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).**

|  |  |  |
| --- | --- | --- |
| **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. |  |
| Xiaomi | Agree with UE\_ID as baseline and more detail should be studied, for example, the number of group, the formula. |  |
| ZTE | Agree with rapporteur’s high-level description, |  |
| Intel | Agree with the qualitative analysis of introducing UE ID based subgrouping.  This is a ‘blind’ split that does not consider any other UE specific information.  From solution description point of view, a mapping between the extended subgrouping ID and corresponding subgroup should be defined and this is similar to the network assigned solution proposed in 2.1.4.  We think having the additional flexibility of network assigning this sub-group ID can allow the network to provide additional UE specific grouping possibly even in a future release in a backward compatible way with no additional UE complexity |  |
| Futurewei | We agree that UE-ID based grouping can be the baseline. |  |
| Sony | We agree that UE sub-grouping based on UE ID can be used as baseline |  |
| Apple | Agree that UE-ID based grouping can be used as initial baseline. Further grouping aspects needs to be discussed. |  |
| CMCC | Yes. And the grouping scheme should be further discussed. |  |
| Sequans | Agree that UE sub-grouping based on UE ID can be used as baseline |  |
| Convida | We agree with this high-level description of UE ID based grouping. |  |
| Lenovo | Yes, UE-ID based grouping is considered as the baseline. |  |
| vivo | We agree the UE-ID based grouping could be considered as the baseline. |  |

Summary for response to Q1-1:

All the companies agree to the high level description and qualitative analysis of the the UE-ID based subgrouping. The main benefit as summarized by one company is that the reduction of false alarm comes from expected fair randomization of UEs distribution into subgroups. Only 1 negative comment was made that UE-ID based subgrouping is just a ‘blind’ split that does not consider any other UE specific information. The details on e.g. how the subgrouping based on UE ID is determined can be further discussed. The following summarizes the commented benefits and drawbacks/limitations (out of 21 companies):

|  |  |
| --- | --- |
| **Commented benefits** (20 companies) | **Commented drawbacks/limitations** (1 company) |
| * the reduction of false alarm comes from expected fair randomization of UEs distribution into subgroups. * Agree/ok to the high level description of the UE-ID based grouping | * This is a ‘blind’ split that does not consider any other UE specific information. |

### 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).**

|  |  |  |
| --- | --- | --- |
| **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.  We think that the MTC/NB-IOT paging probability procedure is too complex/complicated and over-engineered for the small power saving gains it provides. We tind it problematic to rely on the paging probablyt provided by the UE, i.e. everybody would like to ride first calls for free. We also wonder if the grouping using paging probably should be per individual UE or per UE class/type (e.g. redcap, broadband, small data, etc)? Furthermore paging probabilty is expected to change during a day, and day of the week, and not necessarily in the same way for all UEs. In the event this approach is chosen, we think it should not be limited to grouping based on paging probablity, but more general and controlled solely by the NW. |  |
| 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. |  |
| Xiaomi | It is our understanding that probability based subgroup not only aims to fairness but also can reduce false alarm from all UEs perspective (maybe some UEs false alarm might be increased, but it still can reduce the total false alarm in system). Moreover, if the probability of UE varies widely (e.g. IDLE UE and INAVTIVE UE, normal UE and RedCap UE etc.), this scheme can get better performance.  However, from RAN1 simulation result, the power saving gain of subgroup is marginal compared with PEI. So we also accept the simple scheme which only use UE\_ID to achieve subgroup. |  |
| ZTE | We agree with MTK on the intention of the grouping based on the paging probability which is for reducing the false alarm of the UE with the lower frequent paging.  Our understanding is that the UE ID based grouping is a baseline and the paging probability based grouping can be an auxiliary method. From which, we can group the UE with stable and predictable paging probability (i.e REDCAP UE) based on the paging probability. And we can also group the UE with non-stable and non-probability (i.e SmartPhone) via the UE ID based grouping. |  |
| Intel | The high level solution and qualitative analysis are fine with us. However, as mentioned by others, the power saving gain for low paging probability subgroup depends on whether the paging probability difference is differentiable and on whether the network can identify those UEs. |  |
| Futurewei | We agree with the intention of this solution. How to determine the paging probability reliably needs more study. |  |
| Sony | We think that paging propability is a good way to solve the false alarm issue, for instance when IoT devices or RedCap devices with a low paging rate are grouped with smartphones. |  |
| Apple | The effectiveness of paging probability based subgrouping is determined based on how good the initial estimation of the paging probability is going to be. Given the diverse characteristics of NR traffic, it might be difficult to derive at a good estimation and hence practically might be difficult. |  |
| CMCC | The high level view of the paging probability based grouping is reasonable. However, we can not simply reuse the division scheme of UE type associated with different paging probablity which is defined in the eMTC/NBIoT case. To have more detailed analysis, we should perform the evaluation based on certain division scheme. And it is hard to have such efficient division scheme due to the variety of supported traffics or device types. |  |
| Sequans | This could benefit UEs with predictably low paging probability even compared to UEs with unpredictable paging.  However, we agree the benefits can be reather small compared to other solutions; We would not like to see updating of probabilty. |  |
| Convida | We agree that UE ID based grouping is simple and should be the baseline approach to UE grouping. However, we also share the views with MediaTek, ZTE and Sony in that paging probability based grouping should be considered as well. For example UE-ID based grouping can be used in combination with paging probability based paging. |  |
| Lenovo | Although the paging probability based grouping is introduced for NB-IOT/eMTC, we think it could also be used in NR for UE power saving. For paging grouping, the paging indication, such as WUS, PEI, DCI or other mentioned method, will be detected by the UE in same group, any paged UE will trigger all the UE in the same group to decode the following paging message. For paging probability based grouping, the UE with lower paging probability will not be impacted by the UE with high paging probability, since they are in different groups and the UE with high PP(paging probability) will be frequently paged. Even for UE with high paging probability, it coudld also be in different groups, maximum 32 groups is introdueced in legacy. It is beneficial for reducing false alarm and UE power consumption, the legacy mechnism in NB-IOT/eMTC could be baseline. |  |
| vivo | Based on RAN1’s agreement in #103e, if the original group paging rate is 10%, the additional power saving gains of UE sub-grouping indiacation in paging early indication w.r.t. paging early indication without UE sub-grouping is 0.6%-2.7% in high SINR case, and 0.6%-4.7% in low SINR case. The additional power of sub-group isn’t significan when the original group paging rate isn’t so high. Thus, at most the baseline that UE-ID based UE grouping is enough (even the benefit is not so obvious). In this way, additional optimization on top of UE-ID based UE grouping is really not needed.  Besides, supporting paging probability based grouping needs extra signalling to determine the paging probability, so the trade-off between power saving gain with signalling load should be considered.  So we prefer not to introduce any other group method unless the method is easy to implement and with high power saving gain. |  |

Summary for response to Q2:

The main concern of considering paging probability for the subgrouping from majority of companies is that paging probability of NR UEs may not be easily determined due to the variety of NR traffic, particularly if power saving is for smartphone UE only For such case, regular updates may be needed from a UE or CN on the paging probability which may negate the power saving gain due to the signalling overheads either to update the paging probability of a UE or to report by the UE (e.g. if it receives too many paging false alarm). However, 2-3 companies thought that if Redcap UE is to be considered, the paging probability for Redcap UE and for smartphone UE may be sufficient different and fix and thus paging probability based subgrouping useful as in eMTC/NBIoT. However, there is also one company doubting such division on UE types in eMTC/NBIOT is reuseable. The following summarizes the commented benefits and drawbacks/limitations (out of 21 companies):

|  |  |
| --- | --- |
| **Commented benefits (8-9 companies)** | **Commented drawbacks/limitations (12-13 companies)** |
| * the paging probability for device types (e.g. Redcap or IoT UE, smartphone UE etc.) may be sufficiently different and deterministic and thus paging probability based subgrouping is useful as in eMTC/NBIoT * Paging probability based UE grouping is useful for power saving * Agree with the intention of this solution (2 companies) * it can be supported by using LTE mechansim as baseline without too many standardization work | * Paging probability of NR UEs may not be easily and reliably determined due to the variety of NR traffic * Regular updates from CN or UE maybe needed which may negate the power saving gain * May not be easy to find efficient subgrouping based on device types * Prefer to keep the subgrouping scheme simple as RAN1 evaluation shows subgrouping has marginal power saving gain. MTC/NB-IOT paging probability procedure is too complex/complicated and over-engineered for the small power saving gains it provides |

### 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? | [CMCC] Similar to the other UE assistance information introduced in Rel-16, if the UE provided the PCS information, the network takes it into account when subgrouping UEs and sending the determined PCS level.  PCS level can be pre-configured in the UE or updated by the network. |
| 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. |  |
| Xiaomi | It is our understanding that the PCS level determination is not clear, and the PCS itself can not solve the false alarm issue. |  |
| ZTE | It seems there are so many questions shall be answered, we would like to know more. |  |
| Intel | The high level intention is clear for this subgrouping. However, similar to the paging probability subgrouping, the power gain depends on whether there are such huge difference between the PCS of different NR UEs. If the PCS is reported by the UE, then the question is what it is based on (depending on its battery level or preconfiguration). Also if RAN2 is to considered both PCS and paging probability based subgrouping, the 2 may contradict each other and thus we agree with Nokia and Ericsson that it needs to be considered together. |  |
| Futurewei | We share the same view as Ericsson and Samsung. |  |
| Sony | Agree with other companies that we dont see the full benefit of this proposal. |  |
| Apple | It is not clear as to how the PCS attributes are derived, and how it is going to solve the false paging probability if many UEs report the same PCS attribute, as this might lead to aggregation of such similar PCS characteristics UEs to the same paging group, thereby resulting in the original problem that we are trying to solve. |  |
| CMCC | The initial thinking of this method is to indicate the power-sensitive UEs in PEI/WUS/PDCCH that they can skip reading following Paging PDCCH and/or PDSCH to reduce false alarm. Especially for the power-sensitive UEs, PCS related method is aligned with the main purpose of this WI. This method works whatever indicator (PEI, DCI, ...) is employed.  For PCS level determination, the NW can subgrouping UEs based on the information reported by UE, e.g. its available battery, or the device type, e.g. redcap UE.  PCS method can be combined with any other grouping method. |  |
| Sequans | This could be an enhancement for paging probability based grouping, but we do not see how this reliably stands on its own, as described above e.g. by Ericsson and HW |  |
| Convida | We fail to understand how this approach really works and its benefit in reducing false alarm rate and unnecessary paging monitoring or paging reception related power consumption. |  |
| Lenovo | the intention of the proposed solution is clear, but not clear about PCS level definition and how it is beneficial to reduce the false paging alarm, it may be related to the paging probability based grouping. Otherwise, maybe the UE with low paging probability will be impacted by the UE with high paging probability, if these two UEs have the same PCS level. |  |
| vivo | We agree with Erission, it cann‘t be guaranteed that the UEs which are sensitive to power comsumption have low paging probability, grouping them may not reduce false alarm and may not get additional power saving gain.  Besides, see Q2, at most the baseline that UE-ID based UE grouping is enough (even the benefit is not so obvious). In this way, additional optimization on top of UE-ID based UE grouping is really not needed.  So we prefer not to introduce any other group method unless the method is easy to implement and with high power saving gain. |  |

Summary for response to Q3:

The intention of the PCS solution seems to be clear, but how it solves the false alarm is not very clear since the power consumption sensitive level may contradict with the paging probability that the UE needs to be paged which is related to the NR traffic and this will result in paging delay. In particular, UE in the same PCS may have different paging probability and this may increase the false alarm rather than decrease the false alarm. Another concern is on how the UE determine the power consumption sensitive level and how reliable this can be. The following summarizes the commented benefits and drawbacks/limitations (out of 21 companies):

|  |  |
| --- | --- |
| **Commented benefits (2 companies)** | **Commented drawbacks/limitations (19 companies)** |
| * Aligned with the main WI objective to achieve power saving via reducing false alarm for power sensitive UE | * Unclear how false alarm is reduced as the power consumption sensitive level may contradict with the paging probability that the UE needs to be paged which is related to the NR traffic   + May result in paging delay   + UE in the same PCS may have different paging probability and this may increase the false alarm rather than decrease the false alarm. * Not all power sensitive UEs are delay tolerant UE * Unclear on the PCS level determination and how reliably it can be as UE tends to want to reduce power consumption |

### 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.  The subgrouping is not necessarily consistent in case of a multi-vendor gNB environment, unless this is enforced via OAM in the registration area. In our understanding there would be an inter-operability issues with CN paging when the UE moves to a gNB that uses a different number of subgroups (e.g. UE uses subgroup 6, but gNB only uses up to 4 groups)?  Paging is controlled by CN, and we have the impression that grouping should therefore also be controlled by CN for consistency.  Perhaps RAN grouping and CN paging policy can co-exist independently. But this is something to closely monitor. | [Intel]:  Our assumption is that the subgrouping criteria and decisions 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. Similar to PO/PF today, the mapping between the ID and the occassion is defined in the specifications and is unique and unambigous in each cell irrespective of the Paging configuration of the cell. At the simplest, the subgrouping can be just using the UE-ID as Section 2.1.2. We think having the additional flexibility of network assigning this sub-group ID can allow the network to provide additional UE specific grouping possibly even in a future release in a backward compatible way with no additional UE complexity.  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. | [Intel]:  The required signalling depends on which approach is agreed from the other sections. The same signalling as from those approaches can also be applied here. If it is found that only UE ID based subgrouping is needed for this release, there is no need for further signalling, however, it allows for adding further subgrouping method without impacting the UE in the future release. |
| 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). | [Intel]  On 1), as mentioned previously, our assumption is that the subgrouping configuration will generally be consistent over a registration area. As with PO/PF today, the mapping between the ID and the occassion is defined in the specifications and is unique and unambigous in each cell irrespective of the Paging configuration of the cell.  On 2), RAN just provides the subgrouping ID to the UE. When RAN configuration changes (i.e. the number of resources or ID space for the subgrouping has changed), the UE just needs to be redistributed to the resource or the ID space based on the subgrouping ID as explained for 1).  If the NAS configuration changes (e.g. paging probability (if agreed) of a UE changes), this can wait until the next time when the UE goes into RRC Connected state and a new subgroup ID can be provided. The network can consider not just static configuration like UE ID but also more dynamic configuration like probability based grouping etc. to derive the subgroup ID. Meanwhile, there should not be any interoperability issue since the network and UE are still on the existing subgrouping ID. |
| 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. | [Intel]  As mentioned previously, our assumption is that the subgrouping configuration will generally be consistent over a registration area. As with PO/PF today, the mapping between the ID and the occassion is defined in the specifications and is unique and unambigous in each cell irrespective of the Paging configuration of the cell. |
| 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. | [Intel]  Our assumption is that the subgrouping criteria and decisions 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. Similar to PO/PF today, the mapping between the ID and the occasion is defined in the specifications and is unique and unambigous in each cell irrespective of the Paging configuration of the cell.  If the paging configuration is different in different cell, the UE will end up in different group in different cells with any solution. The false alarm probability will also change from cell to cell with any solution. |
| 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. | [Intel]  Network just provides a subgrouping ID to the UE which takes into account of the UE ID and other agreed factors. The actual subgroup in the RAN configuration can be different where the UE uses the network assigned subgrouping ID to determine the actual subgroup. This is no difference to UE deriving the actual subgroup directly from the UE ID and other agreed factors as in LTE GWUS.  We think having the additional flexibility of network assigning this sub-group ID can allow the network to provide additional UE specific grouping possibly even in a future release in a backward compatible way with no additional UE complexity. |
| 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. | [Intel] See above response |
| Sharp | This solution seems complex compared with other solutions, espacially when the UE mobility is considered. | [Intel] As mentioned in our previous response, we think having the additional flexibility of network assigning this sub-group ID can allow the network to provide additional UE specific grouping possibly even in a future release in a backward compatible way with no additional UE complexity. |
| 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. | [Intel] Any solution will impact RAN. The impact on the CN depends on the UE specific grouping methods and if CN impacting is an issue, methods not impacting the CN can be chosen. As mentioned in our previous response, at the simplest, the subgrouping can be just using the UE-ID as Section 2.1.2 and hence no further upgrades between RAN and CN is needed. We think having the additional flexibility of network assigning this sub-group ID can allow the network to provide additional UE specific grouping possibly even in a future release in a backward compatible way with no additional UE complexity. |
| 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. | [Intel] The network assigned subgrouping provides a forward compatible framework where other subgrouping methods can be introduced. Whether UE reports assistance information depends on the UE specific grouping supported (e.g. paging probability, PCSetc.). The impact on the UE depends on the UE specific grouping methods and if UE impacting is an issue, methods not impacting the UE can be chosen. As mentioned in our previous response, at the simplest, the subgrouping can be just using the UE-ID as Section 2.1.2. |
| Xiaomi | The subgroup is left to network implementation can determine the group ID flexibly, but as many companies concerned, different gNB has different strategy unless the same strategy is applied to the TA. And this scheme is complex involving the procedure with CN, gNB. | [Intel]:  As responded, our assumption is that the subgrouping criteria and decisions 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. Similar to PO/PF today, the mapping between the subgrouping ID and the subgroup is defined in the specifications and is unique and unambigous in each cell irrespective of the Paging configuration of the cell. At the simplest, the subgrouping ID can be just using the UE-ID as Section 2.1.2. We think having the additional flexibility of network assigning this sub-group ID can allow the network to provide additional UE specific grouping possibly even in a future release in a backward compatible way with no additional UE complexity.  Any solution will impact RAN. The impact on the CN depends on the UE specific grouping methods and if CN impacting is an issue, methods not impacting the CN can be chosen. |
| ZTE | We have the same concern with other NW vendors, how to align the strategy of the grouping between different gNBs? | [Intel] See previous response. |
| Intel | Agree with the solution description and the qualitative analysis provided by the rapporteur |  |
| Futurewei | We appreciate the flexibility that this solution provides to network implementations. However, we also share the concern with other vendors as how to keep a consistent paging strategy among gNBs, and across RAN and CN. |  |
| Sony | Agree with concern above. |  |
| Apple | We understand the motivation for this proposal and do agree that NW is best positioned to determine the paging subgrouping for the set of UEs. Our understanding is that some inputs from the UE (e.g. UE ID, or a negotiated paging offset ) would be considered by the NW while determining such sub-grouping. |  |
| CMCC | We agree the qualitative analysis. The trade-off between the flexibility and the efficiency should be further discussed. |  |
| Sequans | This is an intriguing idea with potential large benefits, allowing to simply combine several grouping methods and maximizing power gains, while keeping complexity low for UEs. However, we are not convinced that the complexity on NW side is not too large. |  |
| Convida | We agree with the concerns expressed by several other companies above. This approach seems complex and may lead to inconsistencies in grouping of UEs in different areas of the same network. |  |
| Lenovo | Same view as Ericsson and QC, the paging grouping is related to gNB configuration, it is not flexible to let CN to determine the UE group ID. For example, gNB1 may support 10 groups, the gNB2 may support 20 groups, the configured group ID by CN is not flexible considering UE mobility. |  |
| Vivo | It’s feasible using gNBs to allocate the UE with a subgroup ID before the UE enters idle and inactive mode.  However, it seems the group method is non transparent to UE, and we wonder if the network is so intelligent to decide all things. Furthermore, if different gNBs have different grouping policies, when a UE moves to a new cell, maybe the paging will occur before it enters into RRC connected state, then, how the UE gets the UE\_ID in this cell?  Besides, see Q2, at most the baseline that UE-ID based UE grouping is enough (even the benefit is not so obvious). In this way, additional optimization on top of UE-ID based UE grouping is really not needed.  So we prefer not to introduce any other group method unless the method is easy to implement and with high power saving gain. |  |

Summary for response to Q4:

Some companies understood network assigned subgrouping can provide additional flexibility. However, most companies are concerned that it may not work if the paging strategy (i.e. grouping strategy) is different between different gNB. The proponent responded that their assumption is that the subgrouping criteria and decisions 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. Similar to PO/PF today, the mapping between the subgroup ID and the subgroup is defined in the specifications and is unique and unambigous in each cell irrespective of the RAN Paging configuration. Another concern is that the solution may have RAN and CN/UE impact. The proponent responded that any solution will impact RAN. The impact on the CN/UE depends on the UE specific grouping methods and if CN/UE impacting is an issue, methods not impacting the CN/UE can be chosen. The network assigned subgrouping provides a forward compatible framework where other subgrouping methods can be introduced. Based on the comments, it is proposed that proponent provides more information on the solution. The following summarizes the commented benefits and drawbacks/limitations (out of 21 companies):

|  |  |
| --- | --- |
| **Commented benefits (3-4 companies)** | **Commented drawbacks/limitations (17-18 companies)** |
| * Allow the network the flexibility to provide additional UE specific grouping possibly even in a future release in a backward compatible way with no additional UE complexity. * Agree that NW is best positioned to determine the paging subgrouping for the set of UEs. | * Unclear on how it may work if the paging strategy (i.e. grouping strategy) is different between different gNB and across RAN and CN. * Impact to RAN and CN/UE due to the additional signalling required to support the different subgrouping method on the network. * Concern about the complexity to the network due to the flexibility |

### 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).**

|  |  |  |
| --- | --- | --- |
| **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. |  |
| Xiaomi | Same ideas with above companies. Subgroup is only applied to Rel-17 UE and beyond. And there is no impact on legacy UE. |  |
| ZTE | Grouping is just for Rel-17’s UE and future. |  |
| Intel | Agree that this will be a by-product if subgrouping is introduced for Rel-17 and beyond UE |  |
| Futurewei | UE grouping should only be applied to Rel-17 UEs and onwards, unless future releases specify otherwise. |  |
| Sony | The subgrouping is for Rel-17 and onwards, and whether and how to indicate the subgrouping information is independent from Rel-15/16 paging functionality. |  |
| Apple | Agree with Ericsson, that this kind of paging sub-grouping is applicable for R17 and onwards, and pre-R17 UEs would use existing paging grouping determination techniques. |  |
| CMCC | Share the same view with the other companies. |  |
| Seaquns | Agree with above comments by e.g. Ericsson and HW |  |
| Convida | Yes agree with Intel. Release based UE grouping will come at no additional specification cost if subgrouping is for Rel-17 and onwards, and whether and how to indicate the subgrouping information is independent from Rel-15/16 paging functionality |  |
| Lenovo | All the solutions are only be for Rel-17 UEs without impact to legacy UEs. |  |
| Vivo | We also think the grouping solution we are discussing here only apply to Rel-17 and beyond UEs, the Rel-15 and Rel-16 UE cann’t apply the grouping solution, so we don’t think it can be called a subgroup method. |  |

Summary for response to Q5:

All companies’ understanding is that subgrouping (if introduced) applies only to Rel-17 UEs and onwards. If a paging on a PO is only for Rel-15 and Rel-16 UEs, Rel-17 and on wards UE will not need to monitor the PO. As mentioned by 1 company, this can be done by not triggering the PEI or some indication in the paging PDCCH to stop Rel-17 and onwards UE decoding the paging PDSCH. This can probably be possible via network implementation if subgrouping is introduced.

**Observation#5:** Subgrouping (if introduced) applies only to Rel-17 UEs and onwards and should not affect Rel-15/16 UEs.

### 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 performing 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).**

|  |  |  |
| --- | --- | --- |
| **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.  Thanks for the clarification, i.e. the proposal is to have Idle mode UEs avoid receiving Inactive paging. | 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. |  |
| Xiaomi | We admit that there is a unnecessary paging if CN and RAN paging together. But only divide PO into two subgroups is not an efficient way, it can be enhanced in combination with other subgroup schemes. |  |
| ZTE | We understand this is not a grouping method, this is just to use a new indication in PEI or DCI to indicate the paging is for IDLE UE or inactive UE. This only can be a refinement with the grouping, and as a standalone solution, it only can allocate the UE into two groups. |  |
| Intel | Agree with the description of the solution and the qualitiative analysis. Considering that there may be large number of idle mode UEs, such subgrouping may bring small benefit |  |
| Futurewei | We don’t consider this solution as a grouping menthod. But whether combined it with a grouping method (such as UE-ID based) or not, this solution can further reduce false alarms for idle UEs, therefore, should be considered. |  |
| Sony | Seems this method is not related to subgrouping and the approach can be considered as an enhancements on top of the existing UE grouping scheme. |  |
| Apple | We consider this as a possible enhancement (i.e. another way to enable paging grouping distinction) on top of a basic UE paging subgrouping determination scheme. |  |
| CMCC | This subgrouping method is only related to RRC state. We are not sure about the additional gain to be achieved. |  |
| Sequans | We can see the potential benefit to IDLE UEs as an enhancement on top of other grouping methods, though it still reamins to be shown it is actually beneficial |  |
| Convida | We share the same view as Samsung |  |
| Lenovo | This is not related to UE grouping as clarified by the proponent, the benefit should be evaluated and we are not sure about the gain by this method. |  |
| Vivo | We also think the method is more like a paging enhancement rather than a subgrouping method. |  |

Summary for response to Q6:

Most companies think that this is not a standalone solution. If included, it should be considered in combination with other subgrouping scheme(s). However, at least 2 companies do not see gain if RAN2 agreed to e.g. UE ID based subgrouping which already provides finer granularity On its own, it may not provide much power saving gain since only 2 groups (i.e. only for RAN paging or otherwise) can be indicated. The following summarizes the commented benefits and drawbacks/limitations (out of 21 companies):

|  |  |
| --- | --- |
| **Commented benefits (5-12 companies)** | **Commented drawbacks/limitations (8-16 companies)** |
| * Agree that if the reception of RAN paging can be avoided for RRC\_IDLE UEs, it saves power. * This approach can co-exist as enhancement to any other grouping method | * The benefit/gain of this method may be limited since only two groups are considered. * If we already have finer granularity for grouping, this might not provide too much gain on top. * The solution would be beneficial only in very limited case, i.e. when there are much more inactive UEs than IDLE UEs, |

### 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).**

|  |  |  |
| --- | --- | --- |
| **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. |  |
| Xiaomi | This scheme is somehow similar to multiple RNTIs subgroup. It means the network will send multiple DCIs meanwhile which increase the DCI blocking. |  |
| ZTE | Agree with CATT, this is a peculiar case for multiple PRNTI |  |
| Intel | We are unclear of how this method can scale with large number of stationary UEs using UE specific RNTI. The overhead over PDCCH may need to be considered. |  |
| Futurewei | Agree that this is an extreme case of multiple PRNTI. Could be beneficial in some special deployments, e.g., industrial sensors, where the battery life of the stationary UEs is the key concern and the cell load may be light enough to be not concerned with the paging load. |  |
| Sony | We see no benefit for introcuding a separate RNTI for stationary UEs. |  |
| Apple | The usage of UE specific PRNTI was discussed in detail during the last online session, and there were concerns about the paging overload and scalability aspects of this solution. |  |
| CMCC | The benefits are limited with the cost of the paging overhead and latency. |  |
| Sequans | This is a specific case for multiple P-RNTI, whih we supported, but we do not see the benefit of supporting this case only; the stationarity of the UE does not necessarily relate to its paging and static UEs can be covered by the same solutions that other UEs use |  |
| Convida | We do not think UE-specific RNTI should be introduced.This appears to be a special but extreme case of support for multiple PRNTI. Assuming RAN2 decides in the future to support PRNTI based grouping, it can be left to network implementation whether a grouping of UEs may comprise of only one UE. |  |
| Lenovo | This can be considered as UE type-specific RNTI, it is likely to the concept of multiple P-RNTI discussed in last meeting, we are open to this way. |  |
| vivo | It may cause paging overhead when fixed UEs and non-fixed UEs are being paged at the same time since network has to send seperate PDCCH. And the power saving gain may be questionable. |  |

Summary for response to Q7-1:

Majority of the companies are concerned with the increase overhead and DCI blocking of such scheme and also the scalability. Some companies think that this is somehow similar to mulitple P-RNTIs scheme which RAN2 have deprioritised. Even if it is left to network to decide when to use it (e.g. when the load is light), one company think that it is unclear when the UE need to change from UE specific RNTI to P-RNTI when the cell load becomes high. The following summarizes the commented benefits and drawbacks/limitations (out of 20 companies):

|  |  |
| --- | --- |
| **Commented benefits (1-3 companies)** | **Commented drawbacks/limitations (17 companies)** |
| * 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. | * Concerned with the increase overhead and DCI blocking of such scheme and also the scalability * Similar to mulitple P-RNTIs scheme which RAN2 have deprioritised * It is unclear when the UE need to change from UE specific RNTI to P-RNTI when the cell load becomes high |

#### 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) | [ERI]  This will depend on the coding that is selected, i.e. whether there is a mobility bit, or mobility code-point. |
| 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. | [ERI] In our understanding the CN paging policy does not impact the grouping, i.e. the UE is still in the stationary group in the second paging attempt from CN unless the UE has moved between the first and second paging attempt. |
| 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. | [ERI] We agree that this approach reduces the false alarm due to mobility, which we think can be a lot, especially when the CN esclates to the full RNA after the first attempt to keep the paging latency low. |
| 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. |  |
| Xiaomi | This mobility indication can only work in paging message that doesn’t include first attempt paging. And we do not think separating first attempt paging and re-attempt paging is an efficient way. |  |
| ZTE | We understand the solution intends to save the power for no-mobility UE. And we also have the same concern from the sharp where the UE will be lost from NW side if the paging is failed not because the UE is moving outside. |  |
| Intel | This is assuming a particular paging repetition strategy (i.e. first page on a cell level and then paging repetition is over a larger area) and may not be the same for different network. |  |
| Futurewei | Agree with Samsung, MTK, and Sharp. |  |
| Sony | Paging escalation is handled by the network. There may be some merits of grouping based on mobility, as well as using some mobility indicator, but we see no clear benefits nor understand the full usage of using a mobility indicator in the paging message. |  |
| Apple | Agree with comment from MTK. |  |
| CMCC | Share the same view with MTK. |  |
| Sequans | Agree with Samsung and MTK |  |
| Convida | We share the same concerns as expressed by several other companies above such as the ones expressed by MediaTek, Samsumg or CATT. |  |
| Lenovo | Same view as MTK. If the UE fails to receive the first paging attempt and UE is still camped in the last paged cell, this method is not effective since the network wrongly determines that UE is not in the last paged cell. |  |
| vivo | We think this method could bring additional power saving gain when the UE does not locate in the last used cell. However, if the UE locates in the last used cell. But missed the paging for other reasons, it won’t receive the paging next time any more, which will cause paging missing in this case. |  |

Summary for response to Q7-2:

Majority of the companies are concerned that such scheme assumes paging failure only for moving UE. Even if UE has not moved, the first paging attempt may fail due to decoding failure or collision in the MUSIM case. If it is not just for moving but reattempt paging, companies are also wondering whether separating first attempt paging and reattempt paging is an efficient way from the subgrouping bits point of view and it is not clear whether it may further restrict the network paging flexibility in terms of paging attempt and reattempt together. Proponent thinks that this approach reduces the false alarm due to mobility, which we think can be a lot, especially when the CN escalates to the full RNA after the first attempt to keep the paging latency low. The following summarizes the commented benefits and drawbacks/limitations (Out of 20 companies):

|  |  |
| --- | --- |
| **Commented benefits (1-2 companies)** | **Commented drawbacks/limitations (18 companies)** |
| * Reduce false alarm in neighbour cells when CN escalates to full RNA | * Even if UE has not moved, the first paging attempt may fail due to decoding failure or collision in the MUSIM case. * Wondering whether separating first attempt paging and reattempt paging is an efficient way from the subgrouping bits point of view * Restrict the network paging flexibility in terms of paging first attempt (for non-moving UE) and reattempt (for moving UE) together - may lead to increased paging latency for some UEs or limits the benefit of this approach. |

#### 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. | [Lenovo]  This method tries to solve the similar issue to reduce wrong paging alarm to the other UEs in same UE group and in larger coverage(even in TA) caused by one UE mobility and related paging extension. But, not sure about the overlapping on the solutions.  We try to clarify our method in this table.  In this method, the network aleady has the information of the last used cell ID based on the last RRC connection of UE and cell, or the information of the configured set of cell where UE is paged with high paging probability based on CN implementation. The gNB will configure UE not located in the last used cell or not located in a set of cells in some configured groups. For exmple, for gNB, if it is UE last used cell or the cell in a set, it will allocate UE to a group set by group x to y, the group could be further computed based on other paing grouping method such as UE-ID based or combined method. If the cell is not UE last used cell or not a cell in the set, it will allocate UE to another group set by group y+1 to N, the group could be further computed based on the other paing grouping method such as UE-ID based or combined method. By this way, the wrong paging alarm to the UEs in same UE group and in larger coverage(even in TA) caused by UE mobility and related paging extension will be reduced.  Note: the last used cell is legacy information agreed in LTE NB-IOT/eMTC WUS, in this cell, UE has last RRC connection with network. This cell is usually considered as the cell to which the network send the first paging attempt. |
| Samsung | Same comment as Q7-2 |  |
| MediaTek | As commented for the previous question, we do not prefer to group UEs based on mobility. | [Lenovo]  This depends on whether the issue of the wrong paging alarm to the UEs in same UE group and in larger coverage(even in TA) caused by UE mobility and related paging extension needs to be studied. |
| 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. | [Lenovo]  The eNB will configure maximum 32 groups in eMTC and NB-IOT, the similar number of groups maybe introduced in NR. If most of UE in the cell is moving UE, most of the groups will be configured for these UE by gNB, then false alrams will not be increased as mentioned here. |
| 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 |  |
| Xiaomi | It would make an impact on those UEs that assigned into this dedicated group, even increase false alarm for those UE. | [Lenovo]  Please see above response. |
| ZTE | See comments as Q7-2 |  |
| Intel | See previous response in Q7-2 |  |
| Sony | See comment in Q7-2 |  |
| Apple | Same comment as Q7-2 |  |
| CMCC | The high level is the same as the method in Q7-2 and we do not prefer the method based on mobility. |  |
| Sequans | Same comment as Q7-2 |  |
| Convida | Same comment as Q7-2 |  |
| Lenovo | Please see our comment for response in right column.  If we decide to solve the issue of whether the false paging alarm to the other UEs in same UE group and in larger coverage(even in TA) caused by one UE mobility and related paging extension, this is an efficent way. At least, we need to consider whether this issue should be studied. |  |
| vivo | See above. |  |

Summary for response to Q7-3:Most companies have the same comments as Q7-2. The following summarizes the commented benefits and drawbacks/limitations (Out of 20 companies):

|  |  |
| --- | --- |
| **Commented benefits (1-2 companies)** | **Commented drawbacks/limitations (18 companies)** |
| * Same as Observation#7-2 | * Same as Observation#7-2 * 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. |

### 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. |  |
| Xiaomi | Indeed subgroup based on multiple methods can further reduce the false alarm. But from RAN1 simulation result, the power saving gain of subgroup is marginal compared with PEI. So we also accept the simple scheme which only use one way to achieve subgroup. |  |
| ZTE | We share the same view with HuaWei, UE\_ID based grouping can be a baseline, and other enhancement/solution can make a further progress (i.e paging probability) on the powersaving gain from the UE\_ID based solution, and we suggest this enhancement can be realized by UE\_ID directly in order to keep combined solution simple enough. |  |
| Intel | If RAN2 agree on different subgrouping methods, these methods should be able to apply simultaneously in order to allow a network to achieve the desired subgrouping. With a network assigned subgrouping, such combinations can be left to network implementation (e.g. on how to the partition the subgrouping space) |  |
| Futurewei | We prefer a simple solution. Baseline should be UE-ID based. |  |
| Sony | UE sub-grouping based on UE ID can be used as baseline and other methods such as subgrouping based paging pobability can be further studied. |  |
| Apple | We agree with the majority company view that the solution should be simple and UE\_ID based approach is a good start. Additionaly we can consider other differentiation aspects (e.g. RAN/CN) and any other relevant information signalled in PEI/WUS to ensure finer paging granularity. |  |
| CMCC | Though the combination of multiple grouping methods can further reduce the false alarm, it also increase the complexity. To have a more efficient method, we prefer the combination of at most two methods. |  |
| Sequans | NW-assigned grouping can make this question mmot if it can be shown to be not too complex.  Otherwise, UE-ID should be kept as baseline with maybe one additional method on top.  However, methods that allow the UE to not read the paging meassage (e.g. CN v RAN paging) are usually rather simple and can be additionally considered as well. |  |
| Convida | We share similar view as Huawei and ZTE in the sense that the UE sub-grouping based on UE ID can be used as baseline, which is coupled with further UE grouping refinement approaches for e.g. paging probability based grouping or RRC state indication (RAN paging versus CN paging differentiation) as part of the paging. |  |
| Lenovo | The similar view as MTK, the combined method by two levels is efficient. We prefer the combined method by UE-ID based grouping and paing probability based grouping, which is already supported in LTE. No significant impact will be introduced. But, just as we said, if the wrong alarm paging to other UE in large coverage(even in TA) caused by one UE mobility needs be studied, maybe combined method by another level or dimension is needed. |  |
| vivo | In Q2, we have indicated that the subgrouping method can only bring limited  power saving gain compare with no subgrouping if we have PEI. Thus, we prefer not to introduce any other group method unless the power saving gain is enough and will not bring too much signalling load. |  |

Summary for response to Q8:

Majority of the companies want to keep the subgrouping solution simple and as pointed out by some companies, the main power saving gain comes from the support of PEI or the separation between paging PDCCH and paging PDSCH. From the rapporteur point of view, it also depends on whether RAN2 agree to more than 1 subgrouping methods. If so whether a subgrouping method is considered as standalone solution only or that the subgrouping methods can be considered in combination with others. The following summarizes the commented benefits and drawbacks/limitations (out of 21 companies):

|  |  |
| --- | --- |
| **Commented benefits (9-12 companies)** | **Commented drawbacks/limitations (9-12 companies)** |
| * Subgroup based on multiple methods can further reduce the false alarm. | * Keep the subgrouping solution simple * NW-assigned grouping can make this question not relevant if it can be shown to be not too complex. * RAN1 evaluation shows the gain mainly from PEI other than grouping. * supporting multiple solutions would assume also supporting the different associated signaling bits when indicating which subgroup a paging message is intended for and the additional bits are always costly. |

### 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 Phase 1 discussion

The following are a list of observations based on the comments from 21 companies received in the Phase 1 discussion:

**Observation#1:** The following summarizes the commented benefits and drawbacks/limitations from the comments for **UE-ID based subgrouping scheme**:

|  |  |
| --- | --- |
| **Commented benefits (20 companies)** | **Commented drawbacks/limitations (1 company)** |
| * the reduction of false alarm comes from expected fair randomization of UEs distribution into subgroups. * Agree to the high level description of the UE-ID based grouping | * This is a ‘blind’ split that does not consider any other UE specific information. |

**Observation#2:** The following summarizes the commented benefits and drawbacks/limitations from the comments for **paging probability based subgrouping scheme**:

|  |  |
| --- | --- |
| **Commented benefits (8-9 companies)** | **Commented drawbacks/limitations (12-13 companies)** |
| * the paging probability for device types (e.g. Redcap or IoT UE, smartphone UE etc.) may be sufficiently different and deterministicand thus paging probability based subgrouping is useful as in eMTC/NBIoT (4 companies) * Paging probability based UE grouping is useful for power saving (2 companies). * Agree with the intention of this solution (2 companies) * it can be supported by using LTE mechansim as baseline without too many standardization work | * Paging probability of NR UEs may not be easily and reliably determined due to the variety of NR traffic * Regular updates from CN or UE maybe needed which may negate the power saving gain * May not be easy to find efficient subgrouping based on device types * Prefer to keep the subgrouping scheme simple as RAN1 evaluation shows subgrouping has marginal power saving gain.. MTC/NB-IOT paging probability procedure is too complex/complicated and over-engineered for the small power saving gains it provides |

**Observation#3:** The following summarizes the commented benefits and drawbacks/limitations from the comments for **power consumption sensitive level based subgrouping scheme**:

|  |  |
| --- | --- |
| **Commented benefits (2 companies)** | **Commented drawbacks/limitations (19 companies)** |
| * Aligned with the main WI objective to achieve power saving via reducing false alarm for power sensitive UE | * Unclear how false alarm is reduced as the power consumption sensitive level may contradict with the paging probability that the UE needs to be paged which is related to the NR traffic   + May result in paging delay   + UE in the same PCS may have different paging probability and this may increase the false alarm rather than decrease the false alarm. * Not all power sensitive UEs are delay tolerant UE * Unclear on the PCS level determination and how reliably it can be as UE tends to want to reduce power consumption |

**Observation#4:** The following summarizes the commented benefits and drawbacks/limitations from the comments for **network assigned subgrouping scheme:**

|  |  |
| --- | --- |
| **Commented benefits (3-4 companies)** | **Commented drawbacks/limitations (17-18 companies)** |
| * Allow the network the flexibility to provide additional UE specific grouping possibly even in a future release in a backward compatible way with no additional UE complexity. | * Unclear on how it may work if the paging strategy (i.e. grouping strategy) is different between different gNB and across RAN and CN. * Impact to RAN and CN/UE due to the additional signalling required to support the different subgrouping method on the network. * Concern about the complexity to the network due to the flexibility |

**Observation#5:** Subgrouping (if introduced) applies only to Rel-17 UEs and onwards and should not affect Rel-15/16 UEs.

**Observation#6:** The following summarizes the commented benefits and drawbacks/limitations from the comments for **CN/RAN paging differentiation scheme**:

|  |  |
| --- | --- |
| **Commented benefits (5-12 companies)** | **Commented drawbacks/limitations (9-16 companies)** |
| * Agree that if the reception of RAN paging can be avoided for RRC\_IDLE UEs, it saves power. * This approach can co-exist as enhancement to any other grouping method | * The benefit/gain of this method may be limited since only two groups are considered. * If we already have finer granularity for grouping, this might not provide too much gain on top. * The solution would be beneficial only in very limited case, i.e. when there are much more inactive UEs than IDLE UEs, |

**Observation#7-1:** The following summarizes the commented benefits and drawbacks/limitations from the comments for **UE specific RNTI for stationary UE paging**:

|  |  |
| --- | --- |
| **Commented benefits (1-3 companies)** | **Commented drawbacks/limitations (18 companies)** |
| * 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. | * Concerned with the increase overhead and DCI blocking of such scheme and also the scalability * Similar to mulitple P-RNTIs scheme which RAN2 have deprioritised * It is unclear when the UE need to change from UE specific RNTI to P-RNTI when the cell load becomes high |

**Observation#7-2:** The following summarizes the commented benefits and drawbacks/limitations from the comments for **mobility indicator scheme**:

|  |  |
| --- | --- |
| **Commented benefits (1-2 companies)** | **Commented drawbacks/limitations (19 companies)** |
| * Reduce false alarm in neighbour cells when CN escalates to full RNA (from proponent) | * Even if UE has not moved, the first paging attempt may fail due to decoding failure or collision in the MUSIM case and UE may not decode it if the mobility indicator is set. * Wondering whether separating first attempt paging and reattempt paging is an efficient way from the subgrouping bits point of view * Restrict the network paging flexibility in terms of paging first attempt (for non-moving UE) and reattempt (for moving UE) together - may lead to increased paging latency for some UEs or limits the benefit of this approach. |

**Observation#7-3:** The following summarizes the commented benefits and drawbacks/limitations from the comments for **dedicated paging group for moving UE scheme**:

|  |  |
| --- | --- |
| **Commented benefits (1-2 companies)** | **Commented drawbacks/limitations (19 companies)** |
| * Same as Observation#7-2 | * Same as Observation#7-2. * 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. |

**Observation#8:** The following summarizes the commented benefits and drawbacks/limitations from the comments for **combining different subgrouping schemes**:

|  |  |
| --- | --- |
| **Commented benefits (9-12 companies)** | **Commented drawbacks/limitations (9-12 companies)** |
| * Subgroup based on multiple methods can further reduce the false alarm. | * Keep the subgrouping solution simple * NW-assigned grouping can make this question not relevant if it can be shown to be not too complex. * RAN1 evaluation shows the gain mainly from PEI other than grouping. * supporting multiple solutions would assume also supporting the different associated signaling bits when indicating which subgroup a paging message is intended for and the additional bits are always costly. |

# 3 Proposals

While the discussion did not ask for indication of support/no support (as there wasn’t enough time for a second phase), based on the comments provided, the following seems to be a rough number of companies that see some benefits or drawbacks with the subgrouping schemes proposed.

|  |  |  |  |
| --- | --- | --- | --- |
| Index | **Schemes** | **# of companies that see Benefits** | **# of companies that see limitations/drawbacks** |
| 1 | UE ID based grouping | 20 | 1 |
| 2 | Paging probability based grouping | 8-9 | 12-13 |
| 3 | UE power consumption profile based grouping | 2 | 19 |
| 4 | Network assigned subgrouping | 3-4 | 17-18 |
| 6 | CN/RAN paging differentiation | 5-12 | 9-16 |
| 7-1 | UE specific RNTI for stationary UE paging | 1-3 | 18 |
| 7-2 | Mobility indicator | 1-2 | 19 |
| 7-3 | Dedicated paging group for moving UE | 1-2 | 19 |
| 8 | Combination of grouping methods | 9-12 | 9-13 |

A chart below provides a rough illustration (using lower bound):

Based on the analysis, the rapporteur thinks that the following proposal may be acceptable:

**Proposal 1:** RAN2 considers grouping based on UE-ID for subgrouping. FFS on the details (e.g. how the subgrouping is determined based on the UE-ID, e.g. as in [8])

**Proposal 2:** RAN2 to decide which (if any) of the other schemes should be considered further. While there was no consensus on the gain for the other schemes, the following schemes has most number of companies that saw some benefit:

* (2) Paging probability based grouping
* (6) CN/RAN paging differentiation

# 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