**3GPP TSG-RAN WG2 Meeting #114 electronic R2-210xxxx**

Online, May 19 – May 27, 2021

Agenda Item: 8.9.2

Source: MediaTek Inc.

**Title: Report of [AT114-e][025][ePowSav] Subgrouping network architecture**

Document for: Discussion and decision

# Introduction

In this offline discussion, we invite companies to share their views on further details about UE paging subgrouping for UE power saving, as described below.

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| * [AT114-e][025][ePowSav] Subgrouping network architecture (Mediatek)

 Scope: Address whether CN or RAN shall be responsible for paging subgrouping based on UE characteristics. As this may be related to availability of information on UE characteristics in the CN or RAN network entity, can also discuss if needed provisioning of assistance information (e.g. between the network entities or from UE to the responsible network entity). The discussion shall be based on the contributions under 8.9.2.  Intended outcome: Report, with discussion, and presenting the main alternatives on the table with documented justifications, way forward. Deadline: In time for CB online May 25 |

Please also kindly provide your contact information in the table below.

|  |  |  |
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# Discussions

## General issues of CN vs. RAN Assignment

In last meeting, we agreed that UE paging subgroups are assigned by the network based on UE characteristics. Companies provide contributions to this meeting about whether the subgroup assignment is done by CN or RAN. Companies’ views are summarized as follows:

* CN assignment (9): Qualcomm [1], Samsung [2], vivo [4], CATT [7], MediaTek [8], Nokia [10], Ericsson [11], CMCC [17], LG [18]
* RAN assignment (4): OPPO [3], Intel [5], Lenovo [14], Futurewei [16]
* CN or RAN assignment (for different RRC states or subgrouping solutions) (4): Apple [6], Xiaomi [9], HW [12], ZTE [15]

Which entity should assign UE subgroups?

First of all, we invite companies to express their view again on whether CN or RAN.

**Q1.1: Should UE grouping be considered as a kind of paging enhancement for UE power saving? Should it be assigned by CN or RAN?**

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| --- | --- | --- |
| **Company**  | **Yes/No** | **Comments** |
| Ericsson | Yes | We also consider UE\_ID based grouping as a type of "RAN controlled grouping" |
| Qualcomm | Yes |  |
| vivo | Yes | We would like to check the intention for this proposal. Is it to confirm UE grouping could be considered for paging enhancement? I assume RAN2 has agreed UE grouping in last meeting, we think there is no need to discuss this issue again. Or anything I missed. |
| CATT | Yes | We understand the question is for “subgrouping”, not sure though what the question implies. |
| Xiaomi | Yes |  |
| LGE | Yes |  |
| Huawei, HiSilicon | Yes | We think it was agreed in previous meetings to introduce UE grouping, so not sure what the relevance of this question is for deciding CN or RAN. If the question should be “do you prefer CN or RAN” then we think it depends on the solution and more details of the solution need to be agreed before deciding on this.We think that in all cases, CN provides information upon which the subgroup assignment is done. This may be direct subgroup assignment by CN in case the solution is totally up to unspecified NW internal information, or it may be e.g. negotiation of paging probability between UE and CN while the RAN arranges subgroups accordingly – i.e. then UE selects the RAN subgroup corresponding to the paging probability and UE-ID (same as LTE) or RAN directly assigns the subgroup ID accordingly.  |
| Intel | Yes | However we are not sure on the intention of the question. Is this just confirming the previous agreement? |
| Apple | Yes | We do support UE grouping as a method to be used for IDLE/INACTIVE UE power saving. Our understanding was that RAN2 has already agreed on UE\_ID based grouping as a baseline and that how and whether RAN/CN does this grouping is the open issue. |
| Nokia | Yes | As agreed in previous meetings. |
| Samsung | Yes | We have already agreed this in last meeting. |
| MediaTek | Yes | Subgroups should be assigned by CN. |
| ITRI | Yes |  |
| Lenovo | Yes |  |

Subgroup IDs for UE in RRC\_IDLE and RRC\_INACTIVE

There are proposals (e.g. [9]) suggesting that a UE use one subgroup IDs when in RRC\_IDLE and another subgroup ID when in RRC\_INACTIVE, while other proposals suggest that the UE should use the same subgroup ID.

**Q1.2: Should UE use the same subgroup ID when in RRC\_IDLE and RRC\_INACTIVE?**

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| **Company**  | **Yes/No** | **Comments** |
| Ericsson | Yes | We do not see why the UE subgroup should depend on the RRC state. If it would then it could impact monitoring CM-IDLE paging in Inactive like Xiaomi pointed out.  |
| Qualcomm | Yes | We do not see any strong use case for UE to have different subgroup ID in RRC Idle and RRC Inactive. Moreover, if different subgroup IDs are configured, UE needs to monitor both subgroups when in RRC Inactive, otherwise UE may not be able to recover from state mismatch. That would increase rate of false paging. |
| vivo | Yes | Same subgroup ID should be used for both RRC\_IDLE and RRC\_INACTIVE state, otherwise paging missing issue may occur in case of RRC state mismatch between UE and NW.Meanwhile, UEs in RRC\_INACTIVE state need to monitor CN and RAN paging. In this way, two subgroup IDs should be based for paging monitoring.  |
| CATT | Yes | Considering state mismatch it seems difficult to assign a different subgroup to the UE for Idle and Inactive, and we do not see what would be the benefit. |
| Xiaomi | No? | In our understanding, we may need to assign different Group IDs for RRC\_IDLE mode and RRC\_INACTIVE. An example is from the paging probability point of view, UE monitors CN paging less frequent than the RAN paging. It may not be suitable to put a UE with higher paging rate into a group with lower paging rate which may cause false alarm to other UEs.People may argue, since it is the RAN which has the control of UE RAN paging, RAN can assign a smaller DRX cycle compared to the UE specified DRX cycle to imply the RAN paging is more frequently than the CN paging, thus we do not need to differentiate the paging probability by sub-grouping (i.e., the higher paging probability is spread over many DRX cycles). Well, it is reasonable. However, when the default DRX cycle is configured shorter than the CN paging cycle and the RAN paging cycle, this method fails.Considering the observation described above, network assign two types of subgroup ID for RRC\_IDLE and RRC\_INACTIVE mode respectively seems to be a reasonable solution. In the case of RRC IDLE, CN will take the control on the UE’s subgrouping ID while in the case of RRC INACTIVE, it is natural that RAN who RAN buffers DL packets for the UE in RRC\_INACTIVE will decide the subgrouping for the UE. However, we do see some problems with this scheme, as Ericsson mentioned, we may have challenges consider the exceptional case for RRC status mismatch.We think we can first discuss whether we need to have different Group IDs for RRC\_IDLE mode and RRC\_INACTIVE. If people think we do not have to, we can use one group for the two states. |
| LGE | Yes | UE in RRC\_INACTIVE should be able to receive CN paging also just in case that the state mismatch occurs between UE and network. Therefore the same paging subgroup should be used in RRC\_IDLE and RRC\_INACTIVE. |
| Huawei, HiSilicon | Yes | There is a risk of mismatch between UE and NW if the subgroup changes depending on the RRC state, in particular UE has to monitor both CN and RAN paging so may anyway have to monitor multiple groups. |
| Intel | Yes | It will be essential that the subgrouping is the same for both Inactive and Idle mode so that when there is a state mismatch between the UE and NW, UE will not have to monitor different subgroup for Inactive and Idle. |
| Apple | Yes? | We do agree with company views that in case of RRC state mismatch between UE and NW, RRC state specific (IDLE/INACTIVE) subgrouping might result in page miss. At the same time, if there is perfect sync between UE and NW with respect to UE RRC state and that NW wants to implement a mechanism to group IDLE and INACTIVE UEs separately, then such a grouping mechanism should be possible. We feel that if NW assigns the UE to a particular subgroup as part of RRC RELEASE, then there is very little scope for RRC state mismatch. |
| Nokia | Yes | Agree with the others. |
| Samsung | Yes |  |
| MediaTek | Yes | Agree with the others. |
| ITRI | Yes |  |
| Lenovo | Yes | The separate UE group ID will introduce an extra work to deal with the mismatch of UE states in UE side and network side, so, we prefer a same one for CN paging and RAN paging. |

## CN-assigned UE subgroups

We now discuss the details if UE subgroups are assigned by CN. The network assigns UE subgroups, and may update the assignment from time to time. In each PO, a UE monitors the indication for its subgroup, and decode paging message if any UE in its subgroup is paged.

Subgroup assignment

**Q2.1: If UE subgroups are assigned by CN, how does network provide the initial assignment of subgroups to each UE?**

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| **Company**  | **Comments** |
| Ericsson | During NAS registration procedure, i.e. in REGISTRATION ACCEPT (24.501).  |
| Qualcomm | Agree with Ericsson |
| vivo | Network provide the initial assignment of subgroups to each UE during registration procedures.The assignment of subgroups is consistent at least in one registration area.  |
| CATT | Agree with Ericsson |
| Xiaomi | As in eLTE, using NAS procedure. And CT1 should be involved. |
| LGE | Agree with Ericsson |
| Huawei, HiSilicon | NAS registration procedure seems a possible way, but should be a discussion for SA2/CT1. |
| Intel | The initial assignment is provided by the network via NAS during initial registration. Note that it should be up to CT1 to discuss the NAS procedures where the CN-assigned UE subgroups may be provided to UE for initial registration (or future update e.g. during mobility as discussed in next question) |
| Apple | This should involve SA2/CT1, but using REGISTRATION procedure seems to be the most logical things to do.  |
| Nokia | Agree with Ericsson it can be done during NAS registration.Enough to assign the UE to certain subset which share the same characteristics, further subgrouping could be possible via RAN depends on how many subgroups RAN supports. Simplest example would be Redcap UEs within one group and eMBB in the rest of subgroups which can be based on UE ID. |
| Samsung | CN configures UE specific DRX cycle to UE using NAS signalling message. Same message can be used to signal UE's paging group to UE |
| MediaTek | Agree with Ericsson. |
| ITRI | Agree with Ericsson that using the NAS registration procedure is a possible way to assign the subgroup for UE. |
| Lenovo | It is provided by the NAS registration procedure. |

**Q2.2: If UE subgroups are assigned by CN, how does network update the assignment of subgroups for each UE?**

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| **Company**  | **Comments** |
| Ericsson | We should perhaps first discuss why there is a reason to update/change the grouping? The UE characteristics typically do not change e.g. RedCap, power sensitive? But the registration procedure in NR is used during initial registration but also during other periodic updates including mobility, i.e. updates are possible.  |
| Qualcomm | Through NAS signaling |
| vivo | Network may update the assignment of subgroups for each UE during registration procedures for mobility, or periodic registration update. |
| CATT | The network can also update the assignment of subgroups for each UE via NAS message. We can leave the details to CT1. |
| Xiaomi | Through NAS signalling. We think the network should provide a way for UE to update the subgroup information, if needed. Well, whether this is enabled or not should be depend on CT1. |
| LGE | Through NAS signalling. The subgroup ID can be updated only after UE enters RRC CONNECTED. The UE should not be required to establish RRC connection just for the subgroup update. |
| Huawei, HiSilicon | If subgroup assignment is done by CN then any update would also be done by CN, we can leave details to SA2 and CT1. |
| Intel | Any update to the assignment can be done via NAS, for example during mobility registration (i.e. TAU etc.) however the actual NAS mechanism should better be discussed by CT1. |
| Apple | This should again be done via NAS signalling and should be confirmed by SA2/CT1. |
| Nokia | We agree with Ericsson CN assignment should not change much. |
| Samsung | Agree with Ericsson |
| MediaTek | Should be done via NAS, but need to subgroup update can be decided by other WGs |
| ITRI | We share the same view as Huawei that once the subgroup assignment is done by CN, then when and how to update the information is up to CN. |
| Lenovo | It is depended on the specific grouping rule the UE will applied. Generally, for CN-assigned UE subgrouping, the CN based updating is the baseline, but we could not preclude the other way. For example, the UE power sensitive level may be updated based on UE specific issue. |

Assistance information from UE

Although UE subgroups are assigned by network, UE may provide assistance information (e.g. UE’s paging probability, power profile and mobility profile [1]) to assist subgroup assignment. There are also contributions suggesting that UE assistance is not needed [11]. If assistance information can be provided, we may want to know what attributes can be considered.

**Q2.3: If UE subgroups are assigned by CN, can UE provide assistance information for subgroup assignment? What are the attributes to be considered?**

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| --- | --- | --- |
| **Company**  | **Yes/No** | **Comments** |
| Ericsson | No | We do not see the need for UE assistance, i.e. the network has the information it needs to do grouping (e.g. subscription info, paging probability). And in case the NW uses the UE preference, then practically the grouping is controlled by the UE, unless the NW checks if the UE is reporting correctly, e.g. indicates the correct paging probability or checks if is it power sensitive. Such checks are complicated to implement, and typically the NW does not do that. But our main concern is that the group assignment should be left to NW implementation. This does not only mean that the NW should be able to ignore the "preference" indicated by the UE, but also that the UE assistance does not lead to pre-defined groups, e.g. "paging probability group", "power sensitive group", etc. Because in such case the grouping is not left completely to the NW implementation, but it is partially controlled by the UE assistance. In case the UE assistance does not lead to pre-defined groups, and leaves the group assignment to the NW implementation (e.g. the NW just assigns a group number), then UE assistance would be acceptable.  |
| Qualcomm | Yes | Possible attributes may include UE’s paging probability rate (similar to those in NB-IoT), mobility profile (e.g. stationary vs mobile) and power profile (e.g. plugged in or on battery) |
| vivo | No | UE group ID is determined and configured by CN, which should be up to network implementation, i.e. based on individual UE characteristics are not specifiedHence, UE assistance for subgroup assignment is not needed.  |
| CATT | No | We agree with Ericsson that no assistance should be required and CN can do the grouping based on subscription info. |
| Xiaomi | Yes? | We think such paging probability should be provided to CN as an assistance information like NB-IoT did. Since network controlled subgroup is adopted, we are open for other UE characteristics.But we need to discuss first by which way the CN get such assistance, by assistance include in NAS messages or from the gNB? If by NAS, there may be no impact in RAN. |
| LGE | No | It should be up to network implementation. No assistance should be required. |
| Huawei, HiSilicon | Yes | Similar to NB-IoT/eMTC, paging probability can be one assistance information provided by the UE. The device types and user habits can be diverse, for example, the paging probability for smart phones and wearable devices are different, or the paging probability for user during the working hours and spare time may be different. The UE can have precise information about its own situation and thus provides paging probability accordingly. |
| Intel | Maybe | For this release, network can just base it on information already available in CN such as UE subscription, device type, paging policy/strategy. Depending on time available, further UE assistance information can be discussed. |
| Apple | Yes | Some dynamic characteristics of UE like Power Profile, Current Power state, Mobility Status can be considered as inputs. This is in addition to whatever NW can derive about the UE based on the advertised UE capability. |
| Nokia | Yes | UE types e.g. Redcap, eMBB, MUSIM capability etc which have different paging probability implications and paging requirements, mobility characteristics, e.g. if stationary etc. We agree with Ericsson though it is up to NW implementation if and how the UE assistance information is used. |
| Samsung | No | No need of additional assistance information |
| MediaTek | Yes | We understand that network already has subscription information and so on, and may not really need UE assistance information. But in LTE GWUS, UE can provide WUS assistance information, and thus we prefer to keep the possibility at this moment.  |
| ITRI | No | It should be up to the network implementation. |
| Lenovo | Yes | The network may not have a timely information on UE characteristic just based on UE subscription in network. Hence, the assistant information, such as the UE paging probability as in NB-IOT, the UE power sensitive level information and UE mobility information, should be reported to network. Surely, we agree that the network(CN or RAN) will determine the UE assigned group. |

Assistance information between network entities

Network entities may also provide assistance information to each other. For example, RAN may provide information to help subgrouping by CN (e.g. last used cell [13]), and CN may inform RAN of the subgroup assignment.

**Q2.4: If UE subgroups are assigned by CN, can network provide assistance information to each other? What are the attributes to be considered?**

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| **Company**  | **Yes/No** | **Comments** |
| Ericsson | Yes | We understand that the assigned group should be included in the INITIAL CONTEXT SETUP REQUEST in the *Core Network Assistance Information for RRC INACTIVE* IE to enable the use of group info during RAN paging. For CM\_IDLE paging the assigned group needs to be included in the PAGING message to the gNB. We also think that PEI, similar as WUS in LTE, should only be used in "last used" cell, see [13] ([R2-2105736](https://www.3gpp.org/ftp/tsg_ran/WG2_RL2//TSGR2_114-e/Docs/R2-2105736.zip)). Because paging due to mobility may cause the PEI to be triggered frequently which nullifies the power gains with PEI, and paging due to mobility may cause of lot of PEI transmissions while the UE only replies in a single cell within the TA. In case PEI is only used in the last used cell, then this information needs to be exchanged between RAN and CN (e.g. in *Information on Recommended Cells and RAN Nodes for Paging* in UE CONTEXT RELEASE COMPLETE from gNB to AMF, and in *Assistance Data for Recommended Cells* IE in PAGING message). Furthermore the PEI UE capability need to be added to the UE capabilities, i.e. signalled between UE and gNB. The gNB needs to send these UE radio paging capabilities (UCRP) to the CN, such that the CN can include them as the UE radio paging capabilities in the PAGING message to the gNB. In case PEI is added to the UERadioPagingInformation message in Rel-17, then we should also add *ue-RadioPagingInfo* IE in the *UECapabilityInformation*, similar as already has been done for LTE, such that the gNB can just copy it, and does not need to extract it from the reported UE capabilities. Also see also current RAN3 discussion on use of URCP in case of RAN paging in [R3-211621](https://protect2.fireeye.com/v1/url?k=750797bf-2a9caef2-7507d724-86b568293eb5-3cfbb9a53e1c3194&q=1&e=06aac426-6f8d-4ed9-92b8-0f545c69ec20&u=https%3A%2F%2Fwww.3gpp.org%2Fftp%2FTSG_RAN%2FWG3_Iu%2FTSGR3_112-e%2FDocs%2FR3-211621.zip) . We propose to send an LS to RAN3/SA2 about this.  |
| Qualcomm | Yes | When UE is in RRC Idle, CN should provide UE’s subgroup ID to RAN when CN sends paging notification to RAN; when UE is in RRC Inactive, anchor gNB should provide UE’s subgroup ID to serving gNB when it sends paging notification. |
| vivo | - | I think companies may have some mis-understanding on this question. Two parts need to be discussed:1. When determining the subgroup ID, whether assistance information between NW nodes is needed. 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 support subgrouping.
2. After determining the subgroup ID, this assignment should be informed to RAN and UE. Meanwhile, when paging UEs, the corresponding subgroup ID should be included in the paging message.
 |
| CATT | No | CN only needs to inform gNBs in the tracking area about the assigned UE subgroup, but we do not consider this as “assistance information”. |
| Xiaomi | Yes | First of all, the interaction between network entities shall ensure the paging subgroup can work. For CN assignment, CN is anyway required to provide subgroup ID to RAN for CN paging as well as for RAN paging. For CN paging the assigned group needs to be included in the PAGING message to the gNB.For RAN paging, anchor gNB should transfer this to serving gNB in the RAN PAGING messageOf course, UE capability should be transferred to each other. And the way in eLTE can be used.Other assistance information for a wise subgroup assignment can be FFS (see comments to Q2.3). |
| LGE |  | For determination of subgroup ID, no assistance information is required between network nodes.After determining the subgroup ID, it should be delivered to RAN nodes. |
| Huawei, HiSilicon | Yes | One issue is that the CN is not aware of the RAN probability rate because from CN point of view RAN paging is transparent. In case UE assistance (e.g. reporting of paging probability) then maybe we do not need this information sent to CN, however it is likely that CN needs to provide RAN with the paging probability or subgroup ID – it depends on the solution.  |
| Intel | Yes, but | For CN providing the subgroup to RAN: the AMF provides the allocated subgroup to gNB during CN paging when having to page a UE in RRC\_IDLE. For a UE in RRC\_INACTIVE, the assigned subgrouping is stored in the source gNB as part of the UE context (for CN-assigned subgroups, it is in e.g. CN assistance information for RRC\_INACTIVE IE). During RAN paging, the source gNB will provide the paging gNB (for the case RAN paging is in cells of another gNB) with the stored UE subgrouping.Regarding assistance information between CN and RAN or between RAN: As for further attributes, the CN can just base it on UE subscription and paging policy/strategy. However, if time permits, further enhancement (e.g. last used cell, UE type based on UE capability, RAN paging frequency) can also be discussed in RAN3/SA2 between CN and RAN or between RAN  |
| Apple | Yes | CN and RAN can exchange information depending on the RRC state of the UE that is being paged. In this context we agree with the usecases provided by Xiaomi and Qualcomm. |
| Nokia | Yes | If RAN decides the actual number of subgroups for each subset, assistant information is needed from CN to RAN on how to split the bits, e.g. whether multiple groups needed for Redcap UEs based on number of UEs and their paging probabilities etc. and which subset the UE belongs to when sending the paging message to RAN. |
| Samsung | Yes | For CN paging, CN sends UE Identity Index value (i.e. UE\_ID) to gNB in the paging message. In similar manner, CN can send the UE's paging group to gNB in the paging messageFor RAN paging, CN sends the UE specific DRX and UE Identity Index value to gNB in Core Network Assistance Information. In similar manner, UE's paging group can be sent to gNB in Core Network Assistance Information |
| MediaTek | Yes | It may not be very precise to consider the “subgroup ID” as a kind of assistance information, but in general there is some information exchange between RAN and CN.  |
| ITRI | No | In determination of subgroup ID stage, we think network does not need to provide assistance information to CN. |
| Lenovo | Yes | For CN-assigned UE subgroups, the CN should provide the UE subgroups information to gNB in CN paging message, and in the procedure of UE RRC connection to gNB for RAN paging message. The other information could be further studied if the CN-assigned UE subgroups is agreed. |

## RAN-assigned UE subgroups

An alternative is to have UE subgroups assigned by RAN. We now discuss the details in a similar way.

Subgroup assignment

**Q3.1: If UE subgroups are assigned by RAN, how does network provide the initial assignment of subgroups to each UE?**

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| **Company**  | **Comments** |
| Ericsson | We think that the UE\_ID can be used as a "RAN controlled" grouping mechanism. |
| Qualcomm | RAN may configure a subgroup ID for UE by dedicated signaling (e.g. in RRC Release msg). We also agree with Ericsson’s comment that UE\_ID based subgrouping is also one type of RAN-assigned subgrouping. In that case, the number of subgroups is provided in system information. UE derives its subgroup ID by hashing. |
| vivo | RAN provides the initial assignment in RRC dedicated signaling, e.g. in RRC release message. Or we also agree that NW provides number of subgroups, and UE calculates its subgroup ID with UE\_ID.  |
| CATT | We agree with Ericsson that RAN-assigned UE subgroups can reduce to UE\_ID based grouping. In case a different subgrouping method would be used, RAN-assigned specific subgrouping ID should be provided in the *RRCRelease* message. |
| Xiaomi | There are two methods. One is RAN directly assign subgroup via RRC release message. Another is UE-ID-based method through randomization. And we think UE-ID-based method can be a fall-back scheme if network does not provide a subgroup.  |
| LGE | Through RRC dedicated signalling, e.g. RRC release. |
| Huawei, HiSilicon | For the solution that the network provides parameters used for UE subgroup derivation, we assume that the RAN would broadcast subgroups which correspond to particular attribute (paging probability, UE-ID which is assigned by CN). So it is similar to the current LTE mechanism for WUS grouping.For the solution that the network directly provides UE with the subgroup ID, the initial assignment can be done through dedicated RRC signalling e.g. *RRCRelease*. |
| Intel | RAN can provide the subgroups to the UE via dedicated signalling, for example via RRC Reconfiguration message or RRC Release message. |
| Apple | This should be done via dedicated RRC signalling e.g RRCRelease which moves the UE out of RRC CONNECTED to either RRC IDLE/RRC INACTIVE. |
| Nokia | Enough for RAN to broadcast number of bits for subgroups for each subset if subset has been assigned by CN. UE\_ID is used within the same subset e.g. for eMBB UEs.Extreme case is if without subgroup within each subset, then CN assigned subset is equivalent to subgroups.  |
| Samsung | Agree with Ericsson, Qualcomm. |
| MediaTek | If RAN is to assign subgroup ID, it can be done in RRC Release. If we eventually decide that subgroup ID is set by CN, we may further study whether to support UE\_ID as a "RAN controlled" grouping mechanism, as Ericsson suggested. |
| ITRI | RAN could provide the assignment information by using RRC dedicated signalling. |
| Lenovo | Same view as Huawei.Generally, there are two different understanding to the RAN-assigned UE subgroups. * The RAN-assigned UE subgroups is considered as the legacy NB-IOT mechanism, by which the UE group ID is computed based on the UE attributions(common for UE and network) and the information of the mapping of UE attributions and the UE group-ID, which is broadcasted in SI information. Then, the SI changing could be used to update the assignment of the subgroups from the cell level.
* The RAN-assigned UE subgroups is considered as the direct UE group ID or subgroup set allocated to UE by some dedicated signalling.
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**Q3.2: If UE subgroups are assigned by RAN, how does network update the assignment of subgroups for each UE?**

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| **Company**  | **Comments** |
| Ericsson | The UE\_ID based grouping is controlled via parameters configured in System Information e.g. *Ng: Total number of groups*. |
| Qualcomm | If UE’s subgroup ID is configured by dedicated signaling, network should use dedicated signaling to change it when UE is connected.If UE’s subgroup ID is derived based on its UE\_ID, network can change number of subgroups in system information to update all UE’s subgroup IDs. |
| vivo | RAN updates the assignment in case UE enters RRC connected state. Or UE could update the subgroup ID by using the updated number of subgroups.  |
| CATT | Same view as Ericsson for UE\_ID based. For other method, RAN can update the subgroup every time it releases the UE. |
| Xiaomi | RAN directly update the subgroup via RRC release message can be first discussed. |
| LGE | Through RRC dedicated signalling, e.g. RRC release. The subgroup ID can be updated only after UE enters RRC CONNECTED. The UE should not be required to establish RRC connection just for the subgroup update. |
| Huawei, HiSilicon | For the solution that the network provides parameters used for UE subgroup derivation, SI change would be used for updating subgroup information. CN would be used to update any associated information like paging probability.For the solution that the network directly provides UE with the subgroup ID, the update can be done by e.g. RNAU/TAU. |
| Intel | RAN can update the UE when UE is in RRC Connected using RRC messages. |
| Apple | This needs to be updated as part of dedicated RRC signaling.  |
| Nokia | Subgroup related information is broadcasted in SIB. No need to have update via dedicated signalling. |
| Samsung | Agree with Ericsson, Qualcomm. |
| MediaTek | RRC signalling for subgroup ID; system information for UE\_ID based grouping (if supported) |
| ITRI | RAN could update the subgroup information by RRC messages when UE is in RRC connected mode. |
| Lenovo | Generally, there are two different understanding to the RAN-assigned UE subgroups. If the RAN-assigned UE subgroups is considered as the legacy NB-IOT mechanism, by which the UE group ID is computed based on the UE attributions and the information of the mapping of UE attributions and the UE group-ID broadcasted in SI information. Then, the SI changing could be used to update the assignment of the subgroups from the cell level.If the RAN-assigned UE subgroups is considered as the direct UE group ID or subgroup set allocated to UE by some dedicated signalling, the updating is also contained in the dedicated signalling. |

Cell reselection

When in IDLE or INACTIVE mode, UE may move to the coverage of another cell without notifying the network. Paging message is sent from multiple cells in the same tracking area or RAN notification area. If UE subgroup is assigned by one RAN node, we need to discuss how other RAN nodes know the subgroups of UEs to be paged.

**Q3.3: If UE subgroups are assigned by RAN, how do RAN nodes know the subgroups of UEs to be paged, if assigned by other RAN nodes?**

|  |  |
| --- | --- |
| **Company**  | **Comments** |
| Ericsson | The UE-ID based RAN group is cell specific.  |
| Qualcomm | If UE’s subgroup ID is assigned by dedicated signaling, anchor gNB should provide UE’s subgroup ID to serving gNB when it sends paging notification.If UE’s subgroup ID is derived based on UE\_ID, UE can check number of subgroups in system info of the new cell. |
| vivo | RAN nodes should know the subgroups information of UEs from anchor node, who assigned the UE subgroups. |
| CATT | Same view as Ericsson for UE\_ID based. For other method, gNB must inform CN about the UE subgroup and CN stores it as part of UE context. Otherwise, the UE context in RAN is released when the UE is released into RRC\_IDLE and the UE subgroup is lost. Then if CN paging is triggered for the RRC\_IDLE UE, CN sends the UE-specific subgroup ID to RAN nodes within CN paging message. And if RAN paging is triggered for RRC\_INACTIVE UE, anchor gNB may need to send the UE-specific subgroup ID to other RAN nodes within RAN paging message.However see also our answer to Q3.4 |
| Xiaomi | For UE-ID-based method, there is no such an issue as UE can check configuration from system information broadcasted.For RAN direct assignment, anchor gNB needs to send subgroup ID (carried in paging message) via Xn interface to another gNB or the subgrouping ID needs to be sent to CN to be stored when UE is released and then the CN can transfer it the target paging gNB (if RAN assigns the subgrouping for idle mode paging). |
| LGE | Same view as Qualcomm. |
| Huawei, HiSilicon | For the solution that the network provides parameters used for UE subgroup derivation, as mentioned above, the subgroup ID would be determined based on information negotiated at CN level, while the information broadcast by RAN would associate the subgroup ID to a particular subgroup configuration – so this is a non-issue.For the solution that the network directly provides UE with the subgroup ID, the UE’s assigned subgroup ID can be maintained by CN and the anchor gNB. CN and the anchor gNB provide a UE’s subgroup to other RAN nodes in CN paging and RAN paging, respectively. |
| Intel | We are not sure why this question is specific to RAN assignment of subgrouping,even for CN assignment of subgrouping, the subgrouping needs to be provided to other RAN nodes during RAN paging while UE is Inactive mode.For idle mode, the RAN assigned subgroup information is stored in the AMF (e.g. as part of the *UERadioPagingInformation* container) when the UE goes into RRC\_IDLE. During CN paging, the AMF provides to the gNBs with the previously stored subgrouping (e.g. *UERadioPagingInformation* container) so that it can page the UE using the allocated subgroup. For a UE in RRC\_INACTIVE, the RAN assigned subgroup information is stored in the source gNB as part of the UE context. During RAN paging, the source gNB will provide the paging gNB (for the case RAN paging is in cells of another gNB) with the stored UE subgroup.Our assumption is that the subgrouping configuration will generally be consistent over a registration area. However, if different cells in the registration may have different paging configuration (e.g. total number of UE paging subgroup space or different amount of sequence resource configuration), the RAN 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 RAN provides the UE subgroup for cell with 4 sequences as well as for cell with 8 sequences. Another possibility is to have a hashing function at the UE to rationalize the different subgrouping configuration. |
| Apple | This information has to flow from the anchor gNB to serving gNB. Ideally this paging subgroup information should be part of the UE context and should be treated as other UE context information. |
| Nokia | Subgroup configuration should be cell specific. |
| Samsung | Agree with Ericsson, Qualcomm. |
| MediaTek | Agree with Qualcomm. |
| ITRI | Subgroup configuration should be cell specific.  |
| Lenovo | If the RAN-assigned UE subgroups is considered as the legacy NB-IOT mechanism, there is no this question Q3.3, the UE could find its group-ID based on the mapping information in the SI, the legacy NB-IOT mechanism is a cell-specific UE grouping mechanism.If the RAN-assigned UE subgroups is considered as the direct UE group ID or subgroup set allocated to UE by anchor gNB, for the RAN paging in a RAN area, anchor gNB will transmit the UE group ID or subgroup set to the neighbor gNB in the Xn paging procedure. For the RAN paging in another RAN area, the UE group ID or subgroup set could be decided in the RAN updating procedure. |

If UE subgroups assigned by RAN, each RAN nodes may have its own subgroup management. For example, the number of subgroups may be different across cells. We need to discuss whether and how a RAN node can accept the subgroup assigned by other RAN nodes.

**Q3.4: If UE subgroups are assigned by RAN, can a RAN node accept the UE subgroups assigned by other RAN nodes?**

|  |  |  |
| --- | --- | --- |
| **Company**  | **Yes/No** | **Comments** |
| Ericsson | No | RAN2 has not agreed that RAN based group assignment is consistent within a registration area. Furthermore there can be practical problems to enforce such consistency via OAM, especially when the network assignment is left to network implementation, i.e. different vendor nodes providing different interfaces to configure the grouping policy. Obviously it is in-efficient when UE needs to be go connected mode after cell re-selection to obtain the group ID in the new cell, i.e. to make explicit RAN assigned grouping cell specific.  |
| Qualcomm | Yes | Otherwise, UE has to obtain subgroup ID every time it re-selects a cell. That is inpractical.So this means that RAN nodes should try to have the same subgroup ID assignment for a UE as much as possible, which contradicts the motivation for RAN-based assignment. This is one of the reasons why we do not support RAN-based assignment.  |
| vivo | - | This is the problem for RAN node to assign subgrouping. We assume RAN nodes in an area (e.g. TA) should be consistent.  |
| CATT | No | That seems difficult considering it would require different gNBs to coordinate with each other regarding e.g. the maximum number of supported subgroups, and also the subgroup sizes. Also, see associated complexity in maintaining this across RAN nodes in Q3.3. |
| Xiaomi | - | It is not a big deal for this issue if the RAN nodes have different subgroups.When different gNB has different subgroup configuration, there can be a re- mapping function to solve this.  |
| LGE | Yes |  |
| Huawei, HiSilicon | dependent on solution | For the solution that the network provides parameters used for UE subgroup derivation, we do not think RAN-assigned subgroups means that the RAN directly assigns specific ID to a UE, see previous answers.For the solution that the network directly provides UE with the subgroup ID, it should be avoided that the UE is informed to update the assigned subgroup ID every time it changes a camping node. |
| Intel | Yes | As in our response to the previous question Q3.3, our assumption is that the subgrouping configuration will generally be consistent over a registration area. Also the subgroup management is assumed to be performed by the operator. Also the other RAN Nodes can also update the subgroup while the UE is in connected mode. Hence we do not see why RAN node cannot accept the UE subgroups assigned by other RAN nodes. |
| Apple | Yes | If not, the UE treatment is not going to be consistent across different RAN nodes. If they are going to be different across each RAN node, then additional signalling has to be put in place just to get the updated UE subgroup information in the new RAN node, which is not power efficient. |
| Nokia | No | Cell specific. |
| Samsung | Yes |  |
| MediaTek | - | For UE\_ID based grouping (i.e. subgroup ID is derived in each cell), the subgroup is cell-specific.If RAN assigns the subgroup ID, as Intel pointed out, we may need to assume that the subgrouping configuration will generally be consistent over a registration area. |
| ITRI | No | This should be cell specific. |
| Lenovo | - | Same view as Huawei. |

Assistance information from UE

**Q3.5: If UE subgroups are assigned by RAN, can UE provide assistance information for subgroup assignment? What are the attributes to be considered?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Comments** |
| Ericsson | No | The UE-ID is for RAN paging is known by UE and RAN, i.e. no UE assistance is needed. |
| Qualcomm | Yes | For the same reason as using UAI for CN-based assignment. |
| vivo | No | UE group ID is assigned by RAN, which should be up to network implementation, i.e. based on individual UE characteristics are not specified. |
| CATT | No |  |
| Xiaomi | Yes | UAI is OK. |
| LGE | No |  |
| Huawei, HiSilicon | Yes | For the solution that the network provides parameters used for UE subgroup derivation, the mechanism in NB-IoT/eMTC can be reused as a baseline. The UE’s paging probability is coordinated with CN.For the solution that the network directly provides UE with the subgroup ID, the UE’s paging probability may need to be provided to RAN for subgroup assignment. |
| Intel | Yes but not essential | For this release, the RAN can base it on the existing information as follow:* For UE ID, the UE ID is also known to RAN as it is required for legacy paging operation (i.e. CN provides RAN with assistance info on the UE ID (UE Identity Index value in 38.413) as part of RRC Inactive paging). The same information can be used by RAN when assigning the subgroup based on NAS UE ID.
* In the case of paging probability, if it is just for differentiating the paging probability between Redcap UE and eMBB UEs, RAN can already know this via some RedCap UE capability indication (which is currently discussed in RedCap SI/WI)
* If power consumption level is needed, there are already sufficient information in the existing Rel-16 UE assistance (e.g. DRX preference) that RAN can use without affecting other working groups.
* For RAN/CN paging differentiation, RAN node knows whether a UE will be released into RRC\_INACTIVE or RRC\_IDLE.

Further enhancement can be discussed on additional UE assistance, if time permits. |
| Apple | Yes | Using UAI, based on capability signalled by RAN similar to NR UE Power Save R16. |
| Nokia  | No | Assistance information should be only between UE and CN, and between CN and RAN, not needed between UE and RAN since it is for IDLE and INACTIVE mode.  |
| Samsung | No |  |
| MediaTek | Yes | UAI can be used if we agree to have subgroup ID assigned by RAN. |
| ITRI | No |  |
| Lenovo | Yes | The assistance information will be provided to RAN for RAN assigned UE subgroups. Besides, we think it also reasonable to use the assistant information from CN for RAN-assigned UE subgroups. The assistant information could be UE paging probability, UE power sensitive information. For UE paging probability information, some company said it could be associated to the UE type information, it is not sufficient in our view, since it could have different paging probability level information even for RedCap UE. |

Assistance information between network entities

**Q3.6: If UE subgroups are assigned by RAN, can network entities provide assistance information to each other? What are the attributes to be considered?**

|  |  |  |
| --- | --- | --- |
| **Company**  | **Yes/No** | **Comments** |
| Ericsson | Yes | In case of RAN paging the UE radio paging capabilities need to be exchanged on Xn interface in RAN PAGING message in case of paging escalation, i.e. UE is not found on "last used" cell.  |
| Qualcomm | Yes | The same set of attributes provided by UE to network. |
| vivo | - | Similar as above:1. When determining the subgroup ID, whether assistance information between NW nodes is needed. 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 support subgrouping.
2. After determining the subgroup ID, this assignment should be informed to other non-anchor RAN node and CN. Meanwhile, when paging UEs, the corresponding subgroup ID should be included in the paging message.
 |
| CATT | Yes | CN could provide subscription related info to RAN. FFS though what exactly and how would RAN use it. |
| Xiaomi | Yes | For RAN direct assignment, RAN is required to provide subgroup ID to CN for storage in case of CN paging.Other assistance information can be FFS if RAN assignment is adopted. |
| LGE |  | For determination of subgroup ID, no assistance information is required between network nodes.After determining the subgroup ID, it should be delivered between RAN nodes. |
| Huawei, HiSilicon | Yes | For the solution that the network provides parameters used for UE subgroup derivation, a UE’s attributes (e.g. paging probability) used for subgroup determination should be provided to RAN nodes which are involved in paging this UE.For the solution that the network directly provides UE with the subgroup ID, a UE’s subgroup should be known to CN and RAN nodes which are involved in paging this UE. |
| Intel | Yes, but | For RAN-assigned subgroups: the gNB assigned subgrouping is stored in the AMF (e.g. as part of the UERadioPagingInformation container) when the UE goes into RRC\_IDLE. During CN paging, the AMF provides to the gNB with the previously stored subgrouping (e.g. UERadioPagingInformation container) so that it can page the UE using the allocated subgroup. For a UE in RRC\_INACTIVE, the assigned subgrouping is stored in the source gNB as part of the UE context. During RAN paging, the source gNB will provide the paging gNB (for the case RAN paging is in cells of another gNB) with the stored UE subgrouping. It is expected that source gNB can provide target gNB with assistance information to update the subgrouping.As for other attributes, RAN has sufficient information to decide on the subgroup. Further enhancement can also be discussed, if time permits. |
| Apple | Yes  | To transfer the same UE assistance information sent by UE to RAN. |
| Nokia | Yes | If RAN is to assign number of bits for subgrouping of different subset/type of UEs, assistant information could be provided from CN to RAN based on number of UEs, paging probability etc. for RAN to decide the bits split.  |
| Samsung | Yes | For RRC\_IDLE, RAN may have to inform paging group to CN |
| MediaTek | Yes | Agree with Nokia. |
| ITRI |  | Same view as LG. |
| Lenovo | Yes | The assistant information such as the paging probability, UE power sensitive level information could be provided from the AMF to gNB, or form gNB to gNB.Or the assistant information such as UE group ID or subgroup set information could be provided from AMF to gNB, or from gNB to gNB. |

## Other issues

We prepared this material following the scope announced by Chairman. However, companies may find other issues that require RAN2 discussions.

**Q4.1: Are there any other issues about UE paging subgroups that require RAN2 discussion?**

|  |  |
| --- | --- |
| **Company name** | **Comments** |
| Ericsson | As explained with Q2.4 RAN2 needs to discuss whether PEI, similar as WUS in LTE, should only be used in "last used" cell, see [13] ([R2-2105736](https://www.3gpp.org/ftp/tsg_ran/WG2_RL2//TSGR2_114-e/Docs/R2-2105736.zip)). Because paging due to mobility may cause the PEI to be triggered frequently nullifies the power gains with PEI, and paging due to mobility may cause of lot of PEI transmissions while the UE only replies in a single cell. We also think that RAN3 and SA2 should be involved in this discussion, similar as during the LTE time frame.  |
| CATT | We think 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. |
| Huawei, HiSilicon | In our understanding, for the network controlled subgrouping, whether the network directly provides UE subgroup ID or provides subgrouping parameters is not decided yet and this issue may affect the detailed subgrouping mechanism, e.g. CN vs. RAN controlled subgrouping. We can’t decide the responsible node for assigning the subgroup without agreeing more details on the solution because different solutions require different methods of assignment. |
| Apple | We feel that SA2/CT1 needs to be involved if RAN2 decides in favour of CN controlled subgrouping. Additionally RAN2 needs to spend time to discuss the outcome from RAN1 as to how the RAN1 agreement on the power save topic is going to impact RAN2 signaling design.  |
| Nokia | We agree with CATT that it is possible that some UEs are assigned with  |
| Lenovo | As shown in our paper and the comment from Ericsson, we think RAN2 needs to discuss the issue of false paging alarm in a larger area caused by a mobile UE and paging in an extended area(maybe TA area), we think it may be more serious in NR since most of UE in NR are not stationary as UEs in NB-IOT. Then it could discuss to use the legacy “only in last used cell” mechanism or a new mechanism. Generally, it is fine to use the legacy “only in last used cell” mechanism. |

# Conclusion

# Reference

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2. R2-2104783 Paging Enhancements\_UE Grouping Samsung Electronics Co., Ltd discussion Rel-17 NR\_UE\_pow\_sav\_enh-Core
3. R2-2104807 Discussion on grouping-based paging OPPO discussion Rel-17 NR\_UE\_pow\_sav\_enh-Core
4. R2-2104909 UE sub-grouping for paging enhancement vivo discussion Rel-17 NR\_UE\_pow\_sav\_enh-Core
5. R2-2105021 Further considerations of network assigned subgrouping Intel Corporation discussion Rel-17 NR\_UE\_pow\_sav\_enh-Core
6. R2-2105087 NR UE Power Save IDLE/INACTIVE Paging Grouping Schemes Apple discussion Rel-17 NR\_UE\_pow\_sav\_enh-Core
7. R2-2105283 UE subgrouping schemes with paging enhancement CATT discussion Rel-17 NR\_UE\_pow\_sav\_enh-Core
8. R2-2105293 UE Paging Subgroup Assignment for Power Saving MediaTek Inc. discussion
9. R2-2105295 Discussion on idle\_inactive\_mode UE power saving Xiaomi Communications discussion Rel-17 NR\_UE\_pow\_sav\_enh-Core
10. R2-2105411 Details on paging subgrouping determination and indication Nokia, Nokia Shanghai Bell discussion Rel-17 NR\_UE\_pow\_sav\_enh-Core
11. R2-2105656 Grouping methods for Paging Ericsson discussion Rel-17 NR\_UE\_pow\_sav\_enh-Core
12. R2-2105718 Discussion on the control node for UE grouping Huawei, HiSilicon discussion Rel-17 NR\_UE\_pow\_sav\_enh-Core
13. R2-2105736 PEI monitoring in NR: CN and System level impacts VODAFONE Group Plc discussion
14. R2-2105809 Consideration on Idle/inactive-mode UE power saving Lenovo, Motorola Mobility discussion Rel-17
15. R2-2105855 Further Consideration on UE Grouping ZTE, Sanechips discussion Rel-17 NR\_UE\_pow\_sav\_enh-Core
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17. R2-2106257 Considerations on paging subgrouping CMCC discussion Rel-17 NR\_UE\_pow\_sav\_enh-Core
18. R2-2106349 UE subgrouping for paging enhancement LG Electronics Inc. discussion Rel-17 NR\_UE\_pow\_sav\_enh-Core