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

**E-Meeting, 17th – 25th January 2022**

**Agenda Item:** **8.9.3**

**Source:**  **Intel Corporation**

**Title:** **[DRAFT] Summary of AI 8.9.3: UE capabilities**

**Document for:** **Discussion/Decision**

# Introduction

This document aims to summarize all the papers that have been submitted to agenda item 8.9.3 of RAN2#116bis-e.

# UE AS capabilities for PEI and subgrouping

In last RAN1 meeting, the following is endorsed for paging enhancement:

**Agreement**

* FG 29-1 is kept as “Paging enhancement” as follows

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 29. NR\_UE\_pow\_sav\_enh | 29-1 | Paging enhancement | 1. Support paging early indication  2. Support UE subgroup indication |  | ~~N~~ |  | ~~High idle/inactive mode UE power consumption if NR SA networks~~  UE does not support paging enhancement | Per UE | N | N | N | For component 2, it is up to RAN2 whether/how to separate the capability for UE subgroup indication  Leave RAN2 to decide whether ‘optional with capability signalling’ or ‘optional without capability signalling’  Leave RAN2 to decide whether Need for the gNB to know if the feature is supported is Yes or No | Optional ~~without capability signalling~~ |

Note that any contents highlighted in yellow mean FFS and to be discussed further in RAN1.

In the above, it leaves the following questions to RAN2:

1. Whether/how to separate the capability for UE subgroup indication
2. Whether ‘optional with capability signalling’ or ‘optional without capability signalling’
3. Whether Need for the gNB to know if the feature is supported is Yes or No

## Whether/how to separate the capability for UE subgroup indication

On this point, the following view can be gathered from the contributions.

[1] and [10] proposed introducing separate UE capabilities for PEI and paging subgrouping. UE may support PEI only or support both PEI and paging subgrouping. It assumes that there is 1 bit in the DCI payload used to indicate one UE subgroup of a PO or one PO, for a UE supporting PEI but without a subgroup ID. [6] has the same view that PEI could be used alone as a separate feature without subgrouping. [9] also proposed separate the capability for the PEI and subgrouping indication as the PEI is not just used for subgrouping indication but also for TRS/CSI-RS occasions availability indications. [11] also proposed that PEI and subgrouping are separate capabilities: a UE can support PEI without supporting subgrouping but requires UE to monitors the PEI bit associated with subgroup 0 of the subgroup bitmap.

On the other side [2] proposed to use one UE capability bit to indicate support for both PEI and subgrouping indication as suggested by the RAN1 feature list (29-1). The reasoning is that it is not possible for the UE to just support PEI only (i.e. K=1) while the cell is configured with PEI and subgrouping (i.e. K>1) as UE will not know which paging indication bit to monitor for the paging indication value of {0,1}. The PEI only UE may have to end up using legacy paging when camping on a cell that support subgrouping. [5] held the same view and suggested to treat paging early indication and UE subgroup indication into same FG. [12] also proposed that a single UE radio access capability is sufficient for indicating support of UE-ID based and CN assigned subgrouping, and the definition should be based on support of PEI rather than subgrouping method. Similarly, [13] thinks that when the UE and gNB make the effort to support PEI, it makes sense to further enhance the power saving with subgrouping and hence proposed that PEI support is coupled with UE-ID based subgrouping.

If support of PEI and subgrouping indication (i.e.R1 29-1) is coupled, the next question is whether the UEID based subgrouping is coupled with R1 29-1.

[2] does not think that it needs to be and proposed to include as pre-requisite in R1 29-1 that UE indicating support of R1 29-1 shall also indicate support of either CN assigned subgrouping over NAS message or UEID based subgrouping in the AS capability or both. In this way, the UE can either support CN assigned subgrouping only or UEID based subgrouping only or both.

[5], [12] and [13] on the other hand thinks that the support of R1 29-1 is coupled with UEID based subgrouping. [5] also think that if the RAN receives the CN assigned subgroup ID from AMF, it also means that the PEI is supported.

Based on the above:

* 5 companies think that PEI capability and subgrouping indication/mechanism should be decoupled
* 4 companies think that PEI capability and subgrouping indication/mechanism should be coupled
  + 3 companies further think that AS capability should couple with the UEID based subgrouping support
  + 1 company think that a prerequisite can be added to couple the R1 29-1 with the subgrouping mechanism

From the reasoning given by companies that want to decouple PEI capability and subgrouping indication capability, it seems to think that there is currently 1 bit in the PEI DCI payload for UE supporting PEI only. On the other hand, one company supporting PEI only suggests having a subgroup to handle PEI without subgrouping capability/PEI only capable UE. As pointed out by a couple of companies (e.g. [2], [5] etc.), there are currently no subgroup to specifically handle such PEI only capable UE in the cell when the cell supports subgrouping in which case such UE will use legacy paging.

Rapporteur suggests:

**Proposal#1[for discussion]:** RAN2 discuss whether R1 29-1 capability bit indicates UE:

* Option 1: supports only PEI (i.e., does not have to support subgrouping)
* Option 2: supports both PEI and subgrouping

**Proposal#2[for discussion]:** If option 2 is agreed for Proposal 1, discuss whether:

* Option a: A UE supporting Capability R1 29-1 always supports UEID based subgrouping
* Option b: A UE supporting Capability R1 29-1 supports either CN assigned subgrouping or UE ID based subgrouping or both

## Whether ‘optional with capability signalling’ or ‘optional without capability signalling’ and Whether Need for the gNB to know if the feature is supported is Yes or No

[2] and [5] also proposed that the UE capability bit is defined as ‘optional with capability signalling’ (as gNB needs to be aware of its support). The PEI and subgrouping capabilities need to be both known by the gNB so that the gNB know whether to page the UE using PEI and/or subgrouping if the gNB supports PEI and/or subgrouping. [13] also think RAN needs to know if the paged UE supports PEI, i.e., whether RAN needs to transmit the PEI prior to the PO where the UE is paged.

RAN2 also agree the following in RAN2#116e meeting:

**Introduce a *UERadioPagingInfo* IE in the *UECapabilityInformation* message in NR in Rel-17**

[2] proposed to include the UE support of UEID based subgrouping and UE support of R1 29-1 as separate optional indications in the *UERadioPagingInfo* IE in the *UERadioPagingInformation* container to be used during CN and RAN paging. [7] proposed to report the UE capability of UEID based subgrouping in the *UERadioPagingInfo* IE in the *UERadioPagingInformation* while [13] proposed that the PEI capability is added to the UERadioPagingInfo IE (new) in the *UECapabilityInformation* message. [7] and [9] also proposed that the gNB interprets UE’s reported *UECapabilityInformation*, copies the *UERadioPagingInfo* out and includes it as a container *UE-RadioPagingInfo* IE in the *UERadioPagingInformation* inter-node message to AMF for storage and maintenance.

[13] also discuss the informing the PEI/subgroup capability over the Xn and this will depend on whether PEI is only used in the last used cell. [13] also noted that UE Radio Capability for Paging is not present on the F1 interface, but as PEI transmission is typically handled by lower layers in gNB-DU, the information about whether PEI shall be transmitted before a PO needs to be provided to the gNB-DU and therefore think that RAN3 needs to discuss how to best include the UE Radio Capability for Paging over the F1 interface.

Based on the above:

* 5 companies think that gNB needs to know the paging enhancement capability(-ies) (e.g. PEI capability, UEID based subgrouping capability or the combined capability of PEI and UEID based subgrouping)
* 3 companies think that the paging enhancement capability(-ies) can be included into the agreed *UERadioPagingInfo* IE in the *UECapabilityInformation* message
* 2 companies think that the gNB interprets UE’s reported *UECapabilityInformation*, copies the *UERadioPagingInfo* IE out and includes it as a container *UE-RadioPagingInfo* IE in the *UERadioPagingInformation* inter-node message to AMF
* 1 company discuss that there maybe a need to provide UE Radio Capability for Paging over the F1 interface because of PEI/subgroup and think that there is a need to ask RAN3 to discuss including the UE Radio Capability for Paging over the F1 interface.

Rapporteur suggests:

**Proposal#3[Easy agreement]:** Paging enhancement capability(-ies) (e.g. PEI capability, UEID based subgrouping capability or the combined capability of PEI and UEID based subgrouping) are ‘optional with capability signalling’ as gNB needs to know the paging enhancement capability(-ies) to page the UE

**Proposal#4[Easy agreement]:** Paging enhancement capability(-ies) can be included into the *UERadioPagingInfo* IE in the *UECapabilityInformation* message as agreed in RAN2#116 (i.e. **Introduce a *UERadioPagingInfo* IE in the *UECapabilityInformation* message in NR in Rel-17**)

**Proposal#5[Easy agreement]:** gNB interprets UE’s reported *UECapabilityInformation*, copies the *UERadioPagingInfo* IE out and includes it as a container *UE-RadioPagingInfo* IE in the *UERadioPagingInformation* inter-node message to AMF

## Separate UE capabilities for CN based subgrouping and UE-ID based subgrouping

In RAN2#116e meeting, RAN2 discussed whether to introduce common or separate UE capabilities for UE-ID based subgrouping and CN-assigned subgrouping, and made the following working assumptions.

|  |
| --- |
| * We assume separate indications for UE capability of CN based subgrouping and UEID based subgrouping. * UE’s capability of supporting the UE ID based subgrouping is reported to RAN by AS UE capability signalling while R2 assumes that UE’s capability of supporting the CN-assigned subgrouping is reported to CN by NAS signalling. |

[1], [2], [6] confirms the above RAN2 assumptions to have separate UE capabilities for CN based subgrouping and UE-ID based subgrouping. [7] also seems to agree with this.

**Proposal#6[Easy agreement]:** Confirm the following RAN2 working assumption:

|  |
| --- |
| * We assume separate indications for UE capability of CN based subgrouping and UEID based subgrouping. * UE’s capability of supporting the UE ID based subgrouping is reported to RAN by AS UE capability signalling while R2 assumes that UE’s capability of supporting the CN-assigned subgrouping is reported to CN by NAS signalling. |

FFS on whether UEID based subgrouping is part of the PEI capability or a separate capability to the PEI capability

# UE AS capabilities for TRS/CSI-RS in idle and inactive mode

RAN1 also have [29-2] in the feature list for this.

The discussion in [1], [6], [8] and [15] seems to be whether it is an optional capability and whether it should be known to the gNB

[1], [6] proposed that it is an optional AS capability as UE needs to be able to acquire SIBx, identify the TRS/CSI-RS availability indication bits in DCI, etc. and also that it does not need to be reported to the network.

[8] thinks that it is beneficial if the NW knows if there are certain UEs which support this feature are currently camped in the cell and hence proposed to define a UE capability for UEs to indicate support for TRS/CSI-RS configuration for Idle and inactive UEs. Likewise for [15]

[14] just proposed to have UE capability.

Based on the above,

* 2 companies think that it does not need to be reported to the network and can be optional without UE capability
* 2 companies think that it is beneficial to report to the network
* 1 company think it requires a UE capability

From the rapporteur point of view, capability signalling is typically needed if the gNB needs to configure the feature in connected mode. If the TRS/CSI-RS configuration or availability indication needs to be configured in dedicated signalling, it would seem needed to have capability signalling to let the gNB know. However, the TRS/CSI-RS configuration is currently agreed to be only sent in the SIB and the TRS/CSI-RS usage of the UE is in idle mode and inactive mode, it seems more an optional without capability signalling. On the other hand, there is a network vendor that think it is beneficial to report to the gNB so that the network does not waste resources. Hence rapporteur suggests:

**Proposal#7 [for discussion]:** There are 2 options on UE AS capabilities for TRS/CSI-RS in idle and inactive mode:

* Option 7.1) Wait for RAN1 to finalize the [29-2] as the same discussion is happening there
* Option 7.2) RAN2 discuss whether UE capability for TRS/CSI-RS in idle and inactive mode is beneficial for the gNB to know

# UE AS capabilities for RLM/BFD relaxation

In the last RAN2 meeting, the following is agreed:

*R2 assumes to use AS capability procedure to report UE capability of supporting RLM/BFD relaxation. Details FFS*

[1] proposed to introduce separate capability for RLM and BFD relaxation. [6] proposed separate optional per UE capability for RLM and BFD relaxation. [16] proposed using separate AS capability procedure to indicate UE capability of supporting RLM/BFD relaxation and both of them should be optional.

[8] on the other hand think it is not clear if NWs would be interested if UE support RLM/BFD relaxation feature with an intent to save UE power and proposed RAN2 to further discuss the presence/absence of UE capability for RLM/BFD relaxation feature.

[17] proposed one capability indicator of supporting RLM/BFD relaxation, finer granularity for UE capability is not needed.

Based on the above,

* 3 companies think separate capabilities are needed for RLM and BFD relaxation
* 1 company think 1 capability is sufficient
* 1 company wants to discuss further the need of UE capability

As there are not many companies providing their view, rapporteur suggests postponing it to the next meeting. RAN4 may include them in their R4 feature list.

**Proposal#8 [Easy agreement]**: Postpone the discussion of UE AS capabilities for RLM/BFD relaxation to next meeting.

# PDCCH monitoring adaptation

[6] proposed to wait and follow the conclusion on the capability for PDCCH monitoring adaptation from RAN1.

Since RAN1 has [29-3a/b/c/d] for UE capabilities of PDCCH monitoring adaptation in the R1 feature list, rapporteur suggestion is to wait for R1 feature list to implement the UE capability for PDCCH monitoring adaptation

**Proposal#9[Easy agreement]:** Leave it to the R1 feature list implementation for UE capabilities of PDCCH monitoring adaptation

# Conclusion

The proposals of the summary are as follow:

Capability for PEI and subgrouping

**Proposal#1[for discussion]:** RAN2 discuss whether R1 29-1 capability bit indicates UE:

* Option 1: supports only PEI (i.e., does not have to support subgrouping)
* Option 2: supports both PEI and subgrouping

**Proposal#2[for discussion]:** If option 2 is agreed for Proposal 1, discuss whether:

* Option a: A UE supporting Capability R1 29-1 always supports UEID based subgrouping
* Option b: A UE supporting Capability R1 29-1 supports either CN assigned subgrouping or UE ID based subgrouping or both

**Proposal#3[Easy agreement]:** Paging enhancement capability(-ies) (e.g. PEI capability, UEID based subgrouping capability or the combined capability of PEI and UEID based subgrouping) are ‘optional with capability signalling’ as gNB needs to know the paging enhancement capability(-ies) to page the UE

**Proposal#4[Easy agreement]:** Paging enhancement capability(-ies) can be included into the *UERadioPagingInfo* IE in the *UECapabilityInformation* message as agreed in RAN2#116 (i.e. **Introduce a *UERadioPagingInfo* IE in the *UECapabilityInformation* message in NR in Rel-17**)

**Proposal#5[Easy agreement]:** gNB interprets UE’s reported *UECapabilityInformation*, copies the *UERadioPagingInfo* IE out and includes it as a container *UE-RadioPagingInfo* IE in the *UERadioPagingInformation* inter-node message to AMF

**Proposal#6[Easy agreement]:** Confirm the following RAN2 working assumption:

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| --- |
| * We assume separate indications for UE capability of CN based subgrouping and UEID based subgrouping. * UE’s capability of supporting the UE ID based subgrouping is reported to RAN by AS UE capability signalling while R2 assumes that UE’s capability of supporting the CN-assigned subgrouping is reported to CN by NAS signalling. |

FFS on whether UEID based subgrouping is part of the PEI capability or a separate capability to the PEI capability

Capability for TRS/CSI-RS for idle/inactive mode

**Proposal#7 [for discussion]:** There are 2 options on UE AS capabilities for TRS/CSI-RS in idle and inactive mode:

* Option 7.1) Wait for RAN1 to finalize the [29-2] as the same discussion is happening there
* Option 7.2) RAN2 discuss whether UE capability for TRS/CSI-RS in idle and inactive mode is beneficial for the gNB to know

Capability for RLM/BFD relaxation

**Proposal#8 [Easy agreement]**: Postpone the discussion of UE AS capabilities for RLM/BFD relaxation to next meeting.

Capability for PDCCH monitoring adaptation

**Proposal#9[Easy agreement]:** Leave it to the R1 feature list implementation for UE capabilities of PDCCH monitoring adaptation

# References

[1] R2-2200242 Discussion on UE capabilities OPPO discussion Rel-17 NR\_UE\_pow\_sav\_enh-Core

[2] R2-2200452 UE capability for Rel-17 UE power saving Intel Corporation discussion Rel-17 NR\_UE\_pow\_sav\_enh-Core

[3] R2-2200453 Draft running CR to 38331 on UE capabilities for Rel-17 UE power saving Intel Corporation draftCR Rel-17 38.331 16.7.0 B NR\_UE\_pow\_sav\_enh-Core

[4] R2-2200454 Draft running CR to 38306 on UE capabilities for Rel-17 UE power saving Intel Corporation draftCR Rel-17 38.306 16.7.0 B NR\_UE\_pow\_sav\_enh-Core

[5] R2-2200463 Discussing on UE capability for Paging enhancement Beijing Xiaomi Mobile Softwar discussion

[6] R2-2200595 Discussion on capabilities for ePowSav vivo discussion Rel-17 NR\_UE\_pow\_sav\_enh-Core

[7] R2-2201154 UE capability design for paging subgrouping Huawei, HiSilicon discussion Rel-17 NR\_UE\_pow\_sav\_enh-Core

[8] R2-2201205 R17 NR UE Power Save UE capability aspects Apple discussion Rel-17 NR\_UE\_pow\_sav\_enh-Core

[9] R2-2201221 Consideration on the UE capability for Paging Enhancement ZTE Corporation,Sanechips discussion Rel-17 NR\_UE\_pow\_sav\_enh-Core

[10] R2-2200898 Considerations on remaining issues for paging subgrouping CMCC discussion Rel-17 NR\_UE\_pow\_sav\_enh-Core

[11] R2-2201269 Consideration on Paging Sub-grouping CATT discussion Rel-17 NR\_UE\_pow\_sav\_enh-Core

[12] R2-2201541 On the co-existence of UE-ID and CN assigned subgroups Interdigital, Inc. discussion Rel-17 NR\_UE\_pow\_sav\_enh-Core

[13] R2-2201557 Paging Early Indication and Subgroups Ericsson other Rel-17 NR\_UE\_pow\_sav\_enh-Core

[14] R2-2201220 Further Consideration on TRS for Idle and Inactive UE ZTE Corporation,Sanechips discussion Rel-17 NR\_UE\_pow\_sav\_enh-Core

[15] R2-2201556 TRS exposure Ericsson other Rel-17 NR\_UE\_pow\_sav\_enh-Core

[16] R2-2200465 Discussion on RLM\_BFD measurement relaxation Beijing Xiaomi Mobile Softwar discussion

[17] R2-2201156 Discussion on RLM/BFD relaxation and DCI-based power saving adaptation Huawei, HiSilicon discussion Rel-17 NR\_UE\_pow\_sav\_enh-Core