3GPP TSG-RAN WG2 Meeting #116bis electronic R2-2201675

Online, January 17 – 25, 2022

Agenda Item: 8.9.2.1

Source: MediaTek Inc.

**Title: Summary of 8.9.2.1 Paging Sub-grouping and Paging Early Indication**

Document for: Discussion and decision

# Introduction

This document is to summarize the proposals made by the contributions submitted under the AI 8.9.2.1.

Topics about UE capability (there will be another summary), or not related to PEI/subgrouping are excluded from this summary.

# Discussion

## Paging subgrouping

### RAN capability

Contributions [1][3][4][6][11][12][17] mentioned RAN capability of different subgrouping methods.

* Overall RAN capability
	+ *subgroupConfig-r17* is optional present. If *subgroupConfig-r17* is absent, it means the RAN doesn’t support paging subgrouping: [14][17]
	+ The minimum value of *subgroupsNumPerPO-r17* is 2: [17]
	+ The valid value range is between 2 and 8: [12]
* RAN capability for CN based subgrouping
	+ Known implicitly based on configuration: [3][4][7][12]
	+ FFS with an explicit indication or implicitly based configuration: [8]
* RAN capability for UEID-based subgrouping:
	+ Known implicitly based on configuration of number of UEID-based paging subgroups: [1][4][7][12]
	+ FFS with an explicit indication or implicitly based configuration: [8]

It’s a common understanding that the two parameters *subgroupsNumPerPO* and Nsg-UEID are sufficient to indicate RAN capabilities of UE-ID based subgrouping and/or CN-assigned subgrouping. That is, the capabilities are known implicitly based on the configurations.

The contributions further discuss how the values should be configured in different cases.

* CN-assigned subgrouping only (broadcast *subgroupsNumPerPO*):
	+ Nsg-UEID is absent: [3][14][12][17]
	+ Nsg-UEID = 0: [7]
* UEID based only:
	+ Nsg-UEID is absent: [7]
	+ Nsg-UEID is present and equals to subgroupsNumPerPO [12]
* Coexisting CN-assigned and UEID-based subgrouping:
	+ 0 < Nsg-UEID < *subgroupsNumPerPO,* and number of CN assigned subgroup = *subgroupNumPerPO*-Nsg-UEID: [4][7][17][21]

Notice that [7] has different interpretation of “Nsg-UEID is absent” from other contributions. It seems more reasonable that having Nsg-UEID absent implies that there is no UEID-based subgrouping. If only UEID-based subgrouping is supported in a cell, it can broadcast the same values for *subgroupsNumPerPO*

We have the following proposal:

**Proposal 1: (Easy) RAN capabilities of subgrouping are known implicitly based on configuration of the two parameters Nsg-UEID (number of UEID-based subgroups) and *subgroupsNumPerPO* (total number of subgroups in a PO):**

* **If only CN-assigned subgrouping is supported, *subgroupsNumPerPO* is present and the value equals to the number of CN-assigned subgroups, and Nsg-UEID is absent.**
* **If only UEID-based subgrouping is supported, *subgroupsNumPerPO* is present and the value equals to the number of UEID-based subgroups, and Nsg-UEID has the same value as *subgroupsNumPerPO*.**
* **If both subgrouping methods are supported, both *subgroupsNumPerPO* and Nsg-UEID are present, and 0 < Nsg-UEID < *subgroupsNumPerPO*.**

Contributions [12][14][15] mention the value range of SubgroupNumPerPO and Nsg-UEID. We may have some discussion (e.g., should the values start from 1 or 2)

SubgroupNumPerPO

* Value range is from 2 to 8: [12][15]

Nsg-UEID

* Start from 1 [14]
* Value range is from 2 to 8: [15]

**Proposal 2: (Discussion) RAN2 to discuss the value range of SubgroupNumPerPO and Nsg-UEID.**

### Co-existence of CN-assigned and UEID-based subgrouping

RAN2 agreed to support both CN-assigned and UEID-based subgrouping methods, with non-overlapping subgroup IDs. Contributions [3][7][8][12][14][15][17][21] discuss the subgroup ID allocation when the two methods co-exist in a PEI.

* Option 1 – Subgroup ID is allocated to CN-assigned subgroups first: [3][5][8][12][14][21]
* Option 2 – Subgroup ID is allocated to UEID-based subgroups first: [7][15][17]

Considering majority support and easier subgroup ID calculation (e.g., in [5]), we propose to adopt Option 1, and modify the subgroup ID formula accordingly.

**Proposal 3: (Easy) If two subgrouping methods co-exist in a PEI, subgroup ID is allocated to CN-assigned subgroups first.**

**Proposal 4: (Easy) If a cell supports both UE identity based and CN assigned subgrouping, for UEID based paging subgrouping, UE belongs to k-th paging subgroup, where**

**- k = [floor (UE Identity/(N\*Ns)) mod Nsg-UEID] + Nsg-CN,**

**- 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, and**

**- Nsg-CN is the number of CN assigned paging subgroups (= subgroupNumPerPO - Nsg-UEID).**

### PEI and subgrouping with eDRX

Contribution [2][4][8][14][26] suggest that PEI be supported with eDRX. It is suggested in [2][4] that with eDRX:

* For UE-ID based subgroups, UE\_ID is defined as 5G-S-TMSI mod X, where X is 32768 (1024\*4\*8).

Since RAN2 already showed preference to support PEI with eDRX, we propose to formally agree on this, and the ‘X’ value for UEID calculation is modified accordingly.

**Proposal 5: (Easy) Support PEI and subgrouping with eDRX. In case of eDRX, for UE-ID based subgroups, UE\_ID is defined as 5G-S-TMSI mod X, where X is 32768 (1024\*4\*8).**

### RAN sharing

Contribution [13] discussed PEI in RAN sharing scenario, and propose that for the RAN sharing scenario, the CN controlled subgrouping is supported/allowed by the gNB for only one (set of) PLMN(s)/CN(s) in the shared cell.

We suggest having some discussion in RAN2.

**Proposal 6: (Discussion) For the RAN sharing scenario, the CN controlled subgrouping is supported/allowed by the gNB for only one (set of) PLMN(s)/CN(s) in the shared cell.**

## PEI monitoring

### PEI monitoring with eDRX

Contributions [26] suggests no special handling is introduced for PEI when eDRX PTW is configured. The UE wakes up at configured PTW during which PEI is applicable to the POs within.

### Area for PEI monitoring

Contributions [5][6][8][9][11][14][20][25] discuss mobility support for PEI, focusing on whether UE should only monitor PEI in the “last used cell” (i.e. where the UE enters IDLE or INACTIVE).

We see the following options:

* PEI is monitored only in the last used cell: [25]
* PEI/subgrouping is supported for UE mobility: [5][6][8][9][11][14][20]
	+ PEI is sent wherever corresponding Paging message is sent: [5]
	+ Configure cell list for UE to monitor PEI: [8][9]
	+ In *RRCRelease* message, indicating whether UE should monitor PEI only in last used cell: [20]

Unlike NB-IoT where most UEs are stationary and thus it is reasonable to limit (G)WUS monitoring in the last used cell, many NR UEs are likely to be mobile. Limiting PEI monitoring to last used cell means that mobile UEs do not benefit from PEI. However, PEI for mobile UEs may also wake up stationary UEs if the PEI is sent in many cells, and thus we may want some flexibility, i.e., configuring UE to monitor PEI only in some cell(s).

**Proposal 7: (Discussion) Mobility should be supported by R17 PEI mechanism, and PEI is not limited to the last used cell. FFS whether and how to configure UE to monitor PEI only in some cell(s).**

### UE unable to monitor subgroup PEI

Contributions [6][17][19][23] consider different cases where UE is unable to monitor subgroup PEI configured by network in a cell, due to mismatch between RAN capability and UE capability or subgroup assignment. The table below summarizes the identified cases.

|  |  |  |  |
| --- | --- | --- | --- |
| Case | UE support | Network/Cell support/configured | UE behavior |
| 1 | Only PEI, no subgrouping  | PEI with subgrouping indication  | Legacy paging: [6]Subgroup 0 in bitmap: [17] |
| 2 | CN-assigned subgroup, but ID not assigned | PEI with both CN and UEID-based subgrouping methods | Subgroup 0 in bitmap: [17] |
| 3 | Only UEID-based subgrouping; or both subgrouping methods but CN does not assign ID | Only CN-assigned subgrouping | Legacy paging: [6][23]Subgroup 0 in bitmap: [17] |
| 4\* | Only CN assigned subgrouping, with ID | Only UEID based subgrouping is configured  | Legacy paging: [6]UE derive a new subgroup ID based on its UE ID: [19] |

\*Case#4 may not be valid considering the RAN2 assumption 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).”

While there are different reasons that make a UE unable to monitor subgroup PEI configured by network in a cell, there are two ways for paging/PEI monitoring:

* Option 1 - Define specific rules for subgroup PEI monitoring [17][19]
* Option 2 - UE monitor paging as per legacy [6][23]

We suggest that RAN2 first identify valid cases where UE is unable to monitor subgroup PEI configured by network in a cell, probably based on the discussions for UE capabilities. And then for each case we discuss if there can be any rule for subgroup PEI monitoring or UE simply monitor paging as per legacy. We have the following proposal.

**Proposal 8: (Discussion) Identify valid cases where UE is unable to monitor subgroup PEI configured by network. For each case RAN2 discuss if there can be any rule for subgroup PEI monitoring, or UE simply monitor paging as per legacy.**

### Network control over the use of PEI

Contribution [13][22] discuss the network control over the use of PEI. They mention the problem of paging queueing delay with the introduction of PEI and suggest that PEI monitoring can be enabled/disabled for individual UEs. We suggest having some discussions in RAN2.

**Proposal 9: (Discussion) PEI monitoring can be enabled/disabled for individual UEs.**

## Assistance information

### UE assistance information for CN subgroup assignment

Contributions [5][9][13][24] discuss UE assistance information for CN subgroup assignment.

* Power consumption sensitivity
	+ Yes: [5][9]
	+ No: [19]
* Paging probability
	+ Yes: [13][24]
	+ No: [19]

Since RAN2 has already discussed UE assistance information but could not reach consensus, we propose that no UE assistance information for CN subgroup assignment, unless consensus can be achieved easily in this meeting.

**Proposal 10: (Discussion) There is no UE assistance information for CN subgroup assignment.**

### PEI usefulness

Contribution [26] suggests that if configured by the NW, UE indicates whether PEI is currently useful for the UE. We suggest having RAN2 discussion on this.

**Proposal 11: (Discussion) If configured by the NW, UE indicates whether PEI is currently useful for the UE.**

### Network assistance information

Contribution [11] proposes that network assistance information or signaling is needed to support CN to PEI subgrouping. Contribution [26] proposes that CN informs RAN about the number of subgroupsNumPerPO to use for the CN-assigned subgrouping. These should be RAN3 work but RAN2 may discuss if LS to SA2/RAN3 is needed.

**Proposal 12: (Discussion) LS to SA2/RAN3 about network assistance information.**

# Conclusion

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

Easy agreements

**Proposal 1: (Easy) RAN capabilities of subgrouping are known implicitly based on configuration of the two parameters Nsg-UEID (number of UEID-based subgroups) and *subgroupsNumPerPO* (total number of subgroups in a PO):**

* **If only CN-assigned subgrouping is supported, *subgroupsNumPerPO* is present and the value equals to the number of CN-assigned subgroups, and Nsg-UEID is absent.**
* **If only UEID-based subgrouping is supported, *subgroupsNumPerPO* is present and the value equals to the number of UEID-based subgroups, and Nsg-UEID has the same value as *subgroupsNumPerPO*.**
* **If both subgrouping methods are supported, both *subgroupsNumPerPO* and Nsg-UEID are present, and 0 < Nsg-UEID < *subgroupsNumPerPO*.**

**Proposal 3: (Easy) If two subgrouping methods co-exist in a PEI, subgroup ID is allocated to CN-assigned subgroups first.**

**Proposal 4: (Easy) If a cell supports both UE identity based and CN assigned subgrouping, for UEID based paging subgrouping, UE belongs to k-th paging subgroup, where**

**- k = [floor (UE Identity/(N\*Ns)) mod Nsg-UEID] + Nsg-CN,**

**- 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, and**

**- Nsg-CN is the number of CN assigned paging subgroups (= subgroupNumPerPO - Nsg-UEID).**

**Proposal 5: (Easy) Support PEI and subgrouping with eDRX. In case of eDRX, for UE-ID based subgroups, UE\_ID is defined as 5G-S-TMSI mod X, where X is 32768 (1024\*4\*8).**

For discussion

**Proposal 2: (Discussion) RAN2 to discuss the value ranges of SubgroupNumPerPO and Nsg-UEID.**

**Proposal 6: (Discussion) For the RAN sharing scenario, the CN controlled subgrouping is supported/allowed by the gNB for only one (set of) PLMN(s)/CN(s) in the shared cell.**

**Proposal 7: (Discussion) Mobility should be supported by R17 PEI mechanism, and PEI is not limited to the last used cell. FFS whether and how to configure UE to monitor PEI only in some cell(s).**

**Proposal 8: (Discussion) Identify valid cases where UE is unable to monitor subgroup PEI configured by network. For each case RAN2 discuss if there can be any rule for subgroup PEI monitoring, or UE simply monitor paging as per legacy.**

**Proposal 9: (Discussion) PEI monitoring can be enabled/disabled for individual UEs.**

**Proposal 10: (Discussion) There is no UE assistance information for CN subgroup assignment.**

**Proposal 11: (Discussion) If configured by the NW, UE indicates whether PEI is currently useful for the UE.**

**Proposal 12: (Discussion) LS to SA2/RAN3 about network assistance information.**

# Reference

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24. R2-2201542 UE assistance for CN assigned subgroups Interdigital, Inc. discussion Rel-17 NR\_UE\_pow\_sav\_enh-Core
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26. R2-2201557 Paging Early Indication and Subgroups Ericsson other Rel-17 NR\_UE\_pow\_sav\_enh-Core