**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

|  |  |
| --- | --- |
| Company | Name and email address |
| CATT | Pierre Bertrand; pierrebertrand@catt.cn |
| Samsung | Anil Agiwal, anilag@samsung.com |
| Qualcomm | Linhai He, linhaihe@qti.qualcomm.com |
| OPPO | Haitao Li, lihaitao@oppo.com |
| Lenovo | Shijie4@lenovo.com |
| LGE | sangwon7.kim@lge.com |
| Intel | seau.s.lim@intel.com |
| Xiaomi | Rao, shirao@xiaomi.com |
| Sharp | Lei Liu, lei.liu@cn.sharp-world.com |
| vivo | Chenli, Chenli5g@vivo.com |
| ZTE | Fei Dong, dong.fei@zte.com.cn |
| Sequans | Noam Cayron, noam.cayron@sequans.com |
| Apple | Sethuraman Gurumoorthy, sethu@apple.com |
| MediaTek | Li-Chuan TSENG li-chuan.tseng@mediatek.com |
| Huawei, HiSilicon | Yiru Kuang, kuangyiru@huawei.com |
| CMCC | Xiaoxuan Tang, tangxiaoxuan@chinamobile.com |
| Nokia | Chunli Wu, Chunli.wu@nokia-sbell.com |
| Futurewei | Yunsong Yang, yyang1@futurewei.com |
| DENSO | Tatsuki Nagano, tatsuki.nagano.j7f@jp.denso.com |

# Discussion

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

|  |
| --- |
| * 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 #025 [3], the following additional agreements were achieved in RAN2#114-e [2]:

|  |
| --- |
| 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.

****

**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 #025 [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)?**

|  |  |  |
| --- | --- | --- |
| **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. |
| Sharp | Yes |  |
| vivo | Yes with comments | The UE would be informed about its paging subgroup by NAS signaling, which could be new introduced or extended from the existing NAS signaling. It should be decided in SA/CT.  In this way, we suggest to change as below:  **When AMF assigns a UE with a Paging subgroup, some NAS signaling should be introduced or extended between AMF and UE to inform the UE about its Paging subgroup. The design and procedure are up to SA2/CT1.** |
| ZTE | Yes |  |
| Sequans | Yes |  |
| Apple | Yes | This is primarily motivated by the RAN2 agreement that CN is responsible for UE subgrouping. |
| CATT | Yes |  |
| MediaTek | Yes |  |
| Huawei, HiSilicon | Yes |  |
| CMCC | Yes |  |
| Nokia | Yes but | Similar to NB-IoT, the signalling does not necessarily need to be subgroup ID itself since CN does not know how many subgroups RAN would support, and it could be different for different cells. It could be which subgroup set the UE should be in and leave the actual subgrouping to RAN base on RAN configurations. |
| Futurewei | Yes |  |
| DENSO | Yes |  |

**Summary:**

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

In the question Q2.4 of offline #025 [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)?**

|  |  |  |
| --- | --- | --- |
| **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. |
| Sharp | Yes |  |
| vivo | Yes | I assume we could make the decision on the massage, i.e. PAGING message in RAN2, and inform RAN3 to capture this. |
| ZTE | Yes |  |
| Sequans | Yes, with comments | Agree with QC |
| Apple | Yes | The previous RAN2 agreement that both IDLE and INACTIVE UEs would be grouped together in the same UE subgroup needs to be considered as well. |
| CATT | Yes |  |
| MediaTek | Yes | Agree with QC and Apple. |
| Huawei, HiSilicon | Yes |  |
| CMCC | Yes |  |
| Nokia | Yes but | Same comment as Q1 |
| Futurewei | Yes |  |
| DENSO | Yes |  |

**Summary:**

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

In the question Q2.4 of offline #025 [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)?**

|  |  |  |
| --- | --- | --- |
| **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. |
| Sharp | Yes |  |
| vivo | Yes | Same as Q2. |
| ZTE | Yes |  |
| Sequans | Yes, with comments | Agree with QC |
| Apple | Yes |  |
| CATT | Yes |  |
| MediaTek | Yes |  |
| Huawei, HiSilicon | Yes |  |
| CMCC | Yes |  |
| Nokia | Yes | Agree anchor gNB stores subgroup related information as UE context. But same as Q1, “Paging subgroup” information does not necessarily need to be subgroup ID. |
| Futurewei | Yes |  |
| DENSO | Yes |  |

**Summary:**

In the question Q2.4 of offline #025 [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)?**

|  |  |  |
| --- | --- | --- |
| **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. |
| Sharp | Yes |  |
| vivo | Yes |  |
| ZTE | Yes |  |
| Sequans | Yes |  |
| Apple | Yes |  |
| CATT | Yes |  |
| MediaTek | Yes |  |
| Huawei, HiSilicon | Yes |  |
| CMCC | Yes |  |
| Nokia | Yes | Agree anchor gNB stores subgroup related information as UE context and inform to the target gNB when the UE is paged. |
| Futurewei | Yes |  |
| DENSO | Yes |  |

**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 #025 [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?**

|  |  |  |
| --- | --- | --- |
| **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 because   1. 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? |
| Sharp |  | Assistance information is not essential. We have no strong opinion on this issue. |
| vivo | No | UE subgroup is determined and configured by CN, which should be up to network implementation, i.e. based on individual UE characteristics are not specified. In our understanding CN could have sufficient information to determine the subgroup. Hence, UE assistance to CN for Paging subgroup assignment is not needed. |
| ZTE | No | Assistance information is not essential, we think how to implement the grouping is NW implementation. |
| Sequans | Yes | These attributes can change dynamically and assessing them may take a long time, especially paging probability which is likely to most useful one.  UE should not be required to go to Connected solely to report a change though. |
| Apple | Yes | We support the view that Assistance Information from UE to NW to help in UE subgrouping for paging would be helpful. Especially real time changing characteristics of the UE liker power level, Mobility Status, Type of access, NW slice etc. can be used to distinguish UEs. |
| CATT | No | We think the subscription information is enough for the network to decide the subgrouping. Enabling assistance information from UE would also imply some dynamic updates of such assistance information, thus generating the need for CN to update (potentially frequently) the UE’s subgroup, which we should avoid. |
| MediaTek | Yes | Although network has UE subscription information, the values of these attributes may vary. We prefer to keep the mechanism for UE to provide assistance information to network, as we did for NB-IoT. |
| Huawei, HiSilicon | Yes | It depends on whether subscription information can provide enough assistance for determining the UE subgrouping. We believe that at least for paging probability as th assistance information is helpful since this information is mainly recorded in UE. Some companies said that it can be derived from the UE type, e.g. eMBB UE or RedCap UE. However, we think that even for RedCap UEs, the paging probability for wearables and industrial sensors are different and hence it should be provided by the individual UEs. |
| CMCC | Yes | If the UE provided timely information as listed in the next question, the network could take it into account when determining subgroups for UEs. |
| Nokia | Yes | We agree some UE assistance information could be used. |
| Futurewei | Yes | The UE may have more accurate information about its paging probability and power profile than the CN. |
| DENSO | No | Agree with Samsung and LGE. Assistance information that can change dynamically (e.g. paging probability, power consumption profile and mobility profile) should not be introduced. This requires additional signaling for updates and can cause mismatches between the UE and CN (because the UE cannot update information while in IDLE/ INACTIVE mode). CN can do the grouping based on subscription info. |

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)?**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Company** | **1** | **2** | **3** | **4** | **Comments** |
| Qualcomm | Yes | Yes | yes |  |  |
| Lenovo | Yes | Yes | yes |  |  |
| Sequans | Yes | Yes | Yes |  |  |
| Apple | Yes | Yes | Yes |  |  |
| CATT |  |  | Yes |  | Per our answer to Q4, we don’t support dynamically updating the subgroup, hence we don’t support dynamic assistance information in first place. But if we had to choose one, apart from the power profile (plugged/unplugged) we don’t expect the other power attributes to vary dynamically so that it requires some UE assistance information. |
| MediaTek | Yes | Yes | Yes |  |  |
| Huawei, HiSilicon | Yes |  |  | Yes | For other assistance information, considering that the UE can accurately know its own paging false alarm situation, UE paging false alarm rate related information can be provided from UE to CN for optimizing the subgroup assignment. For instance, the UE monitors its paging false alarm situation by e.g., recording the number/rate of paging false alarms within a period of time. The UE can report the logged information when it transfers to connected mode or immediately indicates the paging false alarm issue when the number/rate of false alarms exceeds certain threshold. Thus CN can adjust UE subgroups accordingly. |
| CMCC | Yes |  | Yes |  |  |
| Nokia | Yes | Yes | Yes |  |  |
| Futurewei | Yes |  | Yes |  |  |
|  |  |  |  |  |  |
|  |  |  |  |  |  |
|  |  |  |  |  |  |
|  |  |  |  |  |  |
|  |  |  |  |  |  |
|  |  |  |  |  |  |

**Summary:**

### Assistance information from gNB

The need for RAN providing some assistance information to CN was partly addressed in Q2.4 of offline #025 [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.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Comments** |
| Samsung |  | 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. |
| Sharp |  | UE capability may be enough. We are open to this issue. |
| vivo | - | We think it should be up to NW implementation, as how to determine subgroup is not specified (if agreed). The only part needs to be exchanged between NW nodes is UE capability in supporting subgrouping.  Some may argue that gNB has the paging probability of RAN paging for a UE, however, we think the subgroup should be same for RRC\_INACTIVE and RRC\_IDLE. The Network can determine the paging probability by UE subscription. There is no need to let RAN report the RAN paging probability. While whether sending the last used Cell to CN needs to be further discussed. |
| ZTE |  | Firstly, we tend to share same view which can be up to NW implementation. But we still have a concern that, as intel pointed, CN may have no idea about the detail number of group for each belonged Cell if sequence based WUS is adopted in RAN1. So we suggest, for this issue, waiting for the outcome from RAN1 about the WUS signal format. |
| Sequans | Yes | We think this can be useful as mentioned above (e.g., different paging between Idle/Inactive, number of PEI groups). However, this is not in RAN2 scope and anyway can also be left to NW implementation |
| Apple | - | We are open to this aspect, but would welcome any additional information being provided to CN by gNB to make the UE subgrouping more efficient with an intent to result in UE power savings |
| CATT | No | It is not clear to us what could gNB provide that CN does not already know and that would help CN for subgrouping purpose. |
| MediaTek | - | This may be useful, but seems out of RAN2 scope. |
| Huawei, HiSilicon | Maybe No | It depends on what assistance information needs to be provided, and it is not clear what UE capability here refers to. If it means PEI capability, we think UE reports it as part of radio capability to the RAN and RAN needs to send it to the CN, similar to what is already done for NB-IoT. But we don’t think this capability is used for the subgrouping decision by CN. Assistance information from UE is sufficient for CN to determine the UE subgrouping. |
| CMCC | - | For example, CN could request the RAN to report the state transition between RRC-INACTIVE and RRC-IDLE which is already supported in the spec. But it seems more of NW implement. |
| Nokia |  | There should be some assistant information from CN to gNB as well if gNB makes final subgrouping depending on its own configurations. |
| Futurewei | No | Same view as CATT. |
| DENSO | No | Subgroup determination should be up to CN implementation. |

**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 #025 [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?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Comments** |
|  | No | In our view, Cell may support either NW assigned subgroup or UE ID based sub group  If 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. |
| Sharp | Yes | When the subgroup has not been assigned by the NW, UE ID based subgroup can be used. |
| vivo | - | From UE point of view, we think the capability of supporting subgrouping should include both NW assigned subgrouping and UE\_ID based.  In this way, if the UE is assigned a subgroup ID, this subgroup ID will be used. Else, if a UE is not assigned to a subgroup by Network during registration, it could calculate the subgroup based on its UE\_ID if the network provides the number of subgroups. Otherwise, legacy paging with no subgroup will be performed.  From network point of view:  First, we think network has the information of UE\_ID. So that, the assigned subgroup for a UE could also consider the UD\_ID based. It should be up to NW implementation, to assign paging subgroups for all UEs or some UEs. And it is also up to network whether to provide the number of subgroups for UE\_ID based subgrouping.  If the co-existence of UE-ID based and CN-assigned subgroups in the same cell exists, we wonder whether the subgroup IDs from CN assigned and the subgroup IDs based on UE\_ID should be overlapped. Our understanding is that the UEs having no CN assigned subgroup ID should not impact the paging for UEs with CN assigned subgroup ID.  In this way, a reasonable network/gNB will try to avoid to support co-existence of UE\_ID based and CN-assigned subgroups in the same cell. |
| ZTE | - | In our understanding, there is no need for us to have two independent mechanisms under one cell. For simplicity, we can realize the NW assigned UE group via UE ID based mechanism. For example:   1. CN assign the number of the UE groups to each cell. 2. and then allocate to UE a specific UE ID by taking the number of UE groups for each serving cell into account, |
| Sequans | Yes | Seeing that some UEs will not support NW-assigned subgroups, it seems necessary. |
| Apple | Yes | In our view, atleast during initial deployments, because of differing UE release support (pre-R17 / R17 and beyond) it is very much possible that both NW subgrouping and UE ID based subgrouping will coexist. It would be left to NW implementation to derive a non-overlaping subgrouping configuration for both cases. Needless to say, an UE would be part of either one of the two types of subgrouping at any point in time. |
| CATT | Yes | Both subgrouping methods should coexist in a cell, because if RAN supports UE-ID in a cell, it would mandate CN to either assign all UEs or none from the same cell with a subgroup, which is quite restrictive. |
| MediaTek | Yes | Network implementation can ensure that the NW-assigned and UE ID-based subgroups do not overlap with each other. |
| Huawei, HiSilicon | No | We understand either NW assigned subgrouping or UE ID based subgrouping is supported in a cell, this is simpler. |
| CMCC |  | It is complex to support the mix of these two subgrouping method. UE ID based subgrouping can be used when no subgrouping assigned by CN. |
| Nokia | Yes | NW assignment and UE ID based could work together, e.g. similar to NB-IoT, UE ID based could be done within NW assignment subset and if a UE is not with any assignment, the UEs with UE-ID based using different subgroups than the NW-assigned subgroups. |
| Futurewei |  | We are open to allowing both methods be supported in a cell. However, we understand that it will add complexity. For example, RAN needs to signal (and the UE needs to determine) whether the two methods share the same set of subgroups or not. And if not, RAN/UE may need to convert the CN-assigned subgroup index into a RAN subgroup index that the RAN will finally use in paging the UE. And, such conversion needs to be done per cell. |
| DENSO | No | In our view, there is no benefit to mixing the two grouping methods. CN-assigned subgrouping based on UE characteristics may not work well by mixing with UE\_ID-based subgrouping. The presence of UEs that don't support CN-assigned subgrouping complicates the mechanism and should be avoided. The UE should always support both grouping methods, and it is better to clearly indicate which grouping method is applied in the cell using SI. This also helps to avoid ambiguity. |

**Summary:**

### Subgroup determination

In the context of the discussion about “RAN-assigned UE subgroup” in the offline #025 [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?**

|  |  |  |
| --- | --- | --- |
| **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. |
| Sharp | Yes |  |
| vivo |  | If the co-existence of UE-ID based and CN-assigned subgroups in the same cell does not exist, then, the total number Nsg for subgroups is enough for UE\_ID based subgrouping.  Otherwise, we need to determine whether the UE\_ID based and CN-assigned subgroups are overlapped, which will impact how to determine the subgroup ID based on UE\_ID. |
| ZTE | Yes | As comment in Q6, we think NW assigned subgrouping can be realized via the UE ID based mechanism. |
| Sequans | maybe | A single number can still be enough, though it may not be the total number of subgroups, but e.g. the number of groups “left” for UE-ID |
| Apple | YEs | UE needs to know the total number of subgroups to derive its own subgroup ID. |
| CATT | Yes | We prefer keeping things simple and just reuse the legacy principle and type of formula from UEID-based grouping in POs. |
| MediaTek | Yes | The formula for subgroup determination should be as simple as possible. |
| Huawei, HiSilicon | - | The total number of subgroups is needed and we understand one value is enough, this value is the total number of subgroups that supported/used in this cell, no matter if NW-assigned subgrouping or UE ID-based subgrouping or both are used in this cell.  Besides, for UE ID-based subgroup, we further believe that a weight-UE ID based subgrouping method, where the number of UEs in each subgroup can be adjusted, in addition to the total number of UE subgroups is useful. In this case, the weight for each subgroup and total weight of all UE subgroups are needed. |
| CMCC | Yes |  |
| Nokia | Yes but | For the case of UE-ID based only without NW assigned, then only Nsg is needed.  If NW assigned on top, there could further split for different subgroup set/subset of UEs within the total number for subgroups, how the subgroup sets split and number subgroups within the groups need to be broadcasted as well. |
| Futurewei | Yes and No. | The answer is Yes if only UEID-based subgrouping is supported in the cell or if both network-assigned subgrouping and UEID-based subgrouping are supported in the cell using the same set of subgroups.  The answer is no if both network-assigned subgrouping and UEID-based subgrouping are supported in the cell but using different sets of subgroups.  No matter which way it is, the Nsg advertised in SI should be precisely the total number of subgroups where a UE can be hashed into using the UEID-based subgrouping. |
| DENSO |  | As we commented in Q6, gNB needs to indicate whether UE\_ID based subgrouping or CN-assigned subgrouping is applied. |

**Summary:**

### Who decides the number of subgroups Nsg?

In the context of the discussion about “RAN-assigned UE subgroup” in the offline #025 [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?**

|  |  |  |
| --- | --- | --- |
| **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 |  |
| Sharp | Yes |  |
| vivo | Yes | Using System Information is the easiest and effective way. |
| ZTE | No | It can be decided in CN. |
| Sequans | No | In concept it makes sense that it would be possible, but since the CN is the one deciding, how is the RAN supposed to know how to handle them (e.g. which ones can be merged and which not for a smaller number than given by CN) |
| Apple | Yes |  |
| CATT | Yes |  |
| MediaTek | Yes |  |
| Huawei, HiSilicon | Yes | For UE ID based subgrouping, it is straightforward that it should be decided by RAN. Even for NW-assigned subgrouping method, RAN should decide the total number of subgroups, as RAN may support less number of subgroups than CN due to RAN configuration, e.g. due to the mapping between PEI and its PO and the number of subgroups per PO. |
| CMCC | Yes |  |
| Nokia | Yes | On top of that, how it is split might need to be broadcasted as well. |
| Futurewei | Yes and No | Yes to the aspect that Nsg is decided by RAN and advertised in SI.  However, Nsg is not necessarily the total number of subgroups supported in the cell when both network-assigned subgrouping and UEID-based subgrouping are supported in the cell, depending on whether the total number of subgroups supported in the cell are divided or shared between the two different subgrouping methods. No matter which way it is, the Nsg advertised in SI should be precisely the total number of subgroups where a UE can be hashed into using the UEID-based subgrouping. |
| DENSO | Yes |  |

**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?**

|  |  |  |
| --- | --- | --- |
| **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 |  |
| Sharp | Yes |  |
| vivo | Yes |  |
| ZTE | Yes |  |
| Sequans | Yes |  |
| Apple | Yes | Ideally this should be function of the cell loading (number of UEs in the cell) |
| CATT | Yes |  |
| MediaTek | Yes |  |
| Huawei, HiSilicon | Yes |  |
| CMCC | Yes |  |
| Nokia | Yes |  |
| Futurewei | Yes |  |
| DENSO | Yes |  |

**Summary:**

## False paging alarm due to mobility and PEI

This issue (discussed in [11]) was raised in the offline #025 [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.

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Nokia | In the figure 1 in 3.1, there is a step missing on NW broadcasting subgrouping configuration information.  For assistant information, apart from UE/gNB to CN, there should be some assistant information from CN to gNB as well as gNB could also plays role in subgroups splitting. We assume CN could provide subgrouping related assistance information to RAN while the actual subgrouping could be done by the gNB based on its own PO/PEI configurations similar to NB-IoT. |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

3. Conclusion

4. Reference

1. R2-2104701 RAN2#113bis-e Meeting Report; MCC
2. RAN2-114-e Chairman Notes EOM Rev2 2021-06-15;
3. R2-2106666 Report of [AT114-e][025][ePowSav] Subgrouping network architecture; Mediatek Inc.
4. R2-2106552, LS on Paging Subgrouping, RAN2
5. R2-2105411, Details on paging subgrouping determination and indication, Nokia, Nokia Shanghai Bell
6. R2-2105293, UE Paging Subgroup Assignment for Power Saving, MediaTek Inc.
7. R2-2105283, UE subgrouping schemes with paging enhancement, CATT
8. R2-2104783, Paging Enhancements\_UE Grouping, Samsung Electronics Co., Ltd
9. R2-2105656, Grouping methods for Paging, Ericsson
10. R2-2104909, UE sub-grouping for paging enhancement, vivo
11. R2-2105736, PEI monitoring in NR: CN and System level impacts, Vodafone, Ericsson