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: Summary of [Pre117-e][004][ePowSav] PEI and paging subgrouping Open Issues Input**

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

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| --- | --- | --- |
| 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 RlastUsedCellOnly 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. |

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.  |

**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. |

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

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| --- | --- | --- |
| 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). |

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

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| --- | --- | --- |
| 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. |

**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.**

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| 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. |

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 checks the bit, and there is only one CN-assigned subgroup. However, UEs supporting UEID-based subgrouping monitor legacy paging.
 |
| 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.

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| 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. |

# Conclusion

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

# 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