**3GPP TSG RAN WG1 e-Meeting #104 R1-210XXXX**

**e-Meeting, January 25th – February 5th, 2021**

Agenda Item: 8.7

Source: Moderator (MediaTek)

Title: Summary of reply LS on paging enhancement

Document for: Discussion and Decision

# Introduction

In 3GPP RAN2 #112-e meeting, the following LS on paging enhancement was sent from RAN2 [1].

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| **1. Overall Description:**In RAN2#112-e, RAN2 discussed UE grouping for paging enhancement in Rel-17 UE power saving WI. RAN2 confirmed that UE grouping is considered as a candidate of paging enhancements for UE power saving. Regarding paging for UE subgroups, RAN2 has discussed and considered the following methods: * Paging indication for UE subgroups using paging DCI, with either same-slot or cross-slot scheduling;
* Paging early indication (PEI) / wake-up signal (WUS) for UE subgroups;
* UE subgroup indication by using multiple P-RNTIs;
* Paging for UE subgroups using different time/frequency resources.

From RAN2 perspective, the last two methods are de-prioritized. Notice that these methods are not mutually exclusive.**2. Actions:****To RAN1:**RAN2 respectfully asks RAN1 to take the above information into consideration and provide information on the feasibility and limitations of carrying subgroup information with their recommended solution. |

Based on the above LS and companies’ contributions [4]-[7], this summary is devoted to collect companies’ views on the potential LS reply.

# 1st Round of Discussion and Proposals

According to the LS from RAN2, the following methods have been discussed and considered:

* Paging indication for UE subgroups using paging DCI, with either same-slot or cross-slot scheduling;
* Paging early indication (PEI) / wake-up signal (WUS) for UE subgroups;
* UE subgroup indication by using multiple P-RNTIs;
* Paging for UE subgroups using different time/frequency resources.

And the last two methods are deprioritized. For the 1st round of discussion, UE subgrouping information in paging DCI and the two deprioritized methods can be discussed.

## UE Subgroups Information in Legacy Paging DCI

From the observations in RAN1 #103-e meeting, only marginal power saving gain can be achieved by using paging DCI with either same-slot or cross-slot scheduling, as quoted in the table below. Consequently, the following proposal is suggested:

Proposal 1: Paging indication for UE subgroups using legacy paging DCI, with either same-slot or cross-slot scheduling, is not supported from RAN1 perspective.

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| Agreements:Observation: For NR idle/inactive-mode UEs, UE sub-grouping indication within a PO can provide the following power saving gains w.r.t. Rel-16:* If the original group paging rate is 10%:
	+ [0.3%] - [1.1%] where the baseline assumes 1 SS burst for synchronization before PO reception
	+ [0.4%] - [0.8%] where the baseline assumes 2 SS bursts for synchronization before PO reception
	+ [0.3%] - [1.0%] where the baseline assumes 3 SS bursts for synchronization before PO reception
* Some sources also evaluated performance if the original group paging rate is in the range between 20% and 80% and showed following results:
	+ [0.7%] - [7.6%] where the baseline assumes 1 SS burst for synchronization before PO reception
	+ [0.8%] - [3.0%] where the baseline assumes 2 SS bursts for synchronization before PO reception
	+ [0.5%] - [4.7%] where the baseline assumes 3 SS bursts for synchronization before PO reception

The number of UE sub-groups evaluated ranges from 2 to 16.Some companies show concern on assuming group paging rate larger than 60%.Note: It is FFS in RAN1 another group paging rate > 10% for the evaluation of Rel-17 paging enhancement.Agreements:Observation:For NR idle/inactive-mode UEs with 10% group paging rate, cross-slot scheduling with K0 = 1, which can be supported by Rel-15/Rel-16 for Type 2 CSS, can provide the following power saving gains w.r.t. same-slot scheduling (K0 = 0):* [<1%] –[2.5%] where the baseline assumes 1 SS burst for synchronization before PO reception
* [<1%] -[1.6%] where the baseline assumes 2 SS bursts for synchronization before PO reception
* [<1%] -[1.44%] where the baseline assumes 3 SS bursts for synchronization before PO reception

One source shows that cross-slot scheduling with K0 = 32, which cannot be supported by Rel-15/Rel-16 for Type 2 CSS, can provide the following power saving gains w.r.t. same-slot scheduling (K0 = 0):* [0%] where the baseline assumes 1 SS burst for synchronization before PO reception
* [6.3%] where the baseline assumes 3 SS bursts for synchronization before PO reception

The power saving gain will become lower with higher group paging rate. |

Companies please provide comments/suggested revisions to Proposal 1 and in Table 1:

Table 1: Companies’ comments/suggested revisions to Proposal 1

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| **Company** | **Comment(s)/Suggested Revision(s)** |
| Qualcomm | It is too early to make the conclusion of the proposal.This should depend on the conclusion on paging early indication design. If PEI design is based on paging DCI, sub-grouping indication can be carried by the paging DCI.  |
| ZTE, Sanechips | Agree with the proposal.Based on the observations in the last meeting, the power saving gain from the sub-grouping carried by paging DCI is marginal. |
| CATT | We are OK with the proposal since the power saving gain is very small.  |
| Panasonic | We think before concluding the PEI detailed physical layer design, better not to conclude this. |
| Intel | It is too early to conclude this. The observations captured refer to the scenario when legacy paging DCI only carry the sub-grouping information. These should not be used to preclude considerations such as when PEI and paging DCI can be jointly considered to convey sub-grouping information. It will be more clear after progress on the physical layer signal/channel design for paging early indication. |
| Sony | Agree. We also note that ‘PEI combined with subgrouping using legacy paging DCI’ gives a similarly marginal power saving gain as ~~‘Paging indication for UE subgroups using legacy paging DCI’~~ using ‘PEI for subgrouping’ when paging rate is low. ~~Useful power saving gains are achieved when sub-grouping is indicated within the PEI.~~ |
| Nokia | We are OK with the proposal to preclude UE sub-grouping using paging DCI for the same PO. The benefit of cross-slot scheduling via paging DCI was also seen to be nearly non-existent, thus can be precluded. |
| Huawei, HiSilicon | Share similar view that it is too early to discuss the proposal. Some related discussion is made in paging enhancement. |
| LG | Agree in principle. However, as pointed out by Qualcomm, PEI design based on paging DCI should not be precluded by this proposal. In our understanding, intention of this proposal is not to consider further on UE sub-grouping using paging DCI for the same PO. Therefore, the paging DCI itself should be able to be discussed as a candidate solution for PEI design |
| Ericsson | Not OK. It is too early to conclude, and would depend on the outcome of PEI design, including whether PEI indication via paging DCI is supported. As we mentioned in PEI discussion, the above observation is related to subgrouping indication in the paging DCI of the same PO, and it does not apply when subgrouping is indicated in a paging DCI from another PO. |
| Apple | We have slight preference not to make such a conclusion now.It seems that different companies have different solutions in mind. It could be useful to list different options so that we understand each other better. |
| Samsung  | No. UE sub-grouping is still under discussion. It’s too early to preclude paging DCI based indication. |
| DOCOMO | Agree with this proposal. The reason is that sub-grouping indication in paging DCI can provide marginal power saving gain, although Sub-grouping indication in PEI can provide sufficient power saving gain at least when group paging rate is higher. |
| CMCC | SupportThe power saving gain of UE sub-grouping carried in paging DCI is limited. |
| OPPO | We can focus on the proposal only about the legacy Paging DCI. We assume this proposal is not intended for PEI indication possibly for subgroups. The PEI should not be looked as paging.To clarify this: Proposal 1: **Legacy paging DCI indicating for UE subgroups of Paging**, with either same-slot or cross-slot scheduling, is not supported from RAN1 perspective. |
| MediaTek | We are supportive to exclude legacy paging DCI for carrying UE subgroups information so as to minimize the impact to existing paging DCI. On the other hand, since PEI is being discussed, and it is likely the final selected PEI design is not suitable to carrying additional subgroups information. (For example SSS-based PEI has such issue according to our evaluation). In this regard, we can be fine the keep this option along the evaluation and down-selection of PEI candidate designs |

## RAN1’s view on the deprioritized methods

For the following two methods deprioritized by RAN2, it can expect that their power saving gains are limited because only paging PDSCH reception is possible to be reduced. And the UE processing timeline is similar to that of legacy behaviour.

* UE subgroup indication by using multiple P-RNTIs;
* Paging for UE subgroups using different time/frequency resources.

Consequently, the following proposal is suggested:

Proposal 2: For the down prioritized items, RAN1 agrees that they can be down prioritized and RAN1 will not work further on them.

Table 2: Companies’ comments/suggested revisions to Proposal 2

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| **Company** | **Comment(s)/Suggested Revision(s)** |
| Qualcomm | Agreed with the proposal. |
| ZTE, Sanechips | Agree with the proposal. |
| CATT | Agree with the proposal |
| Panasonic | We are okay with this proposal. |
| Intel | Agree with the proposal. |
| Sony | Agree with Proposal 2. |
| Nokia | Agree with the proposal. |
| Huawei, HiSilicon | Agree.  |
| LG | Agree with the proposal |
| Ericsson | OK. |
| Apple | Agree |
| Samsung  | OK. |
| DOCOMO | Agree with the proposal |
| CMCC | Agree. |
| OPPO | Agree with the proposal |
| MediaTek | Agree with the proposal |
| Xiaomi | Agree with the proposal |

# 2nd Round of Discussion and Proposals

From Section 2.1, there is 16 companies expressed views and 8 companies don’t support the proposal. In this regard explicit exclusion of paging DCI for carrying UE subgroups information is not suggested.

In A.I. 8.7.1.1, there is a related proposal being discussed (as quoted below), and we can use it to provide RAN1 response jointly for the first two items in RAN2 study:

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| Proposal 1: Reply RAN2 LS with the following:* Carrying UE subgroups information is considered in RAN1 physical layer design for paging enhancement
	+ Note: The number of UE subgroups RAN1 evaluated ranges from 2 to 16 for a PO or UE group
* RAN1 kindly ask RAN2 whether UE sub-grouping enhancement is supported from RAN2 perspective
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From Section 2.2, all companies support the proposal so that we can utilize it to provide RAN1 response for the deprioritized items.

By the above the following content, analogizing Nokia’s contribution [6], is suggested for draft LS reply.

Proposal 3: Utilize the following content to reply RAN2 LS on paging enhancement:

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| **1. Overall Description:**RAN1 would like to thank RAN2 for their LS on paging enhancements. RAN1 continued discussing physical layer design for paging enhancement and agreed the following:Carrying UE subgroups information is considered in RAN1 physical layer design for paging enhancement* Note: The number of UE subgroups RAN1 evaluated ranges from 2 to 16 for a PO or UE group

For the down prioritized items, RAN1 agrees that they can be down prioritized and RAN1 will not work further on them.**2. Actions:****To RAN2:**RAN1 respectfully asks RAN2 to take the above information into account for RAN2’s future work and provide information on whether UE sub-grouping enhancement is supported from RAN2 perspective. |

Companies please provide comments/suggested revisions to Proposal 3 and in Table 3:

Table 3: Companies’ comments/suggested revisions to Proposal 3

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| **Company** | **Comment(s)/Suggested Revision(s)** |
| Xiaomi | Agree with above Proposal 3. |
| CATT | We are in general Ok with Proposal 3. However, we would suggest modification of the following wording for Action to RAN2 “provide information on ~~whether~~ RAN2’s decision on UE paging sub-grouping for paging enhancement ~~is supported from RAN2 perspective~~”. |
| Qualcomm | Agree with Proposal 3. |
| Ericsson | OK with proposal 3.One minor suggestion is to explicitly list the down-prioritized items in the reply LS:* UE subgroup indication by using multiple P-RNTIs;
* Paging for UE subgroups using different time/frequency resources.
 |
| Intel | OK with proposal 3. Also, support Ericsson’s suggestion to include the deprioritized items in LS response.  |
| LG | We support proposal 3. Also we prefer to list the down-prioritized items explicitly as Ericsson’s suggestion.  |
| (DOCOMO) | (Skipped the reply as previous document cannot be opened due to some security protection) |
| MediaTek  | Agree with Proposal as well as suggestions from CATT and Ericsson. |
| Apple | Given the discussion during the online session, we think the current proposal reflects the current situation in RAN1 very well/accurately. Obviously we haven’t concluded that sub-grouping is supported by either PEI or paging DCI. So we support the current proposal, and we are also fine with CATT and Ericsson’s suggestions. |
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# Summary

(To be updated)

# References

1. R1-2100020, “LS on Paging Enhancement”, RAN2, MediaTek, online available @ <https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_104-e/LS/Incoming/R1-2100020.zip>
2. R1-2100001, “Report of RAN1#103-e meeting”, MCC Support, online available @ https://www.3gpp.org/ftp/tsg\_ran/WG1\_RL1/TSGR1\_104-e/Inbox/R1-2100001.zip
3. R1-2009753, “Summary for potential paging enhancements”, Moderator (MediaTek)
4. R1-2101152, “Discussion on Paging enhancement”, vivo
5. R1-2101645, “Discussion on the feasibility and limitations of paging subgroup”, ZTE
6. R1-2101667, “[Draft] Reply LS on Paging Enhancement”, Nokia
7. R1-2101746, “Discussion on LS on paging enhancement”, Huawei, HiSilicon