to network B and hence change its Tx capability in NW A, such as dual connectivity) be considered in this WI?**

|  |  |  |
| --- | --- | --- |
| **Company** | **L/M/H** | **Comments** |
| OPPO | H | We can wait for progress of R17 red-cap WI because there is similar performance reduction due to reduced Rx/Tx.  |
| Lenovo, MotM | H | This is required for both single and dual Rx capable UEs. |
| Vodafone  | H  |  |

Summary: TBD

Any other UE switching scenarios to be addressed:

**Question 22: Companies are invited to provide other UE switching scenarios and the corresponding priority.**

|  |  |  |  |
| --- | --- | --- | --- |
| **Company** | **Scenarios** | **L/M/H** | **Comments** |
|  |  |  |  |
|  |  |  |  |

Summary: TBD

For the third WI objective, paging cause, the rapporteur thinks that the urgency and priority to be addressed are relevant to the SA2 decision.

**Question 23: Do companies agree that whether paging cause should be specified depends on SA2?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Comments** |
| OPPO | Yes  |  |
| Lenovo, MotM | Yes |  |
| Vodafone  | Yes | this would be a midd priority also we need to better understand if certain paging cause is accepted and which are rejected etc. this needs further work  |

Summary: TBD

# 3 Conclusions

TBD

# 4 References

1. S2-2006037 LS on System support for Multi-USIM devices
2. R2-2006540 Guidance for SA2 on Solution #16 for Key Issue 2 Vodafone discussion
3. R2-2006916 Considerations for Multi-SIM WI Objectives Charter Communications discussion Rel-17
4. R2-2006981 Consideration on Multi-SIM China Telecom discussion
5. R2-2007418 Discussion on the paging collision and interruption issues for multi-sim UEs CMCC discussion Rel-17 LTE\_NR\_MUSIM-Core
6. R2-2006627 Consideration on the Work Scope for Multi-SIM CATT discussion Rel-17 LTE\_NR\_MUSIM-Core
7. R2-2007207 Overview of Multi-SIM ZTE Corporation, Sanechips discussion Rel-17 LTE\_NR\_MUSIM-Core
8. R2-2007394 Way forward for the progress of Multi-SIM WI in RAN2 Huawei, HiSilicon discussion
9. R2-2007396 Discussion on Multi-SIM WI Objectives 1 and 2 Huawei, HiSilicon discussion
10. R2-2007603 Paging collision avoidance Ericsson discussion
11. R2-2008020 General considerations on potential RAN2 works for Multi-USIM devices Samsung Electronics Co., Ltd discussion Rel-17 LTE\_NR\_MUSIM-Core
12. R2-2008021 Overview on SA2 progress for Multi-USIM devices Samsung Electronics Co., Ltd discussion Rel-17 LTE\_NR\_MUSIM-Core
13. R2-2006807 Discussion on Multi-SIM OPPO discussion Rel-17 LTE\_NR\_MUSIM-Core
14. R2-2006944 Handling of paging collision for Multi-SIM Qualcomm Incorporated discussion
15. R2-2007129 Coordination of concurrent communication for Multi-SIM Qualcomm Incorporated discussion
16. R2-2007164 Initial Considerations for Multi-SIM vivo discussion
17. R2-2007191 Support for Multi-SIM Devices MediaTek Inc. discussion Rel-17
18. R2-2007952 General consideration for solving MUSIM problems Xiaomi Communications discussion
19. R2-2007179 Discussion on Multi-SIM Sony, Convida Wireless discussion Rel-17 LTE\_NR\_MUSIM-Core
20. R2-2007620 RAN2 impacts of Multi-SIM support Futurewei Technologies discussion
21. R2-2007961 Solution analysis for R17 Multi-SIM KI#2 and KI#3 Intel Corporation discussion Rel-17 LTE\_NR\_MUSIM-Core
22. R2-2007208 Consideration on the RAN2 issues on Multi-SIM ZTE Corporation, Sanechips discussion Rel-17 LTE\_NR\_MUSIM-Core
23. R2-2007352 Clarification and Finalisation of Scope for MUSIM Work Nokia, Nokia Shanghai Bell discussion Rel-17
24. R2-2007353 Paging reception for MUSIM scenario Nokia, Nokia Shanghai Bell discussion Rel-17
25. R2-2007357 Support of UE capabilities coordination for Multi-USIM UEs China Telecommunications discussion
26. R2-2007602 Graceful leaving for a MultiSIM device Ericsson discussion
27. R2-2007740 Mechanism for UE to notify network switch ASUSTeK discussion Rel-16 LTE\_NR\_MUSIM-Core
28. R2-2007956 Discussion of the coordinated leaving problem Xiaomi Communications discussion
29. R2-2007163 Work plan for Multi SIM WI vivo, Charter Communications discussion
30. R1-1803375 LS on Maximum TBS for PDSCH containing RMSI/OSI/Paging
31. R2-2005845 General changes resulting from ASN.1 review for LTE RRC REL-16
32. RP-201309 Support for Multi-SIM devices for LTE/NR

# Appendix A

## 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, the MuSIM device decided not to setup the communication for UE B service since the ongoing communication on UE A is more preferred, 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.

NOTE: During the normative phase SA2 can decide whether the Network may apply a set of rules as discussed in solution #10, "Network based paging filtering" or solution#5, "Graceful leaving and resumption solutions" and whether the UE includes a busy time value together with the busy indication or not.

### 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.

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 escalation and paging repetition to the UE B and informs the network node that triggered the Network Triggered Service Request procedure. The failure cause in the Namf\_Communication\_N1N2MessageTransfer response indicates that the N1 transfer failed, but the UE is still reachable.

NOTE 2: The new failure cause needs to be detailed so later MT triggered services still triggers new paging events for the UE. New DL data on same or other QoS Flow can trigger paging after the above mentioned N1 failure response.

8. NAS service request is accepted with release indication to RAN in N2 layer. The accept may include a new GUTI if needed.

9. RAN forwards the NAS Service accept to the UE and releases the UE.

### 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.

- New response to SMF to indicate N1 transfer failed, but UE is still reachable

SMF:

- Handle the new response code from the AMF.

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.

# Appendix B

## 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 3: 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. If yes for UEs that have requested MUSIM assistance, it will be further determined whether AMF indicates the UE request for paging cause to the SMF.

- 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.

- 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 provided by the SMF****. If the Paging Cause is not provided by the SMF, the AMF may determine a Paging Cause based on* HPLMN/DNN/5QI configuration and the ARP/PPI received from the SMF*.*

*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 or access type value (i.e.* paging message indicates paging request is for a PDU Session associated to non-3GPP access*) 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 and ARP of the QoS flows for the downlink data packet and the corresponding PPI in the CN tunnel header.

 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.

#### 6.1.3.4 Paging Cause values

Editor's note: This list is just an example and not capturing a consensus-based agreement on the exact causes.

Editor's note: It shall be decided whether allow for non-uniform support in the RAN of the PLMN, which is pending to RAN's feedback.

Editor's note: The anticpitated use of each paging cause and how it addresses the KI will be documented, so that the solution can be fully evaluated.

Table 6.1.3.x-1: Paging cause value mapping

|  |  |
| --- | --- |
| Paging Cause value | Type of downlink traffic |
| 1  | Voice service |

Table 6.1.3.x-1 provides a Paging cause value mapping for the type of downlink traffic

Editior's note: Other Paging Cause values are FFS.

NOTE: The mechanism UE determines the current network (e.g. the whole PLMN or the current gNB) supports paging cause or not will be determined.

### 6.1.4 Impacts on services, entities and interfaces

**For 5G:**

AF:

- P-CSCF sets 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 and the ARP/PPI received from the SMF.

- sends the N2 paging signalling with Paging Cause for all the UE; or sends Paging Cause only for the UEs indicating request for Paging Cause or send the NAS notification message over non-3GPP access if UE is registered with both 3GPP access and non-3GPP access on same PLMN. The AMF stores the UE request for paging cause in the UE context, if received.

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 and ARP of the QoS flows for the downlink data packet and the corresponding PPI in the CN tunnel header.

UE:

- sends request for paging cause (for the option where Paging Cause is sent only to device who indicate request for paging cause).

- receives paging message with the Paging Cause information.

- UE makes a decision whether to respond to paging or incoming NOTIFICATION message (over non-3GPP access) based on paging cause or access type.

- If UE decides not to respond to incoming request based on paging cause and if UE is registered on both 3GPP access and non-3GPP access then UE shall respond with NAS NOTIFICATION response message indicating its inability to initiate service request procedure.

**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 and the ARP/PPI received in DNN.

- sends the S1 paging signalling with Paging Cause for all the UE; or sends Paging Cause only for the UEs indicating request for Paging Cause. The MME stores the UE request for paging cause in the UE context, if received.

eNB:

- sends the paging message with Paging Cause.

UE:

- sends request for paging cause (for the option where Paging Cause is sent only to device who indicate request for paging cause).

- receives paging message with the Paging Cause information.