3GPP TSG-RAN WG2 Meeting #113-e R2-2101981

Online, Jan 25th – Feb 05th 2021

**Agenda item: 8.3.3**

**Source: vivo**

**Title: [AT113-e][242][NR][Multi-SIM] NAS vs. RRC signalling for paging collision and network switching (vivo)**

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

**Document for: Discussion and Decision**

# Introduction

This document aims to collect views from companies for the following email discussion agreed during RAN2#113e:

* [AT113-e][242][NR][Multi-SIM] NAS vs. RRC signalling for paging collision and network switching (vivo)

Scope:

* + - Collect views which companies support NAS or RRC signalling, including technical reasons **why** NAS/RRC should be used. Should consider contributions submitted to this meeting to highlight technical analysis.

 Intended outcome:

* + - Discussion summary in [R2-2101981](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_113-e/Docs/R2-2101981.zip) (by email rapporteur).

 Deadline for providing comments, for rapporteur inputs, conclusions and CR finalization:

* + - Initial deadline (for companies' feedback): 2nd week Mon, UTC 1200
		- Initial deadline (for rapporteur's summary): 2nd week Tue, UTC 1200

# Discussion

To make it easier to find the correct contact delegate in each company for potential follow-up questions, the rapporteur encourages the delegates who provide input to provide their contact information in this table:

|  |  |
| --- | --- |
| Company | Contact: Name (E-mail) |
| Vivo | kimba@VIVO.COM |
| OPPO | fanjiangsheng@oppo.com |
| ZTE | li.wenting@zte.com.cn |
| Sony | Anders.Berggren@sony.com |
| CATT | zhourui@catt.cn |
| Fraunhofer | nithin.srinivasan@hhi.fraunhofer.de |
| Google | nuggehalli@google.com |
| MITRE | sksharma@mitre.org |
| ASUSTeK | ryan\_ou@asus.com |
| MediaTek | li-chuan.tseng@mediatek.com |
| Huawei/HiSilicon | rama.kumar@huawei.com |
| LG Electronics | hassium.kim@lge.com |
| Lenovo, MotM | pmallick@lenovo.com |
| Nokia | Srinivasan.selvaganapathy@nokia.com |
| CMCC | chenningyu@chinamobile.com |
| CableLabs | h.lin-contractor@cablelabs.com |
| Charter Communications | reza.hedayat@charter.com |
| Apple | sethu@apple.com |
| NEC | wang\_da@nec.cn |
| Samsung | sy0123.jung@samsung.com |
| Spreadtrum | Xiangdong.zhang@unisoc.com |
| Xiaomi | hongwei@xiaomi.com |
| Sharp | fangying.xiao@cn.sharp-world.com |
| China Unicom | gaos30@chinaunicom.cn |
| China Telecom | liujiaxiang6@chinatelecom.cn |
| DENSO | tomoyuki.yamamoto.j5c@jp.denso.com |
| Ericsson | lian.araujo@ericsson.com |
| Intel Corporation | jaemin.han@intel.com |
| Futurewei | mazin.shalash@futurewei.com |

## CN vs. RAN based solution for paging collision

During RAN2#113 online discussion, the following agreements have been made for paging collision objective.

|  |
| --- |
| * **There is support for solution 1 with something else, either solution 3 or 2b.**
* **Option 2b is the preferred solution to address paging collision for “LTE + LTE”.**
* **MUSIM UE determines potential paging collision on two networks and triggers actions on potential paging collision avoidance.**
* **It is left to UE implementation as to how it selects one of the two RATs/networks for paging collision avoidance**
* **FFS if we can make the UE behaviour predictable.**
 |

### 2.1.1 EPS

SA2 has already agreed to use Option 2b for solving the paging collision in EPS side.

|  |
| --- |
| 8.2 Conclusions for Key Issue #2: Enabling Paging Reception for Multi-USIM DeviceEditor's note: To be completed.Based on the evaluation in clause 7.2 the following **interim** conclusions are agreed for the baseline functionality:- For paging reception in EPS when the paging collision is detected, the following principles are agreed:- Upon the UE detecting paging collisions between two networks, the UE initiates a TAU procedure to the MME of one network, to request an IMSI offset.- UE may provide an IMSI offset to MME during TAU procedure.NOTE: Details on the request e.g. offset range will be defined during the normative phase.- The MME returns an IMSI offset to the UE in the TAU Accept.- During CN paging delivery, the MME provides to the RAN the UE\_ID which is derived based on the IMSI and the IMSI offset. RAN and UE use the UE ID as the IMSI to calculate the PF/PO.Editor's note: This conclusion needs to be confirmed in RAN plenary |

And the conclusion has been confirmed in RANP, as follows:

|  |
| --- |
| The detailed objectives of the Work Item are:1. Specify, if necessary, enhancement(s) to address the collision due to reception of paging when the UE is in IDLE/INACTIVE mode in both the networks associated with respective SIMs [RAN2]
	* RAT Concurrency: Network A can be NR or LTE. Network B can either be LTE or NR.
	* Applicable UE architecture: Single-Rx/Single-Tx.

For objective 1, specification change should focus on NR side and the change on LTE side is only for IDLE mode (i.e. related to EPC enhancement in SA2)<Omit> |

From RAN2 point of view, Option 2b is also agreed as the preferred solution to address paging collision for “LTE + LTE”. Thus, we think CN-based solution (Option2b) has already been agreed by SA2/RAN2 for solving paging collision issue in EPS side.

### 2.1.2 5GS

There is still no consensus on whether CN-based or RAN-based solution should be adopted to solve the paging collision issue in 5GS side, where CN-based or RAN-based solution here means that paging collision is solved by CN or RAN, respectively. In the companyies’ contributions [12]-[30], there are some support for both CN-based solutions and RAN-based solultions. The below Table summarizes the analysis given by the companyies’ contributions for the above solutions.

**Table 1: Summary of analysis of solutions**

|  |  |  |  |
| --- | --- | --- | --- |
| **Solutions** | **Whether paging collision can be totally solved?** | **The increased signal overhead on Uu** | **Impact analysis** |
| CN-based solution | 1 | NoPaging collisions may reoccur due to the following reasons, leading to the UE has to request again:- after cell reselection;- 5G-GUTI is reassigned again by other legacy SA2 procedures;- the identity used for CN paging in NR has to be refreshed after every paging message for better security. | No extra paging overhead | / |
| 2a | NoPaging collisions may reoccur after cell reselection, leading to the UE has to request again. | Impact on Uu, NG.  |
| 2b | NoSame with Option 1 | Impact on Uu, NG. |
| RAN-based solution | 3 | Yes | The paging overhead is at least doubled. | Impact on Uu at least. |

Hence, companies are invited to provide their inputs for the following questions.

1. **Do you think which one should be supported for solving paging collision in 5GS side?**
	* + **A: CN-based solution**
		+ **B: RAN-based solution**

|  |  |  |
| --- | --- | --- |
| **Company** | **A or B** | **Technical reasons** |
| vivo | A | Considering the probability of paging collision reoccur after cell reselection is low, solutions 1/2a/2b may work well in most cases, and solution 1 is the simplest. |
| OPPO | A | Share similar view with vivo, anyway paging collision is not a big issue, many UE vendors have solved this issue by implementation for a long time, so it’s not worth to have a complex solution. Solution1 is sufficient. |
| ZTE | A | Share the same view as Vivo |
| Sony | A | The CN based solutions solves the problem with paging collisions by moving one of the paging occasions. The paging occasions can, with UE assistance be moved to a UE preferred position, e.g. it can minimize the power consumption of the UE by having the paging occasions not colliding but aligned. With 2a the position of the paging occasion can be set as not depending on the 5G-GUTI and thereby not risk paging collision when the GUTI is reassigned. |
| CATT | A | Agree with vivo and OPPO |
| Fraunhofer | A | Same view as Vivo |
| Google | A | Agree with Vivo and OPPO that paging collision probability is quite low. We think there is no need for either CN or RAN based solution, but if we have to standardize something, then CN based solution is good enough.  |
| MITRE | A+B | We believe that A itself cannot solve the problem in all cases. A relies on only one ingredient of the PO calculation formula viz. 5G-S-TMSI. However, the formula itself has two more ingredients to play with viz. the DRX/paging cycle and paging frame offset. Moreover, A needs end-to-end signaling between UE and CN and poses significant challenges at the CN (like how to find another ‘non-colliding’ but unique 5G-S-TMSI over a larger TA, with the constraint that only last 10 bits will be significant for PO calculation). In more complex cases (higher number of SIMs supported), the collision probability also increases and this will cause even more RAN-CN signaling overhead. In some cases, UE may be able to find a collision compromise with only RAN level signaling, especially in the RRC\_INACTIVE state. So we believe we should consider the RAN based solution also. We also propose a UE specific paging frame offset (currently it is defined at cell level) to have a simpler solution at RAN level. This is detailed in our contribution [25]. |
| ASUSTeK | A | Agree with vivo. CN-based solutions are preferred. |
| MediaTek | A | Agree with above comments and Solution 1 is sufficient for paging collision avoidance in 5GS. |
| Huawei/ HiSilicon | B if no solution needs to be specified; Solution 1 in A if solution needs to be specified; please see comments | As we mentioned in our contribution [23], Option B with the UE reporting its Multi-SIM capability is the best solution proposal to solve paging collision considering the pros and cons of all the available solution proposals. However, if the Multi-SIM WID goal is to specify a solution, Solution 1 is our preferred solution. |
| LG | A | We think CN based solution is better to make a common solution for both NR and LTE. If we can say this issue is not a big issue, then we don’t need to have a separated solution. |
| Lenovo, MotM | A+B | For B: Instead of repeating paging on consecutive PO for RAN based solution, the paging can be transmitted on the alternative PF+PO instead of the “regular” PF+PO. The “alternative” can be deterministically located at an offset from the “regular” PF+PO. |
| Nokia | A+Assistance information | The purpose of solution described in 1 is to report collision and the collision should be avoided on receiving response message from core network. For this purpose, assistance information from UE suggesting information for GUTI assignment is necessary. Otherwise the whole signalling procedure of solution 1 will not lead to collision avoidance in deterministic way at least for the same cell scenario. |
| CMCC | A | Agree with vivo. |
| Cablelabs | A+B | A solution for idle UE and B solution for inactive UE |
| Charter Communications | B/A+B | Note that Table 1 indicates the worst case overhead for Solution 3. Solution B plus assistance info could resolve paging collision without doubling paging overhead.If Solution 3 is not agreed by majority, we believe that Solution 2b (adding offset, applicable for LTE and NR) serves as a better solution than 1. In A/Solution 1, the maximum duration of 5G-GUTI reassignment is left to implementation, and during it, a multi-SIM UE is locked in the MM procedure and until it is resolved, the UE cannot switch networks.  |
| Apple | A + MUSIM Assistance Information | Companies all agree that merely A would not help to solve the Paging collision issue. It is imperative that some additional assistance information from the UE suggesting to help change the GUTI can be considered as an additional dimension to resolve the collision aspects.  |
| NEC | A | Solution A is sufficient. Repeating paging in RAN will increase paging overhead significantly, which is too much for the paging collision issue with small possibility of occurrence. |
| Samsung | A | We agree with Vivo that Solution 1 is simplest and sufficient given that paging collosion probability is quite low and it brings minimal impact on our specification. |
| Spreadtrum | A | Solution 1 has the minimum specification impacts, and solution 2b means a common mechanism for both EPS and 5GC. |
| Xiaomi | A | We don’t think paging collision is a big problem for MUSIM devices to be solved considering so many MUSIM commercial devices have already worked very well.If one solution has to be chosen without considering the real market situation, we prefer A (solution 1) with less specification impact.  |
| Sharp | B/A+B | We prefer B at least for inactive UE. And for B, we share the same view with Lenovo. |
| China Teleocm | A | Share the same view as Vivo |
| DENSO | A | Agree with vivo. And solution 3 may cause waste of NW resources. |
| Ericsson | A | We also prefer CN solution since it could be simpler and as said above, the paging collision is anyway not a big issue, so there is no need to impact RRC for this. |
| Intel | A | Agree with Vivo |
| Futurewei | A | Agree with Vivo. |

**Summary:**

TBD.

1. **For the selected solution in Q1, do you think whether assistant information is needed?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes or No** | **Technical reasons** |
| vivo | Yes | It is benefit if the UE is allowed to provide assistant information to help the network to decide the new ones. Since the UE knows the POs in multiple USIM precisely and then decide the new 5G-S-TMSI more properly, to avoid requesting multiple times. On top of this, providing the assistant information may enable the UE to wake up once but can monitor the POs for multiple SIM cards. Moreover, if the UE has multiple USIM cards, it is more suitable to determine the PO offset to be switched at the UE side instead of NW side, since the change of 5G-S-TMSI may solve the PO collision between USIM 1 and 2, but bring PO collision between USIM 1 and 3. |
| OPPO |  | If Option A is preferred by companies in Q1, we think the necessity of assistant info can be addressed by NAS. |
| ZTE | No | We under stand the intention on the assistance information. However, to solve re-collision issue, besides sending the assistance information to the Network, it can also be solved without assistance information for that the PO is periodically distributed and the possible paging cycle is specified to be {rf32, rf64, rf128, rf256}. Take the Fig 1 as an example, the network B can have the same (network B2) or different (network B1) paging cycle from the network A, once the collision happened, the network B can shift the PO to the position of original PO+16rf, then the AMF select a 5G-STMSI that can derive a PO next or equal to the original PO+16rf. (We just give a solution example that without assistance information, it doesn’t mean the network must take this method, the detail can be left to the network implementation.)**Fig 1: PO collision**For the benefit propose by vivo above (e.g. wake up one time for the same operator, avoid collision for more than 2 Usims), we think it’s just an enhancement for some corner cases. |
| Sony | Yes | See answer in Q1)  |
| CATT | No | no need to send such assistant information,1. if the old 5G-S-TMSI causes collision, then in principle a new 5G-S-TMSI will avoid the collision at least in the current cell.2. probability of paging collision would be very low after the 5G-GUTI reallocation. |
| Fraunhofer | Yes | Providing the assistance information can help the network make more informed updates thereby reducing the number of requests to resolve the PO collision. Also as pointed out by Sony, can better accommodate UE preferences. |
| Google | No | Since we are of the view that paging collision is quite rare, we are reluctant to over-engineer the proposed solution. In the unlikely event of a paging collision, the UE can awlays request a further reassignment.  |
| MITRE | Yes | UE has a better understanding of all the attached networks and how the respective POs collide with each other. Without UE assitance in more complex cases (higher number of SIMs supported/ independent carrier networks), each CN will have to blindly do the trial and error resolution of the collision problem. |
| ASUSTeK | Yes | Agree with vivo. UE should provide assistance information for NW decision. |
| MediaTek | No | Paging collision rarely happens. Also we believe that upon receiving 5G-GUTI reassignment request (e.g. via MRU), the network is able to reassign a 5G-GUTI that shifts the PF/PO.  |
| Huawei/ HiSilicon | No | There is no need to provide assistance information for the below reasons: 1. Paging collision is a very low probability issue
2. The provided assistance information may not be useful for CN, for example in case of Solution 1, the 5G-GUTI may not be available at CN.
 |
| LG | Yes | As many other companies said, most of solutions cannot resolve the paging collision totally. Considering, from online discussion, there are many supports of option 1 and option 2b, the assistance information can help the network resolve the paging collision precisely if RAN2 chooses a solution between two of them. |
| Lenovo, MotM | Yes | UE only needs to inform the network that it has a Paging collision issue – like in any solution. The **offset** from the “regular” PF+PO for the alternative paging can be specified or even configured by the gNB (using RRC signaling). |
| Nokia  | Yes | As explained in Q1. The basic signalling procedure for collision reporting and avoidance should be at NAS level as the paging occasion is function of NAS identifier. But whether given identifier lead to collision is UE decision based on RAN parameters. So this assistance information needs to be included in the NAS message to ensure that procedure results in outcome which solves the collision problem |
| CMCC | Yes | We support UE to provide the assistance information, since it can help network side to solve the paging collision. |
| Cablelabs | Yes | Assistant information would resolve the paging collision at hand until the UE potentially detects another paging collision via cell reselection later on.  |
| Charter Communications | Yes | While not necessary, Solution 3 benefits from assistant info in order to reduce the overhead of the additional paging load. Assistant info is also helpful for Solution 2b to specify offset value(s) that avoids subsequent paging collision.  |
| Apple | Yes | We do see a need for the UE to provide the assistance information to the network to help in collision resolution, as the UE is best positioned to determine if and where the paging collision occurs and what is the best offset to be considered to resolve the collision. The offset can be considerd as a RAN level RRC signaling. In that perspective Solution 2b would also benefit from such an assistance information. |
| NEC | Yes | How to adjust 5G-GUTI or allocate offset is based on several parameters, which is ignorant to core network, assistance information is useful for the network to allocate invalid value. And also as point out by Sony, UE can provide suggest value for better power saving. |
| Samsung | Not essential | We think that it is unlikely that the paging collision still remains after a new 5G-GUTI is reallocated to UE. Instead, it is more expected that the re-assigned 5G-GU will resolve the paging collision in most cases. Thus, we are not convinced whether it is worth supporting assistance information to address (potential) rare cases. We also would like to point out that it is not clear yet what contents of assistance information are to defined in RAN2. It seems premature to decide the necessity of assistance information. If majority company prefers to support it, we think that it should be left to UE implementation whether to include assistance information i.e. UE is not mandated to include it. |
| Spreadtrum | No | Prefer solution 1 without any feedback from UE.  |
| Xiaomi | No | We don’t think paging collision is a big problem for MUSIM devices to be solved considering so many MUSIM commercial devices have already worked very well. Solution 1 without any assistance information is enough.  |
| Sharp | Yes | Only UE knows exactly which PF/POs are collisioned, the assistant information are helpful for Network/AMF to assign suitable PF/POs or UE ID. |
| China Telecom | No | We understand the purpose of assistant information is to avoid multiple PO collision adjustment procedures. However, we prefer a simplest solution for PO collision. Considering that PO collision is a low probability event, solution 1 without assistant information is sufficient.  |
| DENSO | Yes | Since NW do not know the information about PO in the other NW for the UE, paging collision may reoccur if assistance information is not provided. |
| Ericsson |  | Same view as OPPO, specially because we understand part of the intention with A above is to actually avoid RRC impact. |
| Intel | No | Agree with Huawei |
| Futurewei | No | Agree with Intel |

**Summary:**

TBD.

For CN-based solutions, according to the detailed procedure and descriptions for option 1/2a/2b (referred to Sol#14, #15, #16) in TR 23.761, the UE can trigger paging collision avoidance and provide assistant info to AMF. Thus, companies are invited to provide their inputs for the following question.

1. **If CN-based solution is supported, do you agree that paging collision avoidance and/or the assistant info (if needed) should be indicated to AMF?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes or No** | **Technical reasons** |
| vivo | Yes | For each CN-based solution, paging collision avoidance shall be triggered by the UE side and indicated to the AMF. |
| OPPO |  | See Q2 |
| ZTE | Yes(but no assistance information) | For CN-based solution, paging collision avoidance shall be triggered by the UE side and indicated to the AMF.  |
| Sony | Yes | Thereby the CN can assign a UE\_ID which is at a good non-colliding position. |
| CATT | Yes(but no assistance information) |  |
| Fraunhofer | Yes | Both collision avoidance and assistance information |
| Google | Yes but no assistance information |  |
| MITRE | Yes | Other than negotiating 5G-S-TMSI, UE can also negotiate DRX cycle with the AMF in RRC\_IDLE state. |
| ASUSTeK | Yes |  |
| MediaTek | Yes |  |
| Huawei/ HiSilicon | Yes(but no assistance information) | Agree with ZTE |
| LG | Yes |  |
| Lenovo, MotM | Yes | The PO of another SIM(s) can be submitted to the selected network,which could be helpful for network to assign a suitable parameter e.g. new UE ID or offset. |
| Nokia | Yes  | This question is extension of Q2. Mostly same answers applicable here.  |
| CMCC | Yes |  |
| Cablelabs | Yes |  |
| Charter Communications | Yes | Same response as in Q2.  |
| Apple | Yes |  |
| NEC | Yes |  |
| Samsung | Yes (but FFS for assistance information) | As RAN2 agreed that MUSIM UE determines potential paging collision on two networks and triggers action on potential paging collision avoidance, we understand it is a natural consequence that paging collision avoidance needs to be indicated to AMF. Regarding assistance information, please see our comments on Q2. |
| Spreadtrum | Yes(but no for assistance information) |  |
| Xiaomi | Yes(but no assistance information) |  |
| Sharp | Yes | See our reply in Q2. |
| China Telecom | Yes | An indication of paging collision should be sent to AMF. |
| DENSO | Yes |  |
| Ericsson |  | We agree there should be an indication to the AMF. On the UE assistance information, as indicated in Q2, we think this could be discussed as part of the NAS solution and no impact to RRC would be needed. As a side note, we have a preference for option 2a/b, even though our understanding is that the question is not intended to discuss a particular option at this point. |
| Intel | Yes(but no assistance information) | Agree with ZTE |
| Futurewei | Yes(but no assistance information) | Agree with ZTE |

**Summary:**

TBD.

For RAN-based solution, it is feasible for the UE to trigger paging collision avoidance and provide the assistant information to AMF or gNB. Thus, companies are invited to provide their inputs for the following question.

1. **If RAN-based solution is supported, do you think whether the UE need to indicate paging collision avoidance and/or the assistant info (if needed) to the network? And if yes, to which network node, i.e., AMF, gNB?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes or No** | **Technical reasons** |
| MITRE | Yes | In our RAN level signaling solution [25], we propose a quick RRC Resume/Suspend procedure in RRC\_INACTIVE state. UE provides feedback on paging collision (with ResumeCause); and assistant info with PagingCycle and/or PagingFrameOffset. With this assistance, gNB can decide how to avoid paging collisions at UE. We believe that this solution is more efficient than end-to-end signaling between UE and CN. |
| Huawei/ HiSilicon | No | Only Multi-SIM capability information is enough.  |
| Lenovo, MotM | Yes | The UE needs to indicate to one of gNB/ eNB only (to the network where it likes POs to change) and just that there is a paging collision issue (that the UE can’t solve by itself). |
| Cablelabs | Yes+comment | As commented earlier in Q1, due to RAN-paging, RAN base solution should be considered for paging collision avoidance in inactive case. |
| Charter Communications | Yes | Multi-SIM capability info perhaps with suggested offset values, if (unresolvable) paging collision detected.  |
| Apple | Yes | UE can indicate - MUSIM capability to the NW as part of UECapability- Using MUSIM UE Assistance Information to change the PO whenever it determines a paging collision. |
| Spreadtrum | Yes | Just indicate there is a paging collision issue to AMF. |
| Sharp | Yes | UE can indicate the paging timing information in the other network to gNB. |

**Summary:**

TBD.

## NAS vs. RRC signalling for network switching

During RAN2#113 online discussion, the following agreements have been made for network switching objective.

**Agreements**

1: Switching procedure can be used to notify network A that the UE has a preference to leave RRC\_CONNECTED state in network A.

2: The switching procedure can be used to notify network A that the UE has a preference to be kept in RRC\_CONNECTED state in network A while temporarily switching to network B.

In the subsequent section, the NAS vs. RRC signalling for supporting the above two network switching procedures are discussed. The available technical analysis based on the contributions [2]-[11] will be provided. It would be good that companies can share views to support NAS or RRC signalling, including technical reasons whyNAS/RRC should be used.

To facilitate the discussion, the following terms are used in the discussion:

* switching procedure for keeping in RRC\_CONNECTED: is used as short term for the switching procedure which is used to notify network A that the UE has a preference to be kept in RRC\_CONNECTED state in network A while temporarily switching to network B
* switching procedure for leaving RRC\_CONNECTED: is used as short term for the switching procedure which is used to notify network A that the UE has a preference to leave RRC\_CONNECTED state in network A

### 2.2.1 Switching procedure for keping in RRC\_CONNECTED

When UE wants to perform some short time activities in network B, e.g. paging reception, measurements, UE has a preference to be kept in RRC\_CONNECTED state in network A while temporarily switching to network B. These activities in network B are periodical and have deterministic upper bounds, and consequently can be regarded as some sort of short-term switching [3]. UE may use the existing gaps configured by network A to perform the activities. If the existing gaps cannot meet the Multi-SIM network switching requirement, a switching procedure is needed for UE to request gaps.

Considering the gap scheduling is invisible at CN while has been widely utilized at RAN, and SA2 has not concluded any NAS solution related to gap, thus AS level signalling is needed and feasible for requesting gap.

Technical analysis of AS level solutions, e.g. gap pattern, has been further discussed in contributions[2, 4, 5, 6, 10]. [2][10] thought UE can be configured with multiple gap patterns. [4][6] thought that existing measurement gap pattern may be not suitable, thus dedicated scheduling gap should be supported for multi-SIM purpose. [5] proposed that a UE may be configured with multiple measurement gaps with various attributes.

 In addition, contributions [3, 5, 10] further discussed which AS layers will be impacted. [10] proposed that both RRC and MAC procedure are considered for Scenario 1 (Leaving for short-time periodic activities in USIM B). [5] thought that each measurement gap may be activated/activated via MAC CE. [3] proposed to further discuss whether to use RRC, MAC, or a combination for signaling.

Companies are invited to express their view on the following question.

1. **Which level signalling(i.e. AS or NAS) is suitable to support the switching procedure for keeping the UE in RRC-CONNECTED state?**

|  |  |  |
| --- | --- | --- |
| **Company** | **AS or NAS** | **Technical reasons** |
| vivo | AS | Gap is invisible for Core Network while has been widely utilized at RAN, hence AS level signalling is more suitable. |
| OPPO | AS | For this case, AS based method has less delay, which is more suitable to keep UE in connected mode in another network. |
| ZTE | AS |  |
| Sony | AS | The gap configuration,when still in connected mode is handled in AS. |
| CATT | AS | RRC based switching has Low latency, and extra effort can be avoided by using common procedure as long time switching |
| Fraunhofer | AS | Gap configurations in connected mode should be under AS control  |
| Google | AS |  |
| ASUSTeK | AS |  |
| MediaTek | AS | We still doubt the need of such “short leave”. But if it is to be introduced, the gap configuration in connected mode is handled at AS level. |
| Huawei/ HiSilicon | AS | Firstly, we would like to clarify that for the case where the UE switches to NW B while kept in RRC\_CONNECTED in NW A, the activities performed in NW B are 1) periodical and have deterministic upper bounds as stated by rapporteur and 2) for reception only(e.g. paging reception, measurements), i.e. the UE does not need to setup RRC connection in NW B. The reason for 2) is RAN2 has agreed that “Dual-RX/Single-TX UE stays in RRC\_CONNECTED mode in NW A while performing reception and transmission in NW B(in RRC\_ CONNECTED or during RRC setup/resume period ), is not considered in the WI”. We should follow this principle and don't introduce exceptional case.UE performs such activities in NW B periodically until the activities end. It can be left to UE implementation to use the existing available gap in NW A to perform such activities in NW B. If the majority of companies think a new switching procedure is really needed, we prefer to use AS level signalling since the gap is configured by gNB and has nothing to do with CN. |
| LG | AS | AS based approaches such as DRX, scheduling gap based on TDM pattern, are already available even from LTE, and it is clear that AS based solution provides performance benefit. On the other hand, we do not see any real benefit of NAS based solution for switching to other network in particular for UE in RRC\_CONNECTED in the leaving networkAS based solution is also efficient in case UE in RRC\_CONNECTED switches to other network via state transition to RRC\_INACTIVE  in the leaving network. |
| Lenovo, MotM | AS | It will not impact CN since the UE still stays at the RRC connected state.  |
| Nokia | AS | This is clearly AS solution as the UE remain in CONNECTED mode, there is no need for NAS involvement. |
| CMCC | AS |  |
| Cablelabs | AS+comments | As companies discussed previously, there can be 2 types of short time leave. The 1st type being short time leave for periodic activities such as paging reception. The 2nd type could be short time leave for some maintenance activities such as TAU or even busy indication. 2nd type was referred as one shot short time leave at some point of this discussion. As the 2nd type of activity is event driven and most likely a relatively infrequent subsequent event triggered by the 1st periodic short time leave event, the 2 short time leave should really be treated differently than the 1st short time leave for better system performance. As the 1st type of short time leave has the periodic characteristic, the current measurentgap type of concept in the AS procedure should fulfil the requirement. The 2nd type short time leave should be arranged via AS as the need arised. |
| Charter Communications | AS | AS-based soluition since the UE remains in RRC-Connected. |
| Apple | AS | This is clearly within the scope of RRC based (AS level) solution. This is required to addres the delay requirements for short vs long switching. The Gap pattern are not visible to the CN, and to maintain CONNECTED mode in a given SIM instance implies, there has to be AS level control via RRC signaling. |
| NEC | AS | For the case of maintaining RRC CONNECTED state, the notification should be transparent to NAS. |
| Samsung | AS |  |
| Spreadtrum | AS | In this case, there is no any CN impacts. |
| Xiaomi | AS |  |
| Sharp | AS | This is very similar to measurement gap which is handled by AS. |
| China Telecom | AS | RRC signalling is more suitable to negociate gap pattern between UE and RAN. We should also consider how to activate the gap pattern. Either RRC signling or MAC CE can be used to activate the switching gap. |
| DENSO | AS | Agree with vivo. Core Network do not need to know if there is a gap configured for a UE. |
| Ericsson | AS, but | Even though we though this could actually be addressed by UE implementation, since we will account for this case, then AS would probably be more suitable as it is expected to be a very short switching. |
| Intel | AS | Regardless of keeping or leaving RRC\_CONNECTED, switching/leaving indication is triggered from the UE, so we think it is better to have a unified procedure triggered from the UE, with some assistance information that can help NW to decide wether to configure scheduling gap and keep CONNECTED or move to INACTIVE/IDLE.  |
| Futurewei | AS |  |

**Summary:**

TBD.

### 2.2.2 Switching procedure for leaving RRC\_CONNECTED

Both NAS and RRC based signaling are proposed to support the switching procedure to leave RRC\_CONNECTED state in some contributions.

Contributions [4, 8] propose to use RRC based signaling for the following reasons:

* [4] thought that RRC-based solution is beneficial to fast switching for delay-sensitive activities, which ensures the user experience. NAS-based solution involves AMF and requires a long time, it is not suitable for the case of switching for delay-sensitive activities (e.g. MO VoNR) on another network.
* [8] proposed to reuse the existing RRC-based UE Assistance Information procedure to solve the UE switching problem for all types of switch procedures.

Contributions [2, 5, 7, 9, 10] propose to use NAS based signaling for the following reasons:

* SA2 group agreed to use NAS-level leaving procedure for the E-UTRA/EPS scenario, then it is reasonable to use the same procedure for the other scenarios as well (NR/5GS and E-UTRA/5GS), to keep the specification complexity on reasonable level [7, 9,10]. In addition, it is highlighted that assistance information regarding MT data/signalling handling defined in NAS switching procedure for EPS is also useful for the NR/5GS and E-UTRA/5GS cases as well[2][5][10].
* NAS is currently used for delay-sensitive services like “emergency fallback”, so no issue is expected from timing/delay point of view [7][9].
* Limited RAN impacts and no RAN2 specs impact are expected if the UE uses NAS signaling [9].

Contributions [31] proposed RAN2 to discuss a combination of RRC and NAS-based signalling. It is pointed out that If the UE is configured with NAS level leave indication, the NAS level leave indication can also be included in the RRC message which indicates the leave at AS level, and proposed RAN2 to further discuss the RAN impacts of supporting NAS level Leave indication procedure including the impact of delay in switching to another network.

Regarding the Pros/Cons, they can be summarized as follows based on companies’ contributions:

**Table 2: summary of Pros/Cons of NAS based and RRC based solution**

|  |  |  |
| --- | --- | --- |
| **Signaling Level** | **Pros** | **Cons** |
| **NAS based signaling** | 1. Allow common switching procedure for EPS as well as NR/5GS and E-UTRA/5GS, and assistance information defined for EPS can be reused in NR/5GS and E-UTRA/5GS.2. Limited RAN impacts and no RAN2 specs impact are expected3. Allows for selective suspension of PDU sessions in the first network. | NAS based signaling procedure leads to long latency than RRC based signaling. |
| **RRC based signalling** | 1. Allow UE to perform fast switching towards network B for delay-sensitive activities;2. Existing RRC-based UE Assistance Information can be reused for switching. | 1. Different switching procedures for EPS, NR/5GS and E-UTRA/5GS.2. Incapability to manage PDU sessions during a long-switch. |

Companies are invited to provide their inputs for the following questions.

1. **Do companies support NAS signaling and/or RRC signlling for leaving the RRC\_CONNECTED state?**

|  |  |  |
| --- | --- | --- |
| **Company** | **NAS and/or RRC** | **Technical reasons, including comment on Table 2.** |
| vivo | RRC | As it has been agreed in RAN#90 that E-UTRAN is not impacted for switching notification, NAS based switching is the only choice for the E-UTRAN/5GS case. Naturally, the NAS based switching can be reused for NR/5GS.However, for the *switching procedure for keep in RRC\_Connected* case, no paper submitted has proposed to use the NAS based signalling. We assume RRC based signalling is preferred. Then there will be anyway two switching procedure options for NR/5GS: * RRC based signalling for the switching procedure for keeping in RRC\_Connected case; and
* NAS based signalling for the switching procedure for leaving RRC\_Connected case

The question is whether we need to support RRC based signalling for switching procedure for leaving RRC\_Connected.Our answer is yes. On top of the advantages listed in the Table 2, we also observe other benefits.Firstly, we think it can provide flexbile to network deployment. For a operator which wants to support both switching procedure for keeping in RRC\_Connected and leaving RRC\_Connected, it can choose RRC signalling based solution, which means NO CN upgrade is needed for NR/5GS.Secondly, we think the switching procedure can reuse the RRC based signalling for switching procedure for keep in RRC\_Connected case with limited enhancement, so no big impact is foreseen. |
| OPPO | NAS | When UE has a preference to leave connected mode, it’s quite strange to leave NAS behind, no much benefit we can get by RRC based solution, anyway NAS based solution can work, one single solution is more desirable.  |
| ZTE | NAS | SA2 has defined some assistance information for the MT restriction, for the NR switching procedure with a preference to leave RRC\_CONNECTED state, the UE would bring assistance information for the MT restriction.If adopt RRC based signaling, the AS signaling should include a NAS message container to include the MT restriction information, which would be similar to a NAS signaling based scheme but increase the complexity significantly, e.g. introduce more interaction between UE AS and NAS , also between CN and RAN.With NAS signaling, it has less impact to the RAN and we also don’t see the see the motivation to adopt the same message for the “*long leaving”(leave connected state)* and “*short leaving” (keep at connected state)*, for that different procedures would be adopted for the *long leaving and short leaving*About the delay, the CN and the Ran node will interact only one time, we think compared with the air interface, the delay of the NG can be ignored, and for the LTE when leaving to the idle state, it has been agreed to adopt NAS based procedure.Thus, we think it’s better to adopt a NAS based signaling for the NR switching procedure with a preference to leave RRC\_CONNECTED state. |
| Sony | NAS | When leaving connected mode it is not time critical so simplest to use same procedure in EPS |
| CATT | RRC | A unified procedure for both long time switching and short time switching in 5GS is preferred. |
| Fraunhofer | NAS | Agree with ZTE |
| Google | NAS | We think the CN anyway needs to be informed if UE is switching away. Of course, this can be done by either the UE or the gNB. But we think it is more straightforward to be done by the UE. The RRC based method may be a bit faster but seems more like an optimization. |
| ASUSTeK | RRC | Agree with CATT. |
| MediaTek | RRC | We do have existing RRC procedures for UE to inform network of its preference of leaving RRC\_CONNECTED. Our major concern about NAS-based switching procedure is the uncerntain (not just long) latency.  |
| Huawei/HiSilicon | RRC | Agree with the Pros in the Table 2, RRC based solution has lower latency and less spec impact compared with NAS-based solution. Considering that RRC based UE assistance information for RRC release request has been defined for NR, it can be reused as much as possible.In addition, UE should be allowed to report its preferred RRC state, i.e. idle or inactive, when requesting to leave RRC connected state,and using RRC message to convey this information is more straightforward since it will be used by RAN. As for the assistance information for MT restriction, if it is really needed according to SA2, it is easy to transmit them as a container in the RRC singnaling and we don't see any issue with this way.  |
| LG | RRC | We believe that RRC based solution can be a unified solution for both NR and LTE. Thus, we don’t think ‘Different switching procedures for EPS, NR/5GS and E-UTRA/5GS’ is the cons.However, NAS based solution oviously leads to long latency than RRC based signaling. |
| Lenovo, MotM | RRC | One unified solution is desired for RRC Idle and RRC Inactive state. For the latter, using RRC signaling to gNB is the reasonable choice. |
| Nokia | RRC+ | The solution for switching notification for leaving RRC-CONNECTED state without waiting for response would be required for some scenarios. For example if the UE intend to setup RRC connection for delay sensitive traffic the additional delay for getting network response is not acceptable. In such cases, the L1 level ACK should be sufficient. The default state after leaving can be preconfigured with NTWK-A in these scenarios.If NAS level information needs to be included for AMF to make some decision, it can be considered for inclusion in the RRC switching message. |
| CMCC | RRC | We prefer to have an unified RRC solution for both keeping and leaving RRC\_CONNECTED state, so that this solution only has RAN impact. Otherwise, it would be complex for operators to upgrade both RAN and CN for this feature. |
| Cablelabs | NAS+comment | The NAS preference is based on the assumption that leaving RRC connected state would result in RRC idle state. However, as Huawei pointed out, it seems there is possibility that leaving RRC connected could lead to RRC inactive state. As companies pointed out, both NAS(both 4G and 5G) and RRC(5G) have existing mechanism to transition out of RRC connected state to idle state.So maybe the end state of the procedure should be discussed and settle first so that solutions be developed to optimize system performance. RRC procedure would be preferred if the end state is rrc inactive state (as the UE might prefer). |
| Charter Communications | NAS | We believe the CN should be aware if a UE performs a long-time switch, particularly if the UE happens to have active PDU sessions. Without such capability, gNB may have to buffer data for the UE for an unknown duration, which may lead to loss of the data and subsequent impact on other CN functions, and the network KPIs.RRC-based solutions are incapable to manage PDU sessions, unless layer-separation is broken. |
| Apple | RRC | We prefer to have an RRC level solution defined. Agree that this would imply we need to specify for EPS, NR/5GS and E-UTRA/5GS cases, but the requirements that any MUSIM switching has to satisfy (lower latency, delay sensitivity) make the RRC based approach more preferrable. The existing UE assistance information signaling framework can be expanded for the case of MUSIM to provide additional information to the NW (e.g. duration of switching, preferred RRC state etc.) to develop an efficient MUSIM switching framework. |
| NEC | NAS | As SA2 has agreed to use NAS based solution for E-UTRA/EPS, we prefer to use aligned solution for 5GS. |
| Samsung | NAS | Regarding the following comment, However, for the *switching procedure for keep in RRC\_Connected* case, no paper submitted has proposed to use the NAS based signalling. We assume RRC based signalling is preferred. our understanding is that applying RRC based signalling (i.e. similar concept of measurement gap configuration) is more appropriate and there seems no such concept in NAS based signllaing.But for swithching procedure with a preference to leave RRC\_CONNECTED state, we agree with ZTE that SA2 has defined a well-defined switching procedure i.e. assistance information for the MT restriction. We do not see a need to duplicate for the same purpose. |
| Spreadtrum | RRC |  |
| Xiaomi | RRC | Reuse the existing RRC-based UE Assistance Information procedure as a unified solution to solve the UE switching problem for all types of switch procedures. |
| Sharp | RRC | RRC solution with lower latency has already been supported in NR. |
| China Unicom | RRC | We share the same view with VIVO. |
| China Telecom | Both | We think both RRC and NAS solution can be taken into consideration.If the service in Network B is time-sensitive, we prefer the RRC based solution for fast RRC release message within a timer before switching. The RRC state preference can be sent to base station directly reusing UEAssistanceInformation RRC sinalling.If the service in Network B is not time-sensitive, the NAS based switching is preferred in terms of providing MT data handling information. In addition, 5G NAS level leaving can be used for both NR/5GS access and E-UTRA/5GS access. To summarize, we think RAN2 and SA2 can focus on its own solution. Which one to be used is basded on UE estimation of Network B delay tolerance. |
| DENSO | RRC | NAS based signalling may cause longer latency.Additionally, we think UE should be allowed to indicate the preferred RRC state. To include preferred RRC state, using RRC is natural. |
| Ericsson | NAS | Similar comments as ZTE and OPPO above. Moreover, we think for this case there would be anyway NAS impact, so it is rather in RRC level where we can avoid further impact. It should also be noted that NAS signalling is currently used for EPS fallback for emergency service, so the NAS latency is not an issue. |
| Intel | RRC | Same comment as above – regardless of keeping or leaving RRC\_CONNECTED, switching/leaving indication is triggered from the UE, so we think it is beneficial to have a unified procedure triggered from the UE, with some assistance information that can help NW to decide wether to configure scheduling gap and keep CONNECTED or move to INACTIVE/IDLE.  |
| Futurewei | RRC | Similar view as Intel |

**Summary:**

TBD.

## Other Comments

Companies are invited to express their view if any other overall comments or suggestions.

1. **Any other comments or suggestions?**

|  |  |
| --- | --- |
| **Company** | **Comments** |
| LG | We think, for switching procedure, the legacy RRC procedure, i.e. UE assistance information message can be simply reused.For leaving procedure, the UE can reuse to indicate the preferred RRC state, e.g. set by RRC\_IDLE, via sending UE assistance information.For scheduling gap procedure, the UE can reuse to request the gap, e.g. indicating DRX preference, via sending UE assistance information.Especially for the case of the scheduling gap procedure, to reduce the data loss on the current SIM, it can be a simple way to configure the scheduling gap which is overlapped with the CDRX cycle. Also, to support efficient configuration handling, the scheduling gap and the CDRX don’t need to be separately configured to the UE because the actual data from the current SIM would be scheduled based on the one which has the longest period between the scheduling gap and the CDRX cycle. Thus, the DRX preference indication can be simply reused not only for CDRX but for the scheduling gap. |
| Apple | As outlined before, for switching procedure, we see a good reasons to expand the UE assistance information framework for MUSIM use cases. Additional parameters in the MUSIM UAI can be defined as per the switching use case needs. |
| DENSO | If we discuss about busy indication, we propose to use NAS signalling, and whether busy indication is sent should be up to UE implementation. If we use NAS signalling, we cau define unified solution for both RRC\_IDLE and RRC\_INACTIVE state. However, NAS signalling may take longer time. Therefore, we propose to make it up to UE implementation, since not sending busy indication has no critical issue. |
|  |  |
|  |  |
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|  |  |
|  |  |

**Summary:**

TBD.

# Conclusions

Based on the email discussion, we give the below proposals.

TBD

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