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

Elbonia, 16 – 27 August 2021

**Agenda item: 8.9.2.1**

**Source: Nokia (Rapporteur)**

**Title: [AT115-e][043][ePowSav] Paging Subgrouping (Nokia)**

**WID/SID: NR\_UE\_pow\_sav\_enh-Core - Release 17**

**Document for: Discussion and Decision**

# 1 Introduction

This document is the report of the following email discussion:

* [AT115-e][043][ePowSav] Paging Subgrouping (Nokia)

Scope: Objective is to arrive at conclusions (CB for confirm) and specify Open issues for non-concluded points.

1) Progress the capabilities discussion and handling of non-support, 2) Progress the architecture. Produce an agreeable generic Message sequence chart. Refine aspects of AMF, gNB and UE role and tasks in more detail (what AMF and gNB shall do and may do, what UE shall do). 3) Outline the options for how to map from CN assigned subgroup to L1-indicated subgroup.

Provision of assistance information is not included for now.

Intended outcome: Report

Deadline: Tuesday W2, for on-line CB.

# 2 Contact Points

Respondents to the email discussion are kindly asked to fill in the following table.

|  |  |  |
| --- | --- | --- |
| Company | Name | Email Address |
| Nokia (Rapporteur) | Chunli Wu | Chunli.wu@nokia-sbell.com |
| Xiaomi | Yanhua Li | Liyanhua1@xiaomi.com |
| Huawei, HiSilicon | Yiru Kuang | kuangyiru@huawei.com |
| Qualcomm | Linhai He | linhaihe@qti.qualcomm.com |
| Samsung | Anil Agiwal | anilag@samsung.com |
| MediaTek | Li-Chuan TSENG | li-chuan.tseng@mediatek.com |
| OPPO | Haitao Li | lihaitao@oppo.com |
| ZTE | Fei Dong | Dong.fei@zte.com.cn |
| CATT | Pierre Bertrand | pierrebertrand@catt.cn |
| vivo | Chenli | Chenli5g@vivo.com |
| LGE | SangWon Kim | sangwon7.kim@lge.com |
| Intel | Seau Sian Lim | seau.s.lim@intel.com |
| Apple | Sethuraman Gurumoorthy | sethu@apple.com |
| Lenovo | Jie Shi | Shijie4@lenovo.com |

# 3 Discussion

The following has been agreed during the online session:

|  |
| --- |
| * When AMF has assigned a UE with a Paging subgroup, some NAS signaling should be supported between AMF and UE to convey the related information to the UE. Exact information is FFS. The design and procedure are up to SA2/CT1. * When AMF has assigned a UE with a Paging subgroup, some signaling should be supported between AMF and gNB(s) to inform gNB(s) about the related subgroup information for paging a UE in RRC\_IDLE/RRC\_INACTIVE. Exact information is FFS. The message(s) and associated design are up to RAN3. * It is FFS when a UE in RRC\_INACTIVE has been assigned by CN a Paging subgroup, whether some signaling should be introduced between gNBs to inform each other about the UE’s subgroup for RAN paging. * If RAN2 agrees to support UE assistance information to CN in support of Paging subgroup assignment, RAN2 will focus on the paging probability and power profile attributes. * UEID-based subgroup method requires, in addition to the already available information for legacy UEID-based grouping in PO, the total number of supported UEID-based subgroups by the network. * At least for UEID-based subgroup method the total number, Nsg, of supported subgroups by the network is decided by RAN and broadcasted in System Information. * At least for UEID-based subgroup method the total number, Nsg, of supported subgroups is controlled on a cell basis and can be different in different cells. |

## 3.1 Architecture – CN/RAN responsibilities and mapping to L1 subgroup indication

**The following options has been proposed in the contributions on CN and RAN responsibilities:**

**Option 1:** CN assigns Subgroup ID [2][8][9][10][12][14][17]

* CN assigns subgroup ID to UE and indicates to gNB when the UE is paged
* gNB and the UE apply the assigned subgroup ID
* gNB broadcast subgroup configuration (e.g. number of total subgroups)

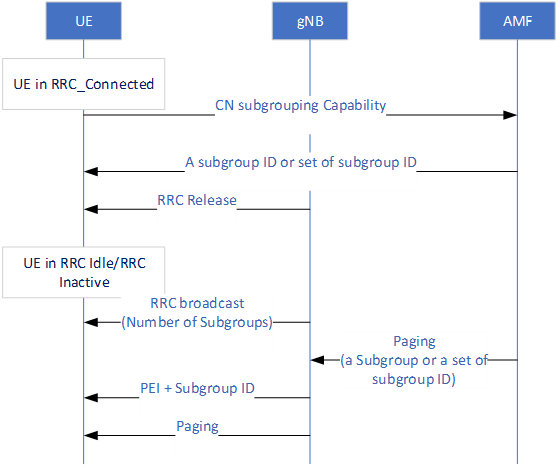


**Figure 1: message sequence chart for option 1 [17]**

* Pros:
  + The assigned subgroup ID could be directly mapped to L1 indication if it can be ensured RAN can support at least the number of subgroups CN assignment
    - Note that there are also proposals on remapping of CN assigned ID to L1 subgrouping.[2]
* Cons:
  + More complexity for CN and RAN coordination on number of subgroups
    - Further discussions needed if it requires all the cells within the registration area to support same number of subgroups and if they are not how it works, e.g. which node decide the number and how the mapping is done if they do not match
      * **Option a1**: The total number of subgroups is fixed and specified [2]
      * **Option a2**: The total number of subgroups is decided by CN and informed to RAN [2]
      * **Option a3**: The total number of subgroups is decided by RAN with mapping rules from CN subgroup ID to RAN subgroup ID if the ID from CN is larger than RAN [2]
      * **Option a3’**: UE applies UE ID based subgroup if the ID assigned by CN is larger than the number of subgroup supported by RAN.
      * **Option a4**: all the cells within the registration area supports the same number of NW assigned subgroups [8]
      * **Option a5**: The number of subgroups is decided by RAN, but it should be no less than the number of subgroups assigned by CN (added from MTK’s comments)
  + More complexity w.r.t. co-existence with UE-ID based subgrouping
    - More discussion needed on how it works for subgroup ID determination for a UE with both CN assignment and UE-ID based subgrouping:
      * whether CN assignment is prioritized over UE-ID based if both supported [5][8][10]
      * whether UE-ID based could override NW assignment [14]
    - More discussion needed on how it works for subgroups splitting in RAN for UEs in the cell with NW assignment and UE-ID based:
      * **Option b1**: Hard split between CN assigned subgroups and UE-ID based subgroups with each broadcasted [6]
      * **Option b2**: CN assignment and UE-ID based can share the same subgroups [14]
      * **Option b3**: either NW controlled subgrouping or UE ID based subgrouping is used in a cell without mixing them [13]
      * **Option b4**: gNB can decide by itself on the number of subgroups it wants to allocate to UE-ID based UEs. It is up to gNB implementation whether there can be any overlap between CN-assigned subgroups and UE-ID based subgroups in its cell. Although hard partition between two types of subgroups is desirable (for avoiding false alarm), we think we can leave that decision to gNB to “keep things simple” [8].

**Option 2:** CN assigns set of subgroup IDs [1][2]:

* gNB provides subgrouping configurations to CN;
* CN provides subgroup ID or subgroups ID set for different configurations;
* gNB and UEs apply corresponding subgroup ID based on the configuration of the cell

  
**Figure 2: message sequence chart for option 2**

* Pros:
  + Possible to support different subgrouping configurations for different cells as the assigned ID can be chosen from the assigned set based on RAN configuration
  + RAN can decide number of subgroups based on its own paging configuration without requiring coordination between CN assignment and RAN configuration (note that RAN indicating the number of subgroups supported is optional)
* Cons:
  + More overhead for gNB to CN assistance information on the configurations and the set needs to consider all possilities
  + More overhead for CN to UE subgroup set assignment to consider all possibilities
  + similar discussions are needed as for option 1 on co-existence with UE-ID based approach.

**Option 3:** Reuse NB-IoT framework [2][3]:

* CN provides subgrouping related information (not limited to paging probability as agreed before) to distinguish the UEs with different characteristics.
* gNB broadcasts subgrouping configurations to split the UEs into different subgroup sets, which enables the aggregation of multiple codepoints from CN into same subgroup set (using *probThreshList*) as well as it allows to aggregate multiple subgroups within one subgroup set (using *groupsForServiceList*) if needed.
* UE-ID is used to derive the subgroup ID within the subgroup set.



**Figure 3: message sequence chart for option 3**

* Pros:
  + Re-use NB-IoT framework without redesigning it, thereby with least impact to other working groups, and thus more realistic to complete the WI on time.
  + Full flexibility to allow CN with finer granularity or RAN with finer granularity.
    - If RAN configures same granularity as CN, it becomes equivalent to option 1.
  + RAN can decide number of subgroups based on its own paging configuration without requiring coordination between CN assignment and RAN configuration
  + No further co-existence issue with UE-ID based subgrouping since UE-ID based subgrouping works within the subgroup set
    - In the current NB-IoT mechanism, if a UE is not assigned with a codepoint from CN, it falls into a default subgroup set
    - It is also possible for RAN to implement UE-ID only by configuring all the CN assigned codepoints into the same subgroup set
* Cons:
  + more complexity for gNB configuration

**Question 1**: Do companies agree with the classification and the analysis of the options and sub-options above?

|  |  |  |
| --- | --- | --- |
| Answers to Question 1 | | |
| Company | Yes/No | Clarifications on the options if needed |
| Xiaomi | Yes | Generally OK.  Some minor comments:  For Option2, “a set of subgroup ID(s)” is more accurate that “subgroups ID set”? Otherwise “subgroups ID set” can be easily confused with “subgroup set” in option3.  For option3: “it allows to aggregate multiple subgroups within one subgroup set (using *groupsForServiceList*) if needed”, in my understanding, what you mean is this parameters is for aggregate multiple L1 subgrouping resources within one subgroup set? |
| Huawei, HiSilicon | Yes |  |
| Qualcomm | No | We do not agree with the cons listed under Option 1.   * Subgrouping is simply a partition among UEs mapped to the same PO and thus does not involve allocation of any physical resources. Therefore, it is not difficult for gNBs in the same TA support the same number of subgroups decided by CN. * To “keep things simple”, gNB can decide by itself on the number of subgroups allocated to UE-ID based UEs. It is up to gNB implementation to decide whether there can be any overlap between CN-assigned subgroups and UE-ID based subgroups. Although hard partition between two types of subgroups is desirable (for avoiding false alarm), we think we can leave that decision to gNB to “keep things simple”.   And we’d like to add to the cons of Option 2 and 3 that both schemes require more complexity to UE implementation. For example, in Option 2, UE needs to maintain multiple sets of subgroup assignment and switch its subgroup whenever it changes a serving cell. In Option 3, UE has to perform extra step of hashing to determine its subgroup assignment. |
| Samsung |  | Do not agree with option 3. This is not inline with agreement made in RAN2#114.  RAN2#114 Agreement: The following is supported:   * CN is responsible for allocating UEs to UE paging subgroups based on UE characteristics * Use same UE subgroups when in RRC\_IDLE and RRC\_INACTIVE   Also agree with QC on comments related to Option 1 |
| MediaTek | - | Classification is good, but we do not fully agree with the cons analysis of Option 1:   * It shouldn’t be that hard for CN and RAN to coordinate on the number of subgroups. A reasonable implementation is that all gNBs in a registration area supports at least as many subgroups as CN assigned. * Then regarding the splitting of CN-assigned and UE-ID based subgroup IDs, one possible way is to have N1 subgroups for CN-assignment (N1 is the same for all gNBs in a registration area), and each gNB additionally assigns N2 subgroup IDs for UE-ID-based subgroups. The subgroup ID calculation in UE is also not hard (a simple hashing plus an offset)   Note that we proposed Option 1 based on our understanding about previous agreements. However if Option 3 was actually not precluded, we are also fine with Option 3. |
| OPPO |  | We think option 3 has been excluded based on previous agreements that CN is responsible for allocating UEs to UE paging subgroups based on UE characteristics.  And we agree with QC to add to the cons of Option 2 and 3 that both schemes require more complexity to UE implementation. |
| ZTE | Yes | For option 1, we agree with Nokia’s analysis, meanwhile, we have provided a simplified solution in R2- 2108272 which can replace the CN assigned subgroup ID, as shown below:  **Proposal 3: For CN assigned subgrouping, CN taken into consideration the attribution value when allocating the UE ID e.g. define UE ID value range for UE upon a certain attribution.**  The solution in proposal 3, we just consider what information is needed by CN (i.e paging probability, power file, the Nsg of each cell within the registered area), and the most work can be left to CN implementation. |
| CATT | Partly | We agree with the classification, not with the analysis. For example, the listed drawbacks (mainly about complexity) of option 1 are significantly reduced if gNB/UE subgrouping capability is common to CN-assigned and UEID-based (in which case UE-ID based cannot be overridden by NW assignment), and considering options a3 and b2 which provide full flexibility of NW and gNB to control independently their subgrouping method. The key point in our view is that RAN should control the total number of subgroups in its cells, as they are related to physical resources. |
| vivo | Partly | Some cons listed under option1 should be handled as open issues, which have not been agreed to have, such as “CN and RAN coordination on number of subgroups”, “co-existence with UE-ID based subgrouping”. Similarly, in our understanding, these open issues also exist in Option2.  Option3 is somehow not aligned with our previous agreement “*CN is responsible for allocating UEs to UE paging subgroups based on UE characteristics*”. |
| LGE |  | Option 3 should be excluded since it goes against previous RAN2 agreements.  Though there are some issues to discuss in option 1, the issues can be resolved in simple way, e.g. Option a3` and b2. |
| Intel | No | **Option 1 and 2:**  General Observations:  Option 1 and 2 are basically the same except that Option 2 also considers different subgrouping configurations in the RAN in a paging area and does not require coordination between the CN and RAN. Hence the difference in the message flow is that a set of subgroup IDs, in place of the just a subgroup ID, can be provided to the UE and gNB. To us, Option 2 is a variation of option 1 as can be seen from the flow chart and the discussion here.  On the Pros for both Option 1 and 2, one of the benefits of direct subgroup ID is that it allows the network to consider multiple UE characteristics that may not be specified. It is unclear how this can be achieved with Option 3 when reusing/following the NBIOT framework.  On the Cons for both Option 1 and 2, the complexity mentioned does not seem like real issues. They are just items that needs to be discussed and decided by RAN2. In our view, we can just pick the simplest in view of the time. Some of the options listed does not require any coordination at all.  CN and RAN coordination on the number of subgroups  For Option 1, we think it is just the case of picking one of the options. Option a4 and a1 looks simple enough but we are not sure if it is possible to ensure that all cells in the paging area can be the same. Option a3 allows for the flexibility of having different number of subgroups for a cell in the paging area. One further option to include is that the gNBs provides the supported number of subgroups to the CN and CN can allocate the UE and gNB with a set of subgroup IDs just like Option 2 – this can reduce the number of subgroup IDs to provide to the UE as CN only needs to consider the number of subgroups actually used by the gNBs.  For Option 2, We don’t think option 2 is complex – UE simply has to pick the subgroup ID corresponding to the number of the subgroups supported in the cell. This is not different to the other options that also need UE to decide the paging occasion based on the number of the paging subgroups supported in the cell. No hashing is required. This option provides full flexibility in terms of number of groups supported in a cell – different cells can support different number of subgroups. There is no need for any coordination between RAN and CN. There is nothing to discuss or implement in the RAN interfaces for coordination. So we think it is the simplest in terms of agreement and specification work. The overhead is minor with 8 subgroups. E.g. for total number of subgroups can be {2,3,4,5,6,7,8), the total number of bits for all combinations of total number of subgroups (1+2+2+3+3+3+3) = 17bits in the NAS message (which is typically already a very large message).  Coexistence between UEID subgrouping and CN based subgrouping for Option 1 and 2:  Option b1, b2 or b4 option is acceptable to us. Option b4 provides most flexibility in that it can be used to implement Option b1 or b2. There is a possibility of false alarm with Option b2. Option b1 is the simplest but hard partition may not lead to uniform distribution depending on the number of UEs that are assigned CN and RAN  As on the case where both UE-ID based subgrouping and network based subgrouping are supported by the UE and network, it is logical that the network based subgrouping is prioritized, since this is the subgroup ID provided by the network. If no subgroup ID is provided by the network, the UEID based subgrouping can be applied. Hence we do not see any coexistence issue or complexity for Option 1 and 2.  **Option 3:**  Our understanding is that this option is ruled out by the previous agreement as mentioned by Samsung. Furthermore, it is also unclear or confusing to us what reusing NBIoT framework means here. In the current NBIoT framework. Is it using the paging threshold to calculate the subgrouping set or the subgroup set is provided to the gNB and the UE?  If reusing NBIoT framework means that the subgroup set is provided by CN during paging, it will have the same coordination issue between CN and gNB like Options 1 and 2. In the case, the pros “RAN can decide number of subgroups based on its own paging configuration without requiring coordination between CN assignment and RAN configuration” will not be possible. This process in the UE is far more complex than selecting a Paging group ID based on the number supported by the gNB as in option 2. From this point, there is complexity in determining the subgroup ID at the network and the UE.  On the Pros related to the following:   * + Full flexibility to allow CN with finer granularity or RAN with finer granularity.     - If RAN configures same granularity as CN, it becomes equivalent to option 1.   We wonder if this is implying that CN is sending subgroup/subgroup set ID as well. If so, it will have the same CN and RAN coordination “issue” on the number of subgroups. |
| Apple | No | We feel that overall Option 1 and 2 are essentially the same from a UE point of view. Also, the cons described for Option 1 and 2 are a bit overstated. Most of them if not all can be agreed over offline or online discussion. For example, the maximum number of subgroups, is something that RAN can decide after taking into account the maximum CN assigned subgroups. This way, both the CN requirement and the RAN responsibility of physical paging resources to subgroup mapping is accounted for. Once decided, this can be broadcasted over the air (SIB signalling). For the co-existence of CN and UE-ID based, and the question of which one takes precedence, this has been discussed earlier that UE would go with CN based subgrouping if supported by both UE and NW and fallback to UE-ID based approach otherwise. |
| Lenovo | Partly | Based on above discussion, we have a clear understanding to option.1 and option.3 as below:   * Option.1 UE paging group ID for CN-assigned method is configured by CN. * Option.3 UE paging group ID is computed based on legacy NB-IOT method, this means that, UE will get the related information(e.g, paging probability) with different characteristics by NAS procedure, and read the configuration information on the mapping of UE group ID and the related information(e.g, paging probability) broadcasted in a cell, then UE will find its group-ID based on UE specific information and the mapping information. * But for option.2, it is not clear how the UE will find the subgroup ID based on subgroups ID set for different configurations in CN side and the configuration in cell side. Does the number of subgroups in a subgroup set and the subgroups threshold in this flow chart will define the subgroup ID(s) in a subgroup set? If it is, then how does UE find its subgroup ID in a subgroup set?   [Intel-Proponent]: Option 2 is like Option 1 where instead of only 1 UE paging group ID, a set of UE paging group IDs for CN-assigned method is configured by CN to UE. Each of the UE paging group IDs in the set corresponds to the one possible total number of subgroups configured by RAN. For example, if RAN can configure the total number of subgroups as {2,4,8} subgroups in acell, then CN provides an ID#1 corresponding to 2, ID#2 to 4 and ID#3 to 8. While in idle/inactive mode, UE will use the ID corresponding to total number of subgroups broadcast in the serving cell. |
| Nokia | Yes | We disagree with Samsung, Oppo and LG. During the discussion “ID” was removed from the agreement by the chairman because the assignment does not necessarily be subgroup ID itself. |
|  |  |  |

**Summary 1**: TBD.

**Proposal 1**: TBD.

**Question 2**: Which option for NW assignment do companies prefer out of option 1-3 described above?

|  |  |  |
| --- | --- | --- |
| Answers to Question 2 | | |
| Company | Option 1/2/3 | Technical comments |
| Xiaomi | Option3/1 | Agree the rapporteur that re-using NB-IoT framework saves us a lot of time.  For option3, we wish CN provides subgrouping ID directly. And RAN aggregate multiple subgrouping ID s from CN into same subgroup set. And if RAN configures same granularity as CN, it becomes equivalent to option 1.  Both option3 and option1 can work.  RAN2 is suggested to consider how gNB configures the mapping between subgrouping information to L1 radio resource(s) on Uu interface. If we map each subgroup to L1 resources, it is option1. If we map multiple subgroups (in form of subgroup Set) to L1 resources, it is option3. |
| Huawei, HiSilicon | 3, can accept 1 | NB-IoT framework is preferred as this is the mechanism already supported in LTE. In this option, UEs can be assigned to different groups based on UE characteristic, and the gNB has the flexibility of determining the subgrouping information, e.g. the total number of supported subgourps.  CN assigned subgroup ID can be supported. However, for this category of solutions, we prefer option 1 since option 2 may provide the unnecessary subgrouping information to the UE, and it is not clear how many subgroup IDs should be assigned by the CN, which in our view also increase the complexity of CN implementation. |
| Qualcomm | 1 | Option 1.a4 + Option 1.b4 require the least implementation complexity for UE, gNB and AMF |
| Samsung | 1 | We do not see additional benefits of option 2 |
| MediaTek | 1 or 3 | Configuration for Option2 can be complicated |
| OPPO | 1 | Option 2 is too complicated and we see no need to support multiple subgroup ID configurations as in the worst case there may be many different subgroup numbers for different cells.  Option 3 has been excluded based on our previous agreements. |
| ZTE | 3,1(simplified solution as above comments) | It is better that Option 3 can be reused which lead the less specification effort. if option 3 is excluded, we can consider the option 1, but we think, for option 1, there are a lot of issues to be discussed as listed above. We are not sure whether it is deserve the heavy discussion for subgrouping by considering the limited power saving gain. |
| CATT | 1 | As commented in Q1, considering a3 and b2 and assuming gNB/UE subgrouping capability is common to CN-assigned and UEID-based, it is the simplest, the least complex and the most flexible (independence of CN and RAN subgroup management). |
| vivo | 1 with comments | Option 3 should be excluded first due to the conflict with previous agreements.  Option 2 is more complex than option 1, but with no additional benefit. Besides, it also introduce more signaling overhead between gNB and CN.  For the 3rd step in option 1, we think if there is no UE\_ID based subgrouping, gNB is not needed to broadcast the number of total subgroups. Thus, we prefer to remove “(e.g. number of total subgroups)”  Besides, we share the same view as ZTE. It seems quite a lot of issues need to be discussed. During the study phase, the benefit for the subgrouping is very limited. We are also doubt that whether it is deserved to spend so much TU to discuss the above issues in option 1. |
| LGE | 1 | If we go with simple sub-options, e.g. a3`/b2, option 1 is more simple than option 2. |
| Intel | Option 1 or 2 | See our comments in Q1, |
| Apple | Option 1 or 2 |  |
| Lenovo | 3/1 | See our comment in Q1. We prefer the legacy option.3 if it is not excluded by current agreement. Not clear about the option.2, generally, option.2 may give gNB some flexibility to configure the number of groups for the UE with specific characteristic. |
| Nokia | Option 3 | Agree with Xiaomi if re-mapping of CN assigned ID to L1 indication is in the end needed for option 1, e.g. with option a3, it becomes basically very close to option 3, regardless whether we called the CN assignment as group ID (but only from CN point of view, not group ID indicated in the L1 signalling) or group information. Further discussion is then needed how the re-mapping is done. Option 3 is one type of remapping which supports CN has assigned either more groups or less groups than RAN supports.  Since we have already a well-designed mechanism, seems no motivation to do something different esp. considering the limited time left for the WI. |
|  |  |  |

**Summary 2**: TBD.

**Proposal 2**: TBD.

**Question 3**: Which sub-option out of a1/a2/a3/a4 of option 1 do companies prefer on whether CN or RAN is to decide the number of subgroups for NW assigned subgrouping?

|  |  |  |
| --- | --- | --- |
| Answers to Question 3 | | |
| Company | Option a1/a2/a3/a4 | Technical comments |
| Xiaomi | A3 | Remapping saves the effort of negotiations between CN and RAN. |
| Huawei, HiSilicon | a3 | In our view sub-option a3 has clear advantages in terms of flexibility of the network configuration  The sub-option a3 is also related to the scenario being discussed in RAN1 on the association between DCI based PEI and POs. We wanted to highlight the the bits that can be used in PEI are limited. These bits may be used to indicate the associated POs and subgroups per PO. If more bits are used to indicate the associated POs, then the bits which can be used to indicate the associated subgroups per PO is reduced.  Considering other sub options, we think that the intention of sub options a2 and a4 is similar but provides lesser flexibility, whereas sub option a1 can be excluded as it seems to impose strict restriction. |
| Qualcomm | a4 | It requires the least complexity for all entities (UE, gNB and CN) |
| Samsung | A2, A3 | Do not support A1. A2 is preferred for simplicity. However, if majority view is to have flexibility, A3 can be supported. |
| MediaTek | A4 or A5 | A5: The number of subgroups is decided by RAN, but it should be no less than the number of subgroups assigned by CN |
| OPPO | A3 | Share the same view as Huawei. |
| ZTE | A2, A4 |  |
| CATT | a3 | Agree with above comments from Xiaomi and Huawei. |
| vivo | A4 | The number of subgroups is restricted by the available bits in PDCCH or sequence number which is used to indicate the UE subgroup. In order to obtain the maximum power saving gain, all available bits/sequences should be used. In this way, the number of UE groups could be as many as possible from network point of view. Besides, supporting different number of assigned subgroups will also lead complexity for NW mechanism to determine UE subgroup. Thus, unified number of UE subgroups is expected.  A2 A3 is related to whether the co-existence case could happen. If not, then, we think there is no need to have coordination/information exchange between RAN and CN for subgrouping number. If Yes, it is then related to whether the subgroup assigned by CN is overlapped with UE\_ID based subgroup.  Option A1 can easily achieve the unified subgrouping number within the registration area, which is the simplest way. A1 is also acceptable. |
| LGE | A3’ | We wonder if all cells are capable of option a1/a2 or a4.  Option a3 is more complex than option 2. So we propose to use UE ID based subgroup if the condition in a3 is met though the subgroup ID is assigned by CN.  **Option a3’**: UE applies UE ID based subgroup if the ID assigned by CN is larger than the number of subgroup supported by RAN. |
| Intel | a3 or a4 | As in our response to Q1, Option a4 looks simple enough but we are not sure if it is possible to ensure that all cells in the paging area can be the same. Option a3 allows for the flexibility of having different number of subgroups for a cell in the paging area. |
| Apple | A3 or A4 | A3 provides the RAN, the much needed flexibility to do the subgrouping based on CN input. |
| Lenovo | A3 | A mapping rule could be further discussed to avoid the negotiation between CN and RAN caused by other method. |
| Nokia | A3 | RAN may benefit from using fewer or more subgroups than CN, therefore we should not impose a single subgroup size in the TA/RA. Each cell may want to assign its RAN subgroups e.g. to optimize the decoding performance of the PEI + L1 subgrouping indication.  For example, if DCI-based PEI is adopted, the maximum number of bits for the L1 subgrouping indication may depend on the frequency range, PDCCH and paging configuration, cell size, etc. Thus, a subgrouping remapping at RAN should be supported. |
|  |  |  |

**Summary 3**: TBD.

**Proposal 3**: TBD.

**Question 4**: For option 1 and 2, do companies think CN assignment should be prioritized over UE-ID based if both are supported?

|  |  |  |
| --- | --- | --- |
| Answers to Question 4 | | |
| Company | Yes/No | Technical comments |
| Xiaomi | Yes | CN assignment is anyway more accurate than the randomization. |
| Huawei, HiSilicon | Yes | CN assignment subgrouping method provides better power saving gain compared with randomization subgrouping. |
| Qualcomm | Yes | Presumably CN uses all the available information to assign subgroups so that false alarm is reduced. Its assignment is better than UE-ID based one, which is generated only based on randomization. |
| Samsung | Yes |  |
| MediaTek | Yes |  |
| OPPO | Yes with comments | This should be stated from UE’s perspective and based on the condition that the current cell supports CN assigned grouping. |
| ZTE | Yes,maybe | Also we can find a way to unify the subgroup ID derived from UE ID based subgrouping and NW assigned subgrouping |
| CATT | Yes | In our understanding, this is the underlying outcome of the earlier agreement, that is, UEID-based is only used if CN does not assign a subgroup.   |  | | --- | | If the network chooses to not provide specific subgrouping information, there will be configuration option where subgrouping can be supported by randomization (by UE-ID) | |
| vivo | Yes | We have agreed in RAN2#113bis-e “*If we go for network controlled subgrouping, If the network chooses to not provide specific subgrouping information, there will be configuration option where subgrouping can be supported by randomization (by UE-ID).*”. in our understanding, CN assignment should be prioritized over UE-ID based subgrouping if both are supported**.**  From UE perspective, if a subgroup ID is provided from CN, UE will apply CN-Controlled subgrouping for paging monitoring. Else, if the number of subgroups is provided from gNB, the UE applies UE-ID based subgrouping. |
| LGE | Yes |  |
| Intel | Yes | As commented in Q1, the UE should follow the CN assignment. |
| Apple | Yes | This is a direct fallout of our previous agreement which state UE-ID based subgrouping is a fallback option of CN based subgrouping is not supported. |
| Lenovo | Yes |  |
| Nokia | Yes but | The question should probably be revised as whether CN assignment, if provided, is always taken into account. Since there could still be UE-ID based within the CN assignment group if RAN provides more subgroups, which is another open issue to be discussed for option 1, not necessarily limited to option 3. |
|  |  |  |

**Summary 4**: TBD.

**Proposal 4**: TBD.

**Question 5**: For option 1 and 2, do companies think UE-ID based subgroup ID could override CN assignment?

|  |  |  |
| --- | --- | --- |
| Answers to Question 5 | | |
| Company | Yes/No | Technical comments |
| Xiaomi | - | What does not mean override?  Will CN assigned group ID still exit or it is overwritten?  Or you mean the UE-ID based subgroup ID will be used if gNB supports UE ID based subgroup only? |
| Huawei, HiSilicon | No | We do not see the scenario and motivation to support this case. |
| Qualcomm | No | If UE supports both and have two subgroup IDs, UE and gNB should use only the one assigned by CN. |
| Samsung | No |  |
| MediaTek | No |  |
| OPPO | Yes | If the current cell does not support CN assigned grouping but support UE-ID based grouping, even though UE is assigned by CN with a subgrouping ID, UE should use UE-ID based grouping ID in this cell. |
| ZTE | - | See above |
| CATT | No | This could only happen if CN assigns a subgroup to the UE but gNB only supports UEID-based. But as mentioned in Q1, we don’t see the need for such independent support and would only consider subgrouping support as a whole. Hence, in our understanding, there is no case where UEID subgrouping could override CN-assigned subgrouping. |
| vivo | No | See comments in Q4. |
| LGE | Yes | As replied in Q4, we also think the CN-assigned subgroup should be prioritized over UE-ID based subgroup. However, if a cell supports less subgroups than CN, the subgroup ID assigned by CN cannot be used in the cell. If UE uses UE ID based subgroup in this case, the first issue in option 1 can be resolved simply. |
| Intel | No | As commented in Q1, the UE should follow the CN assignment. |
| Apple | No | UE should use the CN based subgrouping assignment in this scenario. |
| Lenovo | - | If the gNB could only configure the UE-ID based subgrouping, our answer is yes. |
| Nokia | - | See above |
|  |  |  |

**Summary 5**: TBD.

**Proposal 4**: TBD.

**Question 6**: For option 1 or 2, which sub-option out of b1/b2/b3 do companies prefer for subgroups splitting in RAN for a cell with both NW assignment and UE-ID based subgrouping UEs?

|  |  |  |
| --- | --- | --- |
| Answers to Question 6 | | |
| Company | Option b1/b2/b3 | Technical comments |
| Xiaomi | B2 | B2 is aligned with LTE. So we think it is the baseline.  Other options can be further considered. |
| Huawei, HiSilicon | See comments | For “Option 1 CN assigns Subgroup ID”:  Option b3 is simple and seem enough, if both the CN and RAN support CN assigned subgrouping method, CN assigned subgrouping method can be used in a cell; if either the CN or the RAN cannot support CN assigned subgrouping method, RAN can further decided whether UE-ID based subgrouping method can be used in a cell.  If mixed CN assigned subgrouping and UE-ID based subgrouping method can be supported in a cell, we think that b2 should be excluded since the benefits of CN assigned subgrouping is eliminated by UE-ID based subgrouping, b1 can be one of the candidate solution  For “Option 3: Reuse NB-IoT framework”, b2 is preferred. |
| Qualcomm | b4 | Please see our comment to Q1 |
| Samsung | B2, B3 | B3 is preferred over B2 |
| MediaTek | B1 | Other options are also acceptable, but we think that if CN assigns subgroup IDs to some UEs, it means that CN wants to “protect” these UEs (because they are less frequently paged, or power sensitive). In that sense, other UEs should not share the same groups, otherwise the “false alarm rate” is increased. If extra subgroups can be supported, they can be used by “other” UEs (without CN assignment) to save some power. |
| OPPO | b1 | Since the two grouping schemes are independent, further grouping ID partitioning by hard split is required to mitigate false alarm among the two grouping schemes. |
| ZTE | B2 |  |
| CATT | b2 | By far the simplest approach. Proponents of splitting groups should show the associated performance gains. |
| vivo | See Comments | Firstly, in order to obtain the maximum power saving gain, all available bits in PDCCH/sequences for subgrouping should be used. The subgrouping radio resource should be common for both subgrouping methods.  For B1, the power saving gain is limited because the subgrouping resource (e.g. PEI or PDCCH bits/sequences) cannot be fully used.  For B3, it is not clear how this option works in case of the mix of both NW assignment and UE-ID based subgrouping. it seems that separate subgrouping radio resource or separate mapping between PDCCH/sequence and subgroups are needed for different subgrouping method.  For B2, we understand that the UEs having no CN assigned subgroup ID should not impact the paging for UEs with CN assigned subgroup ID.  Besides, we think network has the information of UE\_ID. So that, the assigned subgroup for a UE could also consider the UD\_ID based. In this way, a reasonable network/gNB will try to avoid to support co-existence of UE\_ID based and CN-assigned subgroups in the same cell, which could reduce the false alarm due to subgroup overlapping. |
| LGE | B2 | The more subgroups, the more power saving gain. If CN-assigned and UE ID based subgroup uses separate subgroups, the power saving gain will be significantly reduced in a cell supporting either CN-assigned or UE ID based subgroup. |
| Intel | b1, b2 or b4 | As in our response to Q1, Option b1, b2 or b4 option is acceptable to us. Option b4 provides most flexibility in that it can be used to implement Option b1 or b2. There is a possibility of false alarm with Option b2. Option b1 is the simplest but hard partition may not lead to uniform distribution depending on the number of UEs that are assigned CN and RAN |
| Apple | B4/B2/B1 | We feel B4 is more flexible and can help to incorporate the requirements of B2 and B1. |
| Lenovo | B4 | It is flexible for gNB configuration and could include the other options. |
| Nokia | B1 or B4 | The UEs with CN assignment should not be mixed randomly with UEs without CN assignment with UE-ID based pure randomization, as otherwise those UEs within the subgroup might have negative impact on the subgroup with very low paging probability. Similar to option 3, the last subgroup (set) could be used for UE-ID. It is up to NW to allocate also CN assignment UEs there or not or only reserved for UE-ID based. |

**Summary 6**: TBD.

**Proposal 6**: TBD.

## 3.2 UE and NW capabilities

The discussion on capabilities would probably be easier after the functionality is a bit clearer, i.e. after the selection of which option is to be adopted in section 3.1. But we can have a preliminary discussion here.

There are several options proposed for UE capabilities:

**Option 1**: common capability for subgroup [4][10][13]

* Pros:
  + Fewer cases to address than allowing only one of NW assignment and UE-ID based is supported
  + Single capability communication among CN, UE, and gNB or can be even implicitly based on the configurations/assistance information if supported
* Cons:
  + The UE needs to implement both

**Option 2**: separate capability for NW assignment and UE-ID based [7][8][9][13][14]

* Pros:
  + More flexibility for UE implementation
* Cons:
  + more complexity for capability indication among CN, UE and gNB
  + more complicated cases to address if CN, UE or gNB only support one of them

**Option 3**: UE supports only NW controlled subgrouping, or supports both, or supports neither [13]

**Option 4**: UE supports only UE ID based subgrouping, or supports both, or supports neither [13]

**Question 7**: Which option do companies prefer on UE capability for subgrouping?

|  |  |  |
| --- | --- | --- |
| Answers to Question 7 | | |
| Company | Option 1/2/3/4 | Clarifications on the options if needed |
| Xiaomi | Option1 | UE’s capability has nothing to do with the subgrouping method the network is using. |
| Huawei, HiSilicon | Option1 | Agree with the Pros listed by the moderator. |
| Qualcomm | Option 2 | NW-assigned subgrouping and UE-ID based subgrouping do involve implementation in different layers (NAS vs AS). RAN2 should not mandate UE to signal only one capability for features in two different functional units. For example, that will make product testing and IOTs more challenging. Moreover, we don’t think having separate capabilities would make design more complicated, as long as we try to “keep things simple”. |
| Samsung | Option 1 |  |
| MediaTek | Option 1 | A reasonable UE implementation is to support both, or none. |
| OPPO | Option 2 | Agree with QC. |
| ZTE | Option 1 first | if we would like to support separate capability, option 4 is our preference, |
| CATT | Option 1 | We don’t see any complexity difference from UE perspective in applying one or the other method. On the contrary splitting capabilities, including on the NW side, will increase the number of subcases thus increasing both implementation complexity and specification effort. |
| vivo | Option 1 | For Option 1, we agree with the above listed Pros.  For Option 2, if UE has separate capabilities of CN-Controlled or UE\_ID based subgrouping, it may cause a mix of UEs in a cell using NW-assigned subgroup and UE\_ID based subgroup. Once the mix of UE\_ID based and CN-Controlled subgroups in the same cell exists, we should discuss whether the subgroup IDs from CN assigned and the subgroup IDs based on UE-ID should be overlapped. As we commented above, our understanding is that the UEs having no CN assigned subgroup ID should not impact the paging for UEs with CN assigned subgroup ID. Besides, option 2 will lead more complicated cases need to be address for subgrouping.  In summary, Option 1 is preferred |
| LGE | Option 1 | A reasonable UE implementation is to support both, or none. |
| Intel | Option 1 or 2 | We think option 1 is sufficient from UE implementation point of view but from indicating inter-operability testing bit perspective, we may need option 2. |
| Apple | Option 2 | Having separate capabilities keeps the distinction clear and the UE implementation simple. |
| Lenovo | Option 1 | Simple and reasonable, it is not necessary to support only one method from the view of UE. |
| Nokia | Option 1 | Agree with others. |
|  |  |  |

**Summary 7**: TBD.

**Proposal 7**: TBD.

For NW capability, it should have full flexibility in principle. For CN, it could choose to provide or not the subgroup ID /subgroup ID set/subgroup related information. If CN provides such information, RAN might still have the possibility to apply either one. For subgroup ID based options there were proposals that RAN can indicate all the subgroups indication bits are for UE-ID based or for CN-assignment based, or it explicitly indicates supporting one of CN-assignment and UE-ID based, or both; for option with NB-IoT mechanism, RAN has the flexibility to put all the UEs within the same subgroup set with configuration of the subgroup set threshold. Details of signalling can be discussed further after the architecture option in section 3.1 to be adopted is clear.

**Question 8**: Do companies agree the RAN capability could be known based on broadcast information? FFS if explicit indication or implicitly based configuration.

|  |  |  |
| --- | --- | --- |
| Answers to Question 8 | | |
| Company | Yes/No | Technical comments |
| Xiaomi | Yes | gNB broadcasts whether to support CN-assigned subgrouping and/or UE-ID based subgrouping.  FFS the signalling. |
| Huawei, HiSilicon | Yes |  |
| Qualcomm | Yes | gNB certainly can advertise which type(s) of subgrouping it supports, either implicitly (e.g. for UE-ID based) or explicitly (e.g. for CN-assigned). |
| Samsung | Yes |  |
| MediaTek | Yes |  |
| OPPO | Yes |  |
| ZTE | Yes |  |
| CATT | Yes | RAN explicitly indicates supporting subgrouping (as a whole) via the broadcast of the total number of subgroups (Nsg). |
| vivo | Yes | RAN capability could be known implicitly based configuration in broadcast information |
| LGE | Yes |  |
| Intel | Yes |  |
| Apple | Yes |  |
| Lenovo | Yes | Implicitly known based on the configuration information. |
| Nokia | Yes | Could be implicitly known based on configuration. |
|  |  |  |

The different combinations of UE/gNB/AMF supporting/not supporting subgrouping or certain sub-feature of subgrouping could be for further discussion after the architecture options and capabilities discussions are concluded.

# 4 Conclusion

TBD.

# References

[1] [R2-2107549](file:///D:\Documents\3GPP\tsg_ran\WG2\TSGR2_115-e\Docs\R2-2107549.zip) Further considerations on Network assigned subgrouping Intel Corporation discussion Rel-17 NR\_UE\_pow\_sav\_enh-Core

[2] [R2-2108027](file:///D:\Documents\3GPP\tsg_ran\WG2\TSGR2_115-e\Docs\R2-2108027.zip) Further discussion on paging subgrouping Huawei, HiSilicon discussion Rel-17 NR\_UE\_pow\_sav\_enh-Core

[3] [R2-2108592](file:///D:\Documents\3GPP\tsg_ran\WG2\TSGR2_115-e\Docs\R2-2108592.zip) CN and RAN responsibility split for paging subgrouping Nokia, Nokia Shanghai Bell discussion Rel-17 NR\_UE\_pow\_sav\_enh-Core [R2-2108011](file:///D:\Documents\3GPP\tsg_ran\WG2\TSGR2_115-e\Docs\R2-2108011.zip)

[4] [R2-2108686](file:///D:\Documents\3GPP\tsg_ran\WG2\TSGR2_115-e\Docs\R2-2108686.zip) Further Consideration on Paging Subgroup CATT discussion Rel-17 NR\_UE\_pow\_sav\_enh-Core

[5] [R2-2106998](file:///D:\Documents\3GPP\tsg_ran\WG2\TSGR2_115-e\Docs\R2-2106998.zip) Further details of UE Subgrouping Samsung Electronics Co., Ltd discussion Rel-17 NR\_UE\_pow\_sav\_enh-Core

[6] [R2-2107067](file:///D:\Documents\3GPP\tsg_ran\WG2\TSGR2_115-e\Docs\R2-2107067.zip) Discussion on grouping-based paging OPPO discussion Rel-17 NR\_UE\_pow\_sav\_enh-Core

[7] [R2-2107068](file:///D:\Documents\3GPP\tsg_ran\WG2\TSGR2_115-e\Docs\R2-2107068.zip) Discussion on UE paging capabilities OPPO discussion Rel-17 NR\_UE\_pow\_sav\_enh-Core

[8] [R2-2107222](file:///D:\Documents\3GPP\tsg_ran\WG2\TSGR2_115-e\Docs\R2-2107222.zip) Paging subgroup assignment Qualcomm Incorporated discussion Rel-17 NR\_UE\_pow\_sav\_enh-Core

[9] [R2-2107385](file:///D:\Documents\3GPP\tsg_ran\WG2\TSGR2_115-e\Docs\R2-2107385.zip) The architecture of paging enhancement Xiaomi Communications discussion Rel-17 NR\_UE\_pow\_sav\_enh-Core

[10] [R2-2107406](file:///D:\Documents\3GPP\tsg_ran\WG2\TSGR2_115-e\Docs\R2-2107406.zip) Architecture for paging enhancement by UE subgrouping vivo discussion Rel-17 NR\_UE\_pow\_sav\_enh-Core

[11] [R2-2107721](file:///D:\Documents\3GPP\tsg_ran\WG2\TSGR2_115-e\Docs\R2-2107721.zip) Further discussion on CN-assigned paging grouping Transsion Holdings discussion

[12] [R2-2107902](file:///D:\Documents\3GPP\tsg_ran\WG2\TSGR2_115-e\Docs\R2-2107902.zip) Consideration on Idle/inactive-mode UE power saving Lenovo, Motorola Mobility discussion Rel-17

[13] [R2-2108028](file:///D:\Documents\3GPP\tsg_ran\WG2\TSGR2_115-e\Docs\R2-2108028.zip) Discussion on paging subgrouping supporting on UE and network Huawei, HiSilicon discussion Rel-17 NR\_UE\_pow\_sav\_enh-Core

[14] [R2-2107880](file:///D:\Documents\3GPP\tsg_ran\WG2\TSGR2_115-e\Docs\R2-2107880.zip) UE ID based subgroup LG Electronics Inc. discussion Rel-17

[15] [R2-2108237](file:///D:\Documents\3GPP\tsg_ran\WG2\TSGR2_115-e\Docs\R2-2108237.zip) Grouping methods for Paging Ericsson discussion Rel-17 NR\_UE\_pow\_sav\_enh-Core

[16] [R2-2108461](file:///D:\Documents\3GPP\tsg_ran\WG2\TSGR2_115-e\Docs\R2-2108461.zip) Handling network nodes not supporting UE paging subgrouping Futurewei Technologies discussion Rel-17 NR\_UE\_pow\_sav\_enh-Core

[17] [R2-2108590](file:///D:\Documents\3GPP\tsg_ran\WG2\TSGR2_115-e\Docs\R2-2108590.zip) UE Paging Subgroup Assignment MediaTek Inc. discussion