**3GPP TSG RAN Meeting #95e Draft RP-220293**

**Electronic Meeting, 17th -23rd March 2022** Revision of RP-211574

**Source: Ericsson**

**Title: Revised WID on support of reduced capability NR devices**

**Document for: Approval**

**Agenda Item: 9.5.1.7**

3GPP™ Work Item Description

For guidance, see [3GPP Working Procedures](http://www.3gpp.org/About/WP.htm), article 39; and [3GPP TR 21.900](http://www.3gpp.org/ftp/Specs/html-info/21900.htm).
Comprehensive instructions can be found at <http://www.3gpp.org/Work-Items>

# Title: Support of reduced capability NR devices

## Acronym: NR\_redcap

## Unique identifier: 900062

|  |  |
| --- | --- |
| **This WID includes a Core part** | **X** |
| **This WID includes a Performance part** | **X** |

Potential target Release: Rel-17

## 1 Impacts

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Affects:** | UICC apps | ME | AN | CN | Others (specify) |
| **Yes** |  | X | X |  |  |
| **No** | X |  |  |  | X |
| **Don't know** |  |  |  | X |  |

## 2 Classification of the Work Item and linked work items

### 2.1 Primary classification

This work item is a

|  |  |
| --- | --- |
| X | Feature |
|  | Building Block |
|  | *Work Task* |
|  | Study Item |

### 2.2 Parent and child Work Items

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| Parent and child Work Items  |
| Unique ID | Title | Nature of relationship |
|  |  | *{mandatory text: "parent WID" or "child WID"}*  |

### 2.3 Other related Work Items and dependencies

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| --- |
| Other related Work Items (if any) |
| Unique ID | Title | Nature of relationship |
| 860035 | Study on support of reduced capability NR devices |  |
| 860036 | Study on NR coverage enhancements |  |
| 860047 | UE power saving enhancements for NR |  |
| 900061 | NR coverage enhancements |  |

## 3 Justification

The usage scenarios that have been identified for 5G are *enhanced mobile broadband* (eMBB), *massive machine-type communication* (mMTC), and *Ultra-Reliable and Low Latency communication* (URLLC). Yet another identified area is *time sensitive communication* (TSC). In particular, mMTC, URLLC and TSC are associated with novel IoT use cases that are targeted in vertical industries. It is envisaged that eMBB, mMTC, URLLC and TSC use cases may all need to be supported in the same network.

In the 3GPP study on "*self-evaluation towards IMT-2020 submission*" it was confirmed that NB-IoT and LTE-MTC (a.k.a. eMTC) fulfil the IMT-2020 requirements for mMTC and can be certified as 5G technologies. For URLLC support, URLLC features were introduced in Release 15 for both LTE and NR, and NR URLLC is further enhanced in Release 16 within the enhanced URLLC (eURLLC) and Industrial IoT work items. Rel-16 also introduced support for Time-Sensitive Networking (TSN) and 5G integration for TSC use cases.

Beside the use cases that are already adequately addressed by the mentioned technologies, the following categories of mid-range use cases have been identified where some NR enhancements may be motivated.

* One important objective of 5G is to enable connected industries. 5G connectivity can serve as catalyst for next wave of industrial transformation and digitalization, which improve flexibility, enhance productivity and efficiency, reduce maintenance cost, and improve operational safety. Devices in such environment include e.g. pressure sensors, humidity sensors, thermometers, motion sensors, accelerometers, actuators, etc. It is desirable to connect these sensors and actuators to 5G radio access and core networks. The massive industrial wireless sensor network (IWSN) use cases and requirements described in TR 22.804, TS 22.104, TR 22.832 and TS 22.261 include not only URLLC services with very high requirements, but also relatively low-end services with the requirement of small device form factors, and/or being completely wireless with a battery life of several years. The requirements for these services are higher than LPWA (i.e. LTE-MTC/NB-IoT) but lower than URLLC and eMBB.
* Similar to connected industries, 5G connectivity can serve as catalyst for the next wave smart city innovations. As an example, TR 22.804 describes smart city use case and requirements for that. The smart city vertical covers data collection and processing to more efficiently monitor and control city resources, and to provide services to city residents. Especially, the deployment of surveillance cameras is an essential part of the smart city but also of factories and industries.
* Finally, wearables use case includes smart watches, eHealth related devices, personal protection equipment (PPE), and medical monitoring devices for use in public safety applications, etc. One characteristic for the use case is that the device is small in size.

As a baseline, the requirements for these three use cases are:

Generic requirements:

* Device complexity: Main motivation for the new device type is to lower the device cost and complexity as compared to high-end eMBB and URLLC devices of Rel-15/Rel-16. This is especially the case for industrial sensors.
* Device size: Requirement for most use cases is that the standard enables a device design with compact form factor.
* Deployment scenarios: System should support all FR1/FR2 bands for FDD and TDD.

Use case specific requirements:

* Industrial wireless sensors: Reference use cases and requirements are described in TR 22.832 and TS 22.104: Communication service availability is 99.99% and end-to-end latency less than 100 ms. The reference bit rate is less than 2 Mbps (potentially asymmetric e.g. UL heavy traffic) for all use cases and the device is stationary. The battery should last at least few years. For safety related sensors, latency requirement is lower, 5-10 ms (TR 22.804)
* Video surveillance: As described in TR 22.804, reference economic video bitrate would be 2-4 Mbps, latency < 500 ms, reliability 99%-99.9%. High-end video e.g. for farming would require 7.5-25 Mbps. It is noted that traffic pattern is dominated by UL transmissions.
* Wearables: Reference bitrate for smart wearable application can be 5-50 Mbps in DL and 2-5 Mbps in UL, and peak bit rate of the device can be higher, up to 150 Mbps for downlink and up to 50 Mbps for uplink. Battery of the device should last multiple days (up to 1-2 weeks).

Techniques for UE complexity reduction, coverage recovery and UE power saving for these use cases have been studied in the RedCap study item documented in TR 38.875.

The intention with this WI is to specify a UE feature and parameter list with lower end capabilities, relative to Release 16 eMBB and URLLC NR to serve the three use cases mentioned above.

## 4 Objective

### 4.1 Objective of Core part WI

This WI has the following objectives:

* Specify support for the following UE complexity reduction features [RAN1, RAN2, RAN4]:
	+ Reduced maximum UE bandwidth:
		- Maximum bandwidth of an FR1 RedCap UE during and after initial access is 20 MHz.
		- Maximum bandwidth of an FR2 RedCap UE during and after initial access is 100 MHz.
	+ Reduced minimum number of Rx branches:
		- For frequency bands where a legacy NR UE is required to be equipped with a minimum of 2 Rx antenna ports, the minimum number of Rx branches supported by specification for a RedCap UE is 1. The specification also supports 2 Rx branches for a RedCap UE in these bands.
		- For frequency bands where a legacy NR UE (other than 2-Rx vehicular UE) is required to be equipped with a minimum of 4 Rx antenna ports, the minimum number of Rx branches supported by specification for a RedCap UE is 1. The specification also supports 2 Rx branches for a RedCap UE in these bands.
		- A means shall be specified by which the gNB can know the number of Rx branches of the UE.
	+ Maximum number of DL MIMO layers:
		- For a RedCap UE with 1 Rx branch, 1 DL MIMO layer is supported.
		- For a RedCap UE with 2 Rx branches, 2 DL MIMO layers are supported.
	+ Relaxed maximum modulation order:
		- Support of 256QAM in DL is optional (instead of mandatory) for an FR1 RedCap UE.
		- No other relaxations of maximum modulation order are specified for a RedCap UE.
	+ Duplex operation:
		- HD-FDD type A with the minimum specification impact (Note that FD-FDD and TDD are also supported.)
* Specify definition of one RedCap UE type including capabilities for RedCap UE identification and for constraining the use of those RedCap 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]
	+ The existing UE capability framework is used; changes to capability signalling are specified only if necessary.
* Specify functionality that will enable RedCap UEs to be explicitly identifiable to networks through an early indication in Msg1 and/or Msg3, and Msg A if supported, including the ability for the early indication to be configurable by the network. [RAN2, RAN1]
* Specify a system information indication to indicate whether a RedCap UE can camp on the cell/frequency or not; it shall be possible for the indication to be specific to the number of Rx branches of the UE. [RAN2, RAN1]
* Specify necessary updates of UE capabilities (38.306) and RRC parameters (38.331). [RAN2]
* Specify support for the following Extended DRX enhancements for RedCap UEs [RAN2, RAN3, RAN4]:
	+ Extended DRX for RRC Inactive and Idle with eDRX cycles up to 10.24 s, without using PTW and PH, and with common design (e.g. common set of eDRX values) between RRC Inactive and Idle
	+ Extended DRX for RRC Inactive and Idle with eDRX cycles up to 10485.76 s; the details of mechanisms and feasibility regarding maximum length of the extended DRX cycles for RRC Inactive and Idle need to be checked by SA2, CT1 and/or RAN4.
	+ RAN2 to decide which Node(s) configure eDRX in RRC\_Idle and RRC\_Inactive.
* Specify support for the following RRM measurement relaxations for neighbouring cells for RedCap devices: for RRC\_Idle/Inactive/Connected [RAN2, RAN4]:
	+ Specify measurement (RSRP/RSRQ) based stationarity criterion and not-at-cell-edge criterion [RAN2]
		- Enabling/disabling of RRM measurement relaxation should be under the network’s control. Specify both broadcast and dedicated signalling for enabling/disabling of RRM measurement relaxation.
	+ Specify UE requirements for RRM measurement relaxation [RAN4]
	+ No RRM measurement relaxations are specified for the serving cell.
* Specify RAN4 core requirements for the above.

Notes:

* Uplink coverage enhancement solutions specified in the NR Coverage Enhancement WI (NR\_cov\_enh) shall be assumed to be available also to RedCap UEs by default (with small modifications for RedCap UEs if found necessary).
* Power saving enhancement solutions specified in the UE Power Saving Enhancements WI (NR\_UE\_pow\_sav\_enh) shall be assumed to be available also to RedCap UEs by default.
* Rel-15 SSB bandwidth is reused and L1 changes minimized.
* The work defined as part of this WI is not to overlap with LPWA use cases.
* Coexistence with non-RedCap UEs is to be ensured.
* This WI focuses on SA mode and single connectivity with operation in a single band at a time.

### 4.2 Objective of Performance part WI

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

## 5 Expected Output and Time scale

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| --- |
| **New specifications** *{One line per specification. Create/delete lines as needed}* |
| Proposed Spec no. or series | Type (see note 1)  | Title | For info at TSG#  | For approval at TSG# | Remarks |
|  |  |  |  |  |  |

|  |
| --- |
| **Impacted existing TS/TR** *{One line per specification. Create/delete lines as needed}* |
| TS/TR No. | Description of change  | Target completion plenary# | Remarks |
| 38.202  | NR; Services provided by the physical layer | RAN#96 | Core part |
| 38.211 | NR; Physical channels and modulation | RAN#96 | Core part |
| 38.212 | NR; Multiplexing and channel coding | RAN#96 | Core part |
| 38.213 | NR; Physical layer procedures for control | RAN#96 | Core part |
| 38.214 | NR; Physical layer procedures for data | RAN#96 | Core part |
| 38.300  | NR; NR and NG-RAN Overall description; Stage-2  | RAN#95 | Core part |
| 38.304  | NR; User Equipment (UE) procedures in idle mode and in RRC Inactive state | RAN#95 | Core part |
| 38.306 | NR; User Equipment (UE) radio access capabilities | RAN#95 | Core part |
| 38.321 | NR; Medium Access Control (MAC) protocol specification | RAN#95 | Core part |
| 38.331 | NR; Radio Resource Control (RRC) protocol specification | RAN#95 | Core part |
| 38.413  | NG-RAN; NG Application Protocol (NGAP) | RAN#95 | Core part |
| 38.101-1  | NR; User Equipment (UE) radio transmission and reception; Part 1: Range 1 Standalone  | RAN#96 | Core part |
| 38.101-2  | NR; User Equipment (UE) radio transmission and reception; Part 2: Range 2 Standalone | RAN#96 | Core part |
| 38.133  | NR; Requirements for support of radio resource management | RAN#96 | Core part |
| 36.133 | Evolved Universal Terrestrial Radio Access (E-UTRA); Requirements for support of radio resource management | RAN#96 | Core part |
| 38.101-4 | NR; User Equipment (UE) radio transmission and reception; Part 4: Performance requirements | RAN#98 | Perf. part |
| 38.104 | NR; Base Station (BS) radio transmission and reception | RAN#98 | Perf. part |
| 38.133  | NR; Requirements for support of radio resource management | RAN#98 | Perf. part |
| 36.133 | Evolved Universal Terrestrial Radio Access (E-UTRA); Requirements for support of radio resource management | RAN#98 | Perf. part |
| 38.141-1  | NR; Base Station (BS) conformance testing Part 1: Conducted conformance testing  | RAN#98 | Perf. part |
| 38.141-2  | NR; Base Station (BS) conformance testing Part 2: Radiated conformance testing | RAN#98 | Perf. part |

## 6 Work item Rapporteur(s)

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## 7 Work item leadership

Primary: RAN WG1

Secondary: RAN WG2, RAN WG4

## 8 Aspects that involve other WGs

SA2 and CT1 potentially impacted in relation to Extended DRX.

## 9 Supporting Individual Members

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| Supporting IM name |
| Ericsson |
| FirstNet |
| Novamint |
| Thales |
| NEC |
| NTT DoCoMo |
| Verizon Wireless |
| TCL Communication |
| Sharp |
| Sequans |
| Nokia |
| Nokia Shanghai Bell |
| Sony |
| DISH Network |
| Futurewei |
| Vodafone |
| SoftBank |
| Sierra Wireless |
| Telstra |
| Deutsche Telekom |
| Huawei |
| HiSilicon |
| Telecom Italia |
| MediaTek |
| WILUS |
| T-Mobile USA |
| Intel |
| u-blox |
| Orange |
| Fujitsu |
| CATT |
| ZTE Corporation |
| Sanechips |
| Oppo |
| InterDigital |
| Xiaomi |
| Facebook |
| Lenovo |
| Motorola Mobility |
| Vivo |
| Guangdong Genius |
| DENSO CORPORATION |
| Spreadtrum communications |