3GPP TSG-RAN WG2 #113 electronic R2-200xxxx

Electronic Meeting, Jan 25 – Feb 5, 2021

Agenda Item: 8.9.2

Source: Intel Corporation

Title: [POST112-e][064][Pow17] Group Determination

Document for: Discussion, Decision

# 1 Introduction

This contribution summarizes the following discussion:

* [Post112-e][064][Pow17] Paging subgroup determination (Intel)

Scope: For how to determine which paging subgroup a UE belongs to, several methods have been proposed, applying hash based on UE-ID similar to today, take into account paging probability, power consumption sensitivity etc. Objective to pave the way for agreements next meeting. Quantitative analysis argumentation is allowed (this is RAN2 scope).

Intended outcome: Report

Deadline: Long

The email discussion is split into 2 phases:

Phase 1: Companies are invited to comment on solution of each of the grouping methods whether they are feasible and on the ‘effectiveness’ of each grouping methods in terms of reducing false alarm and UE power consumption. Deadline is 6th January 2021.

Phase 2: Rapporteur provides summary of the Phase 1 discussion

## 1.1 Contact person

|  |  |  |
| --- | --- | --- |
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# 2 Discussion

In RAN2#112e, based on the email discussion in [0], RAN2 confirmed that UE grouping is considered a candidate of paging enhancement for UE power saving. Due to lack of time, the group determination sections were not discussed online.

In the subsequent section, the different UE grouping methods are being described and the available qualitative argument based on the contributions [1-19] for each grouping method is provided. **It would be good that the proponents of different grouping methods can provide some quantitative analysis for the proposed grouping methods.**

## 2.1 Grouping methods

The followings are the different grouping methods that have been gathered from the various contributions:

1. UE ID based grouping [4,5,8]
2. Paging probability based grouping [1,3,6]
3. UE power consumption profile based grouping [9]
4. Network assigned subgrouping [7]
5. UE release [2,5, 7]
6. RRC State grouping [5, 7, 8]
7. Methods considering mobility
   1. UE specific RNTI for Stationary UE paging [3]
   2. Mobility indicator [4]
   3. Dedicated paging group for moving UE [6]
8. Mix of different grouping methods [5,10,12, 16, 15,17]

In the following sections, each of this grouping methods are explained.

### 2.1.2 (1) UE ID based grouping [4,5,8]

On the UE ID based grouping, this approach is to further group the Ues monitoring the same PO into differrent subgroup based on the UE ID. For example as described in [8], Ues mapped to a PO of PF can be further grouped into ‘P’ paging groups where ‘P’ can be signaled by gNB in system information (e.g. as part of paging configuration). A UE belongs to kth paging group, where ‘k’ = (UE\_ID/N\*Ns) mod P, where N is the number of Paging frames and Ns is the number of Pos per paging frame.

This method was discussed in [0] and majority of the companies think that UE-ID based grouping can be the baseline. The main qualitative analysis here is that it is simple and is a natural or intuitive extension of the current PO/PF design based on UE-ID. It is also thought that to be most likely effective to reduce false alarm as it can potentially reduce UE unnecessarily receives and decodes paging meassge when many Ues monitor the same paging occasion.

**Q1-1. Do companies have any comment on the high level view of the solution and qualitative analysis of UE ID based grouping to reduce false alarm and improve UE power saving gain for Rel-17 UE? Companies can also add any quantitive analysis (if available).**

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| **Company** | **Comments** | **Proponents‘ response** |
| Ericsson | We agree with this basic description of grouping based on UE\_ID. |  |
| Samsung | Agree with the description above |  |
| MediaTek | The high-level description above is reasonable to us. |  |
| Nokia | We agree UE ID based would be the simplest. |  |
| Huawei, HiSilicon | We agree that UE-ID based grouping can be the baseline. The details on how to decide the groups can be discussed further. |  |
| CATT | The high-level description provided by the Rapporteur is OK. UE\_ID grouping is already the legacy method and its main benefit is the expected fair randomization of Ues distribution into subgroups which is the main argument for reducing the false alarm. The next level of detail would be to clarify the addition wrt legacy. Above new formula for identifying a sub-group (k) can be baseline. |  |
| OPPO | Agree with UE ID based grouping. |  |
| Sharp | Agree with rapporteur‘s high level description. |  |
| Qualcomm | We agree that UE-ID based grouping can be the baseline. |  |
| LGE | We agree with the high-level description. |  |

### 2.1.3 (2) Paging probability based grouping [1,3,6]

On the paging probability based grouping, this approach is to further group the UEs monitoring the same PO into differrent subgroups based on the paging probability (i.e. the probability that the UE is paged by the network). For example as described in [3,6], with such grouping, the UEs with low paging probability and UEs with high probability can be split into different subgroups. The solution is similar to the eMTC/NBIoT case where the RAN and the UE are provided with the UE paging probability. Based on the UE paging probability provided by CN, the UE and RAN can determine the subgroup to monitor for a PO of a PF.

The main qualitative analysis here is that UEs with higher paging probability are more likely to cause false paging alarm to UEs with lower paging probability within the same PO, dividing UEs with similar paging probability into one group can reduce the false alarm rate.

**Q2. Do companies have any comment on the high level view of the solution and qualitative analysis of paging probability based grouping to reduce false alarm and improve UE power saving gain for Rel-17 UE? Companies can also add any quantitive analysis (if available).**

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| **Company** | **Comments** | **Proponents‘ response** |
| Ericsson | It is our understanding that this grouping scheme aims towards fairness, i.e. UEs in a group should cause false pages to each other in a fair i.e. equal amount. We do not think that this scheme further reduces the false alarm rate compared to grouping based on UE-ID, i.e. reduction in false alarm rate in first order depends on the number of groups that are used.  This scheme only works (for fairness) when there are different groups with different paging probablities in NR, and when the paging probablities can be determined reliably for individual UEs. |  |
| Samsung | Same view as Ericsson.  Additionaly, the PO monitored and periodicity at which it is monitored is not same in all cells (depends on UE ID and paging configuration of camped cell). So it is not clear how the probability that a UE is paged in its PO determined by CN. |  |
| MediaTek | The purpose of paging probability based UE grouping is to save power for less frequently paged UEs; we are fine with both interpretations of “false alarm” and “fairness”.  As Ericsson mentioned, the key of this method is how paging probabilities can be determined reliably for individual UEs. This may not be a problem in NB-IoT/eMTC since the application of each device can be easily identified; in NR, the situation becomes complicated since varieties of applications run on NR UEs.  However, we believe that paging probability based UE grouping is useful for power saving. To properly adjust paging probability for each UE, we may allow the network to update the paging probability from time to time (not only during initial attach and TAU), considering UE’s recent applications or UE feedback (e.g. a “too many false alarms” indication). |  |
| Nokia | How much gain it can provides depends on how likely the UEs would have different paging probabilities and how well it can be estimated. It also increase the complexity to communication the probability. Further evaluation needed. |  |
| Huawei, HiSilicon | We agree that UEs with higher paging probability are more likely to cause false paging alarm to UEs with lower paging probability within the same PO. It could be observed that the device types and user habits are diverse, at least the paging probability for smart phones and RedCap UEs (wearable devices) are different. So we see the benefits to support paging probability based grouping. Moreover, it can be supported by using LTE mechansim as baseline without too many standardization work. |  |
| CATT | We share the same view as Ericsson that in NR, due to the large variety of supported traffic profiles by a given UE, it might be uneasy to assess the long-term UE‘s paging probability. |  |
| OPPO | Paging probability based grouping is effective for NB-IoT and eMTC due to their limited use cases and quite different paging probability among different device types. However, we don’t think this grouping scheme would be useful for NR. |  |
| Sharp | The high level intention of this solution is fine to us. How to determine the paging probability seems not easy and needs more study. |  |
| Qualcomm | In theory this scheme may work if all UEs have predictable, static paging probabilities. But this assumption clearly does not hold for NR UEs (smartphones in particular). Updating this probability for time to time as it changes can result in unnecessary overhead for UE, which may cancel power savings (if any) enabled by the scheme. |  |
| LGE | UEs need to be reliably categorized by the paging probability to reduce the false alarm as analyzed above. However, it seems impossible due to the many different varieties of supported traffics in NR. |  |

### 2.1.3 (3) UE power consumption profile based grouping [9]

On the UE power consumption profile, this approach is to further group the UEs monitoring the same PO into differrent subgroups based on the UE power consumption profile. For example as described in [9], with such power consumption sensitivity (PCS) grouping, the UEs with high power consumption sensitivity and UEs with low power consumption sensitivity can be split into different subgroups. Following figure 1 from [9] shows one example of the basic working procedure of the PCS subgrouping method:

AMF

gNB

UE

UE’s Power Consumption Sensitivity (PCS) Reporting

UE’s PCS

Paging Indication

Figure 1. working procedure of PCS subgrouping method

1. UE reports its PCS information (e.g. it is power consumption sensitive, or, its detailed PCS level) to the AMF, during the procedure of Attach request or TAU request. Also, UE could update its PCS information during TAU procedure.
2. AMF informs gNB about the PCS information of the UE.
3. gNB informs UE the subgrouping information of this paging message, e.g. whether power consumption sensitive UEs are paged, or, PCS levels of the paged UEs, by paging early indication or wake-up signal (WUS), or paging DCI.
4. UE decides whether it potentially be paged by checking the indication information in step3. For power consumption UE, only when potentially be paged, it will monitor the following PO(s) or receive PDSCH to check whether itself is paged.

The main qualitative analysis here is that it ican help prevent false paging alarm to UEs with high power consumption sensitivity when network is paging UEs with low power consumption sensitivity within the same PO, and thus help reduced power consumption for these high power consumption sensitivity UEs.

**Q3. Do companies have any comment on the high level view of the solution and qualitative analysis of PCS based grouping to reduce false alarm and improve UE power saving gain for Rel-17 UE? Companies can also add any quantitive analysis (if available).**

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| **Company** | **Comments** | **Proponents‘ response** |
| Ericsson | On a high level the intention of the proposed solution is clear, but details are not clear, for example:   * How to ensure that the information provided by the UE is reliable, i.e. most UEs will prefer a group with a low false paging rate? * How does the UE know to which group it belongs, e.g. PCS level is pre-configured in the UE? * Perhaps one UE is more power sensitive than another UE. But the other UE may receive many more pages, and the false alarm impact also depends on that. Theoretically it might make sense to combine the paging probability with PCS? |  |
| Samsung | Benefit is not clear. Within the UEs of same PCS level, some UEs can receive lots of paging, resulting in false alarms for other UEs. |  |
| MediaTek | The high-level view is reasonable for us, and we believe that PCS should be considered as a candidate UE grouping method for Rel-17 power saving.   * Unnecessary wake-up should be reduced for UEs sensitive to power consumption. * To avoid the situations that all UEs claim to be power sensitive, there should be some penalty. For example, power sensitive UEs are configured with longer paging cycle, which saves power at the cost of delayed paging message. |  |
| Nokia | Not clear how PCS level is determined and how it would provide any gain if it is not related to paging probability. |  |
| Huawei, HiSilicon | We also wonder if PCS needs to be combined with paging probability or other information to obtain the power saving gain? Although the UEs with same PCS level are divided into same group, such UEs still need to monitor PO(s) or receive PDSCH if there is one UE in the same group to be paged, then how to reduce the power consumption for such power sensitive UEs? |  |
| CATT | We understand the intention is, for example, to distinguish Redcap UEs from smartphones, but not sure of the gain. For example grouping a large community of Redcap UEs together may end-up resulting in a large false alarm rate for such UEs. Hence further grouping is needed on top and the PCS grouping method by itself may not solve, alone, the high false alarm issue. |  |
| OPPO | Same view as Samsung. UE‘s PCS are independent of paging reception, and we don’t see the benefit for introducing PCS-based grouping to reduce false alarm. |  |
| Sharp | Agree with other companies' view above, i.e. PCS may not work well alone. |  |
| Qualcomm | We share the same view as Ericsson and Samsung. |  |
| LGE | This approach just increases the paging periodicity for power saving at the cost of paging delay. We don’t think all power sensitive UEs are delay tolerant. |  |

### 2.1.4 (4) Network assigned subgrouping [7]

In this method, the subgrouping is left to the network implementation. The gNB allocates the UE with a subgroup ID before the UE enters idle and inactive mode (e.g. the subgroup ID of a UE can be signalled in the RRC release message to the UE). The network stores the subgroup ID in the CN for an RRC Idle UE; this is done by gNB providing it to the CN for storage. In case of RRC inactive mode, the gNB stores the subgroup ID of a UE as part of the UE context.

During CN paging, the AMF includes this subgroup ID with the CN paging message sent to the gNB and gNB uses the subgroup ID to page UE either in the PEI/WUS or the paging PDCCH.

For RAN paging, the UE context is stored at the source gNB along with the stored subgroup ID in the source gNB node. It is used by the gNB to page UE either in the PEI/WUS or the paging PDCCH for the UE in the RAN paging area.

The main qualitative analysis here is that subgrouping can be left to network implementation to provide further grouping which can be based on network considerations including UE ID, power consumption profile, paging probability etc as discussed in other sections or a combination (the signalling details to be discussed further). There is no need to specify the method(s) used for the subgrouping in the RAN2 specifications and it can be made to be transparent to any UE. This makes the solution flexible, future proof and effective, allowing the network to implement the optimal method rather than be tied to the specified algorithm that may not be optimal for a UE or may not be optimal in the future.

**Q4. Do companies have any comment on the high level view of the solution and qualitative analysis of network assigned subgrouping to reduce false alarm and improve UE power saving gain for Rel-17 UE? Companies can also add any quantitive analysis (if available).**

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| **Company** | **Comments** | **Proponents‘ response** |
| Ericsson | Different gNBs may have different policies how to assign the UE to a group, which may result in a inconsistent configuration in the network. We wonder if a mapping configured during registration would results in a more consistent policy in the network. Furthermore the RAN may not be aware of the paging policy in the CN (e.g. paging escalation), and paging statistics available in CN. | [Intel]:  Our assumption is that the subgrouping configuration will generally be consistent over a registration area. Even if it is not, there should not be any inter-operability issues as the paging subgroup is provided to all the nodes involved in the Page and also to the UE.  We do not see why the paging repetition policy in the CN will directly affect this subgrouping as each CN Paging repetition is treated independently by the RAN. If there is further optimisation to the network algorithm that is possible taking into consideration also CN paging policy, that can be discussed further. |
| Samsung | Signalling aspects are not clear enough and may require support of many approaches (NW may select which one to apply) including UE mobility, paging probability, power consumption sensitivity, etc., which may add complexity from signalling perspective. |  |
| MediaTek | We understand that network assigned subgrouping allows network to consider combination of multiple methods (e.g. UE ID, paging probability, power consumption).  There may be concerns about flexibility for the network assigned subgrouping method, e.g. (1) different gNBs may have different grouping policies, and (2) when grouping policies change, how network informs each UE of their new group.  One potential solution is to have two parts of UE grouping, i.e. one part considers network assigned grouping, the grouping policies are consistent in a registration area and seldom change, while another part considers both NAS and RAN configurations to allow flexible grouping (e.g. similar to what we have in paging probability based grouping). |  |
| Nokia | How many groups the a cell supports should be decided in RAN, not clear how it works if different cells support different number of groups. |  |
| Huawei, HiSilicon | The gNB decides the group based on its own policy, however, considering the UE mobility, the load of different groups may be different as the group that UE belongs to is assigned by previous gNB. For the group with more UEs, the false alarm probability is increased. |  |
| CATT | On one hand we understand the key motivation which is to provide full flexibility to NW in deciding the groups at a given time. On the other hand, it’s not clear how to achieve consistent power saving gain if different gNBs have different strategies on subgrouping while a UE receives subgroup ID allocated in one gNB and monitors paging in another gNB. The resulting complexity is a concern as well. |  |
| OPPO | We hava the same concern as Ericsson. We think it is more appropriate to have a consistent UE grouping strategy and UE grouping used in LTE GWUS can be taken as baseline. |  |
| Sharp | This solution seems complex compared with other solutions, espacially when the UE mobility is considered. |  |
| Qualcomm | 1. The decision on how to efficiently group UEs seems best decided by RAN, not CN; 2. This scheme require upgrades to both RAN and CN, which may not be desirable from deployment point of view. |  |
| LGE | This is not a standalone solution and requires UE to report many things to work. We are not convinced that the subgroup ID needs to be alloacted by gNB. |  |

### 2.1.5 (5) UE release [2,5,7]

In this method, the subgrouping is based on the UE release. Basically, the Rel-15 and 16 UEs are in no subgrouping while the Rel-17 Ues and beyond are subgrouped. If UE subgrouping is supported by a Rel-17 UE, it needs to be indicated in the UE paging radio capability container stored in AMF for idle mode UE and later shared with gNB during CN paging mechanism so that gNB can perform UE subgrouping for the Ues that support subgroup. This capability information is also needed by the anchor gNB for paging the inactive mode UE via forwarding this capability to the target gNB to perform the paging based on whether the UE support Rel-17 paging enhancement (e.g. subgrouping). For Rel-15 and Rel-16 Ues, such subgrouping will not be performed and the gNB will follow the legacy paging procedure for paging these Ues.

The main qualitative analysis is that if only Rel-15 and Rel-16 UE are paged in a PO of a PF, the gNB will not indicate any subgrouping during this PO when paging the Rel-17 and beyond UE supporting UE subgrouping. This reduces false alarm and improve power saving gain for the Rel-17 UE and beyond Rel-17 UE when only Rel-15/16 UE is paged.

**Q5. Do companies have any comment on the high level view of the solution and qualitative analysis of considering UE release to reduce false alarm and improve UE power saving gain for Rel-17 UE? Companies can also add any quantitive analysis (if available).**

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| **Company** | **Comments** | **Proponents‘ response** |
| Ericsson | It is our understanding that the all the grouping solutions discussed in this email discussion apply to REL-17 (and onwards) UEs only. It seems that this solution is more an observation, than a specific grouping solution? |  |
| Samsung | Grouping (irrespective of grouping method) apply to Rel-17 (and onwards). |  |
| MediaTek | Rather than a grouping method, UE release can be considered so that paging for Rel-15 and Rel-16 UEs does not trigger PEI, which can only be understood by Rel-17 UEs. |  |
| Nokia | All the solutions should only be for Rel-17 UEs without impact to legacy UEs. |  |
| Huawei, HiSilicon | We also understand UE grouping only applies to Rel-17 and beyond Rel-17 UEs, rather than Rel-15 and Rel-16 UEs. So for UEs with subgrouping, it does not include the Rel-15 and Rel-16 UEs. |  |
| CATT | We agree with above companies that the R17 subgrouping method should come on top of the legacy (UE\_ID based) method and should therefore be backward compatible. |  |
| OPPO | Agree with Ericsson and Samsung. Grouping applies only to Rel-17 UEs. Whether and how to indicate the grouping information is up to network to decide. |  |
| Sharp | If there is any new subgrouping method is introduced in Rel-17, the method is used for Rel-17 UEs and forward. |  |
| Qualcomm | We have the same comment as Ericsson and Samsung. |  |
| LGE | The basic principle of the sub-gropuing is UE doesn't monitor the PO if its subgroup ID is not included in the subgroup indicaiton. So, this approach can be done by NW implementation as long as any type of sub-grouping is introduced. |  |

### 2.1.6 (6) RRC State or CN vs RAN paging differentiation [5,7,8]

In this method, the RRC\_IDLE UEs are subgrouped separately from the RRC\_INACTIVE UE. As explained in [8], the unnecessary RAN paging reception by the RRC\_IDLE UEs can be avoided if UEs can know in advance that the paging message includes only RAN paging (i.e. it does not include any CN paging). The information indicating presence of only RAN paging or absence of CN paging in paging message can be indicated in DCI/short message. Note that this has no impact to legacy UEs as reserved bit in DCI or short message is used of RAN paging indication. In case WUS/PEI (which is being discussed in RAN1) is agreed, RAN paging or absence of CN paging in paging message can also be indicated in WUS/PEI. This approach also has no impact to legacy UEs as WUS/PEI is not processed by legacy UEs.

The main qualitative analysis is that it can prevent false paging alarm to RRC\_IDLE UEs when perfoming RAN paging to RRC\_INACTIVE UEs, and thus help reduced power consumption for these RRC\_IDLE UE during such scenario.

**Q6. Do companies have any comment on the high level view of the solution and qualitative analysis of considering UE release to reduce false alarm and improve UE power saving gain for Rel-17 UE? Companies can also add any quantitive analysis (if available).**

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| **Company** | **Comments** | **Proponents‘ response** |
| Ericsson | We are not convinced that this is an efficient or effective way of grouping. Furthermore this only divides UEs into two groups (idle, inactive), and to be effective more groups should be used. This method could potentially be used in combination with another grouping solution. | The proposal in [8] is not to group UEs based on UE state.  The proposal is to indicate in DCI/short message/WUS, whether the scheduled paging message includes only RAN paging (i.e. it does not include any CN paging) or not. The RRC IDLE UEs can skip paging if its RAN paging.  This approach can co-exist with any other grouping method. |
| Samsung | The proposal in [8] is not to group UEs based on UE state.  The proposal is to indicate in DCI/short message/WUS, whether the scheduled paging message includes only RAN paging (i.e. it does not include any CN paging) or not. The RRC IDLE UEs can skip paging if its RAN paging.  This approach can co-exist with any other grouping method. |  |
| MediaTek | The benefit of this method may be limited since only two groups are considered. |  |
| Nokia | If we already have finer granularity for grouping, this might not provide too much gain on top. |  |
| Huawei, HiSilicon | We agree that if the reception of RAN paging can be avoided for RRC\_IDLE UEs, it saves power. We understand there are two alternative:  1. RRC\_IDLE UEs and RRC\_INACTIVE UEs are divided into different groups, then information indicating presence of only RAN paging is not needed as wake-up indicator in paging DCI or PEI is sufficient.  2. Introduce new information indicating presence of only RAN paging in paging DCI or PEI, even if the RRC\_IDLE UEs and RRC\_INACTIVE UEs are in the same group, the UE further decides whether to receive paging message based on new information. |  |
| CATT | The gain would be for idle UEs only since inactive UEs monitor both CN and RAN paging. And when eDRX is configured with eDRX cycle > 10.24s, CN and RAN POs are somehow already differentiated by PTW (CN paging is only monitored inside PTW). |  |
| OPPO | Same view as Nokia. We doubt the additional gain if we already have finer granularity,e.g. UE ID-based subgrouping. |  |
| Sharp | Seems it is not related to paging grouping. |  |
| Qualcomm | This method may be considered as an enhancements on top of a primary UE grouping scheme, if it can enable additional meaningful power savings. |  |
| LGE | The solution would be beneficial only in very limited case, i.e. when there are much more inactive UEs than IDLE UEs, but ironically, the gain is for IDLE UE only. |  |

### 2.1.7 Methods considering mobility [3,4,6]

#### 2.1.7.1 UE specific RNTI for Stationary UE paging [3]

In this method, it takes into consideration that some UEs may be fixed (e.g., industrial wireless sensors) or stay at certain places for a long time (e.g., eMBB UEs in the office during the day or at home during the night). The solution proposed in [3] is to use UE-specific RNTI paging for such UE. These UEs use UE-specific RNTI to monitor paging and the network uses the UE-specific RNTI to page correspondingly.

The qualitative analysis is that this UE can be paged directly without affecting other UEs and thus other UEs can avoid false alarm paging and thus increase power saving gain. [3] also think that such increased paging overhead is acceptable since such stationary UE would not be paged so frequent.

**Q7-1. Do companies have any comment on the high level view of the solution and qualitative analysis of considering stationary UE to reduce false alarm and improve UE power saving gain for Rel-17 UE? Companies can also add any quantitive analysis (if available).**

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| **Company** | **Comments** | **Proponents‘ response** |
| Ericsson | When RNTI based grouping is used this impacts legacy paging when the NW pages the UEs with the full paging bandwidth to reach all the UEs in the cell reliably. Then either the page for the stationary UE is delayed until the next PO (where a similar collision may occur), or the legacy paging is delayed, which is not acceptable. Furthermore, this leads to excessive NW resource wastage as multiple PDCCHs are transmitted to reach both legacy and new UEs. |  |
| Samsung | It can not reduce false alarms amongst the stationary UEs. It may also lead to increased overhead and latency. |  |
| MediaTek | We do not think UE-specific RNTI should be introduced. If we do this for stationary UEs, other kinds of UEs may also want UE-specific RNTI. |  |
| Nokia | Using UE specific RNTI would increase paging load. Besides, UE-specific RNTI is not kept/reserved for IDLE mode UEs, otherwise it might consume a great number of RNTIs. |  |
| Huawei, HiSilicon | This solution brings benefits in the case that the number of UEs in a cell is limited and paging probability is low, it would not waste too many RNTI resources and the paging signalling overhead. It is up to NW to decide whether to use this solution for some specific UE(s), so the NW could ensure that the resource and signalling overhead are acceptable. |  |
| CATT | In RAN2#112e meeting, we agreed that the solution of PRNTI based group discrimination is deprioritized from RAN2 perspective. And we view this solution of UE specific RNTI as a particular (extreme) case of the multiple P-RNTIs.  Furthermore, it is not clear how it works with some temporary stationary UEs: how to ensure that both the UE and the network have the same understanding on the stationary state? |  |
| OPPO | It may cause larger paging signalling overhead if network wants to page multiple UEs in a PO simultaneously.  Plus, a large number of stationary UEs will use up the RNTI space and therefore this solution is not so scalable. |  |
| Sharp | If it is only used when the paging load is light, then it is not sure whether the UE need to change from specific RNTI to P-RNTI when the paging load is heavy. |  |
| Qualcomm | If UE-specific RNTI can be introduced for stationary UEs, we do not see technical issues in extending the idea to all types of UEs. |  |
| LGE | It seems a false assumption that the stationary UE would not be paged so frequent. This method may sinificantly increase paging overhead/delay. |  |

#### 2.1.7.2 Mobility Indicator [4]

In this approach, the network indicates whether it is paging a moving UE. [4] provides a quick outline of paging using mobility indicator:

* If the UE is monitoring paging in the cell it was last paged, and the mobility bit is set in Paging PDCCH, then the UE may skip reading following Paging PDSCH
* CN may set the mobility indicator in Paging message when the CN escalates paging, i.e. the CN does not receive paging response from the UE

The qualitative analysis is that paging due to mobility can potentially be a significant factor in the number of Paging messages on PDSCH that the UE receives, i.e. source for false paging. In case the first Paging attempt fails because the UE has moved, and the UE is paged in the complete TA in the next step to limit the overall paging latency, then a lot of pressure is put on the first attempt to get it right. Subscribers move and call in a somewhat predictable way, and intelligent paging strategies are possible, but they would require a substantial effort in the NW implementation, and they cannot be expected to be perfect. By indicating that the paging is due to moving UE via the mobility indicator, it allows UE that is still in the cell that it was last paged to skip those paging and hence reduce false paging alarm and increase power saving gain.

**Q7-2. Do companies have any comment on the high level view of the solution and qualitative analysis of considering paging for moving UE to reduce false alarm and improve UE power saving gain for Rel-17 UE? Companies can also add any quantitive analysis (if available).**

|  |  |  |
| --- | --- | --- |
| **Company** | **Comments** | **Proponents‘ response** |
| Ericsson | On a high level there is some overlap with the solution above, but here stationary means that UE has not moved since last paged, i.e. this solution is more generic, i.e. stationary is defined from a paging perspective. |  |
| Samsung | Paging message may include paging for both moving and non moving UE. However in this approach, either a) moving and non moving UEs can not be paged together or b) mobility indicator is not applied when both moving and non moving UEs needs to be paged together.  a) may lead to increased paging latency for some UEs b) limits the benefit of this approach.  Additionally the first paging attempt may fail even if UEs has not moved (e.g. paging decoding failure or paging collsion in case of MUSIM UE) |  |
| MediaTek | This method helps reduce false alarm for stationary UEs. But what if the first paging attempt for a stationary UE fails? Next paging PDCCH carries mobility indicator and UE does not decode the paging PDSCH because it considers itself stationary? Notice that stationary UEs are more likely to miss the paging message since they may be installed indoor (even in a basement).  Therefore, we do not prefer to group UEs based on mobility. |  |
| Nokia | A paging MSG could include paging for first attempt and re-attempt, so not clear how it works in practise without restricting NW flexibility. |  |
| Huawei, HiSilicon | We see benefits if the UE is provided with information which can help it to avoid unnecessary paging reception due to a previously missed paging. But we understand the information is more about whether the paging is a repeated one, e.g. the network can directly indicate that the paging is a repeated one when it escalates or retransmits paging. Mobility state is a UE related information, UE decides whether to receive the paging based on own mobiltiy state and information from the network. |  |
| CATT | This solution focuses on reducing the paging false alarm of paging re-attemps in neighbor cells. It therefore does not address (brings no improvement on) the paging first attempts, which are successful in majority of cases. Hence it could only be considered as an additional solution coming on top of a baseline/generic solution also addressing the first attempts e.g. UE\_ID sub-grouping discussed in Q1-1. Then the issue is the number of available bits in Paging message/PEI/... to support multiple sub-grouping methods (see Q8). Considering the gain, it splits the UE population for re-attempts between old campers and new campers (since the time the target UE was last paged). So its efficiency in reducing the false alarm rate depends on the fraction of new vs old campers and the additional benefit over the baseline subgrouping method (e.g. UE\_ID based) should be shown. |  |
| OPPO | Same concerns as Mediatek. For stationary UEs who have missed the first paging attempt, these UEs will not decode the paging message for which network has set the mobility indicator (since NW has no idea whether UE has moved or UE failed to receive paging message), which lead to paging failure. Therefore, we don’t think this solution works. |  |
| Sharp | This solution is based on the assumption that paging failure is all caused by UE mobility. If the UE does not response the paging due to other causes and it still is in the same cell, then it will miss the following paging with mobility bit. |  |
| Qualcomm | Agree with comments by Samsung and MTK. |  |
| LGE | This solution is beneficail only after the first paging attempt fails. We wonder how often the paging escalation happens. |  |

#### 2.1.7.3 Dedicated paging group for moving UE [6]

The method is to have one or more dedicated groups for UE not located in the last used cell or not located in a set of cells preconfigured by network.

The qualitative analysis is that by having such dedicated groups for the moving UE (i.e. not located in the last used (paged?) cell or not located in a set of cells preconfigured by network), the UE still in its last paged cell or in a set of cells preconfigured by network to skip those paging and hence reduce false paging alarm and increase power saving gain.

**Q7-3. Do companies have any comment on the high level view of the solution and qualitative analysis of considering paging for moving UE to reduce false alarm and improve UE power saving gain for Rel-17 UE? Companies can also add any quantitive analysis (if available).**

|  |  |  |
| --- | --- | --- |
| **Company** | **Comments** | **Proponents‘ response** |
| Ericsson | This solution overlaps with the solution in 2.1.7.2, except for the „preconfigured“ cells. |  |
| Samsung | Same comment as Q7-2 |  |
| MediaTek | As commented for the previous question, we do not prefer to group UEs based on mobility. |  |
| Nokia | See above. |  |
| Huawei, HiSilicon | In this solution, UEs that have moved are all divided into dedicated groups, which may result in that most UEs are in dedicated groups instead of 'normal' ones considering that mobility is common for UEs. UEs in dedicated groups still impact each other and false alarms increase as the number of UEs in the same group becomes larger.  Hence, we think the power saving gain of this solution is not very clear. The solution in 2.7.1.2 may work better for reducing repeated paging reception. |  |
| CATT | It should be considered at high level as same method as Q7-2. |  |
| OPPO | Same comment as Q7-2 |  |
| Sharp | It may impact the latency of other UEs which monitor the normal paging group. |  |
| Qualcomm | Same comment as on Q7-2. |  |
| LGE | Same comment as Q7-2 |  |

### 2.1.8 (8) Multiple grouping methods [5,10,12, 16, 15,17]

Companies also proposed considering multiple grouping methods. For example, [10] proposes to consider paging probabilities on top of the UE ID based grouping, while [17] suggests considering the CN-RAN paging on top of the UE ID based grouping.

The main qualitative analysis of such combinationof diffferent grouping is that it allows to reduce the false paging alarm further and thus improve UE power saving gain.

**Q8. Do companies have any comment on the qualitative analysis of considering multiple group methods to reduce false alarm and improve UE power saving gain for Rel-17 UE? Companies can also add any quantitive analysis (if available).**

|  |  |  |
| --- | --- | --- |
| **Company** | **Comments** | **Proponents‘ response** |
| Ericsson | The power saving gain of grouping is rather limited, i.e. the first order effect is not due to grouping, but due to generating space between PEI/Paging PDCCH and Paging PDSCH. The grouping solution should be kept simple. It is likely that the solution is not kep simple when solutions are combined.  The grouping based on UE-ID can perhaps be evaluated, but the power saving gains for paging probability, power saving profile and others, will depends on assumptions on the accuracy with which paging probably, power saving profile, etc can be determined, |  |
| Samsung | Power saving gain due to grouping is limited. So, prefer a simple solution. |  |
| MediaTek | Since UE\_ID provides simple randomization, other grouping methods should be considered. Actually, in NB-IoT/eMTC GWUS, we already have multiple UE grouping methods combined. The UE first chooses its WUS group set based on paging probability, and then select a WUS group in the set based on UE\_ID.  We believe that similar procedure can be adopted in NR, i.e. UE first chooses a PEI group set using some other UE grouping method(s), and then finally selects its PEI group based on UE\_ID. In addition to UE\_ID, at most two other methods should be considered. Our preferred methods for further evaluations are (1) paging probability, and (2) power consumption profile. |  |
| Nokia | Should keep subgrouping simple since the RAN1 evaluation shows the gain mainly from PEI other than grouping. |  |
| Huawei, HiSilicon | UE ID based grouping is simple and can be the baseline, other information based grouping may provide more power saving gain but the group may be limited, e.g. paging probably (two groups for smart phones and RedCap UEs respectively), RRC State (two groups for RRC\_IDLE and RRC\_INACTIVE UEs respectively). In this case, the UE ID based grouping can be combined together to provide more groups and further reduce false paging alarm. |  |
| CATT | We share the same view as Ericsson that we should keep this solution simple. In addition, supporting multiple solutions would assume also supporting the different associated signaling bits when indicating which subgroup a paging message is intended for. And we know that whatever signal (PEI, DCI, ...) RAN1 ends-up agreeing, the additional bits are always costly. |  |
| OPPO | We prefer a simple solution and UE ID-based grouping can be the baseline. |  |
| Sharp | The solution should be simple. If the combination of multiple grouping methods is necessary, the number of methods should be limited. |  |
| Qualcomm | We share the same view as Ericsson and Samsung. |  |
| LGE | We prefer to have a simple solution unless the sub-grouping based on multiple methods show a significant gain compared to the UE ID based sub-grouping. |  |

### 2.1.9 Any other grouping methods

Please include in the table below any other grouping methods that have been missed:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Company** | **Grouping method** | **Detailed solution** | **Qualitative and/or quantitative analysis** | **Other companies‘ comments** |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |

## 2.2 Summary of the email discussion

- To be updated after discussion -

# 3 Proposals

- To be updated after discussion–

# 4 References

[0] [R2-2009784](file:///D:\Documents\3GPP\tsg_ran\WG2\TSGR2_112-e\Docs\R2-2009784.zip) Report of [Post111-e][907][ePowSav] UE grouping (Mediatek) MediaTek Inc. report

[1] [R2-2008952](file:///D:\Documents\3GPP\tsg_ran\WG2\TSGR2_112-e\Docs\R2-2008952.zip) Discussion on paging enhancement Xiaomi Communications discussion

[2] [R2-2009785](file:///D:\Documents\3GPP\tsg_ran\WG2\TSGR2_112-e\Docs\R2-2009785.zip) Paging Enhancements for UE Power Saving in NR MediaTek Inc. discussion

[3] [R2-2010244](file:///D:\Documents\3GPP\tsg_ran\WG2\TSGR2_112-e\Docs\R2-2010244.zip) Paging enhancements for idle/inactive-mode UE Huawei, HiSilicon, British Telecom discussion Rel-17 NR\_UE\_pow\_sav\_enh-Core

[4] [R2-2009955](file:///D:\Documents\3GPP\tsg_ran\WG2\TSGR2_112-e\Docs\R2-2009955.zip) Paging enhancement to reduce unnecessary UE paging receptions Ericsson discussion Rel-17 NR\_UE\_pow\_sav\_enh-Core

[5] [R2-2010079](file:///D:\Documents\3GPP\tsg_ran\WG2\TSGR2_112-e\Docs\R2-2010079.zip) Paging Enhancements for UE Power Savings Convida Wireless discussion Rel-17 NR\_UE\_pow\_sav\_enh-Core

[6] [R2-2009878](file:///D:\Documents\3GPP\tsg_ran\WG2\TSGR2_112-e\Docs\R2-2009878.zip) Consideration on Idle/inactive-mode UE power saving Lenovo, Motorola Mobility discussion Rel-17

[7] [R2-2009274](file:///D:\Documents\3GPP\tsg_ran\WG2\TSGR2_112-e\Docs\R2-2009274.zip) Paging enhancement using UE subgrouping Intel Corporation discussion Rel-17 NR\_UE\_pow\_sav\_enh-Core

[8] [R2-2009092](file:///D:\Documents\3GPP\tsg_ran\WG2\TSGR2_112-e\Docs\R2-2009092.zip) Paging Enhancements to Reduce False Alarms Samsung Electronics Co., Ltd discussion Rel-17 NR\_UE\_pow\_sav\_enh-Core

[9] [R2-2010397](file:///D:\Documents\3GPP\tsg_ran\WG2\TSGR2_112-e\Docs\R2-2010397.zip) UE Power profile based UE subgrouping CMCC discussion Rel-17 NR\_UE\_pow\_sav\_enh-Core

[10] [R2-2010629](file:///D:\Documents\3GPP\tsg_ran\WG2\TSGR2_112-e\Docs\R2-2010629.zip) Further consideration on the UE grouping methods ZTE corporation, Sanechips discussion Rel-17 NR\_UE\_pow\_sav\_enh-Core

[11] [R2-2008892](file:///D:\Documents\3GPP\tsg_ran\WG2\TSGR2_112-e\Docs\R2-2008892.zip) Power saving enhancements for paging reception Qualcomm Incorporated discussion Rel-17 NR\_UE\_pow\_sav\_enh-Core

[12] [R2-2009083](file:///D:\Documents\3GPP\tsg_ran\WG2\TSGR2_112-e\Docs\R2-2009083.zip) Paging enhancement in idle inactive mode for power saving vivo discussion Rel-17 NR\_UE\_pow\_sav\_enh-Core

[13] [R2-2009442](file:///D:\Documents\3GPP\tsg_ran\WG2\TSGR2_112-e\Docs\R2-2009442.zip) Paging enhancement for power saving LG Electronics Inc. discussion

[14] [R2-2009351](file:///D:\Documents\3GPP\tsg_ran\WG2\TSGR2_112-e\Docs\R2-2009351.zip) General requirements for potential paging enhancement Nokia, Nokia Shanghai Bell discussion Rel-17 NR\_UE\_pow\_sav\_enh-Core

[15] [R2-2009503](file:///D:\Documents\3GPP\tsg_ran\WG2\TSGR2_112-e\Docs\R2-2009503.zip) NR UE Power Save Wakeup and Paging Reception Apple discussion Rel-17 NR\_UE\_pow\_sav\_enh-Core

[16] [R2-2009893](file:///D:\Documents\3GPP\tsg_ran\WG2\TSGR2_112-e\Docs\R2-2009893.zip) Discussion on reduction of unnecessary UE paging receptions Sony discussion Rel-17 NR\_UE\_pow\_sav\_enh-Core

[17] [R2-2009642](file:///D:\Documents\3GPP\tsg_ran\WG2\TSGR2_112-e\Docs\R2-2009642.zip) Discussion on the UE grouping method ITRI discussion NR\_UE\_pow\_sav\_enh-Core

[18] [R2-2009464](file:///D:\Documents\3GPP\tsg_ran\WG2\TSGR2_112-e\Docs\R2-2009464.zip) Discussion on UE group based paging OPPO discussion Rel-17 NR\_UE\_pow\_sav\_enh-Core

[19] [R2-2009502](file:///D:\Documents\3GPP\tsg_ran\WG2\TSGR2_112-e\Docs\R2-2009502.zip) NR UE Power Save False Paging Mitigation Apple discussion Rel-17 NR\_UE\_pow\_sav\_enh-Core