

3GPP TSG RAN Meeting #91-e

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Views on Rel-17 Work Item on RedCap

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Rel-17 RedCap WI scope: Outstanding issues

- Minimum number of Rx branches in FR1 bands in which non-RedCap UEs are required to support 4Rx (FR1 bands > 2496 MHz): 1Rx vs. 2Rx
 - Whether and how to allow for relaxed antenna gains in FR1 in consideration of small form factor constraints
- Whether to introduce optional UE capability of max UE BW of up to 40 MHz in FR1 bands
- Coverage recovery and relationship to Rel-17 WI on Coverage Enh.
- Objectives for RAN2-led items based on outcome of studies in RAN2 on UE power saving enhancements for RedCap UEs

On minimum number of Rx branches

Minimum requirement of 1Rx branch has been agreed for FR1 bands in which non-RedCap UEs are required to support 2Rx branches.

▪ 1Rx in all FR1 bands: Justifications

- Facilitates cost-effective implementations considering small form factor constraints, relevant to wearables use-cases.
- Small form factor constraints limit sufficient antenna spacing to realize spatially uncorrelated Rx chains, thus, performance gaps between 1Rx and 2Rx are smaller than ideal.
- During the SI phase, an additional 3 dB loss was considered for all FR1 bands; performance with 1Rx branch is lower bounded by performance with 2Rx + 3dB antenna gain loss that was studied during the SI phase.

▪ 1Rx in all FR1 bands: Concerns

- Compared to 4Rx branches for non-RedCap UEs, 1Rx branch may result in non-negligible DL link performance degradation, causing system spectral efficiency loss, and adverse impact to non-RedCap UE performance (incr. user blocking, etc.) as well.
- Does not achieve the target DL peak rates (150 Mbps) for wearables with max UE BW of 20 MHz.

Proposal 1:

- For RedCap, minimum requirement on # of Rx branches in FR1 bands in which non-RedCap UEs are required to support 4Rx is 1Rx, with optional support of 2Rx and 4Rx.
 - No further relaxations related to antenna requirements in FR1.

Optional support of max UE BW of up to 40 MHz

Peak DL/UL throughput in FR1 for different channel BW and SCS combinations for single MIMO layer Tx/Rx and 64 QAM

Channel BW (MHz)	SCS (kHz)	Peak DL throughput (Mbps)	Peak UL throughput (Mbps)
5	15	20	22
10	15	42	44
10	30	38	42
15	15	64	68
15	30	60	66
20	15	86	92
20	30	82	88
40	15	174	186
40	30	170	182

- With max single DL MIMO layer, it is not possible to achieve the target peak data rate of 150 Mbps for high-end wearables.
- While 2 DL MIMO layers may be supported by UEs with at least 2Rx branches, latter may not always be feasible for wearables due to form factor constraints.
- Allowing optional support of max UE BW of up to 40 MHz can address this
 - Data rates can be capped to ensure that such solutions do not overlap with low-end smartphone use-cases (e.g., with 2Rx/4Rx and 40 MHz BW, etc.).
 - Minimize specification efforts for introduction of 40 MHz RedCap UEs in addition to 20 MHz RedCap UEs.

Proposal 2:

- In FR1 bands, max UE BW of 40 MHz can be supported as an optional UE capability.
 - Data rates are limited to 150~200 Mbps for DL and ~100 Mbps for UL; details to be resolved during WI phase.
 - Strive to minimize specification efforts in supporting both types of RedCap UEs.

RedCap coverage recovery and coverage enhancements

- Assuming no relaxation in antenna gains in FR1, coverage recovery specific to RedCap UEs may not be necessary.
- In general, features developed in Rel-17 WI on Coverage Enhancements (CE) can be used by RedCap UEs as well to enhance coverage
- However, applicability to RedCap UEs, e.g., relationship between indication of support of Msg3 CE and RedCap UE identification, if any, need to be addressed either in RedCap or CE WIs.

Proposal 3:

- Applicability of and necessary adaptations to CE solutions for RedCap UEs are addressed in either of the two Rel-17 WIs: CE or RedCap (preferred). This includes at least:
 - Relationship between indication of support of CE and RedCap UE identification
 - Mandatory/optionality of CE features for RedCap UEs

RedCap UE power savings

- Support of eDRx for RRC_IDLE/RRC_INACTIVE modes have been observed as beneficial for UE power savings considering RedCap use-cases
 - *Considering impact, further feedback to confirm feasibility would be necessary from RAN4, SA2 and/or CT1.*
- Support of RRM relaxations for neighbor cell measurements in RRC_CONNECTED, RRC_IDLE, and RRC_INACTIVE modes
 - *Further studies are necessary in RAN4 to identify details of the relaxations and their feasibility in RRC_IDLE/RRC_INACTIVE and RRC_CONNECTED modes*
- Based on the studies and recommendations reported in TR 38.875, the above objectives are expanded in the following slides.

RedCap UE power savings: eDRx Enh.

Proposal 4:

Specify following enhancements for UE power saving [RAN2, RAN4]:

- Support of eDRx cycles for RRC_IDLE and RRC_INACTIVE modes where feasibility is to be confirmed with SA2 and/or CT1, includes [RAN2]:
 - The eDRX cycles below and equal to 10.24 seconds are defined with same behavior as legacy paging cycles (i.e. PTW and PH are not used) and a common design is specified for RRC_IDLE and RRC_INACTIVE.
 - For a UE in RRC_IDLE or RRC_INACTIVE, DRX cycles are extended above 10.24 seconds applying LTE eDRX model (e.g., PTW, PH, HSFN) to NR for values greater than 10.24 seconds. Strive for a common design for eDRX when UE is in RRC_IDLE or RRC_INACTIVE modes
 - eDRX cycles in RRC_IDLE are extended up to 10485.76 seconds.
 - eDRX cycles in RRC_INACTIVE are extended above 10.24 seconds.
- *Note: Maximum range of eDRX in RRC_IDLE can be updated if RAN4 indicates this preference (understanding that such eDRX value requires UE to perform RRM on serving cell outside PTW).*
- *Note: Maximum range of eDRX in RRC_INACTIVE to be discussed considering potential restrictions/preferences from RAN4, CT1 and/or SA2.*

RedCap UE power savings: RRM relaxations

Proposal 5:

Specify following enhancements for UE power saving [RAN2, RAN4] (contd.):

- Support of RRM relaxations for neighbor cell measurements in RRC_CONNECTED, RRC_IDLE, and RRC_INACTIVE modes
 - For neighbor cell RRM relaxation for RedCap UEs in RRC_IDLE and RRC_INACTIVE, specify the triggering of RRM relaxations to support 2-level speed evaluation (i.e., stationary and low mobility) [RAN2];
 - For neighbor cell RRM relaxation methods for RedCap UEs in RRC_IDLE and RRC_INACTIVE, study RRM relaxation methods and specify, if supported [RAN4];
 - For neighbor cell RRM relaxation for RedCap UEs in RRC_CONNECTED, specify the triggering of RRM relaxations for fixed or immobile UEs [RAN2];
 - For neighbor cell RRM relaxation methods for RedCap UEs in RRC_CONNECTED, study RRM relaxation methods and specify, if supported [RAN4].

RedCap UE types and identification (1/2)

- UE capability reporting for RedCap
 - Based on studies reported in TR 38.875, UE capability reporting framework for RedCap devices should follow existing Rel-15 UE capability reporting framework.
- RedCap UE identification
 - RedCap UE identification during initial access (e.g., during Msg1, Msg3) should be supported depending on need for proper scheduling for RedCap and non-RedCap UEs, coverage enhancements, or additional access restrictions
 - Without RedCap UE identification during Msg1/Msg3 transmission, system operation flexibility, efficiency, and non-RedCap UE initial access performance are impacted adversely, e.g.,:
 - Cannot support UL BWP #0 for non-RedCap UEs that may be larger than max RedCap UE BW
 - Excessively conservative scheduling of non-RedCap UEs (*in the DL SNR gap between RedCap and non-RedCap UEs can be as large as 6+ dB*)
- Mechanisms for access control for RedCap UEs based on cell barring and UAC approaches need to be specified.
- As noted in TR 38.875, further simplifications aiming to reduce device complexity at Layer 2 need further study for potential specification.

RedCap UE Types and identification (2/2)

Proposal 6:

- Specify definition of RedCap UE type(s) including set(s) of L1 capabilities for RedCap UE identification and for constraining the use of those RedCap L1 capabilities only for RedCap UEs, and preventing RedCap UEs from using capabilities not intended for RedCap UEs including at least carrier aggregation, dual connectivity and wider bandwidths [RAN2, RAN1]
 - *Note: As a baseline, the existing UE capability framework is used to indicate the capabilities of RedCap UEs.*
- Specify functionality that will enable RedCap UEs to be explicitly identifiable to networks during the initial access, e.g., Msg 1 or Msg3, depending on the needs of different scheduling of RedCap UEs, coverage enhancement, or additional access restrictions [RAN2, RAN1]
- Specify mechanisms for access control of RedCap UEs in RAN [RAN2]
- Study reduction of L2 UE capabilities and specify, if justified [RAN2]

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