3GPP TSG-RAN WG2 Meeting #112-e R2-20xxxxx

Online, 2nd – 13th November 2020

Agenda Item: x.x.x

Source: MediaTek Inc.

**Title: [DRAFT] Report of email discussion [Post111-e][907][ePowSav] UE grouping**

Document for: Discussion and decision

# Introduction

During the RAN2#111-e meeting, RAN2 had online discussions about paging enhancements for UE power saving. Since the UE grouping method is mentioned in the contributions from many companies, RAN2 set up the following email discussion:

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| * [Post111-e][907][ePowSav] UE grouping (Mediatek)

 Scope: UE grouping, put solutions on the table, describe intentions / how they work (high level), and their potential to save power. Possibly take into account R1 evaluation methodology (if they have agreements on the evaluation parameters). Intended outcome: Report Deadline: Long |

In this email discussion, we invite companies to share their views on further details about UE grouping as a paging enhancement method for UE power saving. Moreover, since we received RAN1 LS [1] about the evaluation methodology, the models from RAN1 may be taken into account.

# Discussions

## Paging enhancement with UE grouping

The idea of paging enhancement by UE grouping is to reduce the probability that a UE decodes paging message and realizes that itself is not paged (i.e. the “false alarm” rate), using some kind of sub-group paging indication. Among to the contributions submitted to RAN2#111-e, 14 companies mentioned UE grouping as paging enhancement: Qualcomm [2], vivo [4], Xiaomi [6], Samsung [7], OPPO [8], ZTE [9], CATT [10], SONY [13], MediaTek [14], ITRI [15], CMCC [18], Huawei [19], Lenovo [20], and LG [23]. Therefore, we first discuss whether UE grouping should be considered as a kind of paging enhancement for UE power saving.

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

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| **Company name** | **Yes/No** | **Comments** |
| Ericsson | Depends | It depends how much power saving gains a false paging solution using grouping is going to give, i.e. depends on the outcome of the RAN1 evaluation, whether this enhancement is justified. |
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## Paging for UE subgroups

If UE grouping is considered as a kind of paging enhancement for UE power saving, UEs monitoring the same paging occasion (PO) are divided into subgroups, and the network needs to indicate whether a subgroup of UEs need to monitor paging message. Some contributions in RAN2#111-e provided more details about how to indicate paging for UE subgroups, for example

* Paging for UE subgroups using multiple P-RNTI:
	+ Additional P-RNTI(s) are introduced.
	+ Different UE subgroups monitor paging PDCCHs with CRCs scrambled different P-RNTIs.
	+ Supporting company: Qualcomm [2] **(1)**
* Paging for UE subgroups using different time/frequency resources:
	+ The paging message of different UE subgroups are transmitted on different time/frequency resources.
	+ Supporting company: OPPO [8] **(1)**
* Paging indication for UE subgroups using paging DCI:
	+ In paging DCI, network indicates whether each subgroup of UEs needs to monitor the corresponding paging PDSCH.
	+ Spare bits in paging DCI may be used, or we can define new DCI format.
	+ Supporting companies: vivo [4], Xiaomi [6], Samsung [7], OPPO [8], ZTE [9] **(5)**
* Paging early indication or wake-up signal (WUS) for UE subgroups:
	+ Transmit early indication or wake-up signal before paging occasion. The indication or WUS may apply to a subgroup of UEs.
	+ UE needs not to monitor PO in case of negative indication.
	+ Supporting companies: Xiaomi [6], MediaTek [14], ITRI [15], Huawei [19], LG [23] **(5)**

Note: This email discussion focus on UE grouping, and thus other proposals not related to UE grouping are not shown in the above list.

Although many details of this topic require RAN1 involvement, we think that RAN2 may list candidate solutions, and then inform RAN1 to continue the detailed designs. In the following discussions, we invite companies to share their views about the candidate solutions, and analyse what part of the power consumption can be saved with each solution. Initial justifications, e.g., power saving gain, may also be provided, if available. For both qualitative and quantitative analyses, please take in to account the evaluation methodology from RAN1 [1]. Please also specify your own assumptions beyond what RAN1 suggests.

**Q2: Should we consider “paging for UE subgroups using multiple P-RNTI” as a candidate solution? What part of power can be saved with this method? Please provide initial justifications, if available.**

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| **Company name** | **Yes/No** | **Comments** |
| Ericsson | No | We want to be able to use the full Paging bandwidth and maximum aggregation level for Paging to reach all UEs in the cell reliably. In case different P-RNTIs are used for grouping, this would imply that legacy Paging is impacted, when the NW needs to page legacy UE and one or more REL-17 groups. The WID ([RP-200938](https://www.3gpp.org/ftp/tsg_ran/TSG_RAN//TSGR_88e/Docs/RP-200938.zip)) says that the paging enhancement should not impact legacy Paging. Furthermore paging one or more groups with full BW/aggregation level at the same time may also be prevented.**About the “evaluation methodology from RAN1”:** we think that RAN2 can discuss paging enhancements, but RAN2 should not try to re-do the RAN1 evaluation, i.e. this activity belongs in RAN1. RAN2 can inform RAN1 about the results of RAN2 discussions, but RAN2 cannot perform nor judge the evaluations and assumptions performed by RAN1, i.e. this is outside RAN2 expertise.  |
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**Q3: Should we consider “paging for UE subgroups using different time/frequency resources” as a candidate solution? What part of power can be saved with this method? Please provide initial justifications, if available.**

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| **Company name** | **Yes/No** | **Comments** |
| Ericsson | No | In our understanding spending a few bits in paging DCI, compared to doubling the paging capacity in time or frequency, is a much simpler, less costly, and more effective solution with less impact for the false paging alarms.  |
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**Q4: Should we consider “paging indication for UE subgroups using paging DCI” as a candidate solution? What part of power can be saved with this method? Please provide initial justifications, if available.**

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| **Company name** | **Yes/No** | **Comments** |
| Ericsson | Yes, if… | Yes, provided that this paging enhancement is going to give significant power saving gains. |
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**Q5: Should we consider “paging early indication or wake-up signal (WUS) for UE subgroups” as a candidate solution? What part of power can be saved with this method? Please provide initial justifications, if available.**

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| **Company name** | **Yes/No** | **Comments** |
| Ericsson | No | We think WUS/PEI is a complex solution, with a lot of RAN1 impact, that is not justified for the expected power saving gains.  |
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**Q6: Should we consider any other candidate solution(s) for paging for UE subgroups? What part of power can be saved with the method(s)? Please provide initial justifications, if available.**

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| **Company name** | **Yes/No** | **Comments** |
| Ericsson | Yes | In our understanding a PRNTI/DCI based solution requires a K0>0 configuration for Paging to be effective, i.e. typically UE implementation can otherwise not avoid receiving the Paging PDSCH when it is not paged, which is the whole point of this enhancement. In case a PRNTI/DCI based solution is considered the impact of cross-slot scheduling requires further discussion, i.e. how to avoid impact on legacy Paging when both legacy UE and UE supporting cross-slot scheduling are paged. Furthermore capability signalling aspects need to be considered.  |
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## How to group UEs

If UE grouping is applied, we need to find the methods to divide UEs into subgroups. One prior example of UE-group paging is the Group Wake Up Signal (GWUS) introduced in Rel-16, where a UE selects one WUS group based on its UE paging probability information and /or its UE NAS identity (UE ID). For UE grouping in Rel-17, we may start from these methods.

**Q7: Do you support UE grouping based on UE paging probability information?**

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| **Company name** | **Yes/No** | **Comments** |
| Ericsson | No | It is our understanding that grouping based on paging probably, aims to create groups such that UEs in a group “equally disturb each other”. Perhaps there is some fairness principle in that, but we wonder if it effectively reduces the overall false paging alarms? |
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**Q8: Do you support UE grouping based on UE ID?**

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| **Company name** | **Yes/No** | **Comments** |
| Ericsson | Yes | We think this solution is simple (which fits with the expected power saving gains) and we think this solution is (most like) to be effective.  |
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**Q9: Do you support UE grouping based on any other methods?**

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| **Company name** | **Yes/No** | **Comments** |
| Ericsson | TBD | Mobility, i.e. paging the UE in the complete TA because the UE could not be reached in the cell where the UE was paged before, could have a big impact on false paging (in addition to the fact that more than one UE is monitoring the same PO). But the NW can also use intelligent strategy to page the UE based on past mobility patterns, which in many cases are very predictable/repetitive. It is not clear to us whether grouping based on mobility is needed, i.e. TBD.  |
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**Q10: Do you think UE grouping can be based on multiple methods? If yes, what methods should be supported?**

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| **Company name** | **Yes/No** | **Comments** |
| Ericsson | No | In general we do not specify tens different ways to do the same thing, but we should try to compromise on the “best” solution. We think this enhancement is going to give little gain, i.e. from that perspective different options are not justified. Furthermore multiple options are expected to results in multiple option UE capabilities, which makes deployment of the paging enhancement less likely. For the paging enhancement to be effective, the best option is that it is mandatory support for REL-17 UEs, otherwise the little gain will only be experienced in a few UEs.  |
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## Performance metrics

The purpose of paging enhancements in this WI is to reduce UE power consumption. Therefore, one major performance metric is the power saving gain (PSG), which can be calculated as:

$$PSG=\left(1-\frac{P\_{enh}}{P\_{base}}\right)×100\%$$

where *Pbase* and *Penh* denote the average power consumption of baseline and the enhanced methods, respectively.

In addition to power saving gain, there may be other performance metrics for us to evaluate potential solutions.

**Q11: In addition to power saving gain, what are the performance metrics for us to evaluate potential solutions?**

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| **Company name** | **Comments** |
| Ericsson | * Impact on legacy Paging
* Impact on paging response latency (due to reduced paging reliability e.g. UE misses first Paging attempt of the NW)
* Impact on NW resource allocation
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## Other issues

Both RAN1 and RAN2 are working on the paging enhancement topic. Based on our discussion above, we may need to send some information to RAN1.

**Q12: Based on RAN2 discussions, what information about UE grouping do we need to send to RAN1?**

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| **Company name** | **Comments** |
| Ericsson | We indicated earlier in this email discussion that RAN2 should not re-do the RAN1 evaluation, but RAN2 can discuss paging enhancements and inform RAN1 about the RAN2 result. However we think it is too early to discuss a possible LS to RAN1 at this time.  |
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Finally, please let us know if there is any other issue to be discussed.

**Q13: Is there any other issue about UE grouping to be discussed?**

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| **Company name** | **Comments** |
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# Conclusion

# Reference

1. R1-2007425 LS on evaluation methodology for UE power saving enhancements, RAN1
2. [R2-2006608](https://www.3gpp.org/ftp/tsg_ran/WG2_RL2//TSGR2_111-e/Docs/R2-2006608.zip) Power saving enhancements for paging reception Qualcomm Inc
3. R2-2006654 UE power saving for paging procedures ETRI
4. R2-2006690 Paging enhancement in idle inactive mode for power saving vivo
5. R2-2006720 Paging enhancements to reduce UE power consumption Intel Corporation
6. R2-2006729 Discussion on UE Power saving for RRC-IDLE and RRC-INACTIVE State Xiaomi Communications
7. R2-2006774 Paging Enhancements to Reduce Unnecessary Paging receptions Samsung Electronics Co., Ltd
8. R2-2006790 Paging enhancement for power saving OPPO
9. R2-2006874 Solutions to reduce unnecessary paging reception ZTE corporation, Sanechips
10. R2-2006990 Considerations on paging enhancements for Power saving CATT
11. R2-2007115 False Paging Mitigation Apple
12. R2-2007116 Wakeup and Paging Reception Apple
13. R2-2007182 Discussion on reduction unnecessary UE paging receptions Sony
14. R2-2008361 Paging Enhancements for UE Power Saving in NR MediaTek Inc.
15. R2-2007249 Discussion on the UE grouping based solution for idle/inactive-mode UE power saving ITRI
16. R2-2007260 Paging enhancement to reduce unnecessary UE paging receptions Ericsson
17. R2-2007261 Exposure of connected mode TRS occasions to Idle and Inactive mode Ericsson
18. R2-2007437 Paging enhancement for idle inactive-mode UE power saving CMCC
19. R2-2007441 Discussion on paging enhancements Huawei, HiSilicon
20. R2-2007468 Consideration on Idle/inactive-mode UE power saving Lenovo, Motorola Mobility
21. R2-2007562 Potential TRS/CSI-RS occasion(s) Nokia, Nokia Shanghai Bell
22. R2-2007563 IDLE / INACTIVE mode UE power saving Nokia, Nokia Shanghai Bell
23. R2-2007990 Paging enhancement for power saving LG Electronics Inc.