**3GPP TSG-RAN WG2 Meeting #115-e R2-210xxxx**

**Online, August 9 – 27, 2021**

**Source: CATT**

**Title: Summary of [Post114-e][076][ePowSav] Paging SubGrouping**

**Agenda Item: 8.9.2**

**Document for: Discussion and Decision**

# Introduction

This contribution provides a summary of the following email discussion:

* [Post114-e][076][ePowSav] Paging SubGrouping (CATT)

 Scope: Based on the agreements in R2-114-e, make further progress on CN based subgrouping: Identify the impacted signalling incl the new information that need to be exchanged. Identify which different configurations that could/should be supported. Can also take into account non-treated parts of [AT114-e][024] that are applicable to CN based sub-grouping. Identify Open issues, Find agreeable proposals.

 Intended outcome: Report,

 Deadline: Long

 Deadline for companies’ inputs: 08-04-2021 12:00 UTC

# Contact information

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# Discussion

## RAN2 made the following agreements on Paging subgrouping in RAN2#113bis-e [1]:

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| * We adopt Network controlled subgrouping (based on individual UE characteristics, not specified or limited to paging prob as EUTRA, possibly with additional randomization)
* If the network chooses to not provide specific subgrouping information, there will be configuration option where subgrouping can be supported by randomization (by UE-ID).
 |

And as a follow-up of the offline #024 [3], the following additional agreements were achieved in RAN2#114-e [2]:

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| The following is supported:* CN is responsible for allocating UEs to UE paging subgroups based on UE characteristics
* Use same UE subgroups when in RRC\_IDLE and RRC\_INACTIVE
 |

## And RAN2 informed RAN3, SA2 and CT1 about above decisions in an LS [4].

## Signaling needs in support of CN-assigned Paging subgroup

As a minimum, CN needs to inform the UE and gNBs about the assigned UE subgroup. The possible signaling steps are illustrated in Figure 1.

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**Figure 1: Possible signalling steps in support of CN-assigned UE Paging subgroup**

 We discuss each of these steps in the following sub-sections.

### Signaling from CN to UE

In the question Q2.1 of offline #024 [3], several companies considered that CN should inform the UE about its assigned subgroup during the NAS registration procedure. After the agreement that CN decides the UE subgroup, there seems no other node option but AMF to signal it to the UE. On the other hand, an LS was sent to SA2/CT1 about RAN2 decisions and so the NAS procedure and signaling design should be discussed in SA2/CT1. Therefore, from RAN2 perspective, we can stick to expressing our need as follows:

**Proposal: When AMF assigns a UE with a Paging subgroup, some NAS signaling should be introduced between AMF and UE to inform the UE about its Paging subgroup. The design and procedure are up to SA2/CT1.**

**Q1: Do you agree with the above proposal and if not, please provide your suggested change(s)?**

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| --- | --- | --- |
| **Company** | **Yes/No** | **Comments** |
| Samsung | Yes | NAS signaling is used to inform UE about its Paging subgroup |
| Qualcomm | Yes |  |
| OPPO | Yes | Since CN is responsible for decide the UE subgroup, it should be AMF to provide the UE subgroup information to UE. |
| Lenovo | Yes |  |
| LGE | Yes |  |
| Intel | Yes with comments | What information to provide via the NAS signalling should be decided by RAN2 and conveyed to SA2/CT1 |
| Xiaomi | Yes | How to provide UE and gNB with subgroup information is related to N1/N2 message. |
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**Summary:**

### Signaling between network nodes for RRC\_IDLE UEs

In the question Q2.4 of offline #024 [3], several companies proposed that, for Idle UEs, the assigned subgroup is included in the PAGING message to the gNB. On the other hand, which message is used, and the associated design is in RAN3 scope. Therefore, similar to Q1, we suggest limiting RAN2’s discussion to express RAN2 needs as follows:

**Proposal: When AMF assigns a UE with a Paging subgroup, some signaling should be introduced between AMF and gNB(s) to inform gNB(s) about the subgroup where to page a UE in RRC\_IDLE. The message and associated design are up to RAN3.**

**Q2: Do you agree with the above proposal and if not, please provide your suggested change(s)?**

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| **Company** | **Yes/No** | **Comments** |
| Samsung | Yes |  |
| Qualcomm | Yes (see comment) | Given the agreement that UE should use same UE subgroup when in RRC\_IDLE and RRC\_INACTIVE, there needs only one type of signal for AMF to inform gNB about UE’s subgroup assignment. So the proposal could be clarified that “When AMF assigns a UE with a Paging subgroup, some signaling should be introduced between AMF and gNB(s) to inform gNB(s) about the subgroup where to page a UE in RRC\_IDLE/RRC\_INACTIVE” |
| OPPO | Yes |  |
| Lenovo | Yes |  |
| LGE | Yes |  |
| Intel | Yes with comments | What information to provide from AMF to gNB during CN paging while UE is in idle mode should be decided by RAN2 and conveyed to RAN3 |
| Xiaomi | Yes | We think for CN paging, the assigned subgroup by CN can be included in the PAGING message (TS 38.413), that is if the *subgroup information* IE is included in the PAGING message, the NG-RAN node shall use it to determine the subgroup for the UE ((if needed) as specified in TS 38.304). However it is up to RAN3. |
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**Summary:**

### Signaling between network nodes for RRC\_INACTIVE UEs

In the question Q2.4 of offline #024 [3] most companies suggest that for a UE in RRC\_INACTIVE, the assigned subgrouping is stored in the anchor gNB as part of the UE context (e.g. it is provided in CN assistance information for RRC\_INACTIVE IE). This may require another signaling between AMF and gNB(s) specifically for UEs in RRC\_INACTIVE. But, same as above, which message is used, and the associated design is in RAN3 scope. Therefore, similar to Q1/Q2, we suggest limiting RAN2’s discussion to express RAN2 needs as follows:

**Proposal: When AMF assigns a UE with a Paging subgroup, some signaling should be introduced between AMF and gNB(s) to inform gNB(s) about the subgroup where to page a UE in RRC\_INACTIVE. The message and associated design are up to RAN3.**

**Q3: Do you agree with the above proposal and if not, please provide your suggested change(s)?**

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| --- | --- | --- |
| **Company** | **Yes/No** | **Comments** |
| Samsung | Yes |  |
| Qualcomm | Yes (see comment) | Please see our comment on Q2  |
| OPPO | Yes |  |
| Lenovo | Yes |  |
| LGE | Yes |  |
| Intel | Yes with comments | This information should be provided by the AMF to gNB when the UE goes into CONNECTED from IDLE and when a new grouping is assigned while the UE is in CONNECTED. This is stored by the gNB in the UE context if the UE enters INACTIVE. What information to provide should be decided by RAN2 and conveyed to RAN3. The details of the message and associated design are up to RAN3. |
| Xiaomi | Yes | We think for RAN paging, the subgroup information can be included in *Core Network Assistance Information for RRC\_INACTIVE* IE to be provided to NG-RAN node as stored UE context and use it for RAN paging procedure. However it is up to RAN3. |
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**Summary:**

In the question Q2.4 of offline #024 [3] most companies support that anchor gNB should provide UE’s subgroup ID to serving gNB when it sends paging notification. If this is the common view, this requires, at least from RAN2 perspective, the need for some signaling between gNBs to inform about the UE’s subgroup. Same as above, since the selected message and associated design are in RAN3 scope, we suggest limiting RAN2’s discussion to express RAN2 needs as follows:

**Proposal: When a UE in RRC\_INACTIVE has been assigned by CN a Paging subgroup, some signaling should be introduced between gNBs to inform each other about the UE’s subgroup for RAN paging. The message and associated design are up to RAN3.**

**Q4: Do you agree with the above proposal and if not, please provide your suggested change(s)?**

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| --- | --- | --- |
| **Company** | **Yes/No** | **Comments** |
| Samsung | Yes |  |
| Qualcomm | Yes |  |
| OPPO | Yes |  |
| Lenovo | Yes |  |
| LGE | Yes |  |
| Intel | Yes with comments | This information should be provided from the gNB with UE context to other gNBs in the RNA during RAN paging and transferred from source gNB to target gNB as part of the UE context. What information to provide between gNBs to inform each other about the UE’s subgroup for RAN paging should be decided by RAN2 and conveyed to RAN3. The details of the message and associated design are up to RAN3. |
| Xiaomi | Yes | We think the anchor gNB can carry the subgroup information in paging message to other gNB(s) in RNA for RAN paging. However it is up to RAN3. |
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**Summary:**

## Assistance information for CN in support of Paging subgroup assignment

### Assistance information from UE

The need for UE providing some assistance information to CN was discussed in Q2.3 of offline #024 [3], resulting in split views among companies. A group of companies believe that CN can decide the subgrouping based on subscription information only, while supporting companies mention attributes may include UE’s paging probability (similar to those in NB-IoT), mobility profile (e.g. stationary vs mobile) and power profile (e.g. plugged in or on battery). After the agreement that CN decides the subgroup, we can give another try, proceeding step by step:

**Q4: Do you support UE providing some assistance information to CN in support of Paging subgroup assignment?**

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| --- | --- | --- |
| **Company** | **Yes/No** | **Comments** |
| Samsung | - | In our view, assistance information is not essential. Paging probability can be estimated by network itself. Power profile (plugged in or on battery), is not a fixed characteristic for a UE and can dynamically change while the UE is not in RRC\_CONNECTED. |
| Qualcomm | Yes | We think UE assistance information for subgroup assignment is useful because1. Those three attributes are relevant and can be used to help CN make power-efficient assignment of UEs’ subgroups;
2. Those three attributes can be dynamic. So CN can’t always rely on subscription information, which is static, in its assignment decision.
 |
| OPPO | No | The decision to adopt network-assigned subgrouping in RAN2 is to make grouping methods transparent. How to decide UE subgroup should be up to network implementation. We do not see the need for any new UE assistance information. |
| Lenovo | Yes | Same view as Qualcomm, these attributes may be changed in UE side, the CN could be given a real-time correct information based on UE reporting. |
| LGE | No | Same view as Samsung. Something that can be changed during IDLE/INACIVE should not be reported. Since UE cannot update it during IDLE/INACTIVE. For example, after reporting the UE is plugged in, if the UE is plugged out in IDLE state, the UE’s subgroup ID should be updated to reflect the updated power profile, but it is impossible. Then, the UE’s properties that can be changed should not be taken into account. |
| Intel | No | In the email discussion [1], there was more support for the following UE characteristics for subgrouping: UE ID, paging probability and power consumption sensitivity level. In our understanding, these UE characteristics are already or can be known by the CN or if felt necessary, can be provided by the gNB to the CN:* UE ID is known to CN as it is allocated by CN for mobility management and legacy paging operation.
* In the case of paging probability, if it is just for differentiating the paging probability between Redcap UE and eMBB UEs. This can be known to the CN via UE subscription or if felt necessary, can be provided to the CN by gNB based on UE capability.
* If static power consumption sensitivity level is needed (e.g. eMBB UEs, IoT UE), this can be again known to the CN via the UE subscription or if felt necessary, can be provided to the CN by gNB based on UE capability.

Even though UE subscription information may not provide more “dynamic” changing information, we think this aspect can be studied further in future release in view of limited time left in Rel-17.Hence we don’t see a need for UE to provide assistance information. |
| Xiaomi | - | We are open for this issue. Since CN is responsible for subgroup determination by implementation, some UE attributes can be estimated by network itself which is a flexible way.By the way, if assistance information is adopted, since subgroup is provided through the registration procedure, does it mean the assistance information should be carried in registration request?What if the different behavior for assistance information between RRC\_IDLE and RRC\_INACTIVE? |
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Considering the most popular attributes mentioned so far, we suggest discussing further the following options:

1. Paging probability

2. Mobility profile

3. Power Profile

4. Other

**Q5: If some assistance information from UE to CN in support of Paging subgroup assignment would be supported, which attribute would be the most relevant (companies can select multiple)?**

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| --- | --- | --- | --- | --- | --- |
| **Company** | **1** | **2** | **3** | **4** | **Comments** |
| Qualcomm | Yes | Yes | yes |  |  |
| Lenovo | Yes | Yes | yes |  |  |
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**Summary:**

### Assistance information from gNB

The need for RAN providing some assistance information to CN was partly addressed in Q2.4 of offline #024 [3], where most companies think there is no such need. However some companies think it is FFS, could depend on the attributes used for the subgrouping decision, and could be needed at least for letting CN know about the UE capability. We therefore try to progress the issue in the below question.

**Q6: Do you support gNB(s) providing some assistance information to CN in support of Paging subgroup assignment? If “Yes”, please indicated which information would be needed from RAN2 perspective.**

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| --- | --- | --- |
| **Company** | **Yes/No** | **Comments** |
|  |  | If UE type (redcap) is considered for UE sub grouping, capability indication may be needed. |
| Qualcomm | - | We think that in some use cases, it may be useful if gNB is able to provide feedback to CN on subgroup assignment. The RedCap scenario mentioned by Samsung is a good example. Another example can be that UE may have different paging probabilities in RRC Idle and RRC Inactive, as UE in RRC\_INACTIVE when anticipating new data sooner. Hence gNB may want to change UE’s subgroup when releasing it into RRC\_INACTIVE, if it is able to predict (e.g. based on network implementation) the current subgroup assignment for the UE may not match well with UE’s expected paging probability in RRC\_INACTIVE. It is better for this information to be made by gNB than UE, because otherwise UE has to switch to RRC Connected to send UE assistance information, which is power inefficient. |
| OPPO | No | How to decide UE subgroup should be up to CN implementation. We do not see the need for any assistance information from gNB. Plus, CN has all UE capability information. |
| Lenovo | - | We are open to the specific case. |
| LGE | No | It should be up to network implementation.  |
| Intel | Yes with comments | As mentioned in our response in Q5, gNB can also provide the paging probability and static power consumption sensitivity level to CN based on the UE radio capability if these are not available from UE subscription.Also, as different cells in the registration may have different paging configuration/strategy (e.g. total number of UE paging subgroup space or different amount of sequence resource configuration), the CN can provide a set of assigned subgroups to handle the different subgrouping configuration over the different cells. For example, in the case of sequence based PEI, some cells support 4 sequences and other support 8 sequences, the CN provides the gNBs and UE with UE paging subgroup ID for cell with 4 sequences as well as for cell with 8 sequences. Hence it would be good for the gNB(s) to provide the subgrouping configurations of a cell within a TA (e.g. number of paging subgroups) to the CN so that the CN can use it to configure the set of subgroup IDs for the different paging subgroup configuration. On the other hand, if this is not provided to CN, the CN can also provide all combinations of the possible subgrouping configuration to the gNBs and UE. |
| Xiaomi | - | We think UE may have different paging probability in RRC\_IDLE and RRC\_INACTIVE. It seems reasonable that gNB may change the UE subgroup ID when releasing UE into RRC\_INACTIVE. This requires gNB to get a new subgroup ID by negotiating with AMF (what kind of information gNB should provide to AMF: a new subgroup ID or assistance information？) before releasing UE into RRC\_INACTIVE. So that CN and gNB both use this new subgroup ID to perform CN paging and RAN paging. |
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**Summary:**

## UE-ID subgrouping

### Co-existence of UE-ID based and CN-assigned subgroups in the same cell

This issue (discussed in [7]) was raised in the offline #024 [3] as part of the “other issues” to be further discussed in RAN2. Considering the RAN2#113bis-e [1]agreement that “*If the network chooses to not provide specific subgrouping information, there will be configuration option where subgrouping can be supported by randomization (by UE-ID)*”, the point made is that it should be clarified that there can be a mix of UEs in a cell using NW-assigned subgroup and UEID-based subgroup. That is, it should not be mandated to the NW that if it assigns *some* UEs with NW-assigned subgroups, it shall assign *all* UEs with NW-assigned subgroup.

Note this question does necessarily assume the UE subgroup is *either* assigned directly by network *or* calculated based on UE-ID and, for example, does not rule out solutions considering a mix of both as e.g. in LTE GWUS [5][6].

**Q6: Do you agree there can be a mix of UEs in a cell using NW-assigned subgroup and UEID-based subgroup?**

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| --- | --- | --- |
| **Company** | **Yes/No** | **Comments** |
|  | No | In our view, Cell may support either NW assigned subgroup or UE ID based sub groupIf cell supports NW assigned subgroup:* If UE is assigned paging subgroup by NW, it monitors paging based on the paging subgroup. Otherwise, not.

Else if cell supports UE ID based subgroup:* it monitors paging based on the UE ID based paging subgroup.
 |
| Qualcomm | Yes | We think it is possible that some UEs may not be capable of supporting NW-assigned subgroup |
| OPPO | Yes | For UEs configured with a NW-assigned subgroup, the NW-assigned subgroup is used.For UEs not configured with a NW-assigned subgroup, the UE ID based subgroup can be used, which could be configurable by RAN.In order to avoid paging false alarm between UEs using different subgroup methods, the NW-assigned subgroup and UE ID based subgroup should not be overlapped. |
| Lenovo | Yes | From the view of UE, some UE may do not have a NW-assigned subgroup and apply the UEID-based subgroup. |
| LGE | Yes | If a cell supports the UE ID based solution, it should also support the CN-based subgroup. Therefore, if CN always assigns the subgroup ID to all UEs which support the paging subgroup, we don’t need to have the UE ID-based subgroup.  |
| Intel | See comments | We do not see a need for 2 mechanisms operating in a cell since NW-assigned subgrouping can also take into consideration of the UE-ID in the determination of the UE subgroup. At the same time, we do not see any additional effort to allow the mix of UEs in a cell and hence we do not see a need to explicitly prohibit it.As on whether there is a mix of the NW-assigned subgrouping mechanism with UE ID-based subgrouping for a UE as mentioned in the second paragraph above that the question does not rule out solutions considering a mix of both as e.g. in LTE GWUS), in our view, NW-assigned subgrouping can also take into consideration of the UE-ID in the determination of the UE subgroup and hence there is no need of a mix of NW-assigned subgrouping mechanism with UE-ID based subgrouping for a UE.Assuming that the subgrouping configuration for network assigned subgrouping and UE based UEID subgrouping is the same:If a UE is configured with network assigned subgrouping by the CN and the serving cell of the UE supports subgrouping configuration, the UE shall perform network assigned subgrouping and not UE based UEID subgrouping. If the CN configures the UE with the UE based UEID subgrouping and the serving cell of the UE indicates support of subgrouping configuration, UE supporting subgrouping shall perform UE based UE ID subgrouping. Otherwise, the UE performs legacy paging. |
| Xiaomi | - | We want to clarify how to define the mix of subgroup methods, like OPPO mentioned, if two subgroup methods calculate UE into a same group resource, then paging false alarm happens. Therefore, if network support both two subgroup methods, the group resource should be differentiated, otherwise cell should support either NW assigned subgroup or UE-ID based subgroup. |
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**Summary:**

### Subgroup determination

In the context of the discussion about “RAN-assigned UE subgroup” in the offline #024 [3], several companies discussed the UEID-based subgroup method where the only information UE needs, in addition to the already available information for legacy UEID-based grouping in Paging Opportunities (POs), is the total number Nsg of supported subgroups by the network [7]-[9]. We suggest clarifying this assumption.

**Q7: Do you agree that UEID-based subgroup method only requires, in addition to the already available information for legacy UEID-based grouping in PO, the total number Nsg of supported subgroups by the network?**

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| --- | --- | --- |
| **Company** | **Yes/No** | **Comments** |
| Samsung | Yes |  |
| Qualcomm | depends | If a gNB can support only UEID-based subgrouping, then the proposal is correct. Otherwise, i.e. if a gNB can support both NW-assigned and UEID-based subgrouping, then we think UEs may need additional information, depend on 1. Whether a gNB can choose to support less number of subgroups than the maximum number of subgroups that can be assigned by CN; 2. Whether a gNB has the flexible to support less number of subgroups than 8 (the maximum number of subgroups possible). If the answer to either of these two questions are true, then that gNB needs to advertise more information to UEs. |
| OPPO |  | As our comment to Q6, the NW-assigned subgroup and UE ID based subgroup should not be overlapped. So for UE ID based subgrouping, UE needs to know both the maximum NW-assigned subgroup number and the UE ID based subgroup number, since the former may be needed and used as an offset to determine the subgroup ID for UE ID based subgrouping. |
| Lenovo | - | For UEID-based subgroup, the network should configure the subgroup range, such as [x, y], to this UEID based grouping method, then UE could implicitly know the total number of Nsg. Otherwise, UE does not know which PEI associated to the group-ID should be monitored. |
| LGE | Yes |  |
| Intel | Yes for deriving the subgroup ID by the UE. | The subgroup ID should also map to the physical layer resources which should also be provided in the SIB and this mapping may implicitly provide the number of supported subgroups by the cell. |
| Xiaomi | - | Before we introduce the NW-assigned subgroup, we think only Nsg is enough for UE-ID based subgroup. But since NW-assigned subgroup is introduced, UE-ID based subgroup resources could be different from that resources assigned by NW-assigned subgroup. Maybe gNB should provide subgroup range for Nsg. |
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**Summary:**

### Who decides the number of subgroups Nsg?

In the context of the discussion about “RAN-assigned UE subgroup” in the offline #024 [3], several companies discussed the UEID-based subgroup method suggesting the total number Nsg of supported subgroups is decided by RAN and broadcasted in System Information, similar to the legacy UEID-based grouping in Paging Opportunities. This is also proposed in [7]-[10].

**Q8: Do you agree that the total number, Nsg, of supported subgroups by the network is decided by RAN and broadcasted in System Information?**

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| --- | --- | --- |
| **Company** | **Yes/No** | **Comments** |
| Samsung | Yes | For UE ID based subgroups |
| Qualcomm | Yes | We think RAN should have the flexibility in choosing the total number of subgroups that it supports, which may be different from the maximum number of subgroups that can be assigned by CN or less than (the maximum number of subgroups possible). |
| OPPO | Yes | For the maximum NW-assigned subgroup number, it should be FFS whether to broadcast it or fix it in the spec. |
| Lenovo | Yes | See our comment in Q7. |
| LGE | Yes |  |
| Intel | Yes | This is also the case for network based subgrouping. |
| Xiaomi | Yes |  |
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**Summary:**

### Homogeneous/heterogeneous number of subgroups Nsg across cells?

Considering the main trend is that UEID-based subgrouping inherits from the principles of legacy UEID-based grouping, it seems logical that, similarly, the number Nsg of subgroups is controlled on a cell basis and can be different in different cells [7]-[10].

**Q9: Do you agree that the total number, Nsg, of supported subgroups is controlled on a cell basis and can be different in different cells?**

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| --- | --- | --- |
| **Company** | **Yes/No** | **Comments** |
| Samsung | Yes |  |
| Qualcomm | Yes | We think each cell should have the flexibility in choosing the total number of subgroups that it wants to support. |
| OPPO | Yes |  |
| Lenovo | Yes |  |
| LGE | Yes |  |
| Intel | Yes | This is also the case for network based subgrouping. |
| Xiaomi | Yes |  |
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**Summary:**

## False paging alarm due to mobility and PEI

This issue (discussed in [11]) was raised in the offline #024 [3] as part of the “other issues” to be further discussed in RAN2.

In LTE the UE only monitors the WUS in the last used cell, i.e. the cell where the UE was released from connected mode the last time. This means that the NW only transmits the WUS when the UE is paged on the last used cell e.g. during the first paging attempt from the CN. It is proposed to extend this to the NR PEI, to avoid similar useless PEI transmission during paging escalation, e.g. when the NW cannot find the UE and pages the UE in all the cells of the Tracking Area List (TAI List), while the UE only replies in a single cell.

From Rapporteur’s perspective, this issue is out of the scope of this email discussion as it is unrelated to Paging subgrouping. Therefore Rapporteur suggests discussing this issue separately from this email discussion.

## Other issues

Companies are invited to spot other issues within the scope of this email discussion that we would have missed.

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| **Company** | **Comments** |
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3. Conclusion

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