**3GPP TSG-RAN WG2 Meeting #116-e *R2-21xxxxx***

**Online, 1 – 12 November 2021**

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| *CR-Form-v12.1* |
| **CHANGE REQUEST** |
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|  | **36.300** | **CR** | **XXXX** | **rev** | - | **Current version:** | **16.6.0** |  |
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| *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:***  | Running CR: Introduction of Rel-17 enhancements for NB-IoT and eMTC |
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| ***Source to WG:*** | Huawei |
| ***Source to TSG:*** | R2 |
|  |  |
| ***Work item code:*** | NB\_IOTenh4\_LTE\_eMTC6-Core |  | ***Date:*** | 2021-10-xx |
|  |  |  |  |  |
| ***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)* |
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| ***Reason for change:*** | Introduction of Rel-17 enhancements for NB-IoT and eMTC |
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| ***Summary of change:*** | This running CR captures the agreements for Rel-17 enhancements for NB-IoT and eMTC: * NB-IoT neighbor cell measurements and corresponding measurement triggering before RLF.
* NB-IoT carrier selection based on the coverage level, and associated carrier specific configuration.
* 16-QAM for unicast in UL and DL.
* 14-HARQ processes in DL, for HD-FDD Cat M1 UEs
* Maximum DL TBS of 1736 bits for HD-FDD Cat. M1 UEs in CE mode A
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| ***Consequences if not approved:*** | Rel-17 enhancements for NB-IoT and eMTC are not supported |
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| ***Clauses affected:*** | 5.1.2 (FFS), 5.2.2, 10.0, 10.1.3.0, 10.1.4, 23.7a |
|  |  |
|  | **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 ...  |
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| ***Other comments:*** | The running CR is written on the June version of the specification  |
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| ***This CR's revision history:*** |  |

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| Beginning of change |

### 5.1.2 Physical-layer processing

The downlink physical-layer processing of transport channels consists of the following steps:

- CRC insertion: 24 bit CRC for PDSCH and NPDSCH;

- Channel coding: Turbo coding based on QPP inner interleaving with trellis termination, or Tail Biting Convolutional Coding for NPDSCH;

- Physical-layer hybrid-ARQ processing;

- Channel interleaving;

- Scrambling: transport-channel specific scrambling on DL-SCH, BCH, and PCH. Common MCH scrambling for all cells involved in a specific MBSFN transmission;

- Modulation: QPSK, 16QAM, 64QAM, and 256QAM;

- Layer mapping and pre-coding;

- Mapping to assigned resources and antenna ports.

Editor’s Note: FFS whether to capture something here for 16QAM DL in NB-IoT

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| Next change |

5.2.2 Physical-layer processing

The uplink physical layer processing of transport channels consists of the following steps:

- CRC insertion: 24 bit CRC for PUSCH and NPUSCH;

- Channel coding: turbo coding based on QPP inner interleaving with trellis termination;

- Physical-layer hybrid-ARQ processing;

- Scrambling: UE-specific scrambling;

- Modulation: QPSK, 16QAM, 64QAM and 256 QAM (64 QAM and 256 QAM optional in UE) for full-PRB transmission of PUSCH, and π/2-BPSK and QPSK for sub-PRB transmission of PUSCH (optional in UE); π/2-BPSK and π/4-QPSK in single-tone transmission of NPUSCH, QPSK and optionally 16QAM for multi-tone transmission of NPUSCH;

- Mapping to assigned resources and antennas ports.

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# 10 Mobility

## 10.0 General

Load balancing is achieved in E-UTRAN with handover, redirection mechanisms upon RRC release, DC and through the usage of inter-frequency and inter-RAT absolute priorities and inter-frequency Qoffset parameters.

Measurements to be performed by a UE for mobility are classified in at least four measurement types:

- Intra-frequency E-UTRAN measurements;

- Inter-frequency E-UTRAN measurements;

- Inter-RAT measurements for UTRAN and GERAN;

- Inter-RAT measurements of CDMA2000 HRPD or 1xRTT frequencies.

For each measurement type one or several measurement objects can be defined (a measurement object defines e.g. the carrier frequency to be monitored).

For each measurement object one or several reporting configurations can be defined (a reporting configuration defines the reporting criteria). Three reporting criteria are used: event triggered reporting, periodic reporting and event triggered periodic reporting.

The association between a measurement object and a reporting configuration is created by a measurement identity (a measurement identity links together one measurement object and one reporting configuration of same RAT). By using several measurement identities (one for each measurement object, reporting configuration pair) it is possible:

- To associate several reporting configurations to one measurement object and;

- To associate one reporting configuration to several measurement objects.

The measurements identity is as well used when reporting results of the measurements.

Measurement quantities are considered separately for each RAT.

Measurement commands are used by E-UTRAN to order the UE to start measurements, modify measurements or stop measurements.

For NB-IoT:

- Handover, measurement reports and inter-RAT mobility are not supported;

- 10.1.1 Mobility Management in ECM-IDLE, 10.1.3 Measurements, 10.1.4 Paging and C-plane establishment, 10.1.5 Random Access Procedure, 10.1.6 Radio Link Failure, 10.1.7 Radio Access Network Sharing and all their clauses are applicable;

- 10.2.6 Idle mode Inter-RAT Cell Selection to/from NB-IoT is supported;

- All other subclauses of clause 10 are not applicable.

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### 10.1.3 Measurements

#### 10.1.3.0 General

Measurements to be performed by a UE for intra/inter-frequency/inter-RAT mobility can be controlled by E-UTRAN, using broadcast or dedicated control. In RRC\_IDLE state, a UE shall follow the measurement parameters defined for cell reselection specified by the E-UTRAN broadcast. The use of dedicated measurement control for RRC\_IDLE state is possible through the provision of UE specific priorities (see clause 10.2.4). In RRC\_CONNECTED state, a UE shall follow the measurement configurations specified by RRC directed from the E-UTRAN (e.g. as in UTRAN MEASUREMENT\_CONTROL).

In RRC\_IDLE and RRC\_CONNECTED the UE may be configured to monitor some UTRA or E-UTRA carriers according to reduced performance requirements as specified in TS 36.133 [21].

In RRC\_IDLE, for NB-IoT UEs, BL UEs or UEs in enhanced coverage, the UE may further limit the intra-frequency and inter-frequency measurements when the relaxed monitoring criterion is fulfilled as specified in TS 36.304 [11].

In RRC\_IDLE, for NB-IoT UEs, when enabled in the cell and the relaxed monitoring criterion is fulfilled, the UE may perform serving cell measurements on the non-anchor paging carrier as specified in TS 36.133 [21].

For CSI-RS based discovery signals measurements, "cell" should be interpreted as "transmission point of the concerned cell" in the following descriptions.

Intra-frequency neighbour (cell) measurements, inter-frequency neighbour (cell) measurements and inter-RAT measurements are defined as follows:

- Intra-frequency neighbour (cell) measurements: Neighbour cell measurements performed by the UE are intra-frequency measurements when the current and target cell operates on the same carrier frequency.

- Inter-frequency neighbour (cell) measurements: Neighbour cell measurements performed by the UE are inter-frequency measurements when the neighbour cell operates on a different carrier frequency, compared to the current cell.

- Inter-RAT neighbour (cell) measurements: Neighbour cell measurements performed by the UE are inter-RAT measurements when the neighbour cell operates on a different RAT, compared to the current cell.

Whether a measurement is non gap assisted or gap assisted depends on the UE's capability and the current operating frequency. In non gap assisted scenarios, the UE shall be able to carry out such measurements without measurement gaps. In gap assisted scenarios, the UE may not be able to perform such measurements without measurement gaps. The UE determines whether a particular cell measurement needs to be performed in a transmission/reception gap and the scheduler needs to know whether gaps are needed:

- Same carrier frequency and cell bandwidths (Scenario A): an intra-frequency scenario; not measurement gap assisted.

- Same carrier frequency, bandwidth of the target cell smaller than the bandwidth of the current cell (Scenario B): an intra-frequency scenario; not measurement gap assisted.

- Same carrier frequency, bandwidth of the target cell larger than the bandwidth of the current cell (Scenario C): an intra-frequency scenario; not measurement gap assisted.

- Different carrier frequencies, bandwidth of the target cell smaller than the bandwidth of the current cell and bandwidth of the target cell within bandwidth of the current cell (Scenario D): an inter-frequency scenario; measurement gap-assisted scenario.

- Different carrier frequencies, bandwidth of the target cell larger than the bandwidth of the current cell and bandwidth of the current cell within bandwidth of the target cell (Scenario E): an inter-frequency scenario; measurement gap-assisted scenario.

- Different carrier frequencies and non-overlapping bandwidth, (Scenario F): an inter-frequency scenario; measurement gap-assisted scenario.

- Same carrier frequency, the operating frequency of the bandwidth reduced low complexity (BL) UE or the UE in Enhanced Coverage is not guaranteed to be aligned with the center frequency of the current cell (Scenario G): an intra-frequency scenario; measurement gap assisted scenario.







Figure 10.1.3-1: Inter and Intra-frequency measurements scenarios

Measurement gaps may be needed by the UE to carry out inter-RAT measurements on NR frequencies. UE may need measurement gaps to perform inter-RAT measurements on NR frequencies depending on the UE's need for gap capability, as well as the UE capability to support independent FR measurement as specified in TS 38.306 [89]. The UE may not be able to perform inter-RAT NR measurements without measurement gaps in the following cases:

- If the UE only supports per-UE gaps and the UE is required to measure NR frequencies:

- If the UE supports per-FR gaps and the UE is required to measure at least one NR frequency in FR1;

Measurement gaps patterns are configured and activated by RRC.

When CA is configured, the "current cell" above refers to any serving cell of the configured set of serving cells. For instance, for the definition of intra and inter frequency measurements except for NB-IoT, this means:

- Intra-frequency neighbour (cell) measurements: Neighbour cell measurements performed by the UE are intra-frequency measurements when one of the serving cells of the configured set and the target cell operates on the same carrier frequency. The UE shall be able to carry out such measurements without measurement gaps.

- Inter-frequency neighbour (cell) measurements: Neighbour cell measurements performed by the UE are inter-frequency measurements when the neighbour cell operates on a different carrier frequency than any serving cell of the configured set. The UE may not be able to perform such measurements without measurement gaps.

When DC is configured, the following principles are applied:

- The configured set of serving cells includes all the cells from MCG and SCG as for CA;

- The measurement procedure of serving cells belonging to the SeNB shall not be impacted due to RLF of SeNB;

- Common gap for the MeNB and the SeNB is applied;

- There is only a single measurement gap configuration for the UE which is controlled and informed by the MeNB.

- UE determines the starting point of the measurement gap based on the SFN, subframe number and subframe boundaries of the MCG serving cells.

When LAA is configured:

- The eNB configures the UE with one DMTC window for all neighbor cells as well as for the serving cell (if any) on one frequency;

- The UE is only expected to detect and measure cells transmitting DRS during the configured DRS DMTC window;

- For channel selection in an environment where hidden nodes may exist, UE may be configured with one RMTC per a frequency to perform RSSI measurement, and to report average RSSI and channel occupancy (percentage of measurement samples that RSSI value is above a threshold) in a reporting interval.

For NB-IoT, measurements in RRC\_CONNECTED are optionally supported to reduce the time taken for RRC reestablishment. The following principles are applied:

- The "current cell" above refers to the configured carrier in the serving cell. The "target cell" above refers to the anchor carrier in the target cell. For instance, for the definition of intra and inter frequency measurements, this means:

- Intra-frequency neighbour (carrier) measurements: Neighbour carrier measurements performed by the UE are intra-frequency measurements when the configured carrier in the serving cell and the anchor carrier in the target cell operates on the same carrier frequency. The UE shall be able to carry out such measurements without measurement gaps.

- Inter-frequency neighbour (carrier) measurements: Neighbour cell measurements performed by the UE are inter-frequency measurements when the configured carrier in the serving cell and the anchor carrier in the target cell operates on a different carrier frequency. The UE may not be able to perform such measurements without measurement gaps.

- The eNB configures the criteria to perform measurements via broadcast signalling;

- Network assisted measurements gaps are not supported. The UE may need to perform neighbour cell measurements during DL/UL idle periods that are provided by DRX or packet scheduling.

- Measurement reporting is not supported.

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## 23.7a Support of Bandwidth Reduced Low Complexity UEs

A bandwidth reduced low complexity (BL) UE can operate in any LTE system bandwidth but with a limited channel bandwidth of 6 PRBs (corresponding to the maximum channel bandwidth available in a 1.4 MHz LTE system) in downlink and uplink. Interworking with NR is not supported by BL UE (e.g. functions like NR measurement reporting, reselection to NR, handover to NR, redirection to NR are not supported).

To enable higher data rates a BL UE can optionally support a larger maximum PDSCH/PUSCH channel bandwidth of 24 PRBs in downlink and a non-BL UE operating in enhanced coverage can optionally support a larger maximum PDSCH/PUSCH channel bandwidth of 24 or 96 PRBs in downlink, and 24 PRBs in uplink in connected mode for unicast transmission. Table 23.7.a-1 summarizes the maximum PDSCH/PUSCH bandwidth in connected mode for unicast transmission depending on the UE category and enhanced coverage mode (see clause 23.7b). The maximum PDSCH/PUSCH channel bandwidth is configured separately for PDSCH and PUSCH via dedicated RRC signaling.

Table 23.7a-1: Maximum PDSCH/PUSCH bandwidth (in PRBs)

|  |  |  |
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| UE category/CE mode | CE mode A | CE mode B |
| BL (Category M1) | 6/6 | 6/6 |
| BL (Category M2) | 24/24 | 24/6 |
| Non-BL (Category 0 and higher) | 96 (or 24)/24 | 96 (or 24)/6 |

A Category M2 BL UE supports a larger DL and UL maximum TBS size for unicast compared to a Category M1 BL UE. A Category M1 BL UE may support a larger UL maximum TBS size indicated by a separate UE capability.

A Category M1 BL UE may support a larger DL maximum TBS size in CE Mode A for HD-FDD indicated by a separate UE capability.

A Category M1 BL UE may support 14 HARQ processes in downlink for HD-FDD indicated by a separate UE capability.

A BL UE may access a cell only if the MIB of the cell indicates that scheduling information for SIB1 specific for BL UEs is scheduled. If not, the UE considers the cell as barred.

A BL UE receives a separate occurrence of system information blocks (sent using different time/frequency resources). A BL UE has a transport block size (TBS) limited to 1000 bit for broadcast. The BL UE determines the scheduling information for SIB1 specific for BL UEs based on information in MIB. Scheduling information for other SIBs is given in SIB1 specific for BL UEs. The BCCH modification period for BL UEs is a multiple of the BCCH modification period provided in SIB2. The SIB transmission occasions within an SI-window are provided in the SIB1 specific for BL UEs. A BL UE can acquire SI messages across SI windows. The maximum number of SI messages that can be acquired across SI windows is 4. A BL UE is not required to detect SIB change when in RRC\_CONNECTED.

A BL UE is paged based on paging occasions in time domain, and paging narrowbands in frequency domain. The starting subframe of a paging occasion is determined in the same way as the paging occasion in the legacy paging mechanism.

A set of PRACH resources (e.g. time, frequency, preamble), each associated with BL UEs in normal coverage, is provided in SIB. Number of PRACH repetitions and number of maximum preamble transmission attempts for BL UEs in normal coverage are provided in SIB. Time/frequency resources and repetition factor for random access response messages for BL UEs are derived from the used PRACH resources.

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### 10.1.4 Paging and C-plane establishment

Paging groups (where multiple UEs can be addressed) are used on PDCCH:

- Precise UE identity is found on PCH;

- DRX configurable via BCCH and NAS;

- Only one subframe allocated per paging interval per UE;

- The network may divide UEs to different paging occasions in time;

- There is no grouping within paging occasion;

- One paging RNTI for PCH.

When extended DRX (eDRX) is used in idle mode, the following are applicable:

- The DRX cycle is extended up to and beyond 10.24s in idle mode, with a maximum value of 2621.44 seconds (43.69 minutes); For NB-IoT, the maximum value of the DRX cycle is 10485.76 seconds (2.91 hours);

- The hyper SFN (H-SFN) is broadcast by the cell and increments by one when the SFN wraps around;

- Paging Hyperframe (PH) refers to the H-SFN in which the UE starts monitoring paging DRX during a Paging Time Window (PTW) used in ECM-IDLE. The PH is determined based on a formula that is known by the MME/AMF, UE and (ng-)eNB as a function of eDRX cycle and UE identity;

- During the PTW, the UE monitors paging for the duration of the PTW (as configured by NAS) or until a paging message is including the UE's NAS identity received for the UE, whichever is earlier. The possible starting offsets for the PTW are uniformly distributed within the PH and defined in TS 36.304 [11];

- MME/AMF uses the formulas defined in TS 36.304 [11] to determine the PH as well as the beginning of the PTW and sends the S1 paging request just before the occurrence of the start of PTW or during PTW to avoid storing paging messages in the (ng-)eNB;

- ETWS, CMAS, PWS requirement may not be met when a UE is in eDRX. For EAB, if the UE supports SIB14, when in extended DRX, it acquires SIB14 before establishing the RRC connection;

- When the eDRX cycle is longer than the system information modification period, the UE verifies that stored system information remains valid before establishing an RRC connection. Paging message can be used for system information change notification, when including *systemInfoModification-eDRX*, for a UE configured with eDRX cycle longer than the system information modification period.

NB-IoT UEs, BL UEs or UEs in enhanced coverage can use (G)WUS, when configured in the cell, to reduce the power consumption related to paging monitoring. (G)WUS is only applicable in RRC\_IDLE.

When GWUS is used in RRC\_IDLE, the following are applicable:

- Multiple WUS groups, possibly distributed over multiple WUS resources, can be configured in the cell;

- If the UE supports WUS assistance information, the MME/AMF may provide the UE with UE paging probability information (see TS 24.301 [20] and TS 24.501 [91]);

- UE selects one WUS group based on its UE paging probability information and /or its UE NAS identity as defined in TS 36.304 [11];

- A common WUS group may be used to wake up all UEs monitoring the same WUS resource.

When (G)WUS is used in RRC\_IDLE, the following are applicable:

- The UE monitors (G)WUS only in the last used cell as defined in TS 36.304 [11];

- The WUS or WUS group is used to indicate that the UE shall monitor MPDCCH or NPDCCH to receive paging in that cell;

- For a UE not configured with extended DRX, the WUS or WUS group is associated to one paging occasion (N = 1);

- For a UE configured with extended DRX, the WUS or WUS group can be associated to one or multiple paging occasion(s) (N ≥ 1) in a PTW;

- If UE detects the WUS or WUS group, the UE shall monitor the following N paging occasions unless it has received a paging message;

- The paging operation in the MME/AMF is not aware of the use of the WUS in the (ng-)eNB;

- To reduce WUS use in cells not monitored by the UE, WUS-capable (ng-)eNBs provide UE's last used cell information to MME/AMF in the S1-AP/NG-AP UE Context Release Complete or UE Context Suspend Request messages for all UEs, as described in TS 23.401 [17] and TS 23.501 [82]. In case of immediate suspension of a UE, the WUS-capable ng-eNB also provides the UE's last cell information to the AMF in the UE Context Resume Request message, as described in TS 23.501 [82].

The timing between WUS and the paging occasion (PO) is illustrated in Figure 10.1.4-1. The timing between GWUS and the paging occasion (PO) is illustrated in Figure 10.1.4-2 and Figure 10.1.4-3. The UE can expect WUS repetitions during "Configured maximum WUS duration" but the actual WUS transmission can be shorter, e.g. for UE in good coverage. The UE does not monitor WUS during the non-zero "Gap".



Figure 10.1.4-1: Illustration of WUS timing



Figure 10.1.4-2: Illustration of GWUS timing for NB-IoT UEs



Figure 10.1.4-3: Illustration of GWUS timing for BL UEs and UEs in enhanced coverage

NOTE: WUS1/WUS3 could be higher or lower frequency than WUS0/WUS2.

For NB-IoT, UE in RRC\_IDLE receives paging on the anchor carrier or on a non-anchor carrier based on system information. If configured, the paging carrier determination is based on the level of coverage enhancement needed by the UE.

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