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].

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| *-* ***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?**

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| --- | --- | --- |
| **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). |
| Ericsson | Yes | A new 5G-GUTI can solve the paging collision issue. But we think that it is up to the AMF to decide and select a new 5G-GUTI, i.e. the UE should only send to AMF a notification about the paging collision. |
| ZTE | Yes | From RAN2 side, we think this scheme is feasible and effective. We also agree with the Ericsson that “ it is up to the AMF to decide and select a new 5G-GUTI, i.e. the UE should only send to AMF a notification about the paging collision.” |
| Intel | Yes | The probability that paging collision happens again would be very low even if 5G-S-TMSI is re-assigned in random fashion.  Moreover, from the RAT concurrency in our objective (i.e. Network A can be NR; Network B can either be LTE or NR), we don’t need solutions for both RATs. If collision happens, changing over 5G side would be sufficient. |
| Sony | Yes | A new 5G-GUTI may solve the collision but it is up to the AMF (and the operator) to decide and select a new 5G-GUTI as it impacts other functions than the calculation of the paging occasion.  The NW will select a new 5G-GUTI without knowing the purpose of the new 5G-GUTI |
| vivo | Yes.  When paging collision issue is detected, the multi-SIM UE can request the AMF to re-allocate a new 5G-GUTI and may decide whether the new 5G-GUTI can solve the paging collision issue. | The PO/PF is determined by RAN configuration, hence paging collision may re-occur due to cell reselection. Thus, the UE may need to request the AMF again to re-allocate a new 5G-GUTI. |
| Nokia | May be | Requires further analysis of the option for RAN2 impacts. It is not clear whether the above procedure needs to be triggered on paging collision itself or on estimation of collision of PO based on the calculation of PO at the time of receiving identifier. Effectiveness of the solution needs to be assessed from SA2 perspective. For RAN2 the effectiveness is comparative term when multiple solutions are on the table. In that case RAN2 need to first agree on the basis for the comparison.<> |
| Charter Communications | Not Feasible | Not feasible because this is only working “by chance”. Also 33.501 requires a new 5G-GUTI to be sent after a successful of activiation of NAS security (see 33.501/6.12.3) which means very likely that another 5G-GUTI will be used shortly after UE uses this option-1 to obtain a new 5G-GUTI, and even if a new 5G-GUTI resolves paging collision among the two networks, it is not guaranteed that after a cell reselection, for either of the network, paging collision does not happen. Hence we believe that Option 1 is ineffective as well. |
| China Telecom | Yes | Yes. This solution has less impact on existing spec since it only affect the AMF and UE. Acoording to TR 23.761, the Registration Request includes information to assist the AMF for assignment of new 5G-GUTI. AMF should not allocate a new 5G-GUTI which does not fulfill the assistance information. We think it is effective to avoid multiple 5G-GUTI reassignment procedures. |
| Qualcomm | Feasible but not always effective | As commented by others, a new GUTI may or may not work for all cells in the TA. The PO time is determined by the last 10 bits of GUTI (or S-TMSI); therefore, the success of this approach depends on the correlation of the last 10 bits and also the characteristics of the collision (how much separation in PO is needed). Since NR paging has a lot of flexibility in the selection of PO via the configuration of paging parameters, using them can provide a much robust and effective solution compared to this trial and error of GUTI allocation. |
| MediaTek | Yes this is feasible.  NAS solution. No RAN impact.  Mobility Registration Update triggers 5G-GUTI reassignment (as per Rel-15) | Yes this is effective. 5G-GUTI reassignment makes the paging collision risk statistically disappear. |
| Sharp | Yes | We think reassign a 5G-GUTI is feasible and effective from RAN2 persperctive. |
| CATT | Yes | It would be better to leave the detail solution discussion to SA2. From RAN2 perspective, we think this option is feasible. The new GUTI can be decided by AMF. Thus, RAN impact is minor. |
| NEC | Yes | We tend to agree with OPPO/Lenovo/Vodafone that the new 5G-GUTI can work by chance. As this depends on the availiable 5G-GUTI and whether the new 5G-GUTI is randomly selected. |
| Xiaomi | Yes (maybe) | AMF randomly allocates the new 5G-GUTI to UE, which may solve the paging collision. But the new PO derived from new 5G-GUTI may still has collision. |
| Huawei, HiSilicon | Yes, but not completely.  In general we think one solution among these options need to be selected to solve paging collision instead of multiple options. | No, it’s not effective. A new 5G-GUTI does not solve the paging collision issue completely. On one hand, paging collisions may occur after cell reselection in which case UE needs to request new 5G-GUTI again. On the other hand, it is not certain that the available 5G-GUTIs at the AMF when it receives 5G-GUTI reassignment request from the UE can avoid the paging collision. |
| Apple | Yes | This is one possible solution, primarily driven from NAS layers. Other AS centric solutions are possible as well. |
| Convida Wireless | Not for RAN2 to conclude | RAN2 doesn’t have expertise in 5G identities. RAN2 can only comment on the use of such identity in the PF/PO calculation. Per 38.304, the UE\_ID used in PF/PO calculation is defined as 5G-S-TMSI mod 1024. In 23.003, 5G-GUTI is defined as <5G-GUTI> = <GUAMI><5G-TMSI> i.e. <MCC><MNC><AMF Region ID><AMF Set ID><AMF Pointer><5G-TMSI> , and 5G-S-TMSI is defined as <AMF Set ID><AMF Pointer><5G-TMSI>.  This means this solution might not be foolproof and may still lead to paging collisions as the <AMF Set ID><AMF Pointer><5G-TMSI> might be the same for two different 5G-GUTI  A solution like the one in option 2a with assistance from the UE (e.g. an alternative UE\_ID like in option 2c) will be more effective. |
| Google | Yes | This solution seems feasible from a RAN2 perspective. |
| Samsung | Yes | Collision probability with new GUTI assigned by network is expected to be less. UE would be required to again request for new GUTI reassignment in this case. |
| Futurewei | Not really | As other companies have mentioned above, there is no guarantee that the newly assigned 5G-GUTI won’t also result in PO collisions.  Furthermore, even if an assignment works in one cell, it may not work in another cell. This could lead to after a cell reselection that collisions may re-occur, leading the UE to request a new 5G-GUTI again. |

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?**

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| **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. |
| Ericsson | Yes | Similar to Opt.1. The UE can propose the Alt.ID but the CN determines the final value to be used.  This option is very similar to Opt.2b, as well. |
| ZTE | Yes | We think from the RAN2 aspect, this solution is feasible. But the alternative ID shall be provided by CN. |
| Intel | Yes (feasible), but not necessary | Don’t see benefits compared to Option 1.  As commented in Q1, a solution over 5G side is enough considering the RAT concurrency.  Morever, a NAS procedure is inevitable to communicate Alternative UE ID, for which one can simply use it to re-assign 5G-S-TMSI (whose chance of re-collision is very low anyway). |
| Sony | Yes | With the UE\_ID the UE and NW knows that there is no paging collision with any other SIMs. The paging occasions of the different SIMs can also be coordinated in time.  The AMF may be able to decide another alternative UE\_ID than the proposed one |
| vivo | Yes for EPS and 5GS respectively. | Compared to option 1, the AMF also needs to provide the alternative UE\_ID to the RAN for RAN paging, at each time the new alternative UE\_ID is negotiated. |
| Nokia | May be | TBD.This solution seems similar to Option 1. The preference among them is not RAN2 analysis. As per initial analysis RAN2 impacts seems to be similar for both. If RAN2 agrees to indicate the preference then RAN2 needs discussion on comparision of RAN2 aspects of the solution. |
| Charter Communications | No | Like in Q1, the use of an alternative ID will have the same outcome as option 1. |
| China Telecom | Yes | We think this solution involes a new issue of paging with alternative UE\_ID to solve paging collision and has impact on AMF, RAN, UE as well as the N2 interface. The spec impact is larger than option 1 |
| Qualcomm |  | Same answer as Q1. Defining a separate ID is not needed and there doesn’t seem to be any advantage compared to Option 1. |
| MediaTek | Unclear  NAS + AS solution. RAN impact. NAS-controlled. Must be homogeneously supported in all cells of a Tracking Area and due to paging escalation beyond a TA, in all cells of a UE’s Registration Area, without restriction. If not, the UE can be unreachable. | Yes.  If indication is done with MRU, a new 5G-GUTI is anyway assigned as per Rel-15 definition making the paging collision risk statistically disappear. Whether the solution is more effective is debatable, esp. in view of the added system complexity and requirement on RAN support. |
| Sharp | Yes | We think it is feasible to avoid paging collision by using an alternative UE\_ID. |
| CATT | Yes | From RAN2 perspective, we think this option is feasible. Similar as Option 1. We think alternative UE\_ID is provided by CN. Thus, RAN impact is minor. But how to down select is depend on SA2. |
| NEC | Yes | This option has the same effect as Opt.2b offset solution, but the overhead is bigger. |
| Xiaomi | Yes | May be  Similar to Option 1, there may be still paging collision as Question 1. Cannot see much benefit comparing to the Option 1. |
| Huawei, HiSilicon | Yes.  In general we think one solution among these options need to be selected to solve paging collision instead of multiple options. | Similar to option 1, Alternative UE\_ID does not solve the paging collision issue completely. Paging collisions may occur after cell reselection in which case UE needs to calculate Alternative UE\_ID again.  In addition, using the Alternative UE\_ID would change the legacy way to calculate the PF/PO, and there seems no difference compared with Option 1. |
| Apple | Yes | This is one possible solution which can help to resolve the paging collision across the SIM instances. |
| Convida Wireless | Yes | This solution will be more effective than other alternatives under consideration assuming the UE provides assistance information i.e. an alternative UE\_ID to the network. See feedback to Q1. |
| Google | Yes | This solution has some impact on the RAN2 spec (38.304) compared to Option 1 which is transparent to RAN. It seems equally feasible as Option 1 though. |
| Samsung | Yes | Approach is not different from Option 1 |
| Futurewei | Not really | This option seems to be essentially equivalent to option1. Therefore, it will suffer from the same issues. |

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?**

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| **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. |
| Ericsson | Yes | Similar to Opt.1 and 2a. The effect in having a new UE\_ID which is derived from IMSI+offset value is the same as having an “Alternative UE\_ID”.  This option should not be limited to EPS, but it should be considered also for 5GS (TR 23.761 v1.0.0) |
| ZTE | Yes | It’s feasible for the EPS |
| Intel | Yes (feasible), but not necessary | Similar comment in Q2 – don’t see benefits compared to Option 1.  Moreover, having offset for PF/PO calculation affects the legacy way they are calculated based on IMSI (EPS), which are not desired from RAN2 perspective. |
| Sony | Yes | Similar to option 2a, the UE recommends a timing for paging occasion without any collisions. |
| vivo | Yes | The effectiveness of this option is the same as that of option 2a. |
| Nokia | Yes | Require more analysis within RAN2 for effectiveness. |
| Charter Communications | Maybe | The offset value should be negotiated, as Option 2b suggests, but the eNB need to know it. Due to cell reselection on either of the networks, it’d be ineffective as Option 2a. |
| China Telecom | Yes | Same with Option 2a. The only difference is whether to use the offset. |
| Qualcomm | Feasible but not always effective | Assuming an appropriate offset is chosen, this can solve the collision in the current camped cell. However, it may not work when the UE re-selects to another cell since other cells may have different PO occasions due to different configuration as well as due to asynchronicity. Repeating the same negotiation for every cell reselection is not acceptable from UE power perspective. |
| MediaTek | Unclear  NAS + AS solution. RAN impact. NAS-controlled. Must be homogeneously supported in all cells of a Tracking Area and due to paging escalation beyond a TA, in all cells of a UE’s Registration Area, without restriction. If not, the UE can be unreachable. | Yes, given that the calculation is otherwise based on a permanent identifier (i.e. IMSI). |
| Sharp | Yes | We did not see much difference between option 2a and 2b. |
| CATT | Yes | From RAN2 perspective, we think this option is feasible for EPS. Similar comments as Option 2a. |
| NEC | Yes | And the overhead is smaller than option 2a.  But we wonder why this option 2b is only considerd for EPS. As by using offset to 5G-S-TMSI, this solution is also feasible for 5GS. And it is almost the same as option 2a, with only difference is only offset is provide rather than an alternative UE\_ID. |
| Xiaomi | Yes | May be  Share with Intel’s view. The new offset may impact the legacy way for calculating the PO  Cannot see much benefit comparing to the Option 1. |
| Huawei, HiSilicon | Yes.  In general we think one solution among these options need to be selected to solve paging collision instead of multiple options. | We understand this is feasible but there might be cases that different configurations with IMSI+offset value could not solve every PO collision case, and there seems no differencecompared with Option 1.  Another point is that this impacts E-UTRA specifications which seems not in the scope of MUSIM WI. |
| Apple | Yes | This should work to avoid paging collision, but the key issue is how to determine which offset to use. Is it from a set of pre-determined offset values / negotiated offset etc. needs to be worked out. |
| Convida Wireless | Yes | The effectiveness of this solution depends on how the offset is derived. |
| Google | Yes | There is no essential difference between Option 2a and 2b from RAN2 perspective. |
| Samsung | Yes | As in option 1, re-assignment of 5G-S-TMSI by AMF, after UE merely indicates there is paging collision over NAS would be sufficient /simplest considering that the issue itself seems quite rare. But it also means that UE ID (5G-S-TMSI mod 1024) needs to be reallocated well so that paging collision is avoided. So, an appropriate offset from UE i.e. UE ID = 5G-S-TMSI + Offset mod 1024 might be useful. Changing UE ID via NAS can be taken as a baseline and how to achieve it can be further discussed. |
| Futurewei | Maybe, but not for every collision scenario | This option could be construed to be a special case of 2a. This approach might be less likely to still have collisions (compared to option1), especially if the offset is selected judiciously. However, there is still the possibility that the offset may need to be changed upon reselection, etc. |

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?**

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| **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. |
| Ericsson | No | We think the UE should only notify the AMF about the paging collision, without sending any assistance info. The UE does not know the network status (e.g. paging load distribution) and does not need to influence in the calculation of the PF/PO. |
| ZTE | No | We think the paging collision is a low possibility issue, it’s unnecessary to introduce such kind of optimization, we think the paging collision indication is enough. |
| Intel | Yes (feasible), but not necessary | Agree with OPPO and also similar comments in Q2 – no assistance info seems necessary from the UE (re-assigning 5G-S-TMSI would be enough). |
| Sony | Yes | Only the UE knows the location of the other paging occasion(s), then it is more efficient if the UE gives assistance on how much the paging occasion shall move. The cost of sending the assistance in case of collision is low.  With the assistance the paging occasions of the different SIMs can be coordinated. |
| vivo | The MUSIM assistant information included can support several types of solutions, such as alternative UE\_ID, RAN solution. This option needs further discussion, and more detailed information/procedure is also needed to judge the feasibility. | This option needs further discussion, and detailed information/procedure is also needed to judge the effectivity. |
| Nokia | Yes | Require more analysis within RAN2. |
| Charter Communications | Not Feasible | Use of alternative ID has same issues as indicated above. It is also not clear what other info (as described as selector of RAN behavior in S2 TR) is being passed to RAN from CN and they are used, etc.. |
| China Telecom | Yes | Yes. This is a common solution for both LTE and NR. However, it seems to involve much complexity, which has impact on AMF, RAN, UE as well as the N2 interface. |
| Qualcomm | Very likely yes | It depends on what the full solution looks like. However, a RAN based solution based on CN assistance will be more effective since RAN has more control on the paging procedure and configuration and it can be done at cell level. This can also work without any PF/PO assistance from the UE where gNB can find a PO as far away from the current PO. |
| MediaTek | Unclear. More details about the solution are needed. | Unclear.  Similar to Option 2a, if indication is done with MRU, a new 5G-GUTI is anyway assigned as per Rel-15 definition making the paging collision risk statistically disappear. |
| Sharp | Maybe | It may feasible and effective for UE provide some assistance information, e.g., report its available or not available occasion, so that Node B/CN can adjust it PO/PF to avoid collision.  Option 2c can be a complementation to other options. |
| CATT | No | We don’t see the benefit of this solution compared with other solutions. We think just indicate the paging collision to CN by NAS message is enough. |
| NEC | Yes | As the UE has the paging occasion information of both RATs, the UE can provide some information to one of the RAT to assist the network to decide on how to change the paging occasion for the UE. And the final decision is up to the network.  If without assistance information, and the new configuration provided can not solve the collision, the UE and the network can repeat the procedure until the paging collision issue is solved. In this sense, this can be seen as nice to have function. |
| Xiaomi | yes | Assistance information from UE to network may be helpful for network to solve the paging collision. Can also sovle the problem in Option 1 (Randomly allocated 5G-GUTI may still have paging collision). |
| Huawei, HiSilicon | Yes, but not necessary | Agree with other companies that the UE assistance information for solving the paging collision issue is not necessary. |
| Apple | Yes | Yes, using MUSIM UE Assistance Information would be beneficial to both UE and NW, as it takes into account mutual requirements from both UE and NW perspective. |
| Convida Wireless | Maybe, depends on what the assistance information is and the details of the solution. | For example, A UE assistance information based solution that consist of enabling the solution in option 2a or 2b may be feasible and effective. |
| Google | Yes | We think this option is a bit more complex than Option 1, 2a, and 2b, and provides limited benefit. |
| Samsung | Yes | Effectiveness will depend on what and how the MUSIM assistance information is defined, conveyed and utilized by network. However, it is needed that unnecessary complexity is avoided. This would need further analysis and discussion by RAN2 |
| Futurewei | Unclear | More details about this solution would be needed in order to evaluate its effectivess. |

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?**

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| **Company** | **Feasible (Comments)** | **Effective (Comments)** |
| OPPO | Yes  It 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. |
| Ericsson | Possibly | This option will increase the Paging signalling. |
| ZTE | Possibly | It will increase the signalling overhead significantly, |
| Intel | Yes (feasible), but a half measure | This solution could work, but half measure as it does not avoid paging collision. Given it is not clear how the UE alternates paging monitoring or how NW performs paging repetition, the issue may not go away completely if we solely rely on this solution.  We believe a NAS based solution (that changes the value of UE ID and avoids paging collision) is essential to complement such RAN2 based paging repetition scheme. |
| Sony | No | It uses always, also in case of no collision twice as many paging resources than normal and the latency will increase. |
| vivo | Yes.  Since POs are always periodically present, UE can alternately monitor the POs in two networks in which the POs overlapped in time. Hence, if the UE can ensure to monitor at least one of the several consecutive POs in each network and RAN repeats paging on these several consecutive POs, the paging message would be received by the UE. | Yes.  Paging collision can totally be solved but the paging signaling overhead is increased. If this paging collision solution can be only applied to the UE with paging collision issue, the paging signalling overhead may be acceptable. |
| Nokia | Yes | This is possible without RAN2 impacts. But not resource efficient. |
| Charter Communications | No | As pointed by OPPO, the repetition of paging in multiple POs is already supported in R16 NR-U. However, using this solution will be wastful of radio resources, unless the repetition is done selectively for MU-SIM UEs. |
| China Telecom | No. | Maybe.Agree with VDF, ZTE and Ericsson.This solution increases the signaling overhead of RAN. |
| Qualcomm | Depends | The repetition duration should be long enough for the UE to be able to switch between two USIMs. If this is consecutive repetition, it can require many repetitions which will be a waste of resources. Therefore, the paging occasions for the repetition should be sufficiently apart from each other. |
| MediaTek | Maybe.  There may be concerns about paging resource waste, since a UE may have responded in one cell while other cells are still repeating the UE’s paging. | Yes. Paging repetition makes UE to alternating paging reception on each USIM more robust. |
| Sharp | Possible | Repeating paging will waste paging resources and increase the signaling overhead. |
| CATT | Maybe | But this solution can increase the Paging signalling overhead. |
| NEC | Possibly | It will lead to significat increasement of paging overhead. |
| Xiaomi | Possible, but | When the paging collision detected, that means the collision will happen all the time if the parameters for calculating PO are not changed.  When both USIMs in Idle, it wastes the paging resources.  Also UE needs to be aware of the new paging policy |
| Huawei, HiSilicon | Yes | This option together with the UE implementation (e.g. monitoring paging alternately in the two NWs) can solve the paging collision issue. |
| Apple | Yes | This would help as well, as it allows the UE to intelligently determine which paging occasion to use in case of collision. This coupled with MUSIM UAI would help to address most of the collison use cases. |
| Convida Wireless | Yes | We agree with OPPO that the mechanism introduced in R16 for NR-U can be reused for multi-SIM. |
| Google | Maybe | As other companies have observed, this solution increases the resources used for paging. Note that POs between different USIMs may not be aligned and more than 2 repetitions may be warranted. |
| Samsung | Possibly | May be. However, this option has increased paging resource cost to cater to MUSIM devices. |
| Futurewei | Yes, but | However, as other companies have indicated, this may lead to an increase in paging signalling. However, if the probability of collision is low, this may be acceptable. |

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. |
| Ericsson | Yes | We think that the paging collision probability is low and we can rely on the UE implementation. |
| ZTE | Yes | Considering of the low possibility, we think it can be left to the UE implementation. |
| Intel | Yes (feasible), but a half measure | Similar comments in Q5. |
| Sony | No | Similar to Question 5 but now the NW has no control on when the UE reads the paging and thereby does not know how much extra paging resources is needed. |
| vivo | No.  According to TR23.761, this option depends on UE implementation way to minimize paging 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).  However, it is impractical to only rely on UE to solve the paging collision issue. For example, when UE is monitoring NW A but there is no paging, UE may miss paging in NW B at that time. The UE may also miss the repeated paging in NW B since the UE has no idea of the paging repetition pattern of the NW B. | No. |
| Nokia | TBD | The objective of the WID is to minimize the impact of UE based implementations. So we prefer to have solution specified to have deterministic UE behavior. |
| Charter Communications | No | But can we assume this is widely applicable for UE vendor/chipset vendor in the near future? We do need to have a basic standardized solution to address this to avoid waste of system resources. If UE implementation-based solutions become widely available in future to address this issue without network involvement, then that’s great. |
| China Telecom | Yes. This solution can be used to succeed in paging UE in PO collision condition. However, PO overlapping is not solved. | Yes in LTE network. This solution have no spec impact. |
| Qualcomm | No (most of the time) | Depends on what is meant by “solve”. Obviously the UE can’t change the POs and thus collisions will continue. The UE can attempt to find ways to minimize the impact on its overall operation. |
| MediaTek | Yes. | Yes. UE can, for example, let USIM A and USIM B take turns to monitor paging, and this can be purely done by UE implementation without introducing any specification change. |
| Sharp | No | Without network involved, we do not think UE Implementation can avoid paging collision. |
| CATT | Yes | We think paging collision is a low possibility issue and cannot strongly impact the User experience. Thus, the paging collision issue can be left into UE implementation. |
| NEC | Yes, but | This still results in latency when responding to the paging, which is not preferred for the time sensitive traffic. It is better to introduce specification based approach to avoid this issue completely. |
| Xiaomi | yes | This solution causes minimum cost/impacts on system, but can effectively minimize the paging collision.  We also think paging collision is a low possibility issue. UE implementation is a feasible /effective way to minimize the collision with lower cost/impacts on system. |
| Huawei, HiSilicon | Yes | This option together with the option 3 can solve the paging collision issue. |
| Apple | Yes, but | UE specific implementation would address some use cases and this is the current state of the art. The current MUSIM WI objective is a good opportunity to arrive at a unified standard based solution to help address UE and NW Paging KPI metrics. |
| Convida Wireless | No | The reason for the work item is to improve on implementation-based solutions. |
| Google | No | For limited capability UEs (single Rx), it is not clear how implementation alone can solve the paging collision issue, however smart the UE is. |
| Samsung | Yes | If left to UE implementation, solution may not be effective for all the times and for all the UE implementations e.g it may increase UE power consumption or possibily also acquitision delay. There seems also a negative impact on NW as NW anyway needs to repeat paging over and over again as UE will selectively choose one of two SIMs if we go for a UE implementation approach. Considering these potential issues, we prefer to have standardized solution to ensure deterministic and uniform behavior from all UEs. |
| Futurewei | Yes, but | However, this would be at the expense of paging success perrformance. Furthermore, if the network is not aware of a UE is experiencing a paging collision, nor of what action the UE is taking in response to such a collision, how would a operator account for this in their network’s performance KPIs (i.e. Is the poor paging performance due to Multi-SIM operation, poor coverage, a UE specific sensitivity issue, or others?) |

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** |
| Nokia |  | Answer to this question needs to be discussed in online session. Because discussion on new solution and its aspects in this e-mail discussion is not beneficial. We propose to remove this question. |
| NEC |  | We agree with Nokia that this question need to be discussed during online session. |
| Apple |  | Agree with Nokia and NEC. We can discuss it during our online sessions. |

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. |
| Ericsson | a) | No impact to LTE RAN, meaning no impacts to RRC (including LTE/5GC RRC). |
| ZTE | a) |  |
| Intel | B | Our WID listed the impacted TSes of 38.300, 38.331, 38.306, and 38.304 only. |
| Sony | a) |  |
| vivo | a) | We have similar view with Vodafone and Ericsson. |
| Nokia | a) | In our understanding the no impact refers to RRC signalling impacts. RAN3 impacts cannot be excluded in our view based on the objectives. |
| Charter Communications | b | Same as OPPO |
| China Telecom | b) | From our understanding S1\_AP, RRC layer and below should not be influenced. |
| Qualcomm | B | The changes to S1 interface will impact gNB and hence E-UTRA. However, we note that the WID only states “Specification change should focus on NR side for objective 1.” which does not necessarily mean “no E-UTRA impact” |
| MediaTek | (b) | Our understanding is that RAN/CN interface is in the scope. |
| Sharp | a) |  |
| CATT | b) | We should focus on NR side for paging collision, so that S1\_AP, RRC layer and below should not be impact. For NG\_AP, it may be influenced due to NR side. |
| NEC | b) | Agree with OPPO |
| Xiaomi | b) |  |
| Huawei, HiSilicon | b | For Objective 1, MUSIM WID clearly states that the spec changes should focus on NR only, which means no changes for LTE specifications including Uu and S1\_AP. |
| Apple | b |  |
| Convida Wireless | a) | We share the same view as Vodafone in the sense that E-UTRA relates to the radio interface, not radio Network and therefore not the S1-AP signaling. We do not agree with the view that enabling solutions such as solution in option 2a or option 2b which implies change in the NAS to the determination of UE\_ID used in the PF/PO calculation in TS 36.304 constitutes a change to E-UTRA. |
| Google | b) | We are not completely opposed to having some impact on (say) 36.304 but we have to realize that this is strictly out of scope of the current WID. |
| Samsung | a) |  |
| Futurewei | b | B) seems to be more consistent with the objectives and defined in the WID  However, it does not seem very appropriate for RAN2 to discuss impacts to other signalling interfaces. Such discussions (if any) should be addressed by the appropriate WGs. |

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 |
| Ericsson | Yes, but | We think we should try to minimize complexity in RRC, hence if possible to reuse existing mechanisms it may be effective. |
| ZTE | Yes, but | We think we should adopt some methods that introduce less impact on the performance of the other SIM. The scheduling Gap scheme may increase the complexity and meanwhile degrade the performance of the other SIM. |
| Intel | Yes (feasible), but not necessary | Agree with OPPO |
| Sony | Yes | The positions of the paging occasion is periodic and well defined, then it is meaningless for NW-A to send and receive signals when it is known the UE-B is not active in that connection.  There are gaps for other purposes, as measurements, the concept could be reused for reading paging. |
| vivo | Yes | Yes. Using “scheduling gap” on USIM A for paging reception on USIM B is effective, which resolves the Rx collision between DL data reception on USIM A and paging reception on the USIM B, further avoid the connected state performance degradation of USIM A. |
| Nokia | Yes | Need for scheduling gap for idle mode activities of one USIM when UE is connected in other USIM and also corresponding gains should be discussed within RAN2 for conclusion. In our view awareness of the UE idle mode monitoring occasions and adjusting the scheduling can improve the network resource usage at connected mode network. |
| Charter Communications | Yes | We believe negotiating a schediuling gap, or short coordinated leave, helps to resolve the situation described by SA2 for single-RX MU-SIM UEs. Short leave duration can be negotiated in the scheduled gap, however long leave duration requires CN intervention (e.g. PDU suspension). |
| China Telecom | Yes | Yes. We think Access-Stratum based scheduling gap can achieve the switch between two networks rapidly, avoiding the network resource waste. UEs and network can negotiate a scheduling gap of periodical pattern which is similar to the measurement gap. |
| Qualcomm | Yes | This will work. The concept is similar to measurement gaps and it is up to RAN2 to work out the details of the signaling. |
| MediaTek (rev) | Unclear – while it is technically possible to negotiate additional gaps, it may not be technically viable e.g. due to ongoing service. It is not clear how often such additional gaps would be negotiated nor what signaling they would require. | Unclear – gaps can of course allow the UE to do something else but it is imposing a degradation of service on the USIM where the *additional* gap is introduced while the UE may already be able to acquire paging on its own using existing gaps. This is likely to yield worse performance than what can be done by UE implementation. |
| Sharp | Yes | Scheduling gap is a signalling efficient way for UE to receive paging on USIM B without going to IDLE/INACTIVATE state in USIM A. |
| CATT | Yes, but not necessary | This solution should have some negative impact on the QoS performance of traffic on the connected state side, for example the latency. It will introduce extra complexity in the spec. Thus, we don’t see obvious benefit on it. |
| NEC | Yes | The complexity increasement and performce impact can be evaluated by RAN4. |
| Xiaomi | Yes | It is beneficial to schedule a “gap” for another USIM to receive/respond the paging message when one USIM is connected. |
| Huawei, HiSilicon | Yes  We agree that paging reception issue should be considered as one of the switch notification use cases rather than the paging collision use case, i.e., it belongs to the objective 2. In this case, we just need to consider it for the 5GS, i.e. no need to consider it for EPS which is not in the scope of objective 2. | This is a pure RAN issue and further study is needed to see the details.  In the reply LS to SA2 on the Q8, RAN2 can clarify that the option 5 is not for addressing the paging collision issue but can be considered as one of the switch notification uses cases of objective 2 of RAN WID, and it will be studied by RAN2. |
| Apple | Yes | This AS centric approach should work, in similar lines to legacy measurement gaps. |
| Convida Wireless | Yes | Use of scheduling gaps or away gaps similar to measurement gaps will be effective and can be done in a way that minimizes impact or performance degradation to data reception. |
| Google | Yes | Some UE implementations may be able to handle this scenario without the need of scheduling gaps. For single Rx UEs this solution seems quite useful. |
| Samsung | Yes | Whenever MUSIM UE wants to perform one shot or (a)periodic activity on other NW while staying in CONNECTED in current network, AS based solution with scheduling gap is preferable. Such scheduling gap can be designed solely for MUSIM purpose. The details can be discussed further. |
| Futurewei | Yes | It seems obvious that coordinating tune-away gaps can avoid collisions.  To assess how “effective” it is or is not, probably requires input and analysis from RAN4. |

#### 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 |
| Ericsson | See comments | See comments | We agree with VDF that it may be dependent on particular implementations. In any case we expect that it would require a considerable amount of time since more signaling may be needed e.g. due to 5G GUTI change. |
| ZTE | Generally, we are OK with the Table 1 | Generally, we are OK with the Table 1 |  |
| Intel | For step 5, depending on time until the UE sends *RRCConnectionSetupComplete* (IDLE) or *RRCConnectionResumeComplete* (INACTIVE). | For step 5, it depends on the time until the UE sends *RRCSetupComplete* (IDLE) or *RRCResumeComplete* (INACTIVE). | What SA2 asked RAN2 seems only about the step 5, i.e. the expected time to send a NAS busy indication over Uu.  We agree to use the above table as baseline for calculating such expected time. |
| Sony | Variable | Variable | Agree with Vodafone |
| vivo | Around 60+2T ms as a baseline, in which the delays for network implementation and HARQ retransmission are not included. | Step 2: 0.5ms is assumed.  Step 3:1~3.5ms  Step 4: the lower bound can be 1 OFDM symbol, i.e., 0.0045~ 0.0714ms, and the upper bound depends on NW implementation.  Step 6: NT,1 is around 0.071~0.214ms, NT,2 is around 0.089~0.321ms, thus, the delay of this step is about 0.66~1.035ms.  The length of 1 slot: 0.0625 ~ 1ms.  Thus, the total delay is [(42~50)+2T] ms as a baseline, in which the delays for network implementation and HARQ retransmission are not included. | The required time may be larger than 100ms if delays for T, network implementation and HARQ retransmission are included, which will impact the current ongoing service in NW A, thus we think sending the busy indication is not preferred. |
| Nokia | Expected time depends on the maximum time taken for each step of signalling procedure for reporting BUSY indication. The length of the procedure depends on whether RRC connection is needed or not for this purpose. | Same comments as LTE | Depending on the analysis within RAN if BUSY indication is needed for paging response, whether AS or NAS based is suitable needs to be concluded. And based on the outcome RAN can respond to the above question considering the signalling procedure for this BUSY indication. |
| Charter Communications |  |  | The expected latency time depends on the network configuration, and can be left to UE implementation (as long as lower and upper bound can be indicated or negotiated) and the paging cause is known. E.g. if paging is due to a voice service, and operator of A has determined voice to be served from B, then activity in A must be dropped regardless of the nature of such activity. |
| China Telecom | 70~100ms | 70~100ms | The time need for transfer of busy indication is much more compared with just listenting to paging occasion. We don’t think it should be scheduled as a periodic time gap. |
| Qualcomm | This is for MO so total latency until and including step 11 should be valid. | This is for MO so total latency until and including step 11 should be valid (around 35.5 from above table). | In addition to this latency, there is a a power overhead due to moving to Connected mode and interruption on the other Connected USIM. In fact, such a long disruption may not be acceptable to the other USIM link, which may have to relinguish the connection. We think good NW implementation can solve unnecessary paging without creating all this overhead, latency, and disruption. |
| MediaTek | Variable | Variable | It’s uneasy to know exact time required for UE to send busy indication, due to various uncertain delay values. But in general we agree to the analysis in Table 1 that identifies the *minimum delays* involved. However the *maximum delays* need to be understood as well. I.e. a range need to be indicated to SA2. |
| Sharp | We are ok with table 1. | We are ok with table 1. |  |
| CATT | We are OK with Table 1. Thus, the total latency will be almost 100ms. | We are OK with Table 1. Thus, the total latency will be almost 100ms. | We also think there is power control issue and PA switching time between NW A and NW B. Thus, those impact is unacceptable to the other USIM link. We think the busy indication solution is not preferred. |
| NEC | OK with the table | OK with the table |  |
| Xiaomi | Viable | Viable | Same view as MediaTek. And the long gap should not impact the onging session on the other link. |
| Huawei, HiSilicon | See comments | See comments | Before answering this question, RAN2 should first try to understand the necessity of the busy indication. |
| Apple | Variable | Variable | Overall the split looks reasonable, but the total time might be variable and difficult to arrive at a one single value that fits all use cases. |
| Convida Wireless | Variable. See comments | Variable. See comments | This is implementation dependent. As indicated by Vodafone, the design could require a lower bound and an upper bound on the acceptable delay in responding with busy indication to paging. |
| Google | Variable | Variable | The analysis provided by the rapporteur can serve as a baseline. This analysis assumes that the busy indication is sent immediately after paging reception (in Network B) and that the RRC connection setup procedure is used for this purpose. Both those assumptions need to be discussed. |
| Samsung | Up to a hundred of ms | Up to a hundred of ms | We think it would be good to discuss first whether busy indication in response to paging is needed since it involves several signaling changes i.e. does this indication merely enable NW to stop paging or anything else? |
| Futurewei | Variable | Variable | Dependent on implemetation and configurations.  We can take table 1 as a baseline for further discussion |

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 |
| Ericsson | No | It is questionable whether the scheduling gaps could be long enough for the UE to send the busy indication. |
| ZTE | No | We also have some concern on the length of the scheduling Gap, especially for the case that the SCS of network B is larger than that of the network A. |
| Intel | Not sure | It depends on evaluations on how much service interruption would occur in NW A when sending/receiving a NAS busy indication/ accept from NW B, but if it is significant, then we think it is better to consider the solution in 2.1.2.3 (coordinated leaving for NW A) rather than the scheduling gap. |
| Sony | Yes | In case a UE is paged a scheduling gap is needed for the UE with USIM-A for the communication including the busy indication with the UE with USIM-B |
| vivo | No | There are some questions regarding the scheduling gap for busy indication: how long and how often this gap could be.  Usually, the average paging probability is very low. It means after monitoring one PO, most UEs(e.g. more than 99%) just find they are not paged. Among the paged UEs, only some of them will decide not to response the paging and need to send the busy indication. In other word, only very few UE needs to send the busy indication after monitoring the PO.  If one long scheduling gap is configured to monitor the paging occasion and send the busy indication in network B for every PO, it will cause a lot of unnecessary long interruption in network A(i.e. when the UE is not paged), and this periodic long gap could degrade UE performance in network A. |
| Nokia | Maybe | Whether scheduling gap for this duration of BUSY indication without impacting the UE behavior related to synchronization, measurements, and radio link monitoring requires further discussion within RAN2. |
| Charter Communications | Yes | Considering the required times for the steps highlighted in Q10a, a scheduling gap or (short) coordinated leave is required. |
| China Telecom | No | Only scheduling gap for UE to monitor paing occasion is needed. The time required for transmission of busy indication is much longer than monitoring paing occasion. It is inefficient that in each scheduling gap additonal time for busy indication is reserved but be utilized only when a paging message is targed to the UE. |
| Qualcomm | Yes but | However, if the gap is too long, it can cause performance problems on Network A. Therefore, busy indication is not preferred. |
| MediaTek | See comments | The whole procedure requires longer time than simple paging monitoring), and thus it may be necessary for the UE to gracefully leave network A in order to issue a NAS busy indication in network B. |
| Sharp | Yes | At least for monitor paging occasion in NW B. |
| CATT | No | The gap will be too long. The performance impact on Network A is not acceptable. |
| NEC | No | It seems that monitors paging occasion and sending busy indication with one scheduling gap will result in too long break in the other RAT. |
| Xiaomi | Not sure | It should gurantee that the onging service should not be impacted by the scheduling gap. |
| Huawei, HiSilicon | No | Before answering this question, RAN2 should first try to understand the necessity of the busy indication.  Even if the busy indication is necessary, it is not effective to have a large scheduling gap to cover both the paging reception and busy indication transmission in NW B compared with using the “switch notification”. |
| Apple | Maybe | The scheduling gap approach is not fully guaranteed as there is not one size fits all apporach. A graceful coordinated leaving approach is much cleaner for both suspension and resumption. |
| Convida Wireless | Yes | Under network A control, and may depend on the QoS requirements of the data transmission underway in network A. |
| Google | Maybe | We think that a single scheduling gap will not be efficient. The UE needs to send the buys indication relatively rarely, and it may be more efficient for the UE to explicity request additional time resources from theserving network to do so. |
| Samsung | Not sure | We think scheduling gap for busy indication might be useful but whether it is really needed or not can be discussed further as commented in Q10a. |
| Futurewei | No | If this procedure will take several 10’s ~ 100 msec, then using a scheduling gap hardly seems appropriate. Furthermore, such a gap would have to be based on upper bounds (worst case latencies), rather than typical numbers. |

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 NAS  and in inactive state , the busy message sent over RRC  however we are open to hear other options if it is practical |
| Ericsson | Yes, but | We could do it e.g. for RRC INACTIVE case, but in case of RRC IDLE the CN would have to anyway be reached and thus NAS signaling would be required. |
| ZTE | Yes, but | We think it can work for the Inactive state, but if we don’t want to introduce different schemes for the Idle/Inactive state, we think we can also use NAS message for the Inactive state. |
| Intel | No (feasible but not preferred) | Even if a NAS message is not used for indicating “busy” to CN (i.e. RAN instead indicates CN via S1/N2 when it receives a RRC message from the UE including “busy”), we believe that the security over RRC is essential.  We also prefer to have a unified handling for IDLE and INACTIVE as a baseline. |
| Sony | Yes | In RRC Inactive it is feasible with RRC message, in RRC Idle it would require RRC to send the busy signal to NAS. |
| vivo | Yes | It is feasible for RRC INACTIVE state.  It is not feasible for RRC IDLE state. An RRC connection could be required due to security requirement. |
| Nokia |  | Answer to this question needs to be discussed in online session. Because discussion on feasibility of RRC-based solution(s) without finalisation of message sequence in this e-mail discussion is not beneficial. |
| Charter Communications | Yes | Agree with above descriptions. For RRC\_INACTIVE, RRC solution is feasible. For RRC\_Idle, NAS is used due to security concerns. |
| China Telecom | Yes, but | For Inactive State, RRC response is faster than NAS respond.  For Idle State, the security of the Msg3 is not guaranteed. |
| Qualcomm | Yes | A new resume cause can be used for Inactive. Agree that a NAS message is needed when UE transitions from Idle mode. |
| MediaTek | Yes | The RRC Busy Indication can be seen as a kind of “RRC Reject Request” by UE. Similar to *RRCSetupRequest*, this message (msg3) carries *ue-Identity*, but instaed of requesting RRC connection setup, it asks the network not to setup RRC connection. |
| Sharp | Yes | At least for UE in RRC\_Inactivate. For UE in RRC\_Idle, CN should be involved, but we prefer a solution align with the scheme for UE in Inactivate state. |
| CATT | Yes | RRC solution is only feasible for inactive state. For idle state, the NAS solution is needed. We prefer to have a common solution for inactive and idle state. |
| NEC | Yes, But | Agree with companies above that it can work for INACTIVE state, but not IDLE state. But we’de better to have aligned schemes for IDLE/DINTATIVE state. |
| Xiaomi | Yes, | Share Vodafone’s view |
| Huawei, HiSilicon | See comments | Before answering this question, RAN2 should first try to understand the necessity of the busy indication. |
| Apple | Yes | Agree an unified approach between INACTIVE and IDLE would be beneficial. |
| Convida Wireless | Yes | Same view as OPPO, i.e. for idle mode UE, a NAS busy indication should be sent to the AMF node that originates the paging.  For RRC\_INACTIVE mode UE, an RRC busy indication should be sent to the RAN node that initiates the paging. An indication from the RAN node to the CN; i.e. AMF, may also be needed in this case. |
| Google | Maybe | First, it is desirable to handle Idle and Inactive cases in the same fashion. Second, it is not clear to us how this scheme works without NAS involvement. |
| Samsung | Yes, but | Agree with above and we prefer to have a unified solution for IDLE and INACTIVE. |
| Futurewei | Possibly | Anyway the “Busy” message needs to be sent to the AMF, whether this is via a NAS message or an N2 message. Guranteeing that this can be done securely and reliably, seems like a requirement. Otherwise, this could open a new vulnerability that could be exploited by a malicious party.  It seems preferable to use a unified approach for both IDLE and INACTIVE states. |

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 |
| Ericsson | Yes, but | Even though it may be feasible we do not see a need of an RRC-based switching procedure at this point. Since anyway the AMF would be impacted, we should strive for common NAS solutions first and only assess RRC impact in case we could not address it via NAS, |
| ZTE | Yes, | We share the same view as Lenovo |
| Intel | Yes | A “leaving” indication from the UE does not require authorization from CN. From our understanding, this is simply about an indication from the UE not to fall under a kind of failure which is considered bad for network KPI and algorithms. Such a RRC based indication can be used at no problem (given that RAN subsequently informs CN about this) and it can be much faster, while, for 5GS, NG signalling can be further optimized based on RAN’s decision to move the UE to IDLE or INACTIVE.  Moreover, we have introduced *UEAssistanceInformation* > *ReleasePreference-r16* in NR RRC where the UE can request NW to move the UE to IDLE/INACTIVE. This was originally introduced for UE power saving and it is still up to NW, but it can potentially be re-used or enhanced for our purpose here. |
| Sony | Maybe | The solutions in NR and LTE should as far as possible be aligned |
| vivo | Yes | It is feasible to define RRC-based leaving and returning procedure, which can efficiently control the radio resource and RRC states.  Furthermore, RRC-based switching/leaving procedure makes it possible to keep UE in the connected state during the switching/leaving period, which is beneficial for UE data transfer performance. |
| Nokia | Yes | For some short absence RRC based switching should be possible. |
| Charter Communications | Yes | For efficiency sake with 5GS/NR, reusing the RRC based procedure is feasible especially for short leave scenario. However, if specific PDUs need be suspended for long-leaves, then RRC-only is not feasible (without breaking layer seperation). So, for a short coordinated leave, it is feasible to define an RRC-based procedure. But for a long coordinated leave, AMF should be involved. |
| China Telecom | Yes | RRC-based switching/leaving and returning procedure improves the network resoures utilization. No matter short term, such as periodic mobility registration, pick-up an SMS, or long term swithing, the RRC satates between Network and UE can be aligned with each other avoiding the statistic messed up. It needs to investigate the scope of application further compared with NAS based solutions. |
| Qualcomm | Yes | Either NAS or RRC based procedure can work from RAN2 perspective. It will be better to have a common solution for both Idle and Inactive. Also agree with Lenovo on the feasibility of the Note regarding switching from Inactive to Idle. |
| MediaTek | Yes | In R-16 we introduced *releasePreference* in *UEAssistanceInformation*, for power saving purpose. Although the purpose and procedure are different from that for MUSIM, we believe that it is feasible for UE to inform network of its preference to be released using RRC signaling. |
| Sharp | maybe | We agree with Ericsson that RRC-based switching/leaving is needed only when we cannot address it via NAS. |
| CATT | Yes | We share the same view as Qualcomm. |
| NEC | Yes | NAS based solution has longer latency, RRC based with CN informed solution is more efficient for some scenarios. |
| Xiaomi | Yes | Share the same view as Qualcomm. |
| Huawei, HiSilicon | Yes | We could reuse existing *UEAssistanceInformation* with “ReleasePreference”, and if necessary with some enhancement. |
| Apple | Yes | RRC centric solution based on MUSIM UAI would result in lower latency and we can potentially reuse the ReleasePreference option as well. |
| Convida Wireless | Yes |  |
| Google | Yes | At least leaving and returning should be supported. Whether or not the UE should autonomously transit to Idle from Inactive can be further discussed. |
| Samsung | Yes, but | For short duration leaving (e.g. paging monitoring, TAU/RNAU, RRM), RRC-based switching/leaving is feasible and efficient.  For long duration leaving (e.g. no idea how long MUSIM UE leaves the current NW), we think it is more preferable for NAS to execute leaving procedure as NAS is in a better position to judge. |
| Futurewei | Yes | It seems feasible to reuse the *RelasePreference* approach. Enhancements could be considered if needed. |

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 |  |
| Ericsson | No | We think the intention is to avoid RRC impact to LTE RAN in general. |
| ZTE | No | Share the same view as Ericsson |
| Intel | No | Our WID does not list LTE RRC as part of its impacted specifications. |
| Sony | No | This impacts the E-UTRA RRC |
| vivo |  | Based on the existing WID, “Specify mechanism for UE to notify Network A and Network A is NR. Network B can either be LTE or NR.”  We are ok to modify the WID like below to provide clear indication whether 5GS/E-UTRA (Option 5) is included or not, if the majority of companies do not want to change LTE RRC.   * + RAT Concurrency: Network A is NR RAN Network B can either be LTE or NR. |
| Nokia | No | If RRC based switching is agreed as one solution for switching in RAN2, having solution in RRC signalling for LTE (Option 5) can be prioritized based on consensus within RAN2. |
| Charter Communications | No | Duration the formulation of this RAN WI Objective (in RP#86) E-UTRA changes were considered and ruled out (due to lack of agreement). If the sentiments have changed, then we welcome a WI scope change discussion at future RAN Plenaries |
| China Telecom | No | If RRC-based switching apply to option5 it will has impact on E-UTRAN RRC layer and below. |
| Qualcomm | No | This does impact E-UTRA significantly and thus it is better not to have it. |
| MediaTek | Yes | If the solution of RRC-based switching is supported, this case should not be excluded. |
| Sharp | No |  |
| CATT | No | It should be avoid RRC impact on E-UTRA. |
| NEC | No | We prefer not touching LTE spec. |
| Xiaomi | No | No RRC impact on E-UTRAN is preferred. |
| Huawei, HiSilicon | See comments | We are OK to discuss whether Option 5 is in the scope of objective 2. |
| Apple | Yes | If the solution is RRC centric, maybe we can consider it. |
| Convida Wireless | No | Support for Option 5 would require a work item revision. The WID only lists NR specification impacts, therefore impacts to the LTE RRC should be avoided. |
| Google | No | Our understanding is that RAN approved the WID assuming no LTE RRC impact. |
| Samsung | No |  |
| Futurewei | No strong opinion | This seems to be a tradeoff between impacting LTE RRC, or using NAS to indicate “Busy” to the CN. We are open to consider either approach. |

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:

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+) 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 |
| Ericsson | Yes | We think the detailed aspects need further study in RAN2. |
| ZTE | Yes |  |
| Intel | Yes | Good analysis. |
| Sony | Yes | Needs further study in RAN2 |
| vivo | Yes | We think it is feasible to have paging cause on Uu for EPS and 5GS. As shown in the above background info, ASN.1 extension is possible to add paging cause in the EPS/5GS paging message. |
| Nokia | TBD | Before discussing on feasibility, there needs to be decision within SA2. In our view, SA2 based solution which avoids RAN paging cause can resolve this issue. Inclusion of paging cause in RAN paging requires further analysis in addition to overhead such as security. Hence, we propose conclusion within SA2/SA3 on the open issues before RAN2 discussion. |
| Charter Communications | Too early | We agree with Observation 1. |
| China Telecom | Yes |  |
| Qualcomm | Yes | The impact to RRC as well as the overhead is minimal. The decision for the granularity of the cause value is up to SA2. Per RAN WID, we will include at least “voice” if SA2 can’t reach any conclusion. |
| MediaTek | Yes | We agree to the analysis in Observation 1. |
| Sharp | Yes |  |
| CATT | Yes | We agree with Observation 1. But we think we need to wait SA2’s conclusion on paging cause. |
| NEC | Yes |  |
| Xiaomi | Yes |  |
| Huawei, HiSilicon | Too early to make a decision | It’s too early to discuss details on paging cause in RAN2. SA2 should first make a decision whether the paging cause is really useful and necessary. |
| Apple | Yes | Agree with CATT observation on SA2 conclusion as well. |
| Convida Wireless | Yes |  |
| Google | Yes | From a RAN2 point of view, paging cause seems feasible. But we also think that this has security implications and it is up to SA groups to conclude. |
| Samsung | Yes | We think introduction of paging cause in paging message is feasible, and agree with Observation 1. |
| Futurewei | Too early to discuss | Agree with Nokia |

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%. |
| Ericsson |  | We think the detailed aspects need further study in RAN2. |
| ZTE |  | This issue need to be further discussed in RAN2 |
| Intel | May be | But as analyzed well above, can be supported without reducing # of paging records. |
| Sony |  | Needs further study in RAN2 |
| vivo | No | As per above analysis, if the paging cause (3 bits per UE) is added, the paging message size is generally increased by ~6% for E-UTRA and ~8% for NR.  We think the new paging message size is still in the scope of the paging message payload. |
| Nokia |  | As above. This analysis needs to be done once SA2/SA3 concludes on the final solution including addressing of security issues. |
| Charter Communications |  | The addition of paging cause could tehoratically reduce the max number of paging records, if all the records carry a paging cause. Given the low chance of all paging records being associated with MU-SIM UEs, we believe there should not a concern on the number of paging records or the paging coverage. Overall, we’d like to highlight that the need for a paging cause oytweights any potential impact. |
| China Telecom | No | Paging cause only increases a little bits in paging message. The impact of number of paging records in single message is neglectable. |
| Qualcomm | Yes but not important | We don’t think this will cause a problem in real deployments. |
| MediaTek | No | The number of paging records in a paging message should not be affected by paging cause overhead. |
| CATT |  | We can further discuss it after SA2 have conclusion on paging cause. |
| NEC |  | Agree with other companies that it is too eary to discuss this. And we think the issue should be assessed and justified by RAN1/4 after SA2 has made decision. |
| Xiaomi |  | Further discussion in RAN2 is needed on this aspect. |
| Huawei, HiSilicon |  | Same as for Q14 |
| Apple |  | Agree that further RAN2 discussion is need on this aspect. |
| Convida Wireless | Maybe | We think this requires further study by RAN2. |
| Google | Maybe | We tend to agree with Lenovo that this is not a major issue, but more analysis is needed. |
| Samsung | Yes | We think up to 2 or 3 paging records might be reduced considering multiple paging causes on the table under SA2 consideration (e.g. critical services, voice, SMS, IMS signaling, CP signaling, and other data). We further think its impact seems tolerable but the detailed ASN.1 issue can be discussed after the final conclusion of how many paging causes are deemed to be supported in SA2. |
| Futurewei | Too early to discuss | RAN2 can discuss after SA working groups have concluded their assessment |

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. |
| Ericsson | Possbily Option C, but | We think the detailed aspects need further study in RAN2. |
| ZTE | Option B or C | Need further discussion in RAN2. |
| Intel | A | Per PLMN should be baseline. FFS on others. |
| Sony | Option C | Need further study |
| vivo | Option A | We think it is better to support the paging cause per PLMN. |
| Nokia | Tbd | Needs further discussion in RAN2 |
| Charter Communications | Option A | Too early to conclude early granularity. |
| China Telecom | Option A |  |
| Qualcomm | Option A or E | It should be per UE by default but per PLMN is also reasonable. |
| MediaTek | A | The support of paging cause should be PLMN-wide. But deployment can be done on a per RAN node basis. |
| CATT | Option A | But we think it’s better to discuss it after SA2’s conclusion on paging cause. |
| NEC | Option B or C | Need further discussion by SA2 and RAN2. |
| Xiaomi | Option A | Further discussion in RAN2 is needed on this aspect. |
| Huawei, HiSilicon |  | Same as for Q14 |
| Apple | Option A |  |
| Convida Wireless | Option A | Need further discussion in RAN2. Paging cause can be related to the service/message type that triggers the paging and can be a cause at a PLMN level. Also Paging cause can be RAN paging when UE is in RRC\_INACTIVE state. In this case the cause can also be defined at PLMN level. |
| Google | A | Option A should be baseline. |
| Samsung | Option C | We think there seems no real RAN2 dependency, but in order to support paging cause PLMN wide, all the RAN nodes across the PLMN needs to be upgraded at the same time. This in our view creates difficulties during deployment. Thus we think support at gNB should be considered as a baseline. |
| Futurewei | Too early to discuss |  |

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 ! |
| Ericsson | M | We think first it should be considered whether possible UE implementation of this would be already good enough to solve the problem. Also for many cases we think this would be low probability to happen. |
| ZTE | M | We share the same view as OPPO |
| Intel | M | Agree with OPPO and Lenovo. |
| Sony | H | In areas with many UEs, using multiple SIMs, the probability of collisions increases.  It is important to solve it in a controlled way, otherwise the impact is unknown. |
| vivo | H | The paging reception collision may periodically occur at the UE, having an impact on the user experience |
| Nokia | M | Solutions with minimum RAN impacts but also enable better energy efficiency for idle mode operation are preferred. |
| Charter Communications |  | Note that prioritization discussions are not in purview of WGs unless directed by RP.  We belive a standard-based solution for paging collision can complement the UE/chipset vendor implementation, and during the SI, RAN2 should adequetly work on this issue. |
| China Telecom | H | We think PO collision needs to be solved with the help of coordination of UE and network. |
| Qualcomm | H | This is quite relevant in current deployments and thus needs to be solved. |
| MediaTek | M | Paging collision probability is low: The probability that USIM A and USIM B have the same UE\_ID is ~10^-3, and the paging collision probability is usually lower than this considering that two networks may have different paging configurations. |
| Sharp | M | Agree with OPPO. |
| CATT | M | We think the paging collision issue is clear. But whether the UE implementation solution is feasible should be first discussed. If no, we prefer to limit the RAN and CN impact. |
| NEC | H | The issue does exists, and we have both specification impact solutions and UE implementation based solution, we need to make decision in this Release. |
| Xiaomi | L | Paging collision probability is low and it can be solved by UE implementation. |
| Huawei, HiSilicon | M | We share the same view as E/// |
| Apple | H | Paging Collision is an important issue that needs to be resilved with help of UE and NW interworking. |
| Convida Wireless | M |  |
| Google | M | Since this is a systematic problem, it will benefit from a 3GPP based solution |
| Samsung | H | We prefer to address this issue with the aid of a standard-based solution, otherwise it will have an negative impact on both user experience and network operation. |
| Futurewei | M | Generally agree with MediaTek.  However, operators may still be justified to ask for some standardization, even if this would be limited to detecting that paging occasion collisions are occurring, and allow them to assess/bound the magnitude of the issue. |

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 |  |
| Ericsson | H | Both scenario 1 and 2 are relevant, thus a leaving procedure should be applicable to both cases, whether there are particular differences that must be considered in each case can be further discussed. For scenario 1 there may be also two scenarios e.g. scenario 1.1: really short leaving (UE may possibly remain in RRC CONNECTED); scenario 1.2: short leaving (UE may be moved to RRC INACTIVE/IDLE). |
| ZTE | H | Both Scenario 1 and 2 have high priority, and they are also relevant. |
| Sony | H | Fundamental scenario to solve |
| vivo | H | If UE performs these activities on network B without any interworking with network A, some negative impacts on performance could occur on both network A and UE, e.g.:   * + UE is being scheduled by network A while actually UE cannot receive the communication, which could be handled as radio link failure or other errors.   + Frequent switch from network A for short time activities such as paging receptions. |
| Nokia | H | This use case is important to minimize the interruption to the connected mode network due to short/long absence of UE which is currently based on UE implementation without network awareness. Hence, we propose RAN level coordination for this switching scenario. |
| Charter Communications |  | Note that prioritization discussions are not in purview of WGs unless directed by RP.  Given the importance and need for short time switching, we believe RAN2 should adequetly work on this issue. |
| China Telecom | H | This scenario involves the basic procedures in Network B |
| Qualcomm | H |  |
| MediaTek | H | This is fundamental requirement for UE to operate MUSIM. |
| Sharp | H | This is an essensial issue to improve the performance of MultiSIM. |
| CATT | H | Both Scenario 1 and 2 have high priority. |
| NEC | H |  |
| Xiaomi | H |  |
| Huawei, HiSilicon | H | We should aim to have a unified solution for both Scenario 1 and Scenario 2 |
| Apple | H | Graceful UE switching for different use cases (Voice call, Signaling, Paging, Measurement) is an important problem that we should address as part of MUSIM WI. |
| Convida Wireless | H |  |
| Google | H |  |
| Samsung | H |  |
| Futurewei | 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 |  |
| Ericsson | H | Both scenario 1 and 2 are relevant, thus a leaving procedure should be applicable to both cases, whether there are particular differences that must be considered in each case can be further discussed. |
| ZTE | H |  |
| Sony | H | Agree with Oppo |
| vivo | H | If a user switches from the networks without any switch notification, some negative impacts on performance could occur on both network A and UE, e.g.:   * + Wasting the resource on network A while UE absence;   + Distorting network statistics while UE absence;   + Slow data throughput recovery after UE switching back to network A. |
| Nokia | M | For long time switching, NAS based solutions may also be considered with minimum AS impacts. Because the leave for long time activity also impacts the paging /MT services of CN. |
| Charter Communications |  | Note that prioritization discussions are not in purview of WGs unless directed by RP.  Given the importance and need for long time switching, we believe RAN2 should adequetly work on this issue. |
| China Telecom | H | This scenario is important to achieve services in another network without radio resource waste. Another issue is the paging strategy of the original network to reach UE. |
| Qualcomm | H |  |
| MediaTek | H | This is fundamental requirement as well. |
| Sharp | H | This is an essensial issue to improve the performance of MultiSIM. |
| CATT | H |  |
| NEC | H |  |
| Xiaomi | H |  |
| Huawei, HiSilicon | H | We should aim to have a unified solution for both Scenario 1 and Scenario 2 |
| Apple | H |  |
| Convida Wireless | H |  |
| Google | H |  |
| Samsung | H |  |
| Futurewei | 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 |  |
| Ericsson | L | While connected to 2 networks the UE should anyway not report the support of capabilities related to two Rxs when, in fact, the UE cannot support it for the MU-SIM case. |
| ZTE | L | We share the same View as Ericsson. |
| Sony | H | It is important that the NW knows the status and capability of the UE. Therefore this should be studied |
| vivo | M | This case may be useful for example to allow UE, equipped with MIMO, to reduce its MIMO capability in netwrok A and receive paging on network B without interrupting its communication on network A |
| Nokia | H | Capability switching for better performance of MUSIM operation is needed for many use cases. NAS based solutions may also be considered depending on the capability to be changed.  RAN2 should further discuss the scenarios under which such capability reduction should happen (DAPS, MR-DC etc. |
| Charter Communications |  | Note that prioritization discussions are not in purview of WGs unless directed by RP. |
| China Telecom | H | As NR requires UE to support 4Rx, it is common that UE may share Rx chains between two USIMs. When UE switch the Rx to USIM-B, the network associated with USIM-A may face downlink decoder failure for a period. |
| Qualcomm | L | Even though this is an important problem, it is only relevant when the UE is in Connected mode in both USIMs. This is not in the scope of the current WID. It will also require significant discussion and spec change. Note that the issue was discussed in Rel-14 NR SI as part of temporary restrictions but not included in the WI phase. We prefer to do this more comprehensively in Rel-18 and focus on the Idle+Idle and Idle+Connected modes in Rel-17. |
| MediaTek | H | This is fundamental requirement as well. |
| Sharp | H | This is an essensial issue to improve the performance of MultiSIM. |
| CATT | M | We share the same view as China Telecom. But this scenario is related with two connected mode in both USIMs, which is not in the scope of current WID. If we need discuss this scenario, it would be better to update the WID. |
| NEC | L | For simplicity, the solutions for scenario 1 and 2 should be reused for this case, i.e. the UE do not support simultaneous reception for the two RAT. |
| Xiaomi | L |  |
| Huawei, HiSilicon | H | This is important to avoid performance degradation for DL reception |
| Apple | H |  |
| Convida Wireless | L |  |
| Google | L | We are not convinced how realistic these scenarios are. |
| Samsung | L | We generally share the same view with Ericsson and RAN2 can discuss this issue further, if valid, after addressing issues 1 and 2. |
| Futurewei | M ~ L | Tend to agree with QCM |

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 |  |
| Ericsson | L | While connected to 2 networks the UE should anyway not report the support of capabilities related to two Txs when, in fact, the UE cannot support it for the MU-SIM case. |
| ZTE | L | We share the same View as Ericsson. |
| Sony | H | It is important that the NW knows the status and capability of the UE |
| vivo | M |  |
| Nokia | H | Capability switching for better performance of MUSIM operation is needed for many use cases such as dual connectivity , carrier aggregation and MIMO scenarios. |
| Charter Communications |  | Note that prioritization discussions are not in purview of WGs unless directed by RP. |
| China Telecom | H | It is common for 5G devices to support SA 2Tx/4Rx or NSA dual connection. It is straight forward that Multi-USIM UE may spare one transmission chain for another USIM when two USIMs need to communicate with two networks at the same time. We can foresee that more and more 5G Multi-USIM devices will consider to support dual Tx/ dual Rx in the future. It is just the right time to study and solve the key issues of dual Tx/ dual Rx UEs  When two USIMs need to communicate with two networks at the same time the NR capability of USIM 1 will fall back from 2Tx to 1Tx. In this case the NR SA network associate with USIM 1 will face demodulation failure in uplink for a period and it totally relies on network implementation to adapt to uplink layers change in UE.  For the case of USIM1 working on NSA. When the UE has to switch one RF transmission chain from USIM1 to USIM2, it may just locally release the NR SN connection which leads to radio link failure on NR network and an error record. |
| Qualcomm | L | Same comment as Q20 |
| MediaTek | H |  |
| CATT | M | Same comment as Q20. |
| NEC | L | Dual-Rx /Dual-Tx UE is out of the scope of the WID |
| Xiaomi | L |  |
| Huawei, HiSilicon | L | This is not in the scope of RAN WID. |
| Apple | H |  |
| Convida Wireless | L |  |
| Google | L | We are not convinced how realistic these scenarios are. |
| Samsung | L | See our comments in Q20. |
| Futurewei | L |  |

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** |
| Nokia | DC at connected mode network | M | EN-DC /Dual connectivity at NTWK-A (connected mode) also needs to be analysed. |
|  |  |  |  |

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 |
| Ericsson | Yes |  |
| ZTE | Yes |  |
| Intel | Yes |  |
| Sony | Yes |  |
| vivo | Yes |  |
| Nokia | Yes | SA2/SA3 needs to fist conclude on the solution for the key issue related to paging cause. Depending on the conclusion RAN2 can discuss on further analysis if required. This is in line with WID scope. |
| Charter Communications | Yes |  |
| China Telecom | Yes |  |
| Qualcomm | Yes |  |
| MediaTek | Yes | It is necessary to ensure that for forward compatibility reason enough paging causes be defined. It must also be taken into account that with a RAN supporting a new paging cause for voice, a paging cause “Other data” will also be required so a UE supporting new paging cause can differentiate paging that is not for voice, from paging without a paging cause at all (i.e. legacy). Indeed if this is not done, the UE will have to assume that a paging without a paging cause is always operating as per legacy (i.e. could be voice or anything else). |
| Sharp | Yes |  |
| CATT | Yes |  |
| NEC | Yes |  |
| Xiaomi | Yes |  |
| Huawei, HiSilicon | Yes |  |
| Apple | Yes |  |
| Convida Wireless | Yes |  |
| Google | Yes |  |
| Samsung | Yes |  |
| Futurewei | Yes |  |

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.