**3GPP TSG-RAN WG2 Meeting #109 electronicR2-20xxxxx**

Elbonia, 24th Feb – 6th Mar 2020

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| *CR-Form-v11.2* | | | | | | | | |
| **CHANGE REQUEST** | | | | | | | | |
|  | | | | | | | | |
|  | **38.300** | **CR** | **193** | **rev** | **1** | **Current version:** | **16.0.0** |  |
|  | | | | | | | | |
| *For* [***HE******LP***](http://www.3gpp.org/3G_Specs/CRs.htm#_blank)*on using this form: comprehensive instructions can be found at* [*http://www.3gpp.org/Change-Requests*](http://www.3gpp.org/Change-Requests)*.* | | | | | | | | |
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| ***Proposed change affects:*** | UICC apps |  | ME | **x** | Radio Access Network | **x** | Core Network |  |

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| ***Title:*** | Introduction of UE Power Saving in NR | | | | | | | | | |
|  |  | | | | | | | | | |
| ***Source to WG:*** | CATT | | | | | | | | | |
| ***Source to TSG:*** | R2 | | | | | | | | | |
|  |  | | | | | | | | | |
| ***Work item code:*** | NR\_UE\_pow\_sav | | | | |  | | ***Date:*** | | 2020-03 |
|  |  | | | |  | | |  | |  |
| ***Category:*** | **B** |  | | | | | | ***Release:*** | | Rel-16 |
|  | *Use one of the following categories:* ***F*** *(correction)* ***A*** *(mirror corresponding to a change in an earlier release)* ***B*** *(addition of feature),* ***C*** *(functional modification of feature)* ***D*** *(editorial modification)*  Detailed explanations of the above categories can be found in 3GPP [TR 21.900](http://www.3gpp.org/ftp/Specs/html-info/21900.htm). | | | | | | | | *Use one of the following releases: Rel-8 (Release 8) Rel-9 (Release 9) Rel-10 (Release 10) Rel-11 (Release 11) Rel-12 (Release 12) Rel-13 (Release 13) Rel-14 (Release 14) Rel-15 (Release 15) Rel-16 (Release 16)* | |
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| ***Reason for change:*** | | This CR introduces the enhancements specified as part of the Work Item on UE Power Saving in NR. | | | | | | | | |
|  | |  | | | | | | | | |
| ***Summary of change:*** | | 1. Add PS-RNTI and DCP in abbreviation section 3.1 2. Add a new usage of PDCCH in Section 5.2.3 in support of power saving. 3. Add in Section 7.9 support for preferred DRX parameters, number of maximum secondary component carriers, maximum aggregated bandwidth, maximum MIMO layers and minimum scheduling offsets K0 and K2, and wish to transition out of DRX state in UE assistance information. 4. Add PS-RNTI to UE identities in Section 8.1. 5. Section 11: add description of the DCI with CRC scrambled by PS-RNTI procedure for controlling PDCCH monitoring in DRX on-duration. Also captures basic principles of RRM relaxation, per-BWP maximum MIMO Layers configuration and cross-slot scheduling. | | | | | | | | |
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| ***Consequences if not approved:*** | | Enhancements agreed as part of WI on UE Power Saving in NR are not specified in stage-2 specifications. | | | | | | | | |
|  | |  | | | | | | | | |
| ***Clauses affected:*** | | 3.1, 5.2.3, 7.9, 8.1, 11 | | | | | | | | |
|  | |  | | | | | | | | |
|  | | **Y** | **N** |  | | |  | | | |
| ***Other specs*** | |  |  | Other core specifications | | | TS/TR ... CR ... | | | |
| ***affected:*** | |  |  | Test specifications | | | TS/TR ... CR ... | | | |
| ***(show related CRs)*** | |  |  | O&M Specifications | | | TS/TR ... CR ... | | | |
|  | |  | | | | | | | | |
| ***Other comments:*** | |  | | | | | | | | |

*First Modified Subclause*

# 3.1 Abbreviations

For the purposes of the present document, the abbreviations given in TR 21.905 [1], in TS 36.300 [2] and the following apply. An abbreviation defined in the present document takes precedence over the definition of the same abbreviation, if any, in TR 21.905 [1] and TS 36.300 [2].

5GC 5G Core Network

5QI 5G QoS Identifier

A-CSI Aperiodic CSI

AKA Authentication and Key Agreement

AMBR Aggregate Maximum Bit Rate

AMC Adaptive Modulation and Coding

AMF Access and Mobility Management Function

ARP Allocation and Retention Priority

BA Bandwidth Adaptation

BCH Broadcast Channel

BPSK Binary Phase Shift Keying

C-RNTI Cell RNTI

CBRA Contention Based Random Access

CCE Control Channel Element

CD-SSB Cell Defining SSB

CFRA Contention Free Random Access

CMAS Commercial Mobile Alert Service

CORESET Control Resource Set

DFT Discrete Fourier Transform

DCI Downlink Control Information

DCP DCI with CRC scrambled by PS-RNTI

DL-SCH Downlink Shared Channel

DMRS Demodulation Reference Signal

DRX Discontinuous Reception

ETWS Earthquake and Tsunami Warning System

GFBR Guaranteed Flow Bit Rate

I-RNTI Inactive RNTI

INT-RNTI Interruption RNTI

LDPC Low Density Parity Check

MDBV Maximum Data Burst Volume

MIB Master Information Block

MICO Mobile Initiated Connection Only

MFBR Maximum Flow Bit Rate

MMTEL Multimedia telephony

MNO Mobile Network Operator

MU-MIMO Multi User MIMO

NCGI NR Cell Global Identifier

NCR Neighbour Cell Relation

NCRT Neighbour Cell Relation Table

NGAP NG Application Protocol

NR NR Radio Access

P-RNTI Paging RNTI

PCH Paging Channel

PCI Physical Cell Identifier

PDCCH Physical Downlink Control Channel

PDSCH Physical Downlink Shared Channel

PO Paging Occasion

PRACH Physical Random Access Channel

PRB Physical Resource Block

PRG Precoding Resource block Group

PS-RNTI Power Saving RNTI

PSS Primary Synchronisation Signal

PUCCH Physical Uplink Control Channel

PUSCH Physical Uplink Shared Channel

PWS Public Warning System

QAM Quadrature Amplitude Modulation

QFI QoS Flow ID

QPSK Quadrature Phase Shift Keying

RA-RNTI Random Access RNTI

RACH Random Access Channel

RANAC RAN-based Notification Area Code

REG Resource Element Group

RIM Remote Interference Management

RMSI Remaining Minimum SI

RNA RAN-based Notification Area

RNAU RAN-based Notification Area Update

RNTI Radio Network Temporary Identifier

RQA Reflective QoS Attribute

RQoS Reflective Quality of Service

RS Reference Signal

RSRP Reference Signal Received Power

RSRQ Reference Signal Received Quality

SD Slice Differentiator

SDAP Service Data Adaptation Protocol

SFI-RNTI Slot Format Indication RNTI

SIB System Information Block

SI-RNTI System Information RNTI

SLA Service Level Agreement

SMC Security Mode Command

SMF Session Management Function

S-NSSAI Single Network Slice Selection Assistance Information

SPS Semi-Persistent Scheduling

SR Scheduling Request

SRS Sounding Reference Signal

SS Synchronization Signal

SSB SS/PBCH block

SSS Secondary Synchronisation Signal

SST Slice/Service Type

SU-MIMO Single User MIMO

SUL Supplementary Uplink

TA Timing Advance

TPC Transmit Power Control

UCI Uplink Control Information

UL-SCH Uplink Shared Channel

UPF User Plane Function

URLLC Ultra-Reliable and Low Latency Communications

Xn-C Xn-Control plane

Xn-U Xn-User plane

XnAP Xn Application Protocol

*Next Modified Subclause*

### 5.2.3 Physical downlink control channels

The Physical Downlink Control Channel (PDCCH) can be used to schedule DL transmissions on PDSCH and UL transmissions on PUSCH, where the Downlink Control Information (DCI) on PDCCH includes:

- Downlink assignments containing at least modulation and coding format, resource allocation, and hybrid-ARQ information related to DL-SCH;

- Uplink scheduling grants containing at least modulation and coding format, resource allocation, and hybrid-ARQ information related to UL-SCH.

In addition to scheduling, PDCCH can be used to for

- Activation and deactivation of configured PUSCH transmission with configured grant;

- Activation and deactivation of PDSCH semi-persistent transmission;

- Notifying one or more UEs of the slot format;

- Notifying one or more UEs of the PRB(s) and OFDM symbol(s) where the UE may assume no transmission is intended for the UE;

- Transmission of TPC commands for PUCCH and PUSCH;

- Transmission of one or more TPC commands for SRS transmissions by one or more UEs;

- Switching a UE's active bandwidth part;

- Initiating a random access procedure;

- Indicating the UE(s) to monitor the PDCCH during the next occurrence of the DRX on-duration.

A UE monitors a set of PDCCH candidates in the configured monitoring occasions in one or more configured COntrol REsource SETs (CORESETs) according to the corresponding search space configurations.

A CORESET consists of a set of PRBs with a time duration of 1 to 3 OFDM symbols. The resource units Resource Element Groups (REGs) and Control Channel Elements (CCEs) are defined within a CORESET with each CCE consisting a set of REGs. Control channels are formed by aggregation of CCE. Different code rates for the control channels are realized by aggregating different number of CCE. Interleaved and non-interleaved CCE-to-REG mapping are supported in a CORESET.

Polar coding is used for PDCCH.

Each resource element group carrying PDCCH carries its own DMRS.

QPSK modulation is used for PDCCH.

*Next Modified Subclause*

## 7.9 UE Assistance Information

When configured to do so, the UE can signal the network through *UEAssistanceInformation* if:

- it prefers an adjustment in the connected mode DRX cycle length, for the purpose of delay budget reporting, or

- it prefers certain DRX parameter values, and/or a reduced maximum number of secondary component carriers, and/or a reduced maximum aggregated bandwidth and/or a reduced maximum number of MIMO layers and/or minimum scheduling offsets K0 and K2 for power saving purpose, or

- it expects not to send or receive any more data in the near future, and in this case, it can request to transition out of RRC\_CONNECTED and with this indication may express its preferred RRC state, or alternately, upon unexpected new activity it cancels an earlier indicated preference to transition out of RRC\_CONNECTED, or

- it is experiencing internal overheating, and in this case, can express a preference for temporarily reducing the number of maximum secondary component carriers, the maximum aggregated bandwidth and the number of maximum MIMO layers.

In all cases, it is up to the gNB whether to accommodate the request.

*Next Modified Subclause*

# 8 NG Identities

## 8.1 UE Identities

In this clause, the identities used by NR connected to 5GC are listed. For scheduling at cell level, the following identities are used:

- C-RNTI: unique UE identification used as an identifier of the RRC Connection and for scheduling;

- CS-RNTI: unique UE identification used for Semi-Persistent Scheduling in the downlink or configured grant in the uplink;

- INT-RNTI: identification of pre-emption in the downlink;

- MCS-C-RNTI: unique UE identification used for indicating an alternative MCS table for PDSCH and PUSCH;

- P-RNTI: identification of Paging and System Information change notification in the downlink;

- SI-RNTI: identification of Broadcast and System Information in the downlink;

- SP-CSI-RNTI: unique UE identification used for semi-persistent CSI reporting on PUSCH.

For power and slot format control, the following identities are used:

- SFI-RNTI: identification of slot format;

- TPC-PUCCH-RNTI: unique UE identification to control the power of PUCCH;

- TPC-PUSCH-RNTI: unique UE identification to control the power of PUSCH;

- TPC-SRS-RNTI: unique UE identification to control the power of SRS.

During the random access procedure, the following identities are also used:

- RA-RNTI: identification of the Random Access Response in the downlink;

- Temporary C-RNTI: UE identification temporarily used for scheduling during the random access procedure;

- Random value for contention resolution: UE identification temporarily used for contention resolution purposes during the random access procedure.

For NR connected to 5GC, the following UE identities are used at NG-RAN level:

- I-RNTI: used to identify the UE context in RRC\_INACTIVE.

For UE power saving purpose during DRX, the following identity is used:

- PS-RNTI: used to determine if the UE needs to monitor PDCCH on the next occurrence of the connected mode DRX on-duration.

*Next Modified Subclause*

# 11 UE Power Saving

The PDCCH monitoring activity of the UE in RRC connected mode is governed by DRX, BA, and DCP.

When DRX is configured, the UE does not have to continuously monitor PDCCH. DRX is characterized by the following:

- **on-duration**: duration that the UE waits for, after waking up, to receive PDCCHs. If the UE successfully decodes a PDCCH, the UE stays awake and starts the inactivity timer;

- **inactivity-timer**: duration that the UE waits to successfully decode a PDCCH, from the last successful decoding of a PDCCH, failing which it can go back to sleep. The UE shall restart the inactivity timer following a single successful decoding of a PDCCH for a first transmission only (i.e. not for retransmissions);

- **retransmission-timer**: duration until a retransmission can be expected;

- **cycle**: specifies the periodic repetition of the on-duration followed by a possible period of inactivity (see figure 11-1 below);

**- active-time**: total duration that the UE monitors PDCCH. This includes the "on-duration" of the DRX cycle, the time UE is performing continuous reception while the inactivity timer has not expired, and the time when the UE is performing continuous reception while waiting for a retransmission opportunity.



Figure 11-1: DRX Cycle

When BA is configured, the UE only has to monitor PDCCH on the one active BWP i.e. it does not have to monitor PDCCH on the entire DL frequency of the cell. A BWP inactivity timer (independent from the DRX inactivity-timer described above) is used to switch the active BWP to the default one: the timer is restarted upon successful PDCCH decoding and the switch to the default BWP takes place when it expires.

In addition, the UE may be indicated, when configured accordingly, whether it is required to monitor or not the PDCCH during the next occurrence of the on-duration by a DCP monitored on the active BWP. If the UE does not detect a DCP on the active BWP, it does not monitor the PDCCH during the next occurrence of the on-duration, unless it is explicitly configured to do so in that case.

A UE can only be configured to monitor DCP when connected mode DRX is configured, and at occasion(s) at a configured offset before the on-duration. More than one monitoring occasion can be configured before the on-duration. The UE does not monitor DCP on occasions occurring during active-time, measurement gaps, or BWP switching, in which case it monitors the PDCCH during the next on-duration. If no DCP is configured in the active BWP, UE follows normal DRX operation.

When CA is configured, DCP is only configured on the PCell.

One DCP can be configured to control PDCCH monitoring during on-duration for one or more UEs independently.

Power saving in RRC\_IDLE and RRC\_INACTIVE can also be achieved by UE relaxing neighbour cells RRM measurements when it meets the criteria determining it is in low mobility and/or not at cell edge.

UE power saving may be enabled by adapting the DL maximum number of MIMO layers by BWP switching.

Power saving is also enabled during active-time via cross-slot scheduling, which facilitates UE to achieve power saving with the assumption that it won’t be scheduled to receive PDSCH, triggered to receive A-CSI or transmit a PUSCH scheduled by the PDCCH until the minimum scheduling offsets K0 and K2. Dynamic adaptation of the minimum scheduling offsets K0 and K2 is controlled by PDCCH.