**3GPP TSG-RAN WG2 #117-e *R2-220XXXX***

**Online, February 21 – March 3, 2022**

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| *CR-Form-v12.1* | | | | | | | | |
| **CHANGE REQUEST** | | | | | | | | |
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|  | **38.300** | **CR** | **0417** | **rev** | **1** | **Current version:** | **16.8.0** |  |
|  | | | | | | | | |
| *For* [***HELP***](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 | **X** |

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| ***Title:*** | Introduction of UE power saving enhancements In 38.300 | | | | | | | | | |
|  |  | | | | | | | | | |
| ***Source to WG:*** | Huawei, HiSilicon | | | | | | | | | |
| ***Source to TSG:*** | R2 | | | | | | | | | |
|  |  | | | | | | | | | |
| ***Work item code:*** | NR\_UE\_pow\_sav\_enh-Core | | | | |  | ***Date:*** | | | 2022-03-04 |
|  |  | | | |  | |  | | |  |
| ***Category:*** | **B** |  | | | | | ***Release:*** | | | Rel-17 |
|  | *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-15 (Release 15) Rel-16 (Release 16) Rel-17 (Release 17) Rel-18 (Release 18)* | |
|  |  | | | | | | | | | |
| ***Reason for change:*** | | This CR introduces the support of Rel-17 UE power saving enhancements in NR. | | | | | | | | |
|  | |  | | | | | | | | |
| ***Summary of change:*** | | Introduction of general description, message sequence chart for Rel-17 UE power saving enhancements in NR | | | | | | | | |
|  | |  | | | | | | | | |
| ***Consequences if not approved:*** | | Rel-17 UE power saving enhancements are not supported in NR. | | | | | | | | |
|  | |  | | | | | | | | |
| ***Clauses affected:*** | | 3.1, 7.3.1, 9.2.5, 11 | | | | | | | | |
|  | |  | | | | | | | | |
|  | | **Y** | **N** |  | | | |  | | |
| ***Other specs*** | | **X** |  | Other core specifications | | | | TS 38.331 CR 2924  TS 38.304 CR 0227 | | |
| ***affected:*** | |  | **x** | Test specifications | | | | TS/TR ... CR ... | | |
| ***(show related CRs)*** | |  | **x** | O&M Specifications | | | | TS/TR ... CR ... | | |
|  | |  | | | | | | | | |
| ***Other comments:*** | |  | | | | | | | | |
|  | |  | | | | | | | | |
| ***This CR's revision history:*** | |  | | | | | | | | |

*Start of change*

## 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

5GS 5G System

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

BFD Beam Failure Detection

BH Backhaul

BL Bandwidth reduced Low complexity

BPSK Binary Phase Shift Keying

C-RNTI Cell RNTI

CAG Closed Access Group

CAPC Channel Access Priority Class

CBRA Contention Based Random Access

CCE Control Channel Element

CD-SSB Cell Defining SSB

CFRA Contention Free Random Access

CHO Conditional Handover

CIoT Cellular Internet of Things

CLI Cross Link interference

CMAS Commercial Mobile Alert Service

CORESET Control Resource Set

CP Cyclic Prefix

CPC Conditional PSCell Change

DAG Directed Acyclic Graph

DAPS Dual Active Protocol Stack

DFT Discrete Fourier Transform

DCI Downlink Control Information

DCP DCI with CRC scrambled by PS-RNTI

DL-AoD Downlink Angle-of-Departure

DL-SCH Downlink Shared Channel

DL-TDOA Downlink Time Difference Of Arrival

DMRS Demodulation Reference Signal

DRX Discontinuous Reception

E-CID Enhanced Cell-ID (positioning method)

EHC Ethernet Header Compression

ETWS Earthquake and Tsunami Warning System

FS Feature Set

GFBR Guaranteed Flow Bit Rate

HRNN Human-Readable Network Name

IAB Integrated Access and Backhaul

I-RNTI Inactive RNTI

INT-RNTI Interruption RNTI

KPAS Korean Public Alarm System

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

MPE Maximum Permissible Exposure

MT Mobile Termination

MU-MIMO Multi User MIMO

Multi-RTT Multi-Round Trip Time

NB-IoT Narrow Band Internet of Things

NCGI NR Cell Global Identifier

NCR Neighbour Cell Relation

NCRT Neighbour Cell Relation Table

NGAP NG Application Protocol

NID Network Identifier

NPN Non-Public Network

NR NR Radio Access

P-MPR Power Management Maximum Power Reduction

P-RNTI Paging RNTI

PCH Paging Channel

PCI Physical Cell Identifier

PDCCH Physical Downlink Control Channel

PDSCH Physical Downlink Shared Channel

PEI Paging Early Indication

PLMN Public Land Mobile Network

PNI-NPN Public Network Integrated NPN

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 Random Access

RA-RNTI Random Access RNTI

RACH Random Access Channel

RANAC RAN-based Notification Area Code

REG Resource Element Group

RIM Remote Interference Management

RLM Radio Link Monitoring

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

RSSI Received Signal Strength Indicator

RSTD Reference Signal Time Difference

SCS SubCarrier Spacing

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

SNPN Stand-alone Non-Public Network

SNPN ID Stand-alone Non-Public Network Identity

SPS Semi-Persistent Scheduling

SR Scheduling Request

SRS Sounding Reference Signal

SRVCC Single Radio Voice Call Continuity

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

TRP Transmit/Receive Point

UCI Uplink Control Information

UL-AoA Uplink Angles of Arrival

UL-RTOA Uplink Relative Time of Arrival

UL-SCH Uplink Shared Channel

UPF User Plane Function

URLLC Ultra-Reliable and Low Latency Communications

V2X Vehicle-to-Everything

Xn-C Xn-Control plane

Xn-U Xn-User plane

XnAP Xn Application Protocol

*Start of next change*

## 7.3 System Information Handling

### 7.3.1 Overview

System Information (SI) consists of a MIB and a number of SIBs, which are divided into Minimum SI and Other SI:

- **Minimum SI** comprises basic information required for initial access and information for acquiring any other SI. Minimum SI consists of:

- *MIB* contains cell barred status information and essential physical layer information of the cell required to receive further system information, e.g. CORESET#0 configuration. *MIB* is periodically broadcast on BCH.

- *SIB1* defines the scheduling of other system information blocks and contains information required for initial access. SIB1 is also referred to as Remaining Minimum SI (RMSI) and is periodically broadcast on DL-SCH or sent in a dedicated manner on DL-SCH to UEs in RRC\_CONNECTED.

- **Other SI** encompasses all SIBs not broadcast in the Minimum SI. Those SIBs can either be periodically broadcast on DL-SCH, broadcast on-demand on DL-SCH (i.e. upon request from UEs in RRC\_IDLE, RRC\_INACTIVE, or RRC\_CONNECTED), or sent in a dedicated manner on DL-SCH to UEs in RRC\_CONNECTED (i.e., upon request, if configured by the network, from UEs in RRC\_CONNECTED or when the UE has an active BWP with no common search space configured). Other SI consists of:

- *SIB2* contains cell re-selection information, mainly related to the serving cell;

- *SIB3* contains information about the serving frequency and intra-frequency neighbouring cells relevant for cell re-selection (including cell re-selection parameters common for a frequency as well as cell specific re-selection parameters);

- *SIB4* contains information about other NR frequencies and inter-frequency neighbouring cells relevant for cell re-selection (including cell re-selection parameters common for a frequency as well as cell specific re-selection parameters), which can also be used for NR idle/inactive measurements;

- *SIB5* contains information about E-UTRA frequencies and E-UTRA neighbouring cells relevant for cell re-selection (including cell re-selection parameters common for a frequency as well as cell specific re-selection parameters);

- *SIB6* contains an ETWS primary notification;

- *SIB7* contains an ETWS secondary notification;

- *SIB8* contains a CMAS warning notification;

- *SIB9* contains information related to GPS time and Coordinated Universal Time (UTC);

- *SIB10* contains the Human-Readable Network Names (HRNN) of the NPNs listed in SIB1;

- *SIB11* contains information related to idle/inactive measurements;

- *SIBpos* contains positioning assistance data as defined in TS 37.355 [43] and TS 38.331 [12].

- *SIBX* contains information related to TRS configuration for UEs in RRC\_IDLE/RRC\_INACTIVE;

For sidelink, Other SI also includes:

- *SIB12* contains information related to NR sidelink communication;

- *SIB13* contains information related to *SystemInformationBlockType21* for V2X sidelink communication as specified in TS 36.331 clause 5.2.2.28 [29];

- *SIB14* contains information related to *SystemInformationBlockType26* for V2X sidelink communication as specified in TS 36.331 clause 5.2.2.33 [29].

Figure 7.3-1 below summarises System Information provisioning.



Figure 7.3-1: System Information Provisioning

For a cell/frequency that is considered for camping by the UE, the UE is not required to acquire the contents of the minimum SI of that cell/frequency from another cell/frequency layer. This does not preclude the case that the UE applies stored SI from previously visited cell(s).

If the UE cannot determine the full contents of the minimum SI of a cell by receiving from that cell, the UE shall consider that cell as barred.

In case of BA, the UE only acquires SI on the active BWP.

*Start of next change*

### 9.2.2 Mobility in RRC\_INACTIVE

#### 9.2.2.1 Overview

RRC\_INACTIVE is a state where a UE remains in CM-CONNECTED and can move within an area configured by NG-RAN (the RNA) without notifying NG-RAN. In RRC\_INACTIVE, the last serving gNB node keeps the UE context and the UE-associated NG connection with the serving AMF and UPF.

If the last serving gNB receives DL data from the UPF or DL UE-associated signalling from the AMF (except the UE Context Release Command message) while the UE is in RRC\_INACTIVE, it pages in the cells corresponding to the RNA and may send XnAP RAN Paging to neighbour gNB(s) if the RNA includes cells of neighbour gNB(s).

Upon receiving the UE Context Release Command message while the UE is in RRC\_INACTIVE, the last serving gNB may page in the cells corresponding to the RNA and may send XnAP RAN Paging to neighbour gNB(s) if the RNA includes cells of neighbour gNB(s), in order to release UE explicitly.

Upon receiving the NG RESET message while the UE is in RRC\_INACTIVE, the last serving gNB may page involved UEs in the cells corresponding to the RNA and may send XnAP RAN Paging to neighbour gNB(s) if the RNA includes cells of neighbour gNB(s) in order to explicitly release involved UEs.

Upon RAN paging failure, the gNB behaves according to TS 23.501 [3].

The AMF provides to the NG-RAN node the Core Network Assistance Information to assist the NG-RAN node's decision whether the UE can be sent to RRC\_INACTIVE, and to assist UE configuration and paging in RRC\_INACTIVE. The Core Network Assistance Information includes the registration area configured for the UE, the Periodic Registration Update timer, and the UE Identity Index value, and may include the UE specific DRX, an indication if the UE is configured with Mobile Initiated Connection Only (MICO) mode by the AMF, the Expected UE Behaviour, the UE Radio Capability for Paging, and the PEI with Paging Subgrouping assistance information. The UE registration area is taken into account by the NG-RAN node when configuring the RNA. The UE specific DRX and UE Identity Index value are used by the NG-RAN node for RAN paging. The Periodic Registration Update timer is taken into account by the NG-RAN node to configure Periodic RNA Update timer. The NG-RAN node takes into account the Expected UE Behaviour to assist the UE RRC state transition decision. The NG-RAN node may use the UE Radio Capability for Paging during RAN Paging. The NG-RAN node takes into account the PEI with Paging Subgrouping assistance information for subgroup paging in RRC\_INACTIVE. When sending the XnAP RAN Paging to neighbour NG-RAN node(s), the PEI with Paging Subgrouping assistance information may be included.

At transition to RRC\_INACTIVE the NG-RAN node may configure the UE with a periodic RNA Update timer value. At periodic RNA Update timer expiry without notification from the UE, the gNB behaves as specified in TS 23.501 [3].

*Start of next change*

9.2.5 Paging

Paging allows the network to reach UEs in RRC\_IDLE and in RRC\_INACTIVE state through *Paging* messages, and to notify UEs in RRC\_IDLE, RRC\_INACTIVE and RRC\_CONNECTED state of system information change (see clause 7.3.3) and ETWS/CMAS indications (see clause 16.4) through *Short Messages*. Both *Paging* messages and *Short Messages* are addressed with P-RNTI on PDCCH, but while the former is sent on PCCH, the latter is sent over PDCCH directly (see clause 6.5 of TS 38.331 [12]).

While in RRC\_IDLE the UE monitors the paging channels for CN-initiated paging; in RRC\_INACTIVE the UE also monitors paging channels for RAN-initiated paging. A UE need not monitor paging channels continuously though; Paging DRX is defined where the UE in RRC\_IDLE or RRC\_INACTIVE is only required to monitor paging channels during one Paging Occasion (PO) per DRX cycle (see TS 38.304 [10]). The Paging DRX cycles are configured by the network:

1) For CN-initiated paging, a default cycle is broadcast in system information;

2) For CN-initiated paging, a UE specific cycle can be configured via NAS signalling;

3) For RAN-initiated paging, a UE-specific cycle is configured via RRC signalling;

- The UE uses the shortest of the DRX cycles applicable i.e. a UE in RRC\_IDLE uses the shortest of the first two cycles above, while a UE in RRC\_INACTIVE uses the shortest of the three.

The POs of a UE for CN-initiated and RAN-initiated paging are based on the same UE ID, resulting in overlapping POs for both. The number of different POs in a DRX cycle is configurable via system information and a network may distribute UEs to those POs based on their IDs.

When in RRC\_CONNECTED, the UE monitors the paging channels in any PO signalled in system information for SI change indication and PWS notification. In case of BA, a UE in RRC\_CONNECTED only monitors paging channels on the active BWP with common search space configured.

For operation with shared spectrum channel access, a UE can be configured for an additional number of PDCCH monitoring occasions in its PO to monitor for paging. However, when the UE detects a PDCCH transmission within the UE's PO addressed with P-RNTI, the UE is not required to monitor the subsequent PDCCH monitoring occasions within this PO.

**Paging optimization for UEs in CM\_IDLE**: at UE context release, the NG-RAN node may provide the AMF with a list of recommended cells and NG-RAN nodes as assistance info for subsequent paging. The AMF may also provide Paging Attempt Information consisting of a Paging Attempt Count and the Intended Number of Paging Attempts and may include the Next Paging Area Scope. If Paging Attempt Information is included in the Paging message, each paged NG-RAN node receives the same information during a paging attempt. The Paging Attempt Count shall be increased by one at each new paging attempt. The Next Paging Area Scope, when present, indicates whether the AMF plans to modify the paging area currently selected at next paging attempt. If the UE has changed its state to CM CONNECTED the Paging Attempt Count is reset.

**Paging optimization for UEs in RRC\_INACTIVE**: at RAN Paging, the serving NG-RAN node provides RAN Paging area information. The serving NG-RAN node may also provide RAN Paging attempt information. Each paged NG-RAN node receives the same RAN Paging attempt information during a paging attempt with the following content: Paging Attempt Count, the intended number of paging attempts and the Next Paging Area Scope. The Paging Attempt Count shall be increased by one at each new paging attempt. The Next Paging Area Scope, when present, indicates whether the serving NG\_RAN node plans to modify the RAN Paging Area currently selected at next paging attempt. If the UE leaves RRC\_INACTIVE state the Paging Attempt Count is reset.

**UE power saving for paging monitoring:** in order to reduce UE power consumption due to false paging alarms, the group of UEs monitoring the same PO can be further divided into multiple subgroups. With subgrouping, a UE shall monitor PDCCH in its PO for paging if the subgroup to which the UE belongs is paged as indicated via associated PEI. If a UE does not receive PEI i.e. PDCCH for PEI or if the UE is unable to monitor the associated PEI occasion corresponding to its PO, UE shall monitor the paging in its PO..

These subgroups have the following characteristics:

- They are formed based on either CN controlled subgrouping or UE ID based subgrouping.

- If specific subgrouping information is not provided from CN, UE ID based subgrouping is used if supported by the UE and network.

- The RRC state (RRC\_IDLE or RRC\_INACTIVE state) doesn’t impact UE subgroup of one UE.

- Subgrouping support for RAN is broadcast in the system information as one of the following: Only CN controlled subgrouping supported, Only UE ID based subgrouping supported, or both CN controlled subgrouping, and UE ID based subgrouping supported.

- Total number of subgrouping allowed in a cell is limited to 8 and represents the sum of CN-assigned and UEID-based subgrouping configured by the network.

- A UE with CN-assigned subgroup ID shall derive UEID-based subgroup ID in a cell supporting only UEID-based subgrouping.

PEI associated with subgroups has the following characteristics:

- If the PEI is supported by the UE, it shall at least support UEID-based subgrouping method.

- PEI subgroup indices are first allocated to CN-assigned subgroups followed by the subgroup indices for the UEID-based subgroups in case both types of subgrouping are supported in the cell.

- PEI monitoring can be limited via system information of the cell in which its last connection was released...

- A PEI-capable UE shall store its last used cell information

- UE that expects MBS group notification shall ignore the PEI and shall monitor paging in its PO

**CN controlled subgrouping:** AMF is responsible for assigning subgroup ID to the UE. The total number of subgroups for CN controlled subgrouping can be configured up to 8, e.g. by OAM. The following figure describes the procedure for CN controlled subgrouping:



Figure 9.2.5-1: Procedure for CN controlled subgrouping

1. The UE indicates its support of CN controlled subgrouping via NAS signalling.

2. If the UE supports CN controlled subgrouping, the AMF determines the subgroup ID assignment for the UE.

3. The AMF sends subgroup ID to the UE via NAS signalling.

4. The AMF informs the gNB about the assigned subgroup ID for paging the UE in RRC\_IDLE/ RRC\_INACTIVE state.

5. When the paging message for the UE is received from the CN or is generated by the gNB, the gNB determines the PO and the associated PEI occasion for the UE.

6. Before the UE is paged in the PO, the gNB transmits the associated PEI and indicates the subgroup(s) of the UE(s) that is paged in the PEI if supported by the UE(s).

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**UE ID based subgrouping:** gNB and UE can determine the subgroup ID based on the UE ID and the total number of subgroups for UE ID based subgrouping in the cell. The total number of subgroups for UE ID based subgrouping is decided by the gNB for each cell and can be different in different cells. The following figure describes the procedure for UE ID based subgrouping:



Figure 9.2.5-2: Procedure for UE ID based subgrouping

1. The gNB determines the total number of subgroups for UE ID based subgrouping in a cell.

2. The gNB broadcasts the total number of subgroups for UE ID based subgrouping in a cell.

3. When paging message for the UE is received from the CN to the gNB or is generated by the gNB, the gNB determines the PO and the associated PEI occasion for the UE.

4. Before the UE is paged in the PO, the gNB transmits the associated PEI and indicates the subgroup(s) of the UE(s) that is paged in the PEI if supported by the UE(s).

*Start of next change*

# 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, BWP switching, or when it monitors response for a CFRA preamble transmission for beam failure recovery (see clause 9.2.6), 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.

Serving Cells of a MAC entity may be configured by RRC in two DRX groups with separate DRX parameters. When RRC does not configure a secondary DRX group, there is only one DRX group and all Serving Cells belong to that one DRX group. When two DRX groups are configured, each Serving Cell is uniquely assigned to either of the two groups. The DRX parameters that are separately configured for each DRX group are on-duration and inactivity-timer.

UE power saving in RRC\_IDLE/RRC\_INACTIVE may be enabled by using RRC\_CONNECTED state TRS. These TRSs may allow UEs in RRC\_IDLE/RRC\_INACTIVE to sleep longer before waking-up for its paging occasion. The TRS configuration is provided in SIBX. The availability of TRS configured in SIBX is indicated by L1 based TRS availability indication. TRS may also be used by the UEs configured with eDRX.

UE Power saving may be enabled by UE relaxing measurements for RLM/BFD. When configured, UE determines whether it is in low mobility state and/or if its radio link quality is better than a threshold. The configuration for low mobility and good serving cell quality criterion is provided through dedicated signalling.

RLM and BFD relaxation may be enabled/disabled separately. Additionally, RLM relaxation may be enabled/disabled on per-CG basis while the BFD relaxation may be enabled/disabled on per serving cell basis.

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UE Power saving may also be achieved through PDCCH skipping mechanism when configured by the network. In this case UE does not monitor PDCCH during the PDCCH skipping duration. However, in the following cases, UE ignores PDCCH skipping

- on all serving cells of the corresponding Cell Group when SR is sent and is pending

- on SpCell while contention resolution timer is running.

- on SpCell during monitoring of the RAR/MsgB window.

*End of change*

# Annex - RAN2 agreements (To be removed in the next version of the CR)

Green highlight – agreement captured in stage-2 specifications

Blue highlight – agreement captured as editor’s notes

No highlight – agreement with no direct impact on specifications

## RAN2#111-e

* For PowSav solutions for Idle/Inactive (for smart phones) that can easily also be applied to redcap, R2 assume they may be applied. Details FFS and to be discuss case by case when the maturity is high (might in the end just be a question of UE caps).
* Dual DRX not in the scope of current WID.

## RAN2#112-e

* Confirm that UE grouping is considered a candidate of paging enhancement for UE power saving
* RAN2 have discussed and considered “paging indication for UE subgroups using paging DCI”, “paging early indication or wake-up signal (WUS) for UE subgroups”, “cross-slot scheduling of paging for UE subgroups”.
* RAN2 understands that RAN1 have started to evaluate performance and complexity. RAN2 assumes that RAN1 continues with this evaluation, in order that decisions can be made regarding the paging indication/scheduling solution. As R2 is the leading group for this WI objective it is expected that final decisions are made by R2.
* Will send an LS to R1 (action to be discussed offline).
* The solution of PRNTI based group discrimination is deprioritized from RAN2 perspective
* The solution of “paging for UE subgroups using different time/frequency resources” is de-prioritized from RAN2 perspective.

## RAN2#113-e

**There is support to have UE ID based enhancement**

**There is still significant interest to have other additional methods (but also some concerns). The approach to have a single mechanism that can take several aspects into account can be a way forward. There are still questions on the details, e.g. whether CN or RAN would provide a parameter.**

* [041] On signalling providing the configuration of TRS/CSI-RS occasion(s) for idle/inactive UE(s):

SIB signalling is the baseline;

Other dedicated high-layer signalling methods (e.g., dedicated RRC, RRC release message, etc.) can be additionally considered with justification. It is assumed they do not work alone.

* [041] RAN2 will down select from the following options on SIB signalling providing the configuration of TRS/CSI-RS occasion(s) for idle/inactive UE(s):

Option 2: Existing SIB, other than SIB1;

Option 3: New SIB type, e.g. SIB-x;

## RAN2#113bis-e

* If we go for network controlled subgrouping, If the network chooses to not provide specific subgrouping information, there will be configuration option where subgrouping can be supported by randomization (by UE-ID).
* We adopt Network controlled subgrouping (based on individual UE characteristics, not specified or limited to paging prob as EUTRA, possibly with additional randomization)

## RAN2#114-e

**The following is supported:**

**CN is responsible for allocating UEs to UE paging subgroups based on UE characteristics**

**Use same UE subgroups when in RRC\_IDLE and RRC\_INACTIVE**

## RAN2#115-e

* When AMF has assigned a UE with a Paging subgroup, some NAS signaling should be supported between AMF and UE to convey the related information to the UE. Exact information is FFS. The design and procedure are up to SA2/CT1.
* When AMF has assigned a UE with a Paging subgroup, some signaling should be supported between AMF and gNB(s) to inform gNB(s) about the related subgroup information for paging a UE in RRC\_IDLE/RRC\_INACTIVE. Exact information is FFS. The message(s) and associated design are up to RAN3.
* It is FFS when a UE in RRC\_INACTIVE has been assigned by CN a Paging subgroup, whether some signaling should be introduced between gNBs to inform each other about the UE’s subgroup for RAN paging.
* If RAN2 agrees to support UE assistance information to CN in support of Paging subgroup assignment, RAN2 will focus on the paging probability and power profile attributes.
* UEID-based subgroup method requires, in addition to the already available information for legacy UEID-based grouping in PO, the total number of supported UEID-based subgroups by the network.
* At least for UEID-based subgroup method the total number, Nsg, of supported subgroups by the network is decided by RAN and broadcasted in System Information.
* At least for UEID-based subgroup method the total number, Nsg, of supported subgroups is controlled on a cell basis and can be different in different cells.
* Option 2 is excluded
* We go with Option 1
* R2 assumes that All the cells within the registration area supports the same number of CN assigned subgroups, i.e. no remapping of CN assigned group ID to RAN subgroup ID (will revisit only if serious issues are found).
* For the purpose of continued discussions, R2 assumes that UE has separate UE caps for CN assigned and UEID based subgrouping, the actual decision to be taken later.
* RAN capability is known based on broadcast information. FFS with explicit indication or implicitly based configuration.
* The TRS/CSI-RS configuration is provided in a new SIB.
* RAN2 assumes that TRS/CSI-RS configurations are broadcasted. Potential addition of dedicated signalling can be discussed in a later meeting based on company contributions.
* The legacy SI update procedure is used for changing TRS/CSI-RS configurations.
* Postpone the topic about TRS/CSI-RS availability until a later meeting when RAN1 also has progressed.
* On demand SI should be possible for the SIB with TRS/CSI-RS information.
* Postpone the discussion on segmentation of the new SIB until RAN1 has sent the list of the parameters and a potential structure.
* Postpone the discussion on splitting the TRS/CSI-RS information to a common and RS-specific part until RAN1 has sent the list of the parameters and a potential structure.

## RAN2#116-e

* Assume that one subgroup indication refer to either CN assigned subgroups or UE-ID based subgroup (no overlapping)
* Both UE ID based and CN based subgrouping can be supported simultaneously in a cell, it is allowed to just support one of them.
* FFS if the total number of CN-assigned subgroups is OAM configured. Max would be 8 as this is what RAN support.
* The total number of CN-assigned subgroups that is used is not fixed can be configured up to 8 (e.g. by OAM). No impact on signalling is assumed.
* RAN introduces a new parameter Nsg-UEID to indicate its support of UE-ID based subgrouping.
* RAN does not support any type of subgrouping if its configuration for subgrouping is either absent or nullified (e.g. subgroupsNumPerPO is either absent or set to zero). FFS for the signalling details.
* We assume separate indications for UE capability of CN based subgrouping and UEID based subgrouping.
* UE’s capability of supporting the UE ID based subgrouping is reported to RAN by AS UE capability signalling while R2 assumes that UE’s capability of supporting the CN-assigned subgrouping is reported to CN by NAS signalling.
* RAN2 assumes that if PEI is detected, and the PEI indicates that the UE has to monitor the associated PO, then the UE monitors paging DCI in the associated PO, including scheduling information for paging PDSCH (if included) as in legacy. This assumption may be updated based on RAN1 agreements.
* As a baseline RAN2 has a preference to support PEI with both DRX and eDRX, but potential issues (e.g. PEI and PTW) are FFS.
* For UE-ID based subgroups the UE identity is UE\_ID = 5G-S-TMSI mod X, where X is 8192 (1024\*8).
* Introduce a UERadioPagingInfo IE in the UECapabilityInformation message in NR in Rel-17.
* If the UE was not able to monitor the PEI occasion corresponding to its PO the UE shall monitor the PO.
* The scope of the new SIB-X is configurable (either cell or area scope) based on NW implementation.
* RAN2 to wait for additional RAN1 feedback, before finalizing aspects on SIB-X sizing, segmentation etc.
* RAN2 to wait for further RAN1 input on whether TRS/CSI-RS configuration can be split as common and TRS specific part.
* The new SIB-X can be made on demand, and it is up to NW configuration.
* There are no UE side impacts due to any additional NW side restriction on on-demand SIB-X.
* IDLE/INACTIVE UEs do NOT have to report any feedback on its TRS/CSI-RS resource usage.
* RAN2 assumes to support current RAN1 working agreement of L1 based signalling for TRS/CSI-RS availability indication. FFS whether it should be possible to enable / disable the TRS/CSI-RS L1 based availability mechanism by broadcast signalling.
* R2 assumes that additional TRS/CSI-RS configuration by dedicated signalling is not supported. Can revisit e.g. based on R1 provided info if needed.
* Postpone further discussion on TRS/CSI-RS applicability for eDRX UEs. Can consider later
* RLM/BFD relaxation criteria are configured by dedicated signalling (e.g. RadioLinkMonitoringConfig) as a baseline, if RAN4 decides to provide parameters instead of predefined or by implementation.
* R2 assumes to use AS capability procedure to report UE capability of supporting RLM/BFD relaxation. Details FFS.
* RAN2 wait for RAN4 progress on the designing of low mobility criterion.
* RAN2 assumes the presence/absence of configuration for RLM/BFD relaxation criteria in signalling indicates to the UE whether the UE can/should evaluate the criteria.

## RAN2#116bis-e

* RAN configuration (of subgrouping) includes the two parameters Nsg-UEID (number of UEID-based subgroups) and *subgroupsNumPerPO* (total number of subgroups in a PO):

- If only CN-assigned subgrouping is used, *subgroupsNumPerPO* is present (the value then equals to the number of CN-assigned subgroups), and Nsg-UEID is absent.

- If only UEID-based subgrouping is used, *subgroupsNumPerPO* and Nsg-UEID are present, and Nsg-UEID has the same value as *subgroupsNumPerPO*.

- If both subgrouping methods are used, both *subgroupsNumPerPO* and Nsg-UEID are present, and 0 < Nsg-UEID < *subgroupsNumPerPO*.

* RAN2 aims to Support PEI and subgrouping with eDRX. FFS the impact.
* RAN2 assumes that there is no particular impact to Uu signalling to support RAN sharing. It is further assumed that Core Networks must have consistent policy if subgrouping is used by multiple Core Networks.
* RAN2 assumes that PEI can be used “without” subgrouping. FFS whether the bits in the PEI for subgrouping then need to have any particular meaning, or whether this would be done by just having one subgroup.
* RAN2 assumes that PEI monitoring can not be specifically enabled/disabled for individual UEs.
* PEI subgroup indices are allocated to CN-assigned subgroups first. The 1st bit in the PEI bitmap corresponds to the CN-assigned subgroup #1, 2nd bit in the bitmap corresponds to the CN-assigned subgroup #2, and so on. After CN-assigned subgroups, the subsequent bits, if any, correspond to the UEID-based subgroup #1, #2, and so on.
* Both *subgroupNumPerPO* and Nsg-UEID range from 1 to 8.
* If network supports PEI but not subgrouping, the whole *SubgroupConfig-r17* is absent. The parameter *subgroupsNumPerPO* is mandatory present if *subgroupConfig-r17* is configured.
* UE is configured to monitor PEI, either only in the last used cell or any other cells (after cell reselection). FFS how the configuration is provided in [SI, RRCRelease, or NAS message].
* If a cell supports both UE identity based and CN assigned subgrouping, for UEID based paging subgrouping, UE belongs to k-th paging subgroup, where

- k = [floor (UE Identity/(N\*Ns)) mod Nsg-UEID] + Nsg-CN,

- N is the number of Paging frames,

- Ns is the number of POs per paging frame,

- Nsg-UEID is the number of UEID-based paging subgroups, and

- Nsg-CN is the number of CN assigned paging subgroups (= subgroupNumPerPO - Nsg-UEID).

* The number of bits N in the bitmap used for L1 availability indication is derived implicitly from the number of different values of *indBitID*. There is no need for an explicit parameter.
* RAN2 confirm TRS/CSI-RS can be applied to eDRX UEs.
* Confirm that there will be no particular mechanism for availability indication based on SIB (beyond the presence of the RS configuration)
* A UE which acquired SIB-X with a TRS/CSI-RS configuration but didn’t yet receive an associated L1-based availability indication considers the configured TRS/CSI-RS as FFS: “unavailable” or “available”.
* R2 doesn't send an LS to R1 on SIB segmentation

[055] OFFLINE

* [055] Indicating the TRS/CSI-RS availability in Idle/Inactive when releasing the UE to Idle/Inactive in the *RRCRelease* message is not pursued.
* [055] RAN2 follows RAN1 agreement that if TRS resource is configured in SIB, L1 based availability indication is always enabled based on that configuration.
* [055] RAN2 waits for RAN1 to finalize the contents of SIB-X before finalizing aspects on SIB-X sizing, segmentation etc
* BFD relaxation is enable/disable per serving cell (i.e. separately between Pcell/PScell and Scell). FFS on stage-3 details.
* RLM relaxation is enable/disable per-CG (i.e. separately between Pcell and PScell). FFS on stage-3 details, FFS if enable/disable is by the UE or by the network.
* Parameters of SSearchDeltaP and TSearchDeltaP for low mobility criterion is configured in dedicated signaling. FFS on stage-3 details (i.e. value range of parameters, in which IE).
* RAN2 assumes that the criteria for RLM/BFD relaxation will be captured in RAN2 TS, can ask R4
* RAN2 to send an LS to RAN4 for RLM/BFD relaxation including the below aspects:

RAN2 conclusions on RLM/BFD relaxation

Specification split on RLM/BFD relaxation

[056] OFFLINE

* [056] RLM relaxation and BFD relaxation are enabled/disabled separately.
* [056][Post116bis-e][000] Postpone the discussion on how to enable/disable RLM relaxation per-CG, and how to enable/disable BFD relaxation per-serving cell to wait for RAN4 conclusions on the configuration of criteria
* [056] RAN2 assume the criteria configuration for RLM relaxation and BFD relaxation are configured separately. FFS Which criteria configuration(s) could be configured separately (e.g. serving cell quality). RAN2 can come back on this based on RAN4 conclusion.
* [056] Postpone the discussion on how to provide the criteria configuration for RLM relaxation and BFD relaxation for low mobility criterion to wait for progress from RAN4.
* [056] Postpone the discussion on how to provide the criteria configuration for RLM relaxation and BFD relaxation for serving cell quality criterion to wait for progress from RAN4.
* [056] Postpone the discussion on how to evaluate the low mobility criterion for RLM/BFD relaxation to wait for progress from RAN4.
* [056] Postpone the discussion on how to evaluate the serving cell quality criterion for RLM/BFD relaxation to wait for progress from RAN4.
* [056] BWP switch doesn’t impact evaluation of BFD relaxation or ongoing relaxation of BFD measurement.
* [056] if UE report on fulfillment or not (entry/exit) to network for RLM/BFD relaxation is agreeable, UAI is used to provide the report.
* [056] RAN2 assumes the configurations for RLM/BFD relaxation should be captured in RAN2 specification, while the relaxation requirements/approaches should be captured in RAN4 specification.
* From RAN2 point of view, UE ignores PDCCH skipping while the SR is pending.
* From RAN2 point of view, if PDCCH skipping is applied to RNTI(s) monitored during RAR/MsgB window, the UE ignores PDCCH skipping during the RAR/MsgB window.
* From RAN2 point of view, UE ignores PDCCH skipping while contention resolution timer is running.
* If DCP can not be monitored due to PDCCH skipping, FFS whether to a) reuse the *ps-Wakeup* or b) PHY indicate DCP as 1 to MAC. No specification change is expected for either a) and b).
* Send LS to RAN1

include agreed proposals 1, 2, 3

ask RAN1 to take agreed proposals into account

ask RAN1 whether a) Physical layer of UE reports a value of 1 for Wake-up indication bit to higher layer or b) Physical layer of UE does not report Wake-up indication bit to higher layer, in case UE cannot monitor DCP due to PDCCH skipping.

**Take comments above into account**

* [058] Paging enhancement capability(-ies) (e.g. PEI capability, UEID based subgrouping capability or the combined capability of PEI and UEID based subgrouping) are ‘optional with capability signalling’ as gNB needs to know the paging enhancement capability(-ies) to page the UE
* [058] Paging enhancement capability(-ies) can be included into the UERadioPagingInfo IE in the UECapabilityInformation message as agreed in RAN2#116 (i.e. Introduce a UERadioPagingInfo IE in the UECapabilityInformation message in NR in Rel-17)
* [058] gNB interprets UE’s reported *UECapabilityInformation*, copies the *UERadioPagingInfo* IE out and includes it as a container *UE-RadioPagingInfo* IE in the *UERadioPagingInformation* inter-node message to AMF
* [058] Separate indications for UE capability of CN based subgrouping and UEID based subgrouping (confirms earlier assumption)
* [058] UE’s capability of supporting the UE ID based subgrouping is reported to RAN by AS UE capability signalling while UE’s capability of supporting the CN-assigned subgrouping is reported to CN by NAS signalling. (confirms earlier assumption).
* [058] Postpone the discussion of UE AS capabilities for RLM/BFD relaxation to next meeting.
* [058] For UE capabilities of PDCCH monitoring adaptation, implement it as part of the UE capability rapporteur mega CRs from the R1 feature list

## RAN2-117-e

* Not sufficient support to introduce any special functionality for UEs in eDRX. Rely on UE determination on whether he has up to date information or not. Can think about whether clarification is needed.
* The configuration for RLM relaxation feature and BFD relaxation feature are provided in *SpCellConfig* and *SpCellConfig/ScellConfig*, respectively.
* Low mobility criterion is configured in NR Pcell for the case of NR SA/ NR CA/ NE-DC/NR-DC, and in the NR PSCell for the case of EN-DC.
* Introduce optional parameter(s) of offset on Qx (Qin for RLM relaxation and FFS for BFD relaxation) for good serving cell quality criterion in dedicated signaling. If the offset is absent, a pre-defined value is used (e.g. FFS [0dB]). FFS on stage-3 details (i.e. value range of parameters).
* Serving cell quality criterion is configured provided in PCell/PScell for RLM relaxation and in PCell/PScell for BFD relaxation (regarding Scell waiting for R4 input)

**RAN2 clarifications to earlier RAN2 decisions:**

* P1: UE ignores PDCCH skipping on all serving cells of the corresponding CG while SR is pending (FFS if “all” can be further restricted).
* P2: If PDCCH skipping is applied to RNTI(s) monitored during RAR/MsgB window, UE ignores PDCCH skipping on SpCell. (based on the answer form RAN 1 in R2-2204121)
* P3: UE ignores PDCCH skipping on SpCell while contention resolution timer is running.

Working Agreement:

* UE can start/stop RLM/BFD relaxation by itself if it meets/fails the relaxation criteria.
* The feature is configured by RRC dedicated signalling, this is the only enable disable function that is supported.
* PEI + UEID subgrouping is one capability
* gNB does not need to know the UE capability for TRS/CSI-RS in idle and inactive mode. Introduce R1 29-2 as optional without capability signalling
* Introduce 2 separate capability bits for RLM relaxation feature and for BFD relaxation feature
* The capability bit(s) for RLM and BFD relaxation shall be per UE with FR differentiation
* Network indicates whether UE monitors PEI in last used cell in system information.
* A UE which acquired SIB-X with a TRS/CSI-RS configuration but didn’t yet receive an associated L1-based availability indication considers the configured TRS/CSI-RS as “unavailable”.
* RAN2 reuses the existing mechanism used for SIB12 for implementing the SIBX segmentation
* A PEI-capable UE stores its “last used cell” information. FFS how to capture this in the specifications
* Do not introduce an associated timer for the “last used cell” information stored by UE
* The “lastUsedCellOnly” indication is a cell-level configuration and there is no per-subgroup indication
* Introduce a one-bit indication of *lastUsedCellOnly* in PEI-Config.
* RAN2 clarifies the meaning of “last used cell only”: When a cell broadcasts “last used cell only”, a UE monitors PEI only if its last connection was released by this cell.
* A PEI-capable UE must support at least UEID-based subgrouping method.
* RAN2 confirms that “PEI without subgrouping” can be implemented by configuring PEI plus UEID subgrouping with one subgroup.
* “PEI without subgrouping” can be configured by only one method.
* When PEI is applied with eDRX, the UEID for UEID-based subgrouping is determined by 5G-S-TMSI mod 32768.
* No special handling or configuration is introduced for PEI monitoring with PTW (i.e., PEI is applicable to each PO within PTW).
* Send an informative LS to RAN3/SA2/CT1 for RAN2 agreements about PEI and paging subgrouping and ask question about mismatched understanding of “last cell” between network and UE.
* If a UE cannot find its subgroup ID with the PEI configurations in a cell, it monitors legacy paging.
* A UE with CN-assigned subgroup ID should derive UEID-based subgroup ID in a cell supporting only UEID-based subgrouping.