3GPP TSG-RAN WG2 Meeting #117 electronic R2-2202769

Online, Feb. 21 – March 3, 2022

Agenda Item: 8.9.3.1

Source: MediaTek Inc.

**Title: Summary of [Pre117-e][004][ePowSav] PEI and paging subgrouping**

Document for: Discussion and decision

# Introduction

After last meeting, a list of open issues has been summarized in [1]. The following open issues are considered as “Company tdocs invited”

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| --- |
| OI 1.1: How to indicate whether UE monitors PEI in last used cell or any other cells?  OI 1.2: Identify valid cases where UE is unable to monitor subgroup PEI configured by network. Then decide if there can be any rule for subgroup PEI monitoring, or UE simply monitor paging as per legacy.  OI 1.3: RAN2 assumes that PEI can be used “without” subgrouping. FFS whether the bits in the PEI for subgrouping then need to have any particular meaning, or whether this would be done by just having one subgroup. |

Here we invite companies to share their views on the above open issues.

**Deadline: Feb 14th, 2359 UTC**

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# Discussion

OI 1.1: How to indicate whether UE monitors PEI in last used cell or any other cells?

The options mentioned by companies in last meeting included:

Option 1: Indication in system information

Option 2: Indication in *RRCRelease* message

Option 3: Indication via NAS message

|  |  |  |
| --- | --- | --- |
| Company | Preferred option | Comment |
| MediaTek | Option 1 | The reason to have “last used cell” restriction is to “protect” stationary UEs in a cell, that is, not to wake them up due to paging for a moving UE reselecting to this cell. Therefore, the decision (whether to do PEI service for “foreign” UEs) should be made by each cell. This is also a simple approach with low signalling overhead.  Notice that according to TS 36.304 Sec. 7.4, Paging with Wake Up Signal is only used in the cell in which the UE most recently entered RRC\_IDLE. Our understanding about the parameter *noLastCellUpdate* in *RRCConnectionRelease* is that it does not serve as an indication to UE for WUS monitoring in other cells. Instead, it deals with the case where a UE could be unreachable for a period if it remains in the same cell, after a release occurs and the S1 connection was not established (i.e., eNB was not able to provide the “last cell information” to the MME at release). UE receiving the *noLastCellUpdate* indication continues to use WUS if it was using WUS in this cell before it initiated RRC connection, otherwise it does not use WUS. Please see corresponding TS 36.304 CR 0796 (R2-2008593). |
| InterDigital | Option1 | This is idle/inactive, it should be in SI. |
| Samsung | Option 1 |  |
| OPPO | Option 1 |  |
| CATT | Option 1 | Make it 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,  ...  } |
| Intel | Option 1 | Since it is controlling the load of the current camped cell for UE in idle and inactive mode, the indication should be on the current camped in the SI whether to allow for PEI mobility. |
| Ericsson | Option 1 |  |
| Qualcomm | Option 1 | In addition, we think RAN2 should send a LS to SA2 and RAN3 about this issue, because it does have impact on those WGs. |
| ZTE | Option 1 |  |
| vivo | Option 1 | There are some open issues need to be addressed.  First, if we introduce the “last used cell” restriction, the definition of “last used cell” should be clarified. According to TS 36.304 Sec. 7.4, the “last used cell” is the cell in which the UE’s RRC connection was last released/ suspended, and the “last used cell” can be updated if without the parameter *noLastCellUpdate* in RR*CConnectionRelease.* Here in NR, the similar definition can be kept, i.e the “last used cell” is the cell in which the UE’s RRC connection was last released/ suspended.  Second, which cell indicates the range of PEI usage? e.g. UE reselects from the source cell to one target cell. The target cell may broadcast SI, it indicates the PEI usage for “foreign” UEs. |
| Nokia | Option 1 |  |
| NEC | Option 1 | This is a simple approach that each PEI capable Cell broadcast whether the PEI is used in last cell or not.  From UE perspective, UE just simply follow the system information.  From NW perspective, NW can based on paging escalation policy (e.g. Recommended Cells, Paging Attempt Information) to decide how to page UE. |
| CMCC | Option 1 |  |
| Huawei, HiSilicon | Option 1 | Additionally, PEI related assistance information will have to be included in the RAN paging message, when the PEI monitoring is not limited to the last used cell. Hence we think at least we should send a LS to inform RAN3 about it. |
| Xiaomi | Option 3  Or leave to SA2 | The difference of option1 and option3 is which node will provide the PEI policy.  For option3:  The CN can be the node since it knows UE’s paging probability and stationary state. If a group is consist of UEs of high paging probability and high mobility, then CN can indicate to UE belonging to this group not to use the PEI during moving across the cells of a TA.  For example, for UE( using PEI only to the last used cell), CN will provide the PEI related assistance information (PEI only to the last used cell, including UE’s PEI capability and subgrouping ID) as well as Recommended Cells to gNB, and gNB only page UE in the last used cell. And when paging escalation, CN will not provide the PEI related assistance information to gNB other than the last used gNB. And for RAN paging, since the anchor gNB can get the PEI related assistance information from CN and if it knows that UE is only use PEI in the last used cell, there will be no PEI related assistance information carried in the RAN paging message.  For option1:  Yes, the gNB can simply broadcast that my PEI is only used for local UE or not. But how can the gNB properly sets the flag? gNB does not know any the mobility and paging probability of the UE camped on it.  In my understanding, only the UEs with high paging probability and high mobility state will be restricted to use PEI in the last used cell because using PEI during paging escalation causes a lot of PEI transmissions. The UEs with low paging probability or low mobility state can still use PEI after cell reselection. That is the flexibility that people want in the previous discussions. So the NW controlling should be in a finer granularity.  Additionally, the PEI related assistance information anyway will have to be included in the RAN paging message since gNB do not know the PEI policy of another gNB.  So we think we need to take a second thought. And we also noticed that in LTE, this issue is initiated from SA2 not in RAN2. We can accept that SA2 to evaluate it. |
| Futurewei | Option 1 |  |
| DENSO | Option 2 | Option 2 is preferred. Option 2 has a benefit of configuring to monitor PEI in the last used cell or any other cells per UE. If the network knows that UE is stationary (e.g. subscription information), the network can configure to monitor PEI in the last use cell only. Otherwise, the UE is configured to monitor PEI in any cells. So, the network has the flexibility based on UE mobility characteristic.  If the majority prefers Option 1, it is acceptable. However, it has to be clarified whether the indication in SI is the same across all the cells or it is allowed to be different. If the indication is different between cells, the UE behaviour needs to be clarified upon receiving different indication from the last cell after cell reselection. A simple approach is that the UE follows the SI indication in the cell where the UE entered RRC\_IDLE/INACTIVE. |
| LGE | Option 1 |  |
| Apple | Option 1 |  |
| Sequans | Option 3,  Maybe option 1, depending on understanding | Generally agree with Xiaomi.   * Option 1 is a bit weird from granularity PoV – * If the SI indication means “PEI in this cell is only initiated for UEs released in this cell” then it basically breaks the not-in-last-used-cell PEI; in other words, (non-contiguous?) areas where PEI is/is not used outside the last cell are created. This doesn’t seem to make much sense from UEs that want to enjoy the not-in-last-cell PEI, and it does not protect low-powered UEs in some areas. * If the SI indication means “PEI for UEs released in this cell is limited to this cell only”, then at least UE behavior will be more consistent when moving, but this does not protect UEs in the current cell from UEs in other cells. * If the SI indication means both, then we are fine with it, but it seems a quite deprecated solution. Otherwise some more discussion is needed to make sure companies agree on the meaning   So, all in all, it seems better to look for a UE-specific rather than a cell-specific solution   * Option 3 – CN is the correct entity to assess the impact of the UE mobility. * Option 2 is similar to option 3, but the gNB does not have the necessary information.   We also think that in any case this has impact on other groups, and we should send an LS to SA2 and RAN3 |
|  |  |  |

Summary

Totally 20 companies provided their answers to this question.

* Option 1: 17
* Option 2: 1
* Option 3: 2

Considering clear majority, we suggest RAN2 agree to Option 1, i.e., network indicates whether UE monitors PEI in last used cell in system information.

**Proposal 1: Network indicates whether UE monitors PEI in last used cell in system information.**

OI 1.2: Identify valid cases where UE is unable to monitor subgroup PEI configured by network. Then decide if there can be any rule for subgroup PEI monitoring, or UE simply monitor paging as per legacy.

Several cases where UE is unable to monitor subgroup PEI configured by network are listed in [2], based on companies’ contributions in last meeting.

|  |  |  |
| --- | --- | --- |
| Case | UE supports | Cell supports or configures |
| 1 | Only PEI, no subgrouping | PEI with subgrouping indication |
| 2 | Only CN-assigned subgroup, but ID not assigned | PEI with UEID-based subgrouping methods (with or without CN-assigned subgrouping) |
| 3 | Only UEID-based subgrouping; or both subgrouping methods but CN does not assign ID | PEI with only CN-assigned subgrouping |
| 4 | Only CN assigned subgrouping, with ID | Only UEID based subgrouping is configured |

For each case, we first check if it is a valid configuration. If yes, we discuss how UE should monitor PEI and PO.

**Q2: Is Case#1 a valid configuration? If yes, how should UE monitor PEI and PO?**

|  |  |  |
| --- | --- | --- |
| Company | Valid (Y/N)? | PEI & PO monitoring |
| MediaTek | N | We have a bitmap-based PEI (DCI format 2\_7), which implies that UE supporting PEI is able to read the bitmap. Then it’s reasonable that UE supporting PEI supports at least one kind of subgrouping method. A more reasonable implementation is to support both methods. |
| InterDigital | N | Agree with Mediatek, if UE is able to receive the PEI then it should be able to understand the bitmap. No strong opinion how to configure (See Q7) |
| Samsung | N | Agree that UE supporting PEI should also support subgrouping |
| OPPO | Y | This is related to UE capability. In our view, if we decouple UE capabilities for paging subgrouping and PEI, UE may choose whether to support PEI only or support both features, which would be more flexible for UE implementation.  Then, in case#1, since UE has no corresponding PEI indication bit in DCI format 2-7, UE should monitor paging as legacy. |
| CATT | Y | Supporting only PEI should be a valid capability for a UE. RAN1 showed that subgrouping provides little additional power saving benefit on top of PEI, however requires implementing the mechanism for reading the subgroup from PEI as well as the associated NAS signalling procedure (for CN-assigned), the cases of fallback to UEID-based when a cell UE reselected does not support CN-assigned (or vice-versa), etc.  And if both UE and NW support PEI, it seems to us very restrictive to prevent the UE from the power saving benefits of the PEI. So different from OPPO, we support that in this case, UE only monitors its PO in PEI, which corresponds to K=1 and *iSG* = 0 in clause 10.4A of 38.213. Note this does not require changing RAN1 spec and can be handled in 38.304. |
| Intel | N | Agree with MediaTek. In our understanding of RAN1 LS[R1-2200768], RAN1 does not currently support PEI only without subgrouping as there is currently no subgroup index just for PEI “without” subgrouping. Hence if a cell supports PEI and subgrouping, such UE will end up monitoring legacy paging since all the subgroups in the PEI are used by subgrouping methods in the cell. |
| Ericsson | No, but | We also think when UE supports PEI, it should support subgrouping. However, if RAN2 concludes that PEI can be supported by a UE without subgrouping support, we think there could be two solutions (of which one should be chosen):   1. The UE wakes up at the PO in case of PEI reception (CRC match), irrespective of the PEI contents. 2. The UE always wakes up at the PO. |
| Qualcomm | Y | RAN2 already agreed that PEI can be used “without” subgrouping.  A UE which supports only PEI can still process PEI. For example, a possible implementation is that as long as any bit in the bitmap associated with its PO is TRUE, it wakes up to monitor its PO. Such a UE behavior has no impact on the current PEI design. |
| ZTE | N | RAN1 have sent a LS to us, see below:  *If a separate FG for component 2 is introduced, then for a UE supporting FG29-1 and not supporting UE subgroup indication (i.e. UE supporting component 1 only), subgroup index to be received by the UE is undefined in current RAN1 specification. Introducing a separate FG for component 2 would require further RAN1 specification work*.  So we do not think this is a valid scenario. |
| vivo | Y | As we agreed in RAN2#116bis-e, PEI can be used without subgrouping. We think the UE may only support PEI, but not support subgrouping.  In this case, the UE could still process PEI. Considering the UE not supporting subgrouping cannot identify the bit in DCI 2\_7, we could define an approach how to implement the PEI, e.g. once the PEI is received by the UE, then, the UE should wake up for PO monitoring. But this detailed behaviour could be left to RAN1. |
| Nokia | N | UE supporting PEI should at least support subgrouping. |
| NEC | N | Agree with MTK, as subgrouping belongs to PEI mechanism, if PEI including *subgroupConfig*, there is no reason that PEI-capable UE does not support subgrouping. |
| CMCC | N | This is somehow related to the discussion about UE capability. Based on the LS from RAN1, we prefer that UE supporting PEI also supports subgrouping. |
| Huawei, HiSilicon | N | We think this case does not exist. PEI and subgrouping should be coupled based on current RAN1’s UE feature design. |
| Xiaomi | No | This depends on the outcome of [Pre117-e][007][ePowSav] UE capabilities. If PEI and subgrouping are in the same FG, then case1 is invalid.  And RAN1’s LS has captured:  If a separate FG for component 2 is introduced, then for a UE supporting FG29-1 and not supporting UE subgroup indication (i.e. UE supporting component 1 only), subgroup index to be received by the UE is undefined in current RAN1 specification. Introducing a separate FG for component 2 would require further RAN1 specification work.  So we prefer PEI and subgrouping are in the same FG.  Some people argued that we agreed in RAN2#116bis-e, PEI can be used without subgrouping. But that is the NW’s capability not UE’s capability.  When the NW broadcast PEI without subgrouping, it can wake up all the UEs that support subgrouping. |
| Futurewei | N | We also think that a UE supporting PEI should support at least one of the two subgrouping methods. |
| DENSO | N | We think UE supporting PEI should also support subgrouping. |
| LGE | N | Though RAN2 agreed PEI can be used “without” subgrouping, this doesn’t mean we support a separate UE capability to support ‘PEI without subgrouping’. If UE support the PEI without subgroup, the UE should support either CN-assigned subgroup or UE-IE based subgroup.  The agreements means that UE can use the PEI without subgroup as a WUS when NW transmits the PEI without subgroup. |
| Apple | Y | In that case we assume that there is an implicit subgroup of 1, where in UE tries to decode all the bitmap to check if the PO is intended or not. |
| Sequans | No (currently), but OK to change | We agree with the understanding that RAN1 has not specified this scenario. However, a solution is quite simple (only CRC needs to be checked, no bits need to be set), so we are fine to decouple the two; if this is agreed, it should be agreed as RAN2 preference and indicated to RAN1 for confirmation/further work. |

Summary

Totally 20 companies provided their answers to Q2, among them 15 companies don’t think it’s a valid configuration to have UE supporting PEI but not subgrouping, while network configures PEI with subgrouping. Since this is related to UE capabilities, rapporteur suggests that we follow conclusions from corresponding discussions (e.g. [Pre117-e][007]).

**Proposal 2: (Discussion) Whether to allow UE supporting PEI but not subgrouping depends on conclusions from UE capabilities discussions.**

**Q3: Is Case#2 a valid configuration? If yes, how should UE monitor PEI and PO?**

|  |  |  |
| --- | --- | --- |
| Company | Valid (Y/N)? | PEI & PO monitoring |
| MediaTek | Y | In this case, UE cannot determine its subgroup ID, so UE monitors legacy paging. |
| InterDigital | N | We think that UE should always support at least UE-ID based grouping. With the same logic as in Q3, if UE supports PEI then it should understand the bitmap – calculation of UE-ID based subgroup is a simple operation that would not need separate IoT testing compared to e.g. CN based or compared to PEI without any grouping. This also simplifies things somewhat and avoids unnecessary market fragmentation and UE types.  However, agree with Mediatek that if CN group has not been assigned, and only CN method is configured in RAN then UE should use legacy paging monitoring. |
| Samsung | Y | RAN2 #116bis agreement: Separate indications for UE capability of CN based subgrouping and UEID based subgrouping |
| OPPO | Y | In this case, UE has no subgrouping ID, so the UE should monitor paging as legacy. |
| CATT | Y | In this case, UE cannot determine its subgroup ID, so UE only monitors its PO in PEI, i.e. K=1 and *iSG* = 0 in clause 10.4A of 38.213. Note this does not require changing RAN1 spec and can be handled in 38.304.  Same view as for Q2: if both UE and NW support PEI, it seems to us very restrictive to prevent the UE from the power saving benefits of the PEI. |
| Intel | Y | In this case, as all the subgroups in the PEI are used by CN based subgroups or UEID based subgroups in that cell, the UE supporting only CN based subgrouping with no CN subgroup ID will have to monitor PO directly as per legacy. |
| Ericsson | Y | As in Q2, we think one of the 2 solutions could be the way forward. |
| Qualcomm | See comment | We are not sure if the case where UE supports CN assigned subgrouping but does not have any subgroup ID assigned should be allowed.  If companies think it should be allowed, then we think it is necessary to capture in agreements that if UE supports both CN assigned and UE-ID based subgrouping but UE does not have a CN assigned subgroup ID, then UE should use UE-ID based subgrouping. |
| ZTE | Y | Legacy definitely |
| vivo | Y | As we agreed separate capability for CN assigned and UE-ID based subgrouping, this case is valid. But the UE cannot determine its subgroup considering different capabilities. In this way, UE needs to monitor paging as legacy. |
| Nokia | Y |  |
| NEC | Y | Same view as Samsung, separate capabilities means UE may not support UE-ID based subgrouping. In this case, UE monitor legacy PO if network does not assign CN subgroup ID. |
| CMCC | Y | We have agreed separate UE capability for CN-based subgrouping and UEID-based subgrouping. Since UE is capable of subgrouping, it supports the PEI. It is possible to utilize the PEI with one common group. However, to simplify the procedure, we agree with MTK that UE uses the legacy paging monitoring. |
| Huawei, HiSilicon | Y | For this case UE does not have a subgroup ID allocated, so the UE should monitor paging as legacy. |
| Xiaomi | Y | For the case UE does not have a subgroup ID allocated by CN, the UE needs to use the UEID-based subgrouping method, but the UE is CN assigned subgrouping capable only, thus the UE use the legacy paging. |
| Futurewei | depends on if UEID-based subgrouping is mandatory for UEs or not | Assuming the use case is valid, the UE monitors legacy paging, not PEI. |
| DENSO | Y | Agree with MediaTek and Samsung. UE can support CN based subgrouping or UE\_ID based subgrouping or both. |
| LGE | Y | This scenario is valid since RAN2 agreed gNB/UE can support only one subgrouping. |
| Apple | Y | Same comment as MediaTek |
| Sequans | Y | UE should monitor legacy paging |

Summary

Totally 20 companies provided their answers to this question, among them 17 companies think that Case 2 is a valid configuration, 3 companies think that UEID-based subgrouping should be mandatory. Also, most companies think that UE should monitor legacy PO in this case, while one company thinks that PO monitoring may also depend on PEI reception.

Since we have agreed to have separate UE capabilities for CN-assigned and UEID-based subgrouping, rapporteur suggests that we confirm the validity of UE configuration in Case#2, and UE monitors legacy paging (i.e., not deriving UEID-based subgroup ID) in this case.

**Proposal 3: When UE supports only CN-assigned subgrouping but subgroup ID is not assigned, it monitors legacy PO (i.e., not deriving UEID-based subgroup ID) in a network supporting UEID-based subgrouping.**

**Q4: Is Case#3 a valid configuration? If yes, how should UE monitor PEI and PO?**

|  |  |  |
| --- | --- | --- |
| Company | Valid (Y/N)? | PEI & PO monitoring |
| MediaTek | Y | In this case, UE supports UEID-based subgrouping, but the cell does not. UE cannot determine its subgroup ID, so UE monitors legacy paging. |
| InterDigital | Y | CN based grouping should be optional. Support of UE-ID only is a valid case. Agree with Mediatek that if UE does not support CN grouping but cell configures only CN grouping (no UE-ID subgroups available), then UE should monitor as per legacy (this is the same as Q3 – CN group not supported or not configured should be handled the same way) |
| Samsung | Y |  |
| OPPO | Y | In this case, UE has no subgrouping ID in this cell, so the UE should monitor paging as legacy. |
| CATT | Y | In this case, UE cannot determine its subgroup ID, so UE only monitors its PO in PEI, i.e. K=1 and *iSG* = 0 in clause 10.4A of 38.213. Note this does not require changing RAN1 spec and can be handled in 38.304.  Same view as for Q2: if both UE and NW support PEI, it seems to us very restrictive to prevent the UE from the power saving benefits of the PEI. |
| Intel | Y | In this case, as all the subgroups in the PEI are used by CN based subgroups in that cell, the UE with no CN subgroup ID configured or only UEID based subgrouping support will have to monitor PO directly as per legacy. |
| Ericsson | Y | As in Q2, we think one of the 2 solutions could be the way forward. |
| Qualcomm | Y | UE should skip PEI and monitor POs |
| ZTE | Y | Legacy |
| vivo | Y | Similar as case#2, this case is valid, and the UE needs to monitor paging as legacy. |
| Nokia | Y |  |
| NEC | Y | In this case, UE should monitor legacy PO if network does not assign CN subgroup ID (including UE only support UE-ID based). |
| CMCC | Y | Share the same view for Q3. Monitor POs as legacy. |
| Huawei, HiSilicon | Y | For this case UE cannot determine subgroup ID within the cell, so the UE should monitor paging as legacy. |
| Xiaomi | Y | Similar as case#2.  For the case UE does not have a subgroup ID allocated by CN, the UE needs to use the UEID-based subgrouping method, but the NW is CN assigned subgrouping capable only, thus the UE use the legacy paging. |
| Futurewei | Y | The UE monitors legacy paging, not PEI. |
| DENSO | Y | UE doesn’t monitor PEI and follows legacy paging procedure. |
| LGE | Y | This scenario is valid since RAN2 agreed gNB/UE can support only one subgrouping. |
| Apple | Y | This is the legacy scenario |
| Sequans | Y | UE should monitor legacy paging |

Summary

Totally 20 companies provided their answers to this question. All companies think that Case#3 is a valid configuration. Most companies UE should monitor legacy paging, while one company think that PO monitoring may depend on PEI reception. Rapporteur suggests that we confirm the validity of configurations in Case#3, and UE monitors legacy paging in this case.

**Proposal 4: When UE supports only UEID-based subgrouping, or both subgrouping methods but CN does not assign the ID, UE monitors legacy paging in a cell supporting only CN-assigned subgrouping.**

**Q5: Is Case#4 a valid configuration? If yes, how should UE monitor PEI and PO?**

|  |  |  |
| --- | --- | --- |
| Company | Valid (Y/N)? | PEI & PO monitoring |
| MediaTek | N | In RAN2#115-e, we agreed that  “R2 assumes that All the cells within the registration area supports the same number of CN assigned subgroups, i.e. no remapping of CN assigned group ID to RAN subgroup ID (will revisit only if serious issues are found).”  A reasonable interpretation is that if network assigns subgroup ID to some UEs, all cells in the registration area should support CN-assigned subgrouping, with the same number of subgroups. Otherwise, to obey the RAN2 agreement, none of them supports CN-assigned subgrouping, but this is weird. |
| InterDigital | N | As mentioned above, UE supporting PEI should also support UE-ID based. |
| Samsung | N | Agree with Mediatek |
| OPPO | Depends on different interpretation on the working assumption | For the working assumption made in RAN2#115-e, another interpretation is that all the cells within the registration area **which support CN assigned subgrouping** should support the same number of CN assigned subgroups.  Then, in case#4, since UE has no subgrouping ID in this cell, the UE should monitor paging as legacy. |
| CATT | Y | With the RAN2 agreement quoted by MediaTek, we already have one AMF forcing all its serving gNBs to use a *subgroupNumPerPO* to be ≥ Nsg-CN, and in case of network sharing all related AMFs should also use the same Nsg-CN. This already pretty inflexible in our view. So at least we believe we should leave some freedom to gNB to only support UEID based subgrouping.  Same solution as for Cases 1-3: UE cannot determine its subgroup ID, so UE only monitors its PO in PEI, i.e. K=1 and *iSG* = 0 in clause 10.4A of 38.213. Note this does not require changing RAN1 spec and can be handled in 38.304. |
| Intel | See comments | Even though it is strange, we do not see the need to prohibit the configuration. In this case, since all the subgroups in the PEI are used by UEID based subgrouping in the cell, the UE supporting only CN based subgrouping with CN subgroup ID will have to monitor PO directly as per legacy. However, we are fine to go with majority on whether this is a valid configuration. |
| Ericsson | N | Agree with Mediatek |
| Qualcomm | Y | Because UE has separate UE capabilities for CN assigned and UE-ID based subgrouping and network has the option of supporting only UE-ID based subgrouping. |
| ZTE | N | Agree with MTK |
| vivo | N | In case CN supports and applies CN-Controlled subgrouping, if gNB does not support CN-Controlled subgrouping, but only supports UE-ID based subgrouping and provides information/configuration for UE-ID based subgrouping, inconsistent paging transmission and reception may happen between network and UE sides.  We agree with MediaTek. Network should avoid this case: in case CN applies CN-Controlled subgrouping, but gNB does not support CN-Controlled subgrouping, e.g. if some of the gNB(s) in CN does not support CN-Controlled subgrouping, CN should not apply the CN-Controlled subgrouping. |
| Nokia | Y | It should be possible to support UE-ID only for gNB. Depends on whether the UE supports UE-ID based or not, the UE monitors PEI or PO directly. |
| NEC | N | Agree with MTK, we solve this issue by network deployment according to RAN2 agreement. |
| CMCC | N |  |
| Huawei, HiSilicon | N | Agree with Mediatek |
| Xiaomi | Y | In RAN2#115-e, we agreed that  “R2 assumes that All the cells within the registration area supports the same number of CN assigned subgroups, i.e. no remapping of CN assigned group ID to RAN subgroup ID (will revisit only if serious issues are found).”  Our understanding is that is the cell supports the CN assigned subgrouping, it should reserve the same number of CN assigned subgroups with other cell in the RA. But it does not mean all the cells have to support it. Some cells can be configured to support UE-ID based subgrouping. |
| Futurewei | depends on if UEID-based subgrouping is mandatory for UEs or not | Assuming the use case is valid, the UE monitors legacy paging, not PEI. |
| DENSO | N | Agree with Mediatek. |
| LGE | Y | This scenario is valid since RAN2 agreed gNB/UE can support only one subgrouping. |
| Apple | See Comment | This is a NW configuration issue and should be avoided. This would make the UE ID based subgrouping unusable. |
| Sequans | Probably Y | We generally don’t limit NW configuration like that, but are fine to go with majority. Assuming this is a valid configuration, however, then UE should monitor legacy paging |

Summary

Totally 20 companies provided their answers to this question, among them 11 companies don’t think this is a valid configuration or suggest that its should be avoided by network, 7 companies think we may allow gNBs to support only UEID-based subgrouping even if some UEs have CN-assigned subgrouping, one company think it depends on the interpretation of working assumption, and one company think it depends on whether UEID-based subgrouping is mandatory.

Considering majority view, rapporteur suggests that we consider Case#4 as an invalid configuration. From UE perspectives, this means that whenever a UE has CN-assigned subgroup ID, it should monitor PEI using this ID in all cells in the registration area. However, we may need online discussion for this.

**Proposal 5: (Discussion) Whenever a UE has CN-assigned subgroup ID, it should be able to monitor PEI using this ID in all cells in the registration area.**

**Q6: Is there any other valid configurations that make UE unable to monitor subgroup PEI configured by network? How should UE monitor PEI and PO? Any other comments on this issue can also be provided here.**

|  |  |
| --- | --- |
| Company | Comment |
| MediaTek | Lack of “common PEI” and having two separated subgrouping methods and capabilities make UE subgroup PEI monitoring more complicated than UE-group WUS monitoring. Nonetheless, the rules for UE to find its subgroup are clearly defined:   * If UE has CN-assigned subgroup ID, that’s its subgroup ID (no remapping!), and it should be able to find corresponding PEI bit in all cells in the registration area. * Else if UE and network both support UEID-based subgrouping (Nsg-UEID is present), UE determines its UEID-based subgroup ID using the formula in TS 38.304. * Else, UE cannot determine its subgroup ID, and it simply monitors legacy paging. |
| InterDigital | There is no need to specify any other fallback conditions or scenarios other than the one in Q4 if UE-ID based grouping is always supported by a UE supporting PEI. We see no reason to complicate matters or any technical justification for making this optional. |
| Intel | For the case cell support PEI with subgroupConfig-r17 being absent, the UE supporting PEI with any subgrouping methods should be able to monitor its PEI and PO. Just want to check that this is the common understanding. |
| Ericsson | We think it is unfortunate that we have UE capability for subgrouping, and even less fortunate that we have ended up with two separate capabilities for subgrouping.  Agree with Mediatek. However, on the third bullet (Mediatek), we are also OK with UE wakes up based on PEI presence irrespective of contents (see Q2) . |
| Vivo | Similar as Ericsson on the 3rd bullet from MediaTek, we are also fine the UE wakes up based on the decoding of PEI, as discussed in Q2 one case 1. |
| Nokia | If the UE cannot find corresponding subgroup bit in PEI based on SIB configuration and allocated CN assigned ID or it’s subgroup capability, it should monitor PO directly. |
| NEC | Lack of common bit in PEI means we need specify whether UE who has no any subgroup ID need to monitor legacy PO. |
| Xiaomi | On the first bullet (Mediatek):   * If UE has CN-assigned subgroup ID and the cell supports CN-assigned subgrouping, that’s its subgroup ID (no remapping!), and it should be able to find corresponding PEI bit in all cells in the registration area. |

Summary

Totally 8 companies provide d their comments, among them 5 companies mentioned that UE should monitor legacy paging when it cannot determine its subgroup ID or cannot find corresponding subgroup bit in PEI (based on SIB configuration, allocated CN assigned ID, and it’s subgroup capability). Two companies mentioned to possibility of PO monitoring based on PEI reception. One company mentioned fallback conditions if UE-ID based grouping is always supported. One company wants to confirm that UE supporting PEI with any subgrouping methods should be able to monitor its PEI and PO if a cell configures PEI without subgrouping. One company mentioned the issue about network support of CN-assigned subgrouping.

Based on companies’ comments, rapporteur suggests that we confirm the following simple rules:

* When a cell configures PEI without subgrouping, all PEI-capable UEs monitor the PEI.
* When a cell configures PEI with subgrouping, but a UE cannot determine its subgroup ID or cannot find corresponding bit in PEI, UE monitors legacy paging.

**Proposal 6: When a cell configured PEI without subgrouping, all PEI-capable UEs monitor the PEI. When a cell configures PEI with subgrouping, but a UE cannot determine its subgroup ID or cannot find corresponding bit in PEI, UE monitors legacy paging.**

OI 1.3: RAN2 assumes that PEI can be used “without” subgrouping. FFS whether the bits in the PEI for subgrouping then need to have any particular meaning, or whether this would be done by just having one subgroup.

**Q7: How should we support PEI without subgrouping?**

|  |  |
| --- | --- |
| Company | Comment |
| MediaTek | Yes, PEI can be used without subgrouping. In this case, the network allocates one bit in the PEI for the concerned PO, and all PEI-capable UEs monitoring that PO check this bit.  While they both have “K=1” (i.e., one bit in PEI), the meaning of “without subgrouping” is different from “having one subgroup”, due to our UE capability design.   * If PEI is used without subgrouping, the whole *subgroupConfig* is absent. All PEI-capable UEs check the bit in PEI. * If PEI is used with one subgroup and it’s UEID-based, *subgroupConfig* is present, in which *subgroupNumPerPO*=1 and Nsg-UEID=1. All UEs supporting UEID-based subgrouping check the bit. However, UEs supporting CN-assigned subgrouping are not covered by the bit and thus monitor legacy paging (In this case, CN does not assign any subgroup ID). * If PEI is used with one subgroup and it’s CN-assigned, *subgroupConfig* is present, in which *subgroupNumPerPO*=1 and Nsg-UEID is absent. All UEs supporting CN-assigned subgrouping with subgroup ID=0 checks the bit, and there is only one CN-assigned subgroup. However, UEs supporting UEID-based subgrouping monitor legacy paging.   [MTK2] Agree with Nokia, the 3rd bullet is revised |
| InterDigital | PEI without subgrouping is equivalent to PEI with a single subgroup. No strong opinion how it is signalled. |
| Samsung | PEI without subgrouping is equivalent to PEI with a single subgroup. No need to differentiate these. |
| OPPO | Based on RAN2 agreement in RAN2#116bis-e, this case is supported.   |  | | --- | | If network supports PEI but not subgrouping, the whole SubgroupConfig-r17 is absent. |   Based on RAN1 agreement, K would be set to 1 in this case. Then, the 1 bit indication in PEI can be used to indicate whether all the UEs (i.e. without further subgrouping) need to monitor paging DCI in this PO. |
| CATT | The case when PEI is used without subgrouping has already been specified by RAN1 by setting K=1 and *iSG* = 0 in clause 10.4A of 38.213. There is no need to make it more complex.  In MediaTek’s proposal, bullets #2&3 can already be achieved by setting *subgroupNumPerPO*=2 and Nsg-UEID=1, and by CN assigning subgroup #1 to UEs supporting CN-assigned subgrouping. Thus, UEs supporting CN-assigned subgrouping are separated from UEs supporting UEID-based subgrouping, while both can enjoy the power saving provided by PEI.  As already mentioned, if both UE and NW support PEI, it seems to us very restrictive to prevent the UE from the power saving benefits of the PEI, which, as a recall, brings most power saving compared with subgrouping. So we don't see the benefit of supporting MediaTek’s bullets #2&3. |
| Intel | From RAN configuration, PEI can be configured without subgrouping (i.e. absence of subgroupConfig-r17). In this case all UE supporting PEI regardless of the subgrouping methods (i.e. CN assigned or UEID based subgrouping) should be able to monitor the corresponding PEI.  From the UE support perspective, we do not see the need to support PEI without subgrouping. In our understanding of RAN1 LS[R1-2200768], RAN1 does not currently support PEI only without subgrouping as there is currently no subgroup index just for PEI “without” subgrouping. This RAN2 assumption in the open issue should be superseded by the RAN1 LS (R1-2200768). |
| Ericsson | This scenario has specified this case with K=1. However, we think (as mentioned in Q2) that the UE could just wake up based on PEI presence irrespective of the contents. |
| Qualcomm | We think there are actually two cases:   1. Network support only PEI without subgrouping. In this case, we think it is equivalent to having only one subgroup. 2. Network support PEI with subgrouping (number of subgroups >=1), but a particular UE supports only PEI without subgrouping. We think this case is valid. In this case, this particular UE is only required to process the bitmap such that if any bit in the subgrouping bitmap is TRUE, the UE then monitors its PO. |
| ZTE | From RAN1 point of view, UE support PEI shall support Subgrouping as well, otherwise, UE’s behaviour on the subgroup bit in PEI is undefined. So we can define PEI without ‘subgrouping’ is PEI with subgroup=1. |
| vivo | 1. We have similar understanding as MediaTek on the difference between the meaning of “without subgrouping” and “having one subgroup”. 2. Regarding the case PEI without subgrouping, we are fine with either one “common bit” is introduced in PEI for all PEI capable UEs or UE waking up based on the decoding of PEI. Besides, we think RAN1 needs to be consulted for this case. |
| Nokia | Agree with MTK on the three cases categorization, we have a bit of different views on the behaviour though:   * If PEI is used without subgrouping, the whole *subgroupConfig* is absent. All PEI-capable UEs check the bit in PEI. * If PEI is used with one subgroup and it’s UEID-based, *subgroupConfig* is present, in which *subgroupNumPerPO*=1 and Nsg-UEID=1. All UEs supporting UEID-based subgrouping check the bit. However, UEs supporting CN-assigned subgrouping are not covered by the bit and thus monitor legacy paging (it is possible CN might allocate subgroup ID since it does not need to know RAN configurations). * If PEI is used with one subgroup and it’s CN-assigned, *subgroupConfig* is present, in which *subgroupNumPerPO*=1 and Nsg-UEID is absent. Could be discussed if only UEs with CN assigned ID = 1 or all the UEs with CN assigned ID monitor PEI, other UEs monitor PO like legacy. No need to have restriction of only one CN assigned subgroup from system point of view. |
| NEC | RAN2 is suggested to define the meaning of *subgroupNumPerPO* = 1.  RAN2 is suggested to consider whether UE without subgroup ID can use PEI with *SubgroupConfig* presented and *subgroupNumPerPO* = 1.  BTW, we prefer the solution that MTK mentioned above. |
| CMCC | For the FFS in the assumption, we prefer go to the latter choice “one group”. We think case 1 (*subgroupsNumPerPO=2,* Nsg-UEID=1 in the *subgroupConfig* and CN assigns all the UEs supporting CN-assigned into subgroup #1) and case 2 (*subgroupConfig* be absent) both indicates that the NW uses PEI “without” subgrouping for one PO. |
| Huawei, HiSilicon | PEI without subgrouping is equivalent to PEI with a single subgroup. All UEs in one PO that support PEI will interpret one common bit hence there is no need to differentiate these further. |
| Xiaomi | Agree with Nokia that we need to check bullet 3 in MTK:  If PEI is used with one subgroup and it’s CN-assigned, *subgroupConfig* is present, in which *subgroupNumPerPO*=1 and Nsg-UEID is absent. All UEs supporting CN-assigned subgrouping checks the bit, and there is only one CN-assigned subgroup.  Since we have agreed that if UE has CN-assigned subgroup ID, that’s its subgroup ID (no remapping!) to decides the isg, it should be only UEs with CN assigned ID = 0;  So we need to discuss whether we need to make things so complex…If we have a unified solution for K=1, that would be better.  According to RAN1’s agreement:   * + *K* = 1, if  is absent or set to 0 or 1,   We still need to discuss the case that *subgroupNumPerPO*=0. |
| Futurewei | We share the same view as Nokia, including where they differ from MediaTek. |
| DENSO | Agree with MediaTek. PEI without subgrouping is different from PEI with one subgroup.  “PEI without subgrouping” means that all PEI-capable UEs monitor the associated bit in PEI regardless of which subgrouping method the UE supports. On the other hand, “PEI with one subgroup” can be divided into two cases; that is, the cell configures one UE\_ID based subgroup or one CN-assigned subgroup. |
| LGE | PEI without subgrouping is equivalent to PEI with a single subgroup. No need to differentiate these. |
| Apple | We can consider PEI without subgrouping as equivalent to PEI with one subgroup (implicit). |
| Sequans | From NW PoV this is equal to supporting a single group, so no issue.  From UE PoV, this is covered by Q2 (case#1 of “questionable” configs); this should not require the UE to read the bitmap (otherwise, better to already support subgrouping), but only to match CRC |

Summary

Totally 20 companies provided their views, among them 19 companies agreed that PEI without subgrouping means one bit in PEI (K=1), while one company don’t see the need of PEI without subgrouping. Regarding whether “PEI without subgrouping” is equivalent to “PEI with one subgroup”, 7 companies think they are just equivalent, while 8 companies mention that K=1 may have different meaning due to separate UE capabilities for two subgrouping methods.

Rapporteur suggests that we confirm that PEI without subgrouping is supported by allocating one bit in PEI (i.e., K=1) and having *subgroupConfig* absent. Moreover, from proposals above, we know that “PEI without subgrouping” means all PEI-capable UEs monitor the single bit in PEI, while “PEI with one subgroup” means that some UEs monitor the single bit in PEI but others may need to monitor legacy paging. We do not need an agreement about whether they are “equivalent”.

**Proposal 7: PEI without subgrouping is supported by allocating one bit in PEI (i.e., K=1) and having *subgroupConfig* absent.**

# Conclusion

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

Easy agreements

**Proposal 1: Network indicates whether UE monitors PEI in last used cell in system information.**

**Proposal 3: When UE supports only CN-assigned subgrouping but subgroup ID is not assigned, it monitors legacy PO (i.e., not deriving UEID-based subgroup ID) in a network supporting UEID-based subgrouping.**

**Proposal 4: When UE supports only UEID-based subgrouping, or both subgrouping methods but CN does not assign the ID, UE monitors legacy paging in a cell supporting only CN-assigned subgrouping.**

**Proposal 6: When a cell configured PEI without subgrouping, all PEI-capable UEs monitor the PEI. When a cell configures PEI with subgrouping, but a UE cannot determine its subgroup ID or cannot find corresponding bit in PEI, UE monitors legacy paging.**

**Proposal 7: PEI without subgrouping is supported by allocating one bit in PEI (i.e., K=1) and having *subgroupConfig* absent.**

Discussions

**Proposal 2: Whether to allow UE supporting PEI but not subgrouping depends on conclusions from UE capabilities discussions.**

**Proposal 5: Whenever a UE has CN-assigned subgroup ID, it should be able to monitor PEI using this ID in all cells in the registration area.**

# Reference

1. R2-2201785 Summary of [Post116bis-e][080][ePowSav] Open Issues
2. R2-2201675, [Pre116bis][005][ePowSav] Summary of 8.9.2.1 Paging Sub-grouping and Paging Early Indication (MediaTek) MediaTek