

Views on Further UE Complexity Reduction (RedCap) WI

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Rel-18 RedCap SI in RAN1: Summary

- RAN1 completed the study on Rel-18 RedCap in two meetings
- 3 Options for UE bandwidth reduction
 - **BW1:** Both RF and BB bandwidths are 5 MHz for UL and DL.
 - **BW2:** 5 MHz BB bandwidth for all signals and channels with 20 MHz RF bandwidth for UL and DL.
 - **BW3:** 5 MHz BB bandwidth only for PDSCH (for both unicast and broadcast) and PUSCH with 20 MHz RF bandwidth for UL and DL. The other physical channels and signals are still allowed to use a BWP up to the 20 MHz maximum UE RF+BB bandwidth.
- 3 Options for UE peak rate reduction
 - **PR1:** Relaxation of the constraint ($v \cdot Q_m \cdot \alpha \geq 4$) for peak data rate reduction. v is number of layers, Q_m is modulation order, α is a scaling factor (0.4, 0.5, 0.75, 0.8)
 - The relaxed constraint is 1 (instead of 4).
 - **PR2:** Restriction of maximum TBS for PDSCH and PUSCH
 - **PR3:** Restriction of maximum number of PRBs for PDSCH and PUSCH.
 - For 15/30 kHz SCS, the maximum number of PRBs is 25/11. The restricted number of PRBs in PR3 is a hardcoded limit.
- 2 Options for relaxed UE processing timeline
 - **PT1:** Relaxation of UE processing time for PDSCH/PUSCH in terms of N_1 and N_2 (as defined in TS 38.214) compared to those of UE processing time capability 1
 - The relaxation factor for N_1 and N_2 is assumed to be 2 in the study.
 - **PT2:** Relaxation of UE processing time for CSI in terms of Z and Z' compared to the values defined in TS 38.214 clause 5.4
 - The relaxation factor for Z and Z' is assumed to be 2 in the study.

Rel-18 RedCap SI in RAN1: Summary

- Considering the complexity reduction, and impacts of performance, network deployment/coexistence and specification
 - Option BW3/PR3 is commonly preferred in RAN1
 - Some companies want to also consider Option BW1 or PR1
 - RAN1 recommends Option PR1 as potential add-on
 - The support of Option PT1/PT2 is to be decided in RAN plenary
- From the aspect of coverage impact
 - Link budget analysis as done in Rel-17 coverage recovery study
 - Main degradation comes from partial reception (11/12 PRBs for 30kHz, 25 PRBs for 15kHz) of PBCH/SIB1/PDCCH in CSS transmitted with large transmission BW, e.g., 48 PRBs
 - Compared to non-RedCap UEs or Rel-17 RedCap UEs, no additional coverage gaps for Rel-18 eRedCap UE as PUSCH remains as the bottleneck channel for all three UE types, except
 - SIB1, PDCCH CSS in some scenarios when antenna gain loss due to form factor is considered (similar as for Rel-17 RedCap)
 - Most channels for 4GHz with 24dBm PSD for gNB (similar as for Rel-17 RedCap)

Rel-18 RedCap WI in RAN1

- Complexity reduction
 - Option BW1 has the largest gain but the difference between BW1 and BW3/PR3 is small
 - Gain of PR1 is smaller comparing with other options
- Performance impact
 - BW1: Degradation for PBCH/PDCCH CSS/SIB1
 - BW3/PR3: Degradation for SIB1
 - PR1: Small
- Impacts of network deployment/coexistence and specification
 - BW1 has larger impacts than BW3/PR3 in terms of SSB/CORESET #0 and RACH
 - PR1: Small
- Features of BW reduction or peak rate reduction provides medium complexity reduction of around 10%
- Around 5% more complexity reduction can be obtained by additionally supporting PT1/PT2
- It is generally preferred to support more additional features for further complexity reduction
- Proposal 1
 - Specify a solution for further UE complexity reduction based on BW3 or PR3.
 - Support PT1/PT2 in combination with BW3 or PR3.
 - PR1 is further considered as an additional complexity reduction technique.

Rel-18 RedCap WI in RAN1

■ SIB1

- If SIB1 is shared between Rel-18 RedCap UE and legacy UE, it is likely large number of PRBs is allocated to SIB1
 - Partial reception in 5MHz results in around 11.2dB or 3.9dB performance loss for 2.6GHz or 700MHz
- Dedicated SIB1 transmission configured for Rel-18 RedCap UE in 5MHz can provide 0.5 – 3dB gain
- Repetitions of SIB1 can be considered to compensate the performance loss. However, it results in additional resource overhead of common PDCCH and SIB1 PDSCH in the frequency region of CORESET #0

■ Proposal 2

- Enhancement on SIB1 PDSCH transmission for Rel-18 RedCap UE is supported considering the resource overhead of common PDCCH and SIB1.

■ Early identification

- Rel-18 eRedCap UE may have limitations and worse performance for Msg2/Msg3/Msg4 transmissions.
- Without early identification, gNB has to schedule Msg2/Msg3/Msg4 assuming Rel-18 eRedCap UE, which reduces resource efficiency if there are only legacy UEs.
- Schemes for early identification of Rel-17 RedCap UE are considered as baseline.

■ Proposal 3

- Introduce a new UE (sub-)type of RedCap UE in Rel-18; here referred to as Rel-18 eRedCap UE.
- Study and if found necessary, specify support for early identification of Rel-18 eRedCap UE.

Rel-18 RedCap WI in RAN1

- For BW3/PR3, the main contributors of the cost reduction are the following functional blocks:
 - Baseband: Post-FFT data buffering
 - Baseband: Receiver processing block
 - Baseband: LDPC decoding
 - Baseband: HARQ buffer
 - Baseband: UL processing block
- In general, enhancements to reduce complexity of the above function blocks can be considered.
 - E.g., cross-slot scheduling helps to reduce Post-FFT data buffering
- NR supports
 - Frequency multiplexing of two broadcast PDSCHs in a slot
 - Frequency multiplexing of one broadcast PDSCH + one unicast PDSCH in a slot
- Due to reduced BW (BW3) or reduced number of PRBs (PR3), it is hard to multiplex multiple PDSCHs in a slot
- Proposal 4
 - Enhancement to reduce post-FFT data buffer should be considered for BW3/PR3.
 - Support complexity reduction by the limitation on the PDSCH transmissions in a slot.

Rel-18 RedCap WI in RAN2/RAN3/RAN4

- For power saving/energy efficiency, enhanced eDRX in RRC_INACTIVE (>10.24sec.) is also supported
 - In Rel-17, RAN2 WG was supportive to enable eDRX in INACTIVE above 10.24sec. but the work got postponed due to the foreseen impact on SA/CT.
 - SA2 has almost completed its feasibility study as part of Rel-18 FS_REDCAP_Ph2.
 - Possible solutions and corresponding conclusions on the principles for the normative work are captured in TR 23.700-68.
 - SA2 also sent an LS to S2-2204989 to RAN2/RAN3 to get their views on few points.
- Support a lower UE power class for complexity reduction

- Proposal 5:
 - For power saving/energy efficiency, enhanced eDRX in RRC_INACTIVE (>10.24sec.) is also supported.
 - Support a lower UE power class for complexity reduction.

Proposal for Rel-18 WI on eRedCap

■ Objectives of core part

- Specify support for UE complexity reduction based on option BW3 or PR3 for Rel-18 eRedCap UEs. [RAN1, RAN2, RAN4]
 - Down-selection between BW3 and PR3 by RAN #98. [RAN1]
 - Specify support for the following complexity reduction features:
 - Options PT1 and PT2 in combination with option BW3/PR3.
 - Option PR1 as an additional feature.
 - Study and if justified, specify support of enhancement(s) to reduce post-FFT data buffer for BW3/PR3.
 - Specify support of further complexity reduction by limiting the maximum number of PDSCH reception in a slot for BW3/PR3.
 - Specify support of a lower UE power class for complexity reduction. [RAN4]
 - Specify support of a solution to enhance SIB1 PDSCH scheduling/transmission for Rel-18 RedCap UE [RAN1, RAN2]
 - Specify support of early identification of Rel-18 eRedCap UE. [RAN2, RAN1]
 - Specify support for power saving/energy efficiency, enhanced eDRX in RRC_INACTIVE (>10.24s). [RAN2, RAN3, RAN4]

■ Objectives of performance part

- Specify necessary performance requirements, measurement accuracy requirements and test cases related to the above-mentioned enhancements and core requirements. [RAN4]

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