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

Online, May 19 – May 27, 2021

Agenda Item: 8.9.2

Source: MediaTek Inc.

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

Document for: Discussion and decision

# Introduction

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

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| * [AT114-e][025][ePowSav] Subgrouping network architecture (Mediatek)   Scope: Address whether CN or RAN shall be responsible for paging subgrouping based on UE characteristics. As this may be related to availability of information on UE characteristics in the CN or RAN network entity, can also discuss if needed provisioning of assistance information (e.g. between the network entities or from UE to the responsible network entity). The discussion shall be based on the contributions under 8.9.2.  Intended outcome: Report, with discussion, and presenting the main alternatives on the table with documented justifications, way forward.  Deadline: In time for CB online May 25 |

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

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# Discussions

## General issues of CN vs. RAN Assignment

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

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

Which entity should assign UE subgroups?

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

**Q1.1: Should UE grouping be considered as a kind of paging enhancement for UE power saving?**

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| --- | --- | --- |
| **Company** | **Yes/No** | **Comments** |
| Ericsson | Yes | We also consider UE\_ID based grouping as a type of "RAN controlled grouping" |
| Qualcomm | Yes |  |
| vivo | Yes | We would like to check the intention for this proposal. Is it to confirm UE grouping could be considered for paging enhancement? I assume RAN2 has agreed UE grouping in last meeting, we think there is no need to discuss this issue again. Or anything I missed. |
| CATT | Yes | We understand the question is for “subgrouping”, not sure though what the question implies. |
| Xiaomi | Yes |  |

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

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

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

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| **Company** | **Yes/No** | **Comments** |
| Ericsson | Yes | We do not see why the UE subgroup should depend on the RRC state. If it would then it could impact monitoring CM-IDLE paging in Inactive like Xiaomi pointed out. |
| Qualcomm | Yes | We do not see any strong use case for UE to have different subgroup ID in RRC Idle and RRC Inactive. Moreover, if different subgroup IDs are configured, UE needs to monitor both subgroups when in RRC Inactive, otherwise UE may not be able to recover from state mismatch. That would increase rate of false paging. |
| vivo | Yes | Same subgroup ID should be used for both RRC\_IDLE and RRC\_INACTIVE state, otherwise paging missing issue may occur in case of RRC state mismatch between UE and NW.  Meanwhile, UEs in RRC\_INACTIVE state need to monitor CN and RAN paging. In this way, two subgroup IDs should be based for paging monitoring. |
| CATT | Yes | Considering state mismatch it seems difficult to assign a different subgroup to the UE for Idle and Inactive, and we do not see what would be the benefit. |
| Xiaomi | No? | In our understanding, we may need to assign different Group IDs for RRC\_IDLE mode and RRC\_INACTIVE. An example is from the paging probability point of view, UE monitors CN paging less frequent than the RAN paging. It may not be suitable to put a UE with higher paging rate into a group with lower paging rate which may cause false alarm to other UEs.  People may argue, since it is the RAN which has the control of UE RAN paging, RAN can assign a smaller DRX cycle compared to the UE specified DRX cycle to imply the RAN paging is more frequently than the CN paging, thus we do not need to differentiate the paging probability by sub-grouping (i.e., the higher paging probability is spread over many DRX cycles). Well, it is reasonable. However, when the default DRX cycle is configured shorter than the CN paging cycle and the RAN paging cycle, this method fails.  Considering the observation described above, network assign two types of subgroup ID for RRC\_IDLE and RRC\_INACTIVE mode respectively seems to be a reasonable solution. In the case of RRC IDLE, CN will take the control on the UE’s subgrouping ID while in the case of RRC INACTIVE, it is natural that RAN who RAN buffers DL packets for the UE in RRC\_INACTIVE will decide the subgrouping for the UE. However, we do see some problems with this scheme, as Ericsson mentioned, we may have challenges consider the exceptional case for RRC status mismatch.  We think we can first discuss whether we need to have different Group IDs for RRC\_IDLE mode and RRC\_INACTIVE. If people think we do not have to, we can use one group for the two states. |

## CN-assigned UE subgroups

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

Subgroup assignment

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

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| **Company** | **Comments** |
| Ericsson | During NAS registration procedure, i.e. in REGISTRATION ACCEPT (24.501). |
| Qualcomm | Agree with Ericsson |
| vivo | Network provide the initial assignment of subgroups to each UE during registration procedures.  The assignment of subgroups is consistent at least in one registration area. |
| CATT | Agree with Ericsson |
| Xiaomi | As in eLTE, using NAS procedure. And CT1 should be involved. |

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

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| **Company** | **Comments** |
| Ericsson | We should perhaps first discuss why there is a reason to update/change the grouping? The UE characteristics typically do not change e.g. RedCap, power sensitive? But the registration procedure in NR is used during initial registration but also during other periodic updates including mobility, i.e. updates are possible. |
| Qualcomm | Through NAS signaling |
| vivo | Network may update the assignment of subgroups for each UE during registration procedures for mobility, or periodic registration update. |
| CATT | The network can also update the assignment of subgroups for each UE via NAS message. We can leave the details to CT1. |
| Xiaomi | Through NAS signalling.  We think the network should provide a way for UE to update the subgroup information, if needed. Well, whether this is enabled or not should be depend on CT1. |

Assistance information from UE

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

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

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| **Company** | **Yes/No** | **Comments** |
| Ericsson | No | We do not see the need for UE assistance, i.e. the network has the information it needs to do grouping (e.g. subscription info, paging probability). And in case the NW uses the UE preference, then practically the grouping is controlled by the UE, unless the NW checks if the UE is reporting correctly, e.g. indicates the correct paging probability or checks if is it power sensitive. Such checks are complicated to implement, and typically the NW does not do that.  But our main concern is that the group assignment should be left to NW implementation. This does not only mean that the NW should be able to ignore the "preference" indicated by the UE, but also that the UE assistance does not lead to pre-defined groups, e.g. "paging probability group", "power sensitive group", etc. Because in such case the grouping is not left completely to the NW implementation, but it is partially controlled by the UE assistance.  In case the UE assistance does not lead to pre-defined groups, and leaves the group assignment to the NW implementation (e.g. the NW just assigns a group number), then UE assistance would be acceptable. |
| Qualcomm | Yes | Possible attributes may include UE’s paging probability rate (similar to those in NB-IoT), mobility profile (e.g. stationary vs mobile) and power profile (e.g. plugged in or on battery) |
| vivo | No | UE group ID is determined and configured by CN, which should be up to network implementation, i.e. based on individual UE characteristics are not specified  Hence, UE assistance for subgroup assignment is not needed. |
| CATT | No | We agree with Ericsson that no assistance should be required and CN can do the grouping based on subscription info. |
| Xiaomi | Yes? | We think such paging probability should be provided to CN as an assistance information like NB-IoT did. Since network controlled subgroup is adopted, we are open for other UE characteristics.  But we need to discuss first by which way the CN get such assistance, by assistance include in NAS messages or from the gNB? If by NAS, there may be no impact in RAN. |

Assistance information between network entities

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

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

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| **Company** | **Yes/No** | **Comments** |
| Ericsson | Yes | We understand that the assigned group should be included in the INITIAL CONTEXT SETUP REQUEST in the *Core Network Assistance Information for RRC INACTIVE* IE to enable the use of group info during RAN paging. For CM\_IDLE paging the assigned group needs to be included in the PAGING message to the gNB.  We also think that PEI, similar as WUS in LTE, should only be used in "last used" cell, see [13] ([R2-2105736](https://www.3gpp.org/ftp/tsg_ran/WG2_RL2//TSGR2_114-e/Docs/R2-2105736.zip)). Because paging due to mobility may cause the PEI to be triggered frequently which nullifies the power gains with PEI, and paging due to mobility may cause of lot of PEI transmissions while the UE only replies in a single cell within the TA. In case PEI is only used in the last used cell, then this information needs to be exchanged between RAN and CN (e.g. in *Information on Recommended Cells and RAN Nodes for Paging* in UE CONTEXT RELEASE COMPLETE from gNB to AMF, and in *Assistance Data for Recommended Cells* IE in PAGING message).  Furthermore the PEI UE capability need to be added to the UE capabilities, i.e. signalled between UE and gNB. The gNB needs to send these UE radio paging capabilities (UCRP) to the CN, such that the CN can include them as the UE radio paging capabilities in the PAGING message to the gNB. In case PEI is added to the UERadioPagingInformation message in Rel-17, then we should also add *ue-RadioPagingInfo* IE in the *UECapabilityInformation*, similar as already has been done for LTE, such that the gNB can just copy it, and does not need to extract it from the reported UE capabilities. Also see also current RAN3 discussion on use of URCP in case of RAN paging in [R3-211621](https://protect2.fireeye.com/v1/url?k=750797bf-2a9caef2-7507d724-86b568293eb5-3cfbb9a53e1c3194&q=1&e=06aac426-6f8d-4ed9-92b8-0f545c69ec20&u=https%3A%2F%2Fwww.3gpp.org%2Fftp%2FTSG_RAN%2FWG3_Iu%2FTSGR3_112-e%2FDocs%2FR3-211621.zip) . We propose to send an LS to RAN3/SA2 about this. |
| Qualcomm | Yes | When UE is in RRC Idle, CN should provide UE’s subgroup ID to RAN when CN sends paging notification to RAN; when UE is in RRC Inactive, anchor gNB should provide UE’s subgroup ID to serving gNB when it sends paging notification. |
| vivo | - | I think companies may have some mis-understanding on this question. Two parts need to be discussed:   1. When determining the subgroup ID, whether assistance information between NW nodes is needed. We think it should be up to NW implementation, as how to determine subgroup is not specified (if agreed). The only part needs to be exchanged between NW nodes is UE capability in support subgrouping. 2. After determining the subgroup ID, this assignment should be informed to RAN and UE. Meanwhile, when paging UEs, the corresponding subgroup ID should be included in the paging message. |
| CATT | No | CN only needs to inform gNBs in the tracking area about the assigned UE subgroup, but we do not consider this as “assistance information”. |
| Xiaomi | Yes | First of all, the interaction between network entities shall ensure the paging subgroup can work. For CN assignment, CN is anyway required to provide subgroup ID to RAN for CN paging as well as for RAN paging.  For CN paging the assigned group needs to be included in the PAGING message to the gNB.  For RAN paging, anchor gNB should transfer this to serving gNB in the RAN PAGING message  Of course, UE capability should be transferred to each other. And the way in eLTE can be used.  Other assistance information for a wise subgroup assignment can be FFS (see comments to Q2.3). |

## RAN-assigned UE subgroups

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

Subgroup assignment

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

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| **Company** | **Comments** |
| Ericsson | We think that the UE\_ID can be used as a "RAN controlled" grouping mechanism. |
| Qualcomm | RAN may configure a subgroup ID for UE by dedicated signaling (e.g. in RRC Release msg). We also agree with Ericsson’s comment that UE\_ID based subgrouping is also one type of RAN-assigned subgrouping. In that case, the number of subgroups is provided in system information. UE derives its subgroup ID by hashing. |
| vivo | RAN provides the initial assignment in RRC dedicated signaling, e.g. in RRC release message. Or we also agree that NW provides number of subgroups, and UE calculates its subgroup ID with UE\_ID. |
| CATT | We agree with Ericsson that RAN-assigned UE subgroups can reduce to UE\_ID based grouping. In case a different subgrouping method would be used, RAN-assigned specific subgrouping ID should be provided in the *RRCRelease* message. |
| Xiaomi | There are two methods. One is RAN directly assign subgroup via RRC release message. Another is UE-ID-based method through randomization. And we think UE-ID-based method can be a fall-back scheme if network does not provide a subgroup. |

**Q3.2: If UE subgroups are assigned by RAN, how does network update the assignment of subgroups for each UE?**

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| **Company** | **Comments** |
| Ericsson | The UE\_ID based grouping is controlled via parameters configured in System Information e.g. *Ng: Total number of groups*. |
| Qualcomm | If UE’s subgroup ID is configured by dedicated signaling, network should use dedicated signaling to change it when UE is connected.  If UE’s subgroup ID is derived based on its UE\_ID, network can change number of subgroups in system information to update all UE’s subgroup IDs. |
| vivo | RAN updates the assignment in case UE enters RRC connected state. Or UE could update the subgroup ID by using the updated number of subgroups. |
| CATT | Same view as Ericsson for UE\_ID based. For other method, RAN can update the subgroup every time it releases the UE. |
| Xiaomi | RAN directly update the subgroup via RRC release message can be first discussed. |

Cell reselection

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

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

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| **Company** | **Comments** |
| Ericsson | The UE-ID based RAN group is cell specific. |
| Qualcomm | If UE’s subgroup ID is assigned by dedicated signaling, anchor gNB should provide UE’s subgroup ID to serving gNB when it sends paging notification.  If UE’s subgroup ID is derived based on UE\_ID, UE can check number of subgroups in system info of the new cell. |
| vivo | RAN nodes should know the subgroups information of UEs from anchor node, who assigned the UE subgroups. |
| CATT | Same view as Ericsson for UE\_ID based. For other method, gNB must inform CN about the UE subgroup and CN stores it as part of UE context. Otherwise, the UE context in RAN is released when the UE is released into RRC\_IDLE and the UE subgroup is lost. Then if CN paging is triggered for the RRC\_IDLE UE, CN sends the UE-specific subgroup ID to RAN nodes within CN paging message. And if RAN paging is triggered for RRC\_INACTIVE UE, anchor gNB may need to send the UE-specific subgroup ID to other RAN nodes within RAN paging message.  However see also our answer to Q3.4 |
| Xiaomi | For UE-ID-based method, there is no such an issue as UE can check configuration from system information broadcasted.  For RAN direct assignment, anchor gNB needs to send subgroup ID (carried in paging message) via Xn interface to another gNB or the subgrouping ID needs to be sent to CN to be stored when UE is released and then the CN can transfer it the target paging gNB (if RAN assigns the subgrouping for idle mode paging). |

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

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

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| **Company** | **Yes/No** | **Comments** |
| Ericsson | No |  |
| Qualcomm | Yes | Otherwise, UE has to obtain subgroup ID every time it re-selects a cell. That is inpractical.  So this means that RAN nodes should try to have the same subgroup ID assignment for a UE as much as possible, which contradicts the motivation for RAN-based assignment. This is one of the reasons why we do not support RAN-based assignment. |
| vivo | - | This is the problem for RAN node to assign subgrouping. We assume RAN nodes in an area (e.g. TA) should be consistent. |
| CATT | No | That seems difficult considering it would require different gNBs to coordinate with each other regarding e.g. the maximum number of supported subgroups, and also the subgroup sizes. Also, see associated complexity in maintaining this across RAN nodes in Q3.3. |
| Xiaomi | - | It is not a big deal for this issue if the RAN nodes have different subgroups.  When different gNB has different subgroup configuration, there can be a re- mapping function to solve this. |

Assistance information from UE

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

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| **Company** | **Yes/No** | **Comments** |
| Ericsson | No | The UE-ID is for RAN paging is known by UE and RAN, i.e. no UE assistance is needed. |
| Qualcomm | Yes | For the same reason as using UAI for CN-based assignment. |
| vivo | No | UE group ID is assigned by RAN, which should be up to network implementation, i.e. based on individual UE characteristics are not specified. |
| CATT | No |  |
| Xiaomi | Yes | UAI is OK. |

Assistance information between network entities

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

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| **Company** | **Yes/No** | **Comments** |
| Ericsson | Yes | In case of RAN paging the UE radio paging capabilities need to be exchanged on Xn interface in RAN PAGING message in case of paging escalation, i.e. UE is not found on "last used" cell. |
| Qualcomm | Yes | The same set of attributes provided by UE to network. |
| vivo | - | Similar as above:   1. When determining the subgroup ID, whether assistance information between NW nodes is needed. We think it should be up to NW implementation, as how to determine subgroup is not specified (if agreed). The only part needs to be exchanged between NW nodes is UE capability in support subgrouping. 2. After determining the subgroup ID, this assignment should be informed to other non-anchor RAN node and CN. Meanwhile, when paging UEs, the corresponding subgroup ID should be included in the paging message. |
| CATT | Yes | CN could provide subscription related info to RAN. FFS though what exactly and how would RAN use it. |
| Xiaomi | Yes | For RAN direct assignment, RAN is required to provide subgroup ID to CN for storage in case of CN paging.  Other assistance information can be FFS if RAN assignment is adopted. |

## Other issues

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

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

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| **Company name** | **Comments** |
| Ericsson | As explained with Q2.4 RAN2 needs to discuss whether PEI, similar as WUS in LTE, should only be used in "last used" cell, see [13] ([R2-2105736](https://www.3gpp.org/ftp/tsg_ran/WG2_RL2//TSGR2_114-e/Docs/R2-2105736.zip)). Because paging due to mobility may cause the PEI to be triggered frequently nullifies the power gains with PEI, and paging due to mobility may cause of lot of PEI transmissions while the UE only replies in a single cell. We also think that RAN3 and SA2 should be involved in this discussion, similar as during the LTE time frame. |
| CATT | We think it should be clarified that there can be a mix of UEs in a cell using NW-assigned subgroup and UEID-based subgroup. That is, it should not be mandated to the NW that if it assigns *some* UEs with NW-assigned subgroups, it shall assign *all* UEs with NW-assigned subgroup. |
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# Conclusion

# Reference

1. R2-2104773 Paging subgroup assignment Qualcomm Incorporated discussion Rel-17 NR\_UE\_pow\_sav\_enh-Core
2. R2-2104783 Paging Enhancements\_UE Grouping Samsung Electronics Co., Ltd discussion Rel-17 NR\_UE\_pow\_sav\_enh-Core
3. R2-2104807 Discussion on grouping-based paging OPPO discussion Rel-17 NR\_UE\_pow\_sav\_enh-Core
4. R2-2104909 UE sub-grouping for paging enhancement vivo discussion Rel-17 NR\_UE\_pow\_sav\_enh-Core
5. R2-2105021 Further considerations of network assigned subgrouping Intel Corporation discussion Rel-17 NR\_UE\_pow\_sav\_enh-Core
6. R2-2105087 NR UE Power Save IDLE/INACTIVE Paging Grouping Schemes Apple discussion Rel-17 NR\_UE\_pow\_sav\_enh-Core
7. R2-2105283 UE subgrouping schemes with paging enhancement CATT discussion Rel-17 NR\_UE\_pow\_sav\_enh-Core
8. R2-2105293 UE Paging Subgroup Assignment for Power Saving MediaTek Inc. discussion
9. R2-2105295 Discussion on idle\_inactive\_mode UE power saving Xiaomi Communications discussion Rel-17 NR\_UE\_pow\_sav\_enh-Core
10. R2-2105411 Details on paging subgrouping determination and indication Nokia, Nokia Shanghai Bell discussion Rel-17 NR\_UE\_pow\_sav\_enh-Core
11. R2-2105656 Grouping methods for Paging Ericsson discussion Rel-17 NR\_UE\_pow\_sav\_enh-Core
12. R2-2105718 Discussion on the control node for UE grouping Huawei, HiSilicon discussion Rel-17 NR\_UE\_pow\_sav\_enh-Core
13. R2-2105736 PEI monitoring in NR: CN and System level impacts VODAFONE Group Plc discussion
14. R2-2105809 Consideration on Idle/inactive-mode UE power saving Lenovo, Motorola Mobility discussion Rel-17
15. R2-2105855 Further Consideration on UE Grouping ZTE, Sanechips discussion Rel-17 NR\_UE\_pow\_sav\_enh-Core
16. R2-2105956 Discussion on UE grouping control entity Futurewei Technologies discussion Rel-17 NR\_UE\_pow\_sav\_enh-Core
17. R2-2106257 Considerations on paging subgrouping CMCC discussion Rel-17 NR\_UE\_pow\_sav\_enh-Core
18. R2-2106349 UE subgrouping for paging enhancement LG Electronics Inc. discussion Rel-17 NR\_UE\_pow\_sav\_enh-Core