**3GPP TSG RAN WG1 Meeting #106bis-E R1-211xxxx**

**e-Meeting, October 11th – 19th, 2021**

**Source: Moderator (Intel Corporation)**

**Title: FL summary #1 on other aspects of UE complexity reduction for RedCap**

**Agenda item: 8.6.1.3**

**Document for:** **Discussion and Decision**

# Introduction

This document presents a summary of submitted contributions to AI 8.6.1.3 (Other aspects of RedCap complexity reduction).

/This one is to use NWM – please use ***RAN1-106bis-e-NWM-NR-R17-RedCap-03*** as the document name

[106bis-e-NR-R17-RedCap-03] Email discussion regarding other aspects of UE complexity reduction – Debdeep (Intel)

* 1st check point: October 14
* Final check point: October 19

Based on the submitted contributions to RAN1 #106b-E meeting, the discussion points are categorized into the following topics:

* L2 buffer size reduction and scaling factor for peak data rates for RedCap
* Supported DCI formats for RedCap
* Miscellaneous including UE features

**Please provide your feedback to the “FL1 Question”s #1, #2, FL1 Proposal 1 by October 12th, 23:00 UTC.**

# L2 buffer size and peak rate scaling factor for RedCap

RAN1 received an LS from RAN2 [19], informing that RAN2 discussed several options during RAN2 #114-e meeting but could not arrive at a conclusion on whether and how to reduce L2 buffer size for Rel-17 RedCap UEs, and asking RAN1 to discuss the issue and provide feedback to RAN2.

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| **1. Overall Description:**RAN2 discussed several options for L2 buffer size reduction for Rel-17 RedCap in RAN2#114 and RAN2#115 but did not reach any conclusion on whether and how the possible reduction should be made.As this is related to RAN1, RAN2 respectfully ask RAN1 to discuss L2 buffer size reduction and provide feedback to RAN2.**2. Actions:****To RAN1 group****ACTION:** RAN2 respectfully ask RAN1 to discuss L2 buffer size reduction and provide feedback to RAN2. |

As one of the means to realize L2 buffer size reduction, adaptations to Rel-15 specifications on scaling factors for DL/UL peak rates have been considered by RAN2 and RAN1.

The primary motivation is to allow RedCap UEs to support peak data rates that are much lower than the corresponding achievable peak rates considering the agreed complexity reduction features (on BW, # of Rx branches, max modulation order, etc.) for RedCap. It is noted by the proponents that some of the RedCap use-cases (e.g., IWSN) may require much lower data rates than the min. peak rates achievable for currently-agreed capabilities for RedCap UEs.

As specified in TS 38.306, the peak rate scaling factor was introduced in Rel-15 based on the following motivations [21].

* *Scaling factor is used to reflect the association of capability mismatch between the baseband capability and RF capability for both SA UE and NSA UE.*
* *Scaling factor is used to scale down maximum throughput of NSA UEs operating in EN-DC scenario that share hardware resources between LTE and NR.*

Clearly, neither of the above motivations directly apply to RedCap use-cases.

Further, to ensure that the scaling factor is utilized by UEs primarily for the originally intended use-cases, it is currently specified that for single carrier NR SA operation, a UE would need to ensure that any indicated value of scaling factor (default value = 1) is such that the product $v\_{Layers}^{(j)}⋅Q\_{m}^{\left(j\right)}⋅f\_{}^{\left(j\right)}$ is no less than 4.

Considering that RedCap UEs are limited to single carrier operations, allowing RedCap UEs to indicate scaling factors < 1 is effectively limiting one or more of: (i) max PDSCH TBS; and (ii) max # of HARQ processes, without relaxing them for PHY layer operations.

During RAN1 #106-E meeting, the issue was discussed within RAN1, again without the group arriving at a consensus on whether and how to facilitate L2 buffer size reduction and the applicability of peak rate scaling factors for Rel-17 RedCap. However, as part of the RAN1 #106-E discussions, the following options were identified [22]:

* ***Opt. 1:*** *Scaling factors for peak DL/UL rates with existing values {0.4, 0.75, 0.8, 1} are available to RedCap UEs, with the same constraint on the minimum value of the product of max number of layers, max modulation order, and scaling factor as applicable for single carrier NR SA operation.*
	+ *No change to current specs for RedCap.*
* ***Opt. 2:*** *Scaling factors for peak DL/UL rates with existing values {0.4, 0.75, 0.8, 1} are available to RedCap UEs, with the relaxation/removal of the constraint on the minimum value of the product of max number of layers, max modulation order, and scaling factor as applicable for single carrier NR SA operation.*
* ***Opt. 3:*** *Scaling factors for peak DL/UL rates with existing values {0.4, 0.75, 0.8, 1} and new smaller values from one or more of: {0.1, 0.2} are available to RedCap UEs, with the relaxation/removal of the constraint on the minimum value of the product of max number of layers, max modulation order, and scaling factor as applicable for single carrier NR SA operation.*
* ***Opt. 4:*** *Scaling factors for peak DL/UL rates are NOT available to RedCap UEs.*
* *Other options are not precluded.*

In contributions [1], [4], [6], [7], [8], [9], [10], [12], [15], [16], [17], [18], submitted to RAN1 #106bis-E, companies shared their views on applicability of peak rate scaling factor for RedCap UEs.

A summary of indicated preferences based on submitted contributions:

* Optimize applicability and/or introduce smaller values of scaling factors for Rel-17 RedCap to enable lower L2 buffer sizes
	+ Yes: [1], [4], [7], [12], [15], [17]
	+ No (not optimized or not applicable at all for Rel-17 RedCap): [6], [7], [8], [9], [10], [16]

Primary reasons for supporting optimization of peak rate scaling factors for Rel-17 RedCap, as cited by proponents:

1. Better match of supported peak rates to low-end data rate requirements of IWSN.
2. Potential UE cost/complexity reduction via L2 buffer size reduction (without any quantitative estimates on the expected cost/complexity benefits).

Primary reasons for either not supporting scaling factor for Rel-17 Redcap UEs or not optimizing from that for non-RedCap UEs, as cited in company contributions:

1. The original reasons for application of peak rate scaling factor do not apply to RedCap UEs.
2. For single-carrier operation, UE cost/complexity reduction via L2 buffer size reduction is upper bounded by cost/complexity reduction features like limiting max TBS or reducing max number of HARQ-ACK processes. Both methods were studied during the SI phase and was decided to be not considered as part of the Rel-17 WI on RedCap.

Further inputs from companies are solicitated below to determine whether and how to enable reduced L2 buffer size for Rel-17 RedCap UEs and optimize the support of scaling factor for RedCap in Rel-17 NR.

## FL1 Question 1

* *Please share your views on the following for potential reduction in L2 buffer size requirements via peak rate scaling factors for Rel-17 RedCap.*
	+ ***Opt. 1:*** *Scaling factors for peak DL/UL rates with existing values {0.4, 0.75, 0.8, 1} are available to RedCap UEs, with the same constraint on the minimum value of the product of max number of layers, max modulation order, and scaling factor as applicable for single carrier NR SA operation, i.e., equal to 4.*
		- *No change to current specs for RedCap.*
	+ ***Opt. 2:*** *Scaling factors for peak DL/UL rates with existing values {0.4, 0.75, 0.8, 1} are available to RedCap UEs, with the relaxation/removal of the constraint on the minimum value of the product of max number of layers, max modulation order, and scaling factor as applicable for single carrier NR SA operation.*
	+ ***Opt. 3:*** *Scaling factors for peak DL/UL rates with existing values {0.4, 0.75, 0.8, 1} and new smaller values from one or more of: {0.1, 0.2} are available to RedCap UEs, with the relaxation/removal of the constraint on the minimum value of the product of max number of layers, max modulation order, and scaling factor as applicable for single carrier NR SA operation.*
	+ ***Opt. 4:*** *Scaling factors for peak DL/UL rates are NOT available to RedCap UEs.*
	+ *Other options are not precluded.*

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| **Company** | **Preferred option** | **Comments** |
| Nordic | Option 2 | **relax to 2** |
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# DCI formats for RedCap

Contributions [2], [3], [4], [5], [13], [14] discuss applicability of various DCI formats for Rel-17 RedCap.

Contributions [2], [6], and [14] propose not to pursue optimizations to DCI formats for RedCap UEs, especially in view of reducing PDCCH blocking probability.

Most discussions on DCI formats for RedCap consider support of DCI formats 2\_x and 3\_x for Rel-17 RedCap.

For **DCI formats 3\_x**, optional support for these formats can follow from conclusions on optional support of SL/V2X features by Rel-17 RedCap, while the latter is expected to be discussed further as part of discussions on UE features, as part of AI 8.6.2 and/or AI 8.17.6.

Companies generally seem to agree that **DCI format 2\_5** is not supported by Rel-17 RedCap, and that **DCI formats 2\_0, 2\_1, 2\_2, 2\_3, and 2\_6** can be supported by Rel-17 RedCap as optional feature(s).

Contributions [3], [4], and [13] propose that **DCI format 2\_4** is supported for Rel-17 RedCap as an optional feature. Contributions [5] and [14] suggest that DCI format 2\_4 may be supported by Rel-17 RedCap UE in TDD deployments or that support FD-FDD, but not supported by HD-FDD RedCap UEs. Given that the basic constraints between TDD and HD-FDD are the same when considering applicability of DCI 2\_4 and the fact proper grouping of UEs can address differentiated handling between FD-FDD and HD-FDD UEs, the UL CI feature and DCI 2\_4 can still be supported as optional feature by Rel-17 RedCap if it can be supported by TDD or FD-FDD RedCap UEs.

Considering the above, the following FL proposal is made as below.

## FL1 Proposal 1

* *Following DCI formats can be optionally supported by Rel-17 RedCap UEs:*
	+ *DCI formats 2\_0, 2\_1, 2\_2, 2\_3, 2\_4, 2\_6*
* *DCI format 2\_5 is NOT supported by Rel-17 RedCap UEs.*

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| **Company** | **Comments** |
| Nordic  | **Agreement:*** **For Case 2 (semi-statically configured DL reception vs. dynamically scheduled UL transmission), a HD-FDD RedCap UE is not required to monitor ULCI**
	+ **No special handling on the priority rule for PDCCH carrying ULCI**

**Therefore, it should be clarified that 2\_4 is not supported by HD-FDD UE** |
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# Miscellaneous including UE features

In contribution [16], it is proposed that SRS transmissions outside of active UL BWP and frequency selective scheduling outside of active DL BWP are not supported by RedCap UEs. It is also proposed that the max BW specified for R17 RedCap UE (20 MHz in FR1, 100 MHz in FR2) applies to both BB and RF. The latter is indeed interpretation for the cost/complexity reduction feature of reduced max BW for RedCap UEs. However, if necessary, these details can be further discussed and confirmed as part of AI 8.6.1.1.

Contribution [7] proposes to consider configuration of separate PDCCH SS set for RedCap UEs to reduce PDCCH blocking in case of shared initial DL BWP between RedCap and non-RedCap UEs. However, contributions [2], [6], and [14] propose that mechanisms for PDCCH blocking reduction are not pursued further in Rel-17.

Contribution [14] also suggests not to pursue enhancements for DL coverage recovery for RedCap UEs in Rel-17.

In contribution [20], updated evaluation results for cost/complexity reduction estimates, considering the possible combinations of cost/complexity reduction features finally being specified in Rel-17, have been presented.

## FL1 Question 2

* *Please indicate below if you think any of the above aspects or any other issue related to UE cost/complexity reduction needs to be discussed further during RAN1 #106bis-E meeting.*

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| **Company** | **Comments** |
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# References

1. R1-2108822, Other UE complexity reduction aspects for RedCap, Ericsson
2. R1-2109232, Discussion on other aspects related to complexity reduction, CATT
3. R1-2109289, Discussion on potential modification of existing DCI formats, CMCC
4. R1-2109334, Discussion on other issues for RedCap, ZTE, Sanechips
5. R1-2109419, Discussion on the DCI format for RedCap, Xiaomi
6. R1-2109432, Other UE Complexity Reduction Aspects, Nokia, Nokia Shanghai Bell
7. R1-2109498, Other aspects for complexity reduction for RedCap UEs, Samsung
8. R1-2109619, Other aspects on UE complexity reduction for RedCap, Intel Corporation
9. R1-2109728, Discussion on L2 buffer size reduction, Sierra Wireless. S.A.
10. R1-2109751, Other complexity reduction aspects for RedCap UEs, Huawei, HiSilicon
11. R1-2109760, Discussion on UE Capability of DL MIMO and Rx branches for RedCap, NEC
12. R1-2109837, Discussion on L2 buffer size reduction for RedCap, Spreadtrum Communications, CAICT, CATT, CEPRI, China Unicom
13. R1-2109853, Other aspects on UE complexity reduction for RedCap, Panasonic Corporation
14. R1-2109977, Other aspects related to UE complexity reduction of RedCap, LG Electronics
15. R1-2110042, Discussion on L2 buffer size reduction for Redcap, Apple
16. R1-2110195, Other Aspects of UE Complexity Reduction, Qualcomm Incorporated
17. R1-2110280, On other aspects related to RedCap UE, Nordic Semiconductor ASA
18. R1-2108893, Discussion on RAN2 LS on L2 buffer size reduction, Spreadtrum Communications
19. R1-2108713, LS to RAN1 on L2 buffer size reduction, RAN2 (Intel, Spreadtrum)
20. R1-2108824, Other aspects for RedCap, Ericsson
21. R1-1807651, Reply LS on formula or table for L1 data rate, RAN1
22. R1-2108524, FL summary #2 on other aspects of UE complexity reduction for RedCap, Moderator (Intel), RAN1 #106-E