**3GPP TSG-RAN WG2 Meeting #115 Electronic R2-210xxxx**

**Online Meeting, Aug 16 – 27, 2021**

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| *CR-Form-v12.1* |
| **CHANGE REQUEST** |
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|  | **38.300** | **CR** | **Draft CR** | **rev** | **-** | **Current version:** | **16.5.0** |  |
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| *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 Rel-17 UE power saving enhancements |
|  |  |
| ***Source to WG:*** | Huawei, HiSilicon |
| ***Source to TSG:*** | R2 |
|  |  |
| ***Work item code:*** | NR\_UE\_pow\_sav\_enh-Core |  | ***Date:*** | 2021-09-01 |
|  |  |  |  |  |
| ***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 canbe 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:*** | 7.3.1, 9.2.5, 11 |
|  |  |
|  | **Y** | **N** |  |  |
| ***Other specs*** |  | **X** |  Other core specifications  | TS/TR ... CR ... |
| ***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*

## 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/CSI-RS configuration;

Editor’s NOTE: RAN2 assumes that on demand SI mechanism should be possible for requesting the SIB with TRS/CSI-RS information.

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*

9.2.5 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 power consumption in the UE due to false paging alarms i.e. when the UE receives a paging message on PDSCH, which is not intended for that UE, UEs within a PO can be further divided into multiple subgroups.

These subgroups have the following characteristics:

- These subgroups may be formed based on either CN controlled subgrouping or gNB controlled UE ID based subgrouping.

- If CN controlled subgrouping is not supported by the AMF, UE ID based subgrouping may be configured in the gNB.

- The same UE subgroups shall be used by the UE for RRC\_IDLE and RRC\_INACTIVE state.

- The support of CN controlled subgrouping and/or UE ID based subgrouping is signalled in the system information.

Editor’s NOTE: Details on whether the subgrouping is signalled by explicit indication or implicitly is FFS.

**CN controlled subgrouping:** AMF is responsible for assigning UE subgroup information, including subgroup ID, to the UE based on its characteristics. All the cells within the registration area shall support the same number of CN assigned subgroups. The following figure describes the procedure for CN controlled subgrouping:



Figure 9.2.5-1: Procedure for CN controlled subgrouping

1. The AMF determines the UE subgroup information, including subgroup ID assignment for the UE based on its characteristics.

2. The AMF sends UE subgroup information to the UE via NAS signalling.

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

Editor’s NOTE: Exact information in step 2 above is FFS. The design and procedure are up to SA2/CT1.

Editor’s NOTE: Exact information in step 3 above is FFS. The message(s) and associated design are up to RAN3.

Editor’s NOTE: We will revisit the assumption “All the cells within the registration area supports the same number of CN assigned subgroups” only if serious issues are found.

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



Figure 9.2.5-2: Procedure for gNB controlled UE ID based subgrouping

1. The gNB determines the total number of subgroups in a cell.

2. The gNB broadcasts the total number of subgroups in a cell.

*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.

Power saving in RRC\_IDLE/RRC\_INACTIVE may be enabled by using TRS/CSI-RS. The TRS/CSI-RS configuration is provided in SIBX.

Editor’s NOTE: Need for dedicated signalling for TRS/CSI-RS configuration is FFS.

*End of change*

# Annex - RAN2 agreements

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.