3GPP TSG-RAN WG2 Meeting #117 electronic R2-220xxxx

Online, Feb. 21 – March 3, 2022

Agenda Item: 8.9.3.1

Source: MediaTek Inc.

**Title: Report of [AT117-e][004][ePowSav] PEI and paging subgrouping**

Document for: Discussion and decision

# Introduction

This report is for the following offline discussion during RAN2#117-e:

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| --- |
| * [AT117-e][004][ePowSav] PEI and paging subgrouping (MediaTek)   Scope:  Following the on-line discussion on R2-2202769:  a) clarify details on UE behaviour for PEI in last cell, e.g. UE storing last cell info etc, and related TS impacts (can ask input on what need to be clarified).  b) whether we can assume that PEI with no subgrouping is implemented by using PEI + UEID subgrouping with one subgroup, or whether also other variants should be supported.  Treat R2-2203720 (taking into account on-line agreements).  Determine agreeable points, points for discussion if needed  Intended outcome: Report.  Deadline: In time for CB online W2 Tuesday |

In Week1, RAN2 made the following agreements, which should be taken into account in this discussion.

|  |
| --- |
| * PEI + UEID subgrouping is one capability * Network indicates whether UE monitors PEI in last used cell in system information. |

Rapporteur invites companies to provide their comments before **23:59 UTC, Feb. 27 (Sun)**, so as to allow some time report preparation.

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# Discussion

## UE behaviour for PEI in last cell

RAN2 just agreed that the network indicates whether UE monitors PEI in last used cell in system information. A rough description of UE behaviour could be as follows: When PEI-capable UE is released, it monitors the PEI in the same cell if PEI is broadcasted there. Once the UE moves and reselects to another cell, it checks the “last used cell” indication in the new cell, and monitors PEI only if the indication is negative (i.e., PEI is not restricted to the last used cell).

From the online and offline discussions, Rapporteur sees the following discussion points for UE behaviour:

* A UE may reselect to another cell and then reselect back to the last used cell, while keeping Idle/Inactive. Should UE store the “last used cell” information so that it can monitor PEI in the last used cell?
* If UE stores the “last used cell” information, will this information expire? (i.e., is there an associated timer?)
* Can one “last used cell only” indication be applied to all subgroups, or separate indication is needed for each subgroup?
* Do we need “no last cell update” in *RRCRelease* message for NR PEI (similar to *noLastCellUpdate* in *RRCConnectionRelease* for LTE WUS)?
* Implementation in TS: RRC CR rapporteur suggested that we make the “last used cell only” indication cell-specific and broadcast it along with PEI configuration, for example:

PEI-Config-r17 ::= SEQUENCE {

pei-SearchSpace-r17 SearchSpaceId,

po-NumPerPEI-r17 ENUMERATED {1, 2, 4, 8},

payloadSizeDCI-2-7-r17 INTEGER (1..maxDCI-2-7-Size-r17),

pei-FrameOffset-r17 FFS,

firstPDCCH-MonitoringOccasionOfPEI-O-r17 FFS,

subgroupConfig-r17 SubgroupConfig-r17 OPTIONAL, -- Need R

lastUsedCellOnly ENUMERATED {true} OPTIONAL,

...

}

The abovementioned discussion points are formulated into the questions below.

**Q1.1: Should a PEI-capable UE store the “last used cell” information?**

|  |  |  |
| --- | --- | --- |
| Company | Y/N | Comment |
| MediaTek | Y | If UE reselects back to the cell where it was released, it should be able to monitor PEI there even if a “last used cell only” indication is set. |
| Samsung | Y | Agree with MediaTek views. |
| Nokia | Y |  |
| Ericsson | Y |  |
| InterDigital | Y |  |
| Qualcomm | Y |  |
| Apple | Y | This aligns with the definition of “last used cell only” |
| ZTE | Y |  |
| DENSO | Y |  |
| OPPO | Y |  |
| LGE | Y | Agree with MediaTek. |
| CATT | Y or impl. | Network anyways behaves as if the UE didn’t reselect, i.e. it sends the PEI. But from UE perspective, it can actually be left to UE implementation. After all, if UE does not want to recall its last used cell to save complexity, it will not take profit of the PEI sent by the network when it comes back to its last used cell. So it can be viewed as a UE implementation tradeoff. |

**Q1.2: If UE stores “last used cell” information, is there an associated timer for it?**

|  |  |  |
| --- | --- | --- |
| Company | Y/N | Comment |
| MediaTek | N | If a timer is introduced, the network and UE behaviors may be more complicated. |
| Samsung | N | Do not see any need to have timer. |
| Nokia | N |  |
| Ericsson | N |  |
| InterDigital | N |  |
| Qualcomm | N |  |
| Apple | N |  |
| ZTE | N |  |
| DENSO | N |  |
| OPPO | N |  |
| LGE | N |  |
| CATT | N |  |

**Q3: Can one “last used cell only” indication be applied to all subgroups?**

|  |  |  |
| --- | --- | --- |
| Company | Y/N | Comment |
| MediaTek | Y | We do not see the need of finer granularity then cell-specific configuration. |
| Samsung | Y | Do not see any need to have this indication on subgroup level |
| Nokia | Y |  |
| Ericsson | Y |  |
| InterDigital | Y |  |
| Qualcomm | Y |  |
| Apple | Y |  |
| ZTE | Y | No introduce any complicate mechanism for ‘last used cell only’ |
| DENSO | Y |  |
| OPPO | Y |  |
| LGE | Y | No reason to support the finer granularity for this. |
| CATT | Y |  |

**Q1.4: Do we need “no last cell update” in *RRCRelease* message for NR PEI?**

|  |  |  |
| --- | --- | --- |
| Company | Y/N | Comment |
| MediaTek | Y | We can reuse the mechanism. |
| Samsung | - | Not clear why this is needed. |
| Nokia | - | Not clear |
| Ericsson | Y | There needs to be a clear agreement between the UE and the NW what the “last used cell” means. There is a risk for mismatch in case the connection is setup and released without CN involvement. Such scenario was identified for NB-IoT/eMTC (R2-2005985). We also think that the same mechanism can be reused. |
| InterDigital | Y | Agree with Ericsson |
| Qualcomm | Y | We are fine with reusing the corresponding LTE mechanism |
| Apple | Y |  |
| ZTE | Y | As LTE, it is needed. |
| DENSO | Y |  |
| OPPO | No | We don’t understand why this needed. |
| LGE | N | Not needed in NR. UE can just follow the PEI-Config in SIB. |
| CATT | Y but | … we should clarify the interaction with *lastUsedCellOnly* e.g. it is our understanding that if “no last cell update” is present in the release message, UE uses *lastUsedCellOnly* normally i.e., when reselecting a new cell, to check from that cell, whether it should continue monitoring PEI. But if “no last cell update” is absent in the release message, UE monitor PEI neither in the cell where it is released nor in any other reselected cell, irrespective of *lastUsedCellOnly*, right? |

**Q1.5: Can we adopt the proposed RRC configuration for *lastUsedCellOnly*?**

|  |  |  |
| --- | --- | --- |
| Company | Y/N | Comment |
| MediaTek | Y |  |
| Samsung | Y |  |
| Nokia | Y |  |
| Ericsson | Y |  |
| InterDigital | Y | Can alternatively reverse the meaning (so true means UE can monitor in other cells reselection) but either way seems fine. |
| Qualcomm | Y |  |
| Apple | Y |  |
| ZTE | Y |  |
| DENSO | Y |  |
| OPPO | Y |  |
| LGE | Y |  |
| CATT | Y |  |

**Q1.6: Is there any other issue to be discussed for UE behaviors about “last used cell only”? Please also provide your preference or proposed solutions.**

|  |  |
| --- | --- |
| Company | Comment |
| ZTE | We think we need to clarify the actual meaning of the ‘last used cell only’, because the current agreements can not reflect how to use the RRC configuration of ‘lastusedcellOnly’   * Network indicates whether UE monitors PEI in last used cell in system information.   To our understanding, there are two interpretation on this agreements:  1: Upon a cell configured with *lastUsedCellOnly,* it indicates whether all UE released by this cell can use the PEI after re-selection to other cells.  2: Upon a cell configured with *lastUsedCellOnly,* it indicates whether all foreign UEs can use the PEI to receive paging.  To our understanding, the second interpretation maybe majorities’ understanding, so we would like to suggest to reflect the actual intention of the *lastUsedCellOnly* in the following discussion |

## Implementation of PEI with no subgrouping

RAN2 just agreed that “PEI + UEID subgrouping is one capability”. If PEI-capable Ues always support UEID-based subgrouping, it seems that “PEI without subgrouping” can be implemented by having PEI plus UEID subgrouping with one subgroup.

We may first confirm companies’ understanding about the RAN2 agreement of “PEI + UEID subgrouping is one capability”: Does it mean that a PEI-capable UE must support at least UEID-based subgrouping method?

**Q2.1: Do you agree that a PEI-capable UE must support at least UEID-based subgrouping method?**

|  |  |  |
| --- | --- | --- |
| Company | Y/N | Comment |
| MediaTek | Y | This is our understanding about the RAN2 agreement. |
| Samsung | Y |  |
| Nokia | Y |  |
| Ericsson | Y |  |
| InterDigital | Y | Agreement is already clear, the question seems redundant |
| Qualcomm | Y | “PEI-capable UE” could be interpreted in different ways. But it does simplify both UE and RAN implementation if UE must support at least UE-ID based subgrouping if it supports PEI. |
| Apple | Y | Our understanding based on the agreement is that PEI and UEID based subgrouping go together |
| ZTE | Y |  |
| DENSO | Y |  |
| OPPO | Y |  |
| LGE | Y |  |
| CATT | Y | Per agreement |

If the answer to Q2.1 is ‘yes’, we would like to know if network can implement “PEI without subgrouping” by configuring PEI plus UEID subgrouping with one subgroup (and no CN-assigned subgroups). That is, in *PEI-Config*, *subgroup-Config* is present, and Nsg-UEID = 1.

**Q2.2: If PEI-capable UEs always support UEID-based subgrouping, do you agree that “PEI without subgrouping” can be implemented by configuring PEI plus UEID subgrouping with one subgroup?**

|  |  |  |
| --- | --- | --- |
| Company | Y/N | Comment |
| MediaTek | Y | Then we need an additional rule: UEs with CN-assigned subgroup ID should derive UEID-based subgroup ID when monitoring PEI in a cell supporting only UEID-based subgrouping. |
| Samsung | Y |  |
| Nokia | Y | Agree with MediaTek. But it should be supported anyway for more than one subgroup case as well since it is possible that UE support CN assignment and UE-ID based while the cell support UE-ID only. |
| Ericsson | Y | We are fine with either this, or that the subgrouping configuration is absent. Note that for both of these cases (if NW uses either 0 or 1 group) RAN1 has already defined that that there will be one bit in PEI that the UEs follow, see highlighted below:   * The paging indication field of PEI DCI format comprises of *POnumPerPEI* segment(s) of *K* bit   + *K* = 1, if  is absent or set to 0 or 1,  * + *K* = , if  is configured. |
| InterDigital | Y | Agree with Ericsson that either of those ways work fine. Also agree with Mediatek – if the cell configures only UE-ID based then this is what UE should use even if it has an assigned CN based subgroup. |
| Qualcomm | Y | Agree with both MediaTek and Ericsson. |
| Apple | Y | In this case, we understand that the specific bit corresponding to K=1 is used to carry the paging indication to that single (implicit) subgroup |
| ZTE | Y | With the agreement that there is only one capability for PEI and UE ID based subgrouping, it is for sure that there are two UE types:  1: PEI+UE ID based subgrouping  2: PEI+UE ID based subgrouping+CN assigned subgrouping  The main intention of ‘PEI configuration without subgoupConfig’ is to wake up all PEI capable UEs based on the assumption of separate capabilities of UE ID based subgrouping and CN assigned subgrouping. If CN assigned subgrouping capable UE must support UE ID based subgrouping, the PEI with out subgroupConfig become non-sense since PEI+ 1 UE ID subgroup can realize the intention. |
| DENSO | Y | And we think the NW can also configure PEI with one CN-assigned subgroup to implement “PEI without subgrouping”. That is, *subgroup-Config* is present and *subgroupsNumPerPO* = 1, but Nsg-UEID is absent in *PEI-Config*. |
| OPPO | Y |  |
| LGE | Y |  |
| CATT | Y | Agree with Ericsson and MediaTek. |

Another way to implement “PEI without subgrouping” is to have *subgroup-Config* absent in *PEI-Config*. If the answer to Q2.2 is ‘yes’, we will have two method for network to implement “PEI without subgrouping”.

**Q2.3: Should we allow multiple methods for network to implement “PEI without subgrouping”?**

|  |  |  |
| --- | --- | --- |
| Company | Y/N | Comment |
| MediaTek | N | We’d like to keep thing simple. In RAN1 discussion of (PDCCH-based) PEI format, RAN1 implicitly assumed that every UE has a subgroup ID, and a corresponding bit is used for paging indication. What described in Q2.2 can be considered as the only implementation for “PEI without subgrouping”. Then *subgroup-Config* must present in *PEI-Config*. |
| Samsung | N |  |
| Nokia | N | Depends on the result of Q2.1. and Q2.2 whether *subgroup-Config* absent in *PEI-Config* needs to be supported. |
| Ericsson | N | One method is enough. However, we are fine with any of the two methods discussed. None of these methods have impact on RAN1 either as indicated by us in Q2.2. |
| InterDigital | N |  |
| Qualcomm | N | We have the same comment as Ericsson |
| Apple | N | In the interest of keeping it simple, this one method is enough |
| ZTE | N |  |
| DENSO | N |  |
| OPPO | Y | Why do we need to restrict network’s implementation if both methods work and have no impact on RAN1. |
| LGE | N |  |
| CATT | N | We also prefer to keep things simple. We would then have a slight preference for the method of Q2.2 (*PEI-Config*, *subgroup-Config* is present, and Nsg-UEID = 1). |

## Proposals in R2-2203720 (AI summary)

AI summary for 8.9.3.2.1 is provided in [1], where we have the following proposals:

|  |
| --- |
| Easy agreements  **Proposal 1: When PEI is applied with eDRX, the UEID for UEID-based subgrouping is determined by 5G-S-TMSI mod 32768.**  **Proposal 2: No special handling or configuration is introduced for PEI monitoring with PTW (i.e., PEI is applicable to each PO within PTW)**  **Proposal 4: No additional handling for PEI and PO monitoring is introduced, even if certain gNB within a RNA does not support CN controlled subgrouping.**  **Proposal 5: UE PHY processing for DCI format 2\_7 is the same for PEI without subgrouping and PEI with one subgroup if UE monitors PEI.**  For discussion  **Proposal 3: RAN2 to check PEI-related signaling between AMF and UE, between AMF and gNB, and between gNBs, and decide if LS to SA2/CT1/RAN3 is still needed.**  **Proposal 6: RAN2 to confirm the configurations and PEI/PO monitoring for different cases with “K=1”.**  **Proposal 7: RAN2 discuss the following proposals about PEI configurations:**   * + **(a) PEI configuration is included in SIBx currently proposed for TRS resource configuration.**   + **(b) CN informs RAN about the number of *subgroupsNumPerPO* to use for the CN-assigned subgrouping.**   + **(c) Network can optionally configure a separate set of PO(s) dedicated to Rel-17 UEs with new paging capabilities.**   + **(d) Network can configure dedicated POs for UEs supporting PEI and K0>0 via a second set of ns, and/or *nAndPagingFrameOffset* and/or *firstPDCCH-MonitoringOccasionOfPO* parameters.**   + **(e) If configured by the NW, UE indicates whether PEI is currently useful for the UE.** |

First, we would like to know if the “easy agreements” in [1] can be accepted.

**Q3.1: Can we accept the “easy agreements” in [1]?**

|  |  |  |
| --- | --- | --- |
| Company | Y/N | Comment |
| MediaTek | Y |  |
| Samsung | Y |  |
| Nokia | Y | Proposal 5 depends on the discussion whether we have the case of PEI without subgrouping in Q2.3 for P5. We might not need PEI without subgrouping if all the PEI UEs supports at least UE-ID based |
| Ericsson | Y |  |
| InterDigital | Y | For p5, it is true that both approaches are equivalent, but the proposal is redundant if we solve Q2.2/2.3 |
| Qualcomm | Y |  |
| Apple | Y |  |
| ZTE | Y |  |
| DENSO | - | P4: If the anchor gNB does not support CN controlled subgrouping but the current gNB and UE does, additional handling for PEI and PO monitoring may need to be introduced. If this case is valid, the anchor gNB doesn’t transmit CN-assigned ID via Xn interface, so UE cannot use PEI with CN controlled subgrouping in RAN paging. On the other hand, considering CN paging includes CN-assigned ID, it is necessary to clarify which subgroup ID in PEI field the UE should monitor.  If the configuration for supporting CN controlled subgrouping is the same in all cells within RNA, P4 is fine. |
| OPPO | Y |  |
| LGE | Y |  |
| CATT | Y | Agree with Nokia. P5 may no longer matter. |

Then regarding the “for discussion” proposals in [1], rapporteur thinks that

* “Proposal 3”: We may discuss here is LS to RAN3/SA2/CT1 is need.
* “Proposal 6”: This overlaps with the “PEI without subgrouping” discussion above, so it can be skipped.
* “Proposal 7”: These are proposals extracted from [2]. It may be a bit late to discuss them, but we may still consider some of them if we see a good support.

**Q3.2: Do we need to send LS to RAN3/SA2/CT1?**

|  |  |  |
| --- | --- | --- |
| Company | Y/N | Comment |
| MediaTek | Y | We believe that at least they need to know RAN2 agreements about UE capability. We can send a copy of RAN2 agreements after this meeting and let them check if any work is needed. |
| Samsung | Y |  |
| Nokia | Y |  |
| Ericsson | Y |  |
| InterDigital | Y | Seems fine to send informative LS on the agreements |
| Qualcomm | Y |  |
| Apple | Y | Atleast the other groups should be informed about the agreements and the capability aspects that were agreed |
| ZTE | Y |  |
| DENSO | Y |  |
| OPPO | Y |  |
| LGE | Y | Same view as MediaTek. |
| CATT | Y |  |

**Q3.3: Should we agree to any items in “Proposal 7” in [1]?**

|  |  |  |
| --- | --- | --- |
| Company | Items (a)-(e) | Comment |
| MediaTek | (b) | It seems that this has been implemented by SA2/CT1 |
| Samsung | (b) |  |
| Nokia | (a), (b) | For (a), PEI does not need to be in SIB1 since they are only needed for PEI capable UEs and not urgent. RAN2 already agreed segmentation for SIBX, so size should not be a concern.  For (b) it could be useful information for RAN to take into account for the subgroup configurations. |
| Ericsson | (a), (b), (c), (d), (e) | (a) unnecessary to pollute SIB1 with high-rate transmission with non-essential PEI configuration  (c)/(d) important for the NW to be able to concentrate PEI capable UEs to same POs. Benefit for the NW is less PEI transmissions (only PEI transmission for Pos with PEI capable UEs), benefit for legacy UEs is that there will be less false paging messages for them if they are in separate POs.  (e) As indicated similarly for TRS in the meeting, we don’t want to implement features that are not used by the UEs. Even if UEs indicate that they are capable of PEI, it does not mean that they are actually using them. For example, if they are in sufficiently good coverage, they will most probably not use PEI (this has clearly been indicated by UE vendors). We don’t want to transmit PEI in vain, we could introduce a very light weight mechanism with piggybacking on existing signaling, e.g. in a paging response whether UE is using PEI. |
| InterDigital | (b)  Maybe (c), (d) | For, (a) we do have sympathy with the comments from Nokia and Ericsson, the information is not essential for access. However, this is logically part of the paging common configuration, and also putting it into the new SIB means the UE has to acquire potentially large amount of information even if it does not support the TRS resource config creating a feature dependency.  For (c)+(d) this may allow NW to more efficiently manage the paging resources and it seems not much effort to implement the signalling, however it seems not essential and does introduce additional broadcast overhead, if configured. It would be fine if we do also have (a) but otherwise maybe not.  For (e) we would assume PEI is always useful if it is supported, in idle mode the UE moves between better and worse coverage without sending any indication so it is not clear how this helps the network decide whether to use PEI. The example given by Ericsson in paging response sounds like a SON/MDT enhancement, maybe it could be considered later. |
| Qualcomm | (b) and (d) | (b) can be useful for RAN in its configuration of paging subgroups.  (d) helps enable cross-slot scheduling for paging message, which can help UE save more power in paging reception. Although CSS for paging is a mandatory feature since R15 but it can’t be used in practice because it is mandatory with capability signaling. |
| Apple | 1. and (b) | For (a) with SIB segmentation, sizing restriction is not an issue  For (b) it would be useful for gNB to have this information |
| ZTE | b | Seems only B is needed according to the current situation |
| DENSO | (b) |  |
| OPPO | None | We don’t think (b) is needed. subgroupsNumPerPO is configured by RAN. How can CN inform RAN of this? |
| LGE | b |  |
| CATT | None | (a): SIB1 contains some important and necessary info, e.g. info for initial access, scheduling info of other SIB, info for paging reception and so on. PEI doesn’t change frequently. And overhead of PEI is small. There is no motivation to broadcast it with on-demand. But if it is included in SIB-X, PEI feature will be impacted by the update of TRS configuration, which can be frequent because TRS is shared with Connected UEs. For example: If TRS configuration needs to be updated while PEI configuration is unchanged, PEI feature cannot be used until SIB-X is received successfully. So if PEI configuration is included in SIB-X, it will impact the effectiveness of PEI feature.  (b): Agree with MediaTek  (c) (d) (e): non-essential optimizations at this late stage. |

## Other comments

**Q4.1: Please provide your comments here.**

|  |  |
| --- | --- |
| Company | Comment |
| MediaTek | By confirming that a PEI-capable UE must support at least UEID-based subgrouping, we can eliminate many cases of “RAN-UE mismatch”. If UE still cannot find its subgroup ID (e.g., UE supports UEID-based subgrouping only, but RAN configures CN-assigned subgrouping only), we suggest that RAN2 confirm that UE monitors legacy paging. |
| Samsung | Agree with MediaTek |
| Nokia | Assuming same number of CN assignment subgroups for all the cells seems to put too much restrictions to the NW since it has been agreed each cell can decide its own configuration. As long as we define the behavior that the UE monitors legacy if the UE cannot find corresponding bit in PEI, it covers already the case of if the bit allocated for CN is less than the CN assigned ID of the UE without remapping. |
| Ericsson | Agree with Mediatek |
| InterDigital | Agree with Mediatek |
| Qualcomm | We are fine with MediaTek’s proposal, |
| Apple | Agree with Mediatek, that in case of any mismatch UE falls back to legacy paging monitoring. This is also in line with one of RAN2 earlier agreement on this topic |
| ZTE | Fine with MTK’s proposal. |
| DENSO | Agree with MediaTek. |
| LGE | Agree with MediaTek |
| CATT | We agree that only Case 3 from OI 1.2 is left after the capability agreement, i.e. when a cell only supports CN-assigned subgrouping.  However, here again, we would prefer a solution where the UE can benefit from the PEI, rather than the legacy fallback. So we would suggest 2 possibilities:  - Option 1: Same as for the UE cap: if RAN supports PEI, it also supports at least UEID-based subgrouping (if we were able to agree this for a UE, it should then be straightforward for the network)  Or:  - Option 2: UE falls back to only monitoring its PO by e.g. using 1st subgroup of the bitmap (i.e. it uses *iSG* = 0) which requires no RAN1 specification change and can be captured in 38.304.  Proactively addressing comments on option 2:  - It does not require transmitting multiple PEIs (PEI for “fallback” UEs and PEI for CN-assigned UEs) since a single PEI can anyways indicate different subgroups of the same PO via setting different bits of the bitmap.  - It does not disturb the CN-assigned subgroups if CN implementation chooses to allocate CN-assigned UEs in subgroups starting with *iSG* = 1 onwards. Alternately, CN implementation may choose to also allocate *iSG* = 1 to UEs not meeting any of its classification criteria, kind of “default” bin (as an example). |

# Conclusion

It is proposed to discuss and decide on the following proposals:

# Reference

1. R2-2203720, “Summary of 8.9.3.2.1 PEI and Paging Subgrouping,” MediaTek
2. R2-2203252, “PEI and paging subgrouping,” Ericsson