3GPP TSG-RAN WG2 Meeting #116bis electronic R2-220xxxx

Online, January 17 – 25, 2022

Agenda Item: 8.9.2.1

Source: MediaTek Inc.

**Title: Summary of [AT116bis-e][054][ePowSav] Subgrouping and PEI**

Document for: Discussion and decision

# Introduction

This document is to summarize the following offline discussion:

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| * [AT116bis-e][054][ePowSav] Subgrouping and PEI (MediaTek)

      Scope: Based on online agreements, 1) Address the FFS from discussion on R2-2201675 on the interpretation PEI bits map to paging subgroups, and confirm value ranges of SubgroupNumPerPO and Nsg-UEID. 2) Discuss whether LS should be sent with specific questions to RAN1, e.g. on PEI applicability to eDRX, if so then draft agreeable LS. 3) For “PEI used in last cell” (only), attempt to find an agreeable compromise, e.g. a simple way of configurability that can let different operators choose if to use it or not. Chair: Simplicity is important.      Intended outcome: Report, LS out if applicable.      Deadline: Tue W2 |

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# Discussion

## PEI and paging subgrouping

### Interpretation of PEI bits map to paging subgroups

RAN2 has agreed that both CN-assigned and UEID-based paging subgrouping are supported. According to current RAN2 agreements and running CRs, we have

For CN-assigned paging subgrouping, UE belongs to the n-th (CN-assigned) paging subgroup, where n is assigned by CN;

For UEID-based paging subgrouping, UE belongs to the k-th (UEID-based) paging subgroup, where

* k = floor (UE Identity/(N\*Ns)) mod Nsg-UEID
* N is the number of Paging frames,
* Ns is the number of POs per paging frame,
* Nsg-UEID is the number of UEID-based paging subgroups

In a PDCCH-based PEI, there is a bitmap, where each bit is used to indicate paging for a subgroup of UEs. When both CN-assigned and UEID-based subgrouping methods and supported, they share the bits in the (bitmap-based) PEI. According to RAN1 design of DCI format 2\_7, the bitmap in a PEI may indicate paging for multiple subgroups in multiple POs in at most 2 paging frames, and UE checks $\left(i\_{PO}×K+i\_{SG}\right)$-th bit for paging, where

* $i\_{SG}$: Subgroup index by network
* *K* = $subgroupsNumPerPO$, if configured
* $i\_{PO}$ is the relative PO index in PEI

A simple example is given below:



Now we need to discuss how $i\_{SG}$ (subgroup index) is allocated to the two subgrouping methods.

* Option 1 – Subgroup index is allocated to CN-assigned subgroups first
* Option 2 – Subgroup index is allocated to UEID-based subgroups first

Rapporteur’s understanding is that both options work well. Some details may require proper stage-3 description, but that does not violate RAN2 agreements. We’d like to know companies view on each option. Do you accept, or really object to each option? In the comment field, please also indicate your preference, and share your views on how to describe subgroup index allocation in the spec.

**Q1: What are your views on the subgroup index allocation?**

|  |  |  |  |
| --- | --- | --- | --- |
| **Company** | **Accept Opt1?** | **Accept Opt2?** | **Comments** |
| Qualcomm | Accept Opt1 |  | We prefer Option 1, because of the agreements that no remapping of CN assigned subgroup ID and CN assigned subgroups have higher priority than UE-ID based subgroups |
| Samsung | Accept Opt 1 | Accept Opt 2 | In the RAN1 formula to map the bits in PEI to paging subgroups, $i\_{SG}$ refers to paging subgroup index. This formula will be defined in RAN1 spec and upper layer needs to provide paging subgroup index to PHY.In case of CN assigned paging subgroups, paging subgroup index is provided by CN to UE. If the number of CN assigned groups are N, paging subgroup index assigned by CN to UE is one of 0 to N-1.In case of UE ID based subgrouping paging subgroup index is calculated by UE based on formula (k = floor (UE Identity/(N\*Ns)) mod Nsg-UEID). As per this formula, If the number of UE ID based groups are X, paging subgroup index is one of 0 to X-1.If paging subgroup index is not unique for CN assigned and UE ID based paging subgroups, there will be overlapping (i.e. both CN and UE ID based subgroup will map to same bit in PEI). This is against our previous agreement.For option 2 to work, UE indicates to PHY Paging subgroup index isgFor CN based paging subgroup: Paging subgroup index isg = Paging subgroup index received from CN + number of UE ID based subgroupsFor UE ID based paging subgroup: Paging subgroup index isg = Paging subgroup index derived from formulaFor option 1 to workUE indicates to PHY Paging subgroup index isgFor CN based paging subgroup: Paging subgroup index isg = Paging subgroup index received from CN For UE ID based paging subgroup: Paging subgroup index isg = Paging subgroup index derived from formula + number of CN based subgroupsBoth options are similar in the sense that offset is either added to Paging subgroup index received from CN or offset is added to formula to determine UE ID based paging subgroup index. Since UE ID based paging subgroup index is determined by UE based on formula, it is simple to add offset to formula. So we slightly prefer option 1.  |
| OPPO | Accept Opt 1 |  | Both options can work.For Option 1:* For CN-assigned subgrouping, isg = CN-assigned subgroup index.
* For UE-ID based subgrouping, Subgroup index = floor (UE Identity/(N\*Ns)) mod Nsg-UEID+ offset 1, where the offset 1 value is the total subgrouping number for CN-assigned subgrouping

For option 2:* For CN-assigned subgrouping, isg = CN-assigned subgroup index + offset 2, where the offset value is the total subgrouping number for UE-ID based subgrouping
* For UE-ID based subgrouping, Subgroup index = floor (UE Identity/(N\*Ns)) mod Nsg-UEID

For Option 1, the CN-assigned subgroup index can be used without remapping, which would make the spec simpler. So we prefer option 1. |
| Intel | Accept Opt 1 |  | Both options could work in our view. We have opted for Option 1 because the number of subgroups for UEID based subgrouping can vary from cell to cell. If so, if the start of the CN subgroups always starts from the last subgroup for the UEID based subgrouping, the CN subgroup index may have to be shifted by the max number of UEID based subgroups, which is not aligned to RAN2 agreement that there is no remapping. We are fine to go with the majority |
| **CATT** |  | Accept Opt 2 | We agree both options work and we would not object any. However, we have a preference for option 2 because:- No offset needs to be added in the above UEID-based subgroup formula- No parameter needs to be defined for Nsg-CN- When a UE is assigned a subgroup nsg-CN by AMF, both gNB and UE apply *iSG* = nsg-CN + Nsg-UEIDThis is by far the simplest stage 3 implementation.Considering the above capturing in spec, the argument that the number of subgroups for UEID based subgrouping can vary from cell to cell does not seem relevant. |
| Ericsson | Accept Opt 1 | Accept Opt 2 | Both work, should just go with majority. It doesn’t seem to matter much which option we take. |
| Huawei, HiSilicon | Accept Opt1 |  | We support Option 1 with the UE ID subgroup ID to be k = floor (UE Identity/(N\*Ns)) mod Nsg-UEID + Nsg-CN (or subgroupsNumPerPO - Nsg-UEID) because of the following reasons. 1. RAN2 has already agreed that we will not do remapping on CN subgroups and
2. CN assigned subgroups has higher priority than UE-ID based subgroups.
3. Number of CN subgroups is not likely to change frequently.

Furthermore, if we adopt option 1, for both CN subgrouping and UE ID subgrouping, the UE can directly use the assigned or calculated subgroup index to determine the bit in PEI to be checked for paging. No additional rules or descriptions are needed.Conversely, if we adopt option 2, we need to specify how the UE determines or interprets the subgroup indication in PEI, which makes the bitmap determination more complex and may have further RAN1 impact or issues.Considering these subgroup index should be allocated to CN-assigned subgroups first and the UE ID subgroup ID to be k = floor (UE Identity/(N\*Ns)) mod Nsg-UEID + Nsg-CN (or subgroupsNumPerPO - Nsg-UEID). |
| **InterDigital** | yes | yes | We have a slight preference for option 2 because it simplifies the formula slightly by removing the unnecessary offset and agree with CATT and Ericsson comments.The options are actually functionally identical. It makes no difference whether the CN allocates (e.g. in case of 4 bits each) from the range 1-4 or 5-8. Some of the arguments above in support of option 1 are artificial – there is no remapping needed, no reconfiguration needed, no impact from priority and no difference in complexity. CN would simply allocate the subgroups from the lower or upper range (or in other words from the left or right of the range), that’s all. |
| vivo | Yes |  | 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 is need for option 1. But for UEID-based subgroup method, the number of supported subgroups Nsg-UEID is controlled per-cell basis and can be different between cells. For example, cell1 supports 4 subgroups, while cell2 supports 5 subgroups. Then, CN could only assign 3 subgroups in all cells including cell1 and cell2. In this way, in cell 1, CN subgroup is remapped to subgroup 5 6 7, while in cell 2, CN subgroup is remapped to subgroup 6 7 8. For a UE moving from cell1 to cell2, it will change their subgroup ID. It is very strange. But I agree there is no technique issue, and I am not sure whether this is conflict with our previous agreement, there is no remapping for CN assigned subgroup.Therefore, we accept option1. |
| ZTE | Yes | Yes | Both options can work, we can not see any significant implementation gap between these two options. |

### Value ranges of SubgroupNumPerPO and Nsg-UEID

It seems a common understanding that

* *SubgroupNumPerPO* ranges from 2 to 8
	+ If network configures subgrouping, there is at least 2 subgroups
	+ If network does not configure subgrouping, there is no subgrouping related information
* Nsg-UEID ranges from 1 to 8
	+ Nsg-UEID means that one bit in PEI is for UEID-based subgroups, while other bits are for CN-assigned subgroups

We would like to confirm companies’ views on the value ranges.

**Q2: Do you agree that *SubgroupNumPerPO* ranges from 2 to 8 and *Nsg-UEID* ranges from 1 to 8?**

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| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| Qualcomm | See comments | Value ‘1’ may seem degenerate for SubgroupNumPerPO, but it may still be needed. For example, in the case where network supports PEI but no subgrouping is configured, each PO still requires one bit in PEI. Then according to the diagram and formula in Q1, SubgroupNumPerPO should be 1. At least it would simplify spec text. |
| Samsung | Yes |  |
| OPPO | See comments | We think the minimum value of SubgroupNumPerPO should be 1, which could at least separate UEs supporting subgrouping from others not supporting subgrouping. |
| Intel | Partially, see comments | For subgroupNumPerPO, RAN1 already provided the following:**Agreement**Confirm the following working assumption:**Working Assumption*** 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.
	+ UE identifies its paging indication bit as follows:
		- Let  denote the relative PO index, with starting value of 0, among the POs associated with the PEI
			* , where  are as defined in clause 7 of TS 38.304
		- when *K* = 1 ~~and UE is not provided a subgroup index~~
		- when UE is provided a subgroup index
		- UE checks the corresponding paging indication from -th bit of the paging indication field where the starting bit index is 0
* If the corresponding paging indication value is set to ‘1’, it indicates the UE to monitor the PO
* If the corresponding paging indication value is set to ‘0’, it indicates the UE is not required to monitor the PO

From the above, 1 subgroup is always defined since K needs to be at least 1. As suggested in RAN1 agreement, it can be signal by  is absent or set to 0 or 1’So the bullet should be (based on RAN1 input):* If network signals *SubgroupNumPerPO*, and its value is > 1, there is at least 2 subgroups
* If network does not signal *SubgroupNumPerPO* or set it to 0 or 1, there is 1 subgroup (though the actual ASN.1 signalling and code points should be discussed in RAN2 during stage 3 – we don’t see a need to have three ways to signal one value)

Absence of Nsg-UEID means that UEID based subgrouping is not configured. While we agree that it can take a value of 1 to 8, the value 1 is not useful as all UEs belong to the same subgroup (it is equivalent to not using UE ID based subgrouping). Therefore, we think the useful range is from 2 to 8. |
| CATT | Y | The simplest stage 3 implementation.@Intel, yes indeed, in their agreement, RAN1 assume *subgroupsNumPerPO* is either absent or set to 0 or 1 when subgrouping is not supported in PEI. However, the latest endorsed running 38.331 CR includes all subgroup parameters in the IE *subgroupConfig-r17*, which is optional, see below. Therefore, the support/no-support of subgrouping is already captured in RRC spec via the configuration or absence of *subgroupConfig-r17*, not by the parameter *subgroupsNumPerPO*, which is mandatory present if *subgroupConfig-r17* is configured, and equals at least 2 because if subgrouping is supported it means you have at least 2 subgroups. RAN1 will have to capture their agreements in specifications taking into account the stage 3 finalization of RRC.PEI-Config-r17 ::= SEQUENCE {pei-SearchSpace-r17 FFS,subgroupConfig-r17 SubgroupConfig-r17 OPTIONAL, -- Need R...}SubgroupConfig-r17 ::= SEQUENCE {subgroupsNumPerPO-r17 INTEGER (FFS.. maxNrofPagingSubgroups-r17), subgroupsNumforUEID-r17 INTEGER (FFS.. maxNrofPagingSubgroups-r17)...} |
| Ericsson |  | Agree with QC. |
| Huawei, HiSilicon | Yes | This would avoid any possibility of having misinterpretations and have a simple stage 3 implementation. |
| InterDigital |  | Agree with QC.  |
| vivo | **Partially** | We would like to check the range of two parameters case by case:

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| **Case** | **SubgroupNumPerPO range** | **Nsg-UEID range** |
| only CN-assigned subgrouping is use | subgroupsNumPerPO is present, the value then equals to the number of CN-assigned subgroups.i.e. ranges from 2 to 8  | Nsg-UEID is absent |
| only UEID-based subgrouping is used | subgroupsNumPerPO has the same value as Nsg-UEID, i.e. ranges from 1 to 8 | Nsg-UEID ranges from 1 to 8 |
| both subgrouping methods are used | 0 < Nsg-UEID < subgroupsNumPerPO.i.e. ranges from 2 to 8 | Nsg-UEID ranges from 1 to 8 |
| Only PEI is used without subgrouping | *SubgroupNumPerPO*=1 | Nsg-UEID =1  |
| Summary | subgroupsNumPerPO ranges from 1 to 8 | Nsg-UEID ranges from 1 to 8 |

Therefore, Both SubgroupNumPerPO and Nsg-UEID ranges from 1 to 8. |
| ZTE | Yes | Proponent |

## LS to RAN1

RAN2 intend to support eDRX with PEI and subgrouping. We may need consult RAN1 for the applicability.

**Q3: Should we send LS to RAN1 on the applicability of PEI and subgrouping to eDRX? Are there any related questions to ask RAN1?**

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| **Company** | **Y/N** | **Comments** |
| Qualcomm | No | We don’t see any impact of this agreement on RAN1 spec. |
| Samsung | No |  |
| OPPO | Yes | If PEI is applied to eDRX, the time required for DL synchronization before PO may be longer than that for DRX case since UE wakes up from deep sleep for a long time. This may have an impact on the offset required between PEI and PO, which is RAN1 scope. As we know, RAN1 has not discussed supporting PEI for eDRX so far, so we think we need to check with RAN1. |
| Intel | No |  |
| CATT | Y | OK to send an LS to check if any RAN1 concern, indicating RAN2’s preference per this week’s agreement. |
| Ericsson | No | Agree with QC. |
| Huawei, HiSilicon | No  | It seems there are no impact on RAN1 spec.  |
| InterDigital | No | Agree with QC and others. |
| vivo | **Y** | Inform RAN1 that RAN2 aims to Support PEI and subgrouping with eDRX. Suggest RAN1 to discuss PEI for e-DRX, if any feedback or concern. |
| ZTE | No | We think it still can work to eDRX UE without any involvement of RAN1, regarding above comments, we do not think there is no any room for RAN1 to discuss this. |

We may have other issues to discuss with RAN1.

**Q4: Are there any other information or questions to be included in a LS to RAN1?**

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| **Company** | **Comments** |
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## PEI monitoring only in last used cell

In LTE WUS, UE monitors WUS only in its last used cell, and companies proposed to have the same rule for PEI monitoring. While this ensures power saving for stationary UEs, mobile UEs may not benefit from PEI/WUS. There are also proposals to make this configurable, i.e., operator can choose the behavior. To help reach consensus, we’d like to know if companies can accept, or really object to, each method.

If you think PEI monitoring area can be configurable, please also suggest how the configurations are provided to UEs.

**Q5: Do you accept to have PEI monitoring only in the last used cell?**

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| **Company** | **Y/N** | **Comments** |
| BT | **N** | Last visited cell helps to reduce the paging load in the TAI/RNA but it removes completely all PEI benefits to mobile UEs. Therefore, it is BT preference to have a configurable solution rather than a solution that was designed for static UEs. |
| Qualcomm | No |  |
| Samsung | No |  |
| **Sony** | **N** | Our view is that only supporting static UE´s is clearly a limitiating when it comes to supporting mobile UE´s, e.g. for tracking use cases.But also the fact the UE´s that are stationary but at cell edge, may under some circumstances may have to do cell reselection and hence fall outside last cell paging.The drawback with doing paging over large area is the increase of false wake-up, but this can be mitigated by placing stationary UE´s together in same subgroup.When it comes to network complexity, there is no additional complexity. The same signalling toward the gNB and UE would be the same for doing paging in one cell or multiple cells. So there should in principle be no additional impact on specifications.Further, most UE´s are mainly stationary, so the extra paging load should be able to be regarded as fairly small, or mobility can be foreseen in limited area covering a few number of cells. |
| OPPO | No | We see no need to introduce such restriction as UEs will not always camp on the last used cell. |
| **Intel** | Y | With the limited time left to complete the WI, we can accept to go with just supporting PEI monitoring in the last used cell. |
| CATT | N | We prefer to let it configurable. Note that it is our understanding that it is already configurable in legacy LTE, via the parameter *noLastCellUpdate* (TS36.304):

|  |
| --- |
| 7.4        Paging with Wake Up SignalPaging with Wake Up Signal is only used in the cell in which the UE most recently entered RRC\_IDLE triggered by:-     reception of *RRCEarlyDataComplete*; or-     reception of *RRCConnectionRelease* not including *noLastCellUpdate*; or-     reception of *RRCConnectionRelease* including *noLastCellUpdate* and the UE was using (G)WUS in this cell prior to this RRC connection attempt. |

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| Ericsson | Y | We are surprised to see that some companies object to the behaviour which we already have in LTE! It is difficult to understand how to interpret this.We note that PEI in only last used cell is simpler since it does not require any RAN3 work for this. |
| Huawei, HiSilicon | No  | We think that mobile UE (smart phone) is one of the important device type considered for power saving enhancements and mobility of such devices is a general and important attribute that needs to be taken into account. If we introduce such restriction, we believe the designed solution will be too restrictive and the power saving gain will be very limited for the mobile UEs.If there are concerns about the waking up stationary UEs due to false paging alarms caused by mobility, we think this can be easily avoided by including stationary UEs in a separate CN subgroup.  |
| InterDigital | Y | There is limited, if any, gain to support the mobility case – note that this would not only impact “stationary” UEs but any UE which happens to be in the same TA as a UE being paged after cell reselection (assuming the NW would escalate paging to be throughout the TA) - any gains to the mobile UE come at a cost to all of the other UEs in the TA and therefore may cause the performance in the system overall to be worse. Furthermore this limitation would simplify things somewhat which at this stage in the release would be welcome. |
| vivo | N | As we all know, the LTE WUS is only used for NB-IoT and eMTC UEs which are less mobile. However, things are different in R17, the UE types are various and some UEs may move around.If PEI monitoring is only applied in the last used cell, the UE cannot use it after moving out of the last used cell, which will limit the power saving gain from paging PEI/subgrouping. |
| ZTE | No strong view | Can follow majorities. |

**Q6: Do you accept to have configurable PEI monitoring area? If yes, how should the configurations be provided to UEs?**

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| **Company** | **Y/N** | **Comments** |
| BT | **Y** | A compromise could be reached for paging escalation introducing a new PEI subgroup TAI/RNA list area that works similar to Paging optimization for UEs in CM\_IDLE and for Paging optimization for UEs in RRC\_INACTIVE.Each PEI subgroup can contain a list of RAN nodes, *<1 .. max number of nodes>*, where PEI is sent. Then, operators can choose to engineer the network to have a last used cell approach if the list contains a single node or specific patterns to match mobility if more than one node is included. |
| Qualcomm | Y | We can accept configurable PEI monitoring area as a compromise, for the sake of moving forward. A simple option can be {no restriction, or the last TA used}. |
| Samsung | - | Our preference is not to have any configuration. However, if there is significant majority supporting configuration as an compromise, we will accept. |
| **Sony** | **Y** | Yes, for paging escalation any variant of TAI/RNA list area could be supported, e.g. similar as for paging optimization for UE´s in RRC-Inactive, using RNA (RAN Notification Area) for limiting the number of cells supported for paging escalation.So, all mechanisms are in place to support also non-stationary UE´s to benefit from the usage of PEI monitoring in order to save power. |
| **OPPO** | - | Share the same view as Samsung. |
| **Intel** | - | Even though we could accept it if there is significant support, we prefer not to have it in view of the limited time left for the work item as it will lead to further discussion on the details. |
| **CATT** | Y | We can either follow the LTE way, UE-specific through dedicated signaling in the *RRCConnectionRelease* message (see Q5), or make it cell-specific and broadcast it along with PEI configuration as follows: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,...} |
| **Ericsson** | Y | As a compromise, we could have it configurable whether PEI applies only in last used cell or in any cell. Its one bit in system info. |
| Huawei, HiSilicon | **-** | We prefer not to have such configuration for the reasons stated in Q5. |
| InterDigital | Y | Agree with Ericsson, it could be 1 bit to indicate whether the last cell limitation is applied or not, but we do question whether the added complexity is worth the gain (if any) |
| **vivo** | - | We agree with Samsung.If companies really want to achieve some compromise by configuring PEI monitoring area, we think a suitable area of using paging PEI/subgrouping should be defined. In this way, network can balance the PEI gain for a mobile UE and its impact to the stationary UEsIn our understanding, the CN can determine the area of using paging PEI/subgrouping, e.g. with taking account of UE characteristics, such as a list of cells according to UE movement area, or RNA in the registration area, etc. it’s flexible to configure the applied area of PEI, e.g. RNA area. |

# Conclusion

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

# Reference

1. [R2-2201675](file:///D%3A%5C%5CDocuments%5C%5C3GPP%5C%5Ctsg_ran%5C%5CWG2%5C%5CTSGR2_116bis-e%5C%5CDocs%5C%5CR2-2201675.zip%22%20%5Co%20%22D%3ADocuments3GPPtsg_ranWG2TSGR2_116bis-eDocsR2-2201675.zip) [Pre116bis][005][ePowSav] Summary of 8.9.2.1 Paging Sub-grouping and Paging Early Indication (MediaTek) MediaTek