**3GPP TSG-RAN WG2 Meeting #115 electronic R2-21xxxxx**

**Online, Aug. 16th – Aug. 27th, 2021**

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| *CR-Form-v12.1* | | | | | | | | |
| **CHANGE REQUEST** | | | | | | | | |
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|  | 38.321 | **CR** |  | **rev** | - | **Current version:** | 16.5.0 |  |
|  | | | | | | | | |
| *For* [***HE******LP***](http://www.3gpp.org/3G_Specs/CRs.htm#_blank)*on using this form: comprehensive instructions can be found at* [*http://www.3gpp.org/Change-Requests*](http://www.3gpp.org/Change-Requests)*.* | | | | | | | | |
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| ***Proposed change affects:*** | UICC apps |  | ME | **X** | Radio Access Network | **X** | Core Network |  |

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| ***Title:*** | 38.321 running CR for NR MBS | | | | | | | | | |
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| ***Source to WG:*** | OPPO | | | | | | | | | |
| ***Source to TSG:*** | R2 | | | | | | | | | |
|  |  | | | | | | | | | |
| ***Work item code:*** | NR\_MBS-Core | | | | |  | ***Date:*** | | | 2021-09-03 |
|  |  | | | |  | |  | | |  |
| ***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:*** | | Introduction of MBS support in NR.  Changes for section 4 based on following agreements:  RAN2#112 agreements   * The function of mapping from QoS flows to MBS RBs in SDAP is needed for NR MBS. TBD whether any SDAP header is needed.   RAN2#114 agreements   * MCCH is mapped to the DL-SCH for NR MBS delivery mode 2. * MTCH is specified for PTM transmission of NR MBS. * MTCH is mapped to the DL-SCH. * DTCH is reused for PTP transmission of NR MBS. * Multiplexing/de-multiplexing of different logical channels associated with the same G-RNTI is supported for NR MBS. * FFS if Multiplexing/de-multiplexing of different logical channels associated with the same G-CS-RNTI is supported for NR MBS. * Multiplexing/de-multiplexing of different logical channels associated with the C-RNTI is supported for NR MBS.   Changes for section 5.7a based on following agreements:  RAN2#114 agreements   * For NR MBS delivery mode 2, LTE SC-PTM DRX scheme is used as baseline.   RAN2#115 agreements   * For NR Broadcast, the DRX pattern is configured per G-RNTI. * For NR Broadcast, DRX configuration includes: drx-onDurationTimerPTM, drx-SlotOffsetPTM, drx-InactivityTimerPTM, drx-CycleStartOffsetPTM.   Changes for section 5.7b based on following agreements:  RAN2#115 agreements   * For multicast PTM transmission, Multicast DRX pattern is configured on a per G-RNTI basis (i.e. independent of legacy UE-specific DRX for unicast transmission). * Legacy UE-specific DRX pattern for unicast is reused for PTP transmission of NR MBS, which means the UE specific DRX pattern are for both unicast services and the MBS PTP bearer of UE * Multicast long DRX support is baseline for PTM. FFS whether to support optional short DRX or not. * The Multicast Long DRX operation has to support the following parameters which are similar to the UE-specific DRX for unicast, where the last two parameters are needed if the HARQ- feedback is enabled:   - drx-onDurationTimerPTM  - drx-InactivityTimerPTM  - drx-LongCycleStartOffsetPTM  - drx-SlotOffsetPTM  - drx-HARQ-RTT-TimerDLPTM  - drx-RetransmissionTimerDLPTM  Changes for section 5.19 based on following agreements:  RAN2#115 agreements   * If Data Inactivity timer is configured, data monitoring is applied both for unicast and MBS multicast (i.e. both PTM and PTP data) (but not MBS broadcast)   Changes for section 6 based on following agreements:  RAN2#115 agreements   * Single bearer ID is used for each Multicast RB. * Multicast PTP and Unicast DTCH/DRB share common LCID space. * Broadcast PTM/MTCH uses reserved LCID(s), which is different than Unicast DTCH/DRB LCID space. * Broadcast MCCH uses reserved LCID .   Changes for section 7 based on following agreements:  RAN2#114 agreements   * One-to-one mapping between G-RNTI and MBS session is supported in NR MBS. Other mappings FFS * One-to-one mapping between G-CS-RNTI and MBS session is supported in NR MBS. Other mappings FFS. * A UE can support multiple G-RNTIs/G-CS-RNTIs, It is FFS whether this depends on UE capability. Inform RAN1 of this agreement. | | | | | | | | |
|  | |  | | | | | | | | |
| ***Summary of change:*** | | Introduction of MBS support in NR. | | | | | | | | |
|  | |  | | | | | | | | |
| ***Consequences if not approved:*** | | NR MBS is not supported in NR. | | | | | | | | |
|  | |  | | | | | | | | |
| ***Clauses affected:*** | |  | | | | | | | | |
|  | |  | | | | | | | | |
|  | | **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:*** | |  | | | | | | | | |

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# 3 Definitions, symbols and abbreviations

## 3.1 Definitions

For the purposes of the present document, the terms and definitions given in TR 21.905 [1] and the following apply. A term defined in the present document takes precedence over the definition of the same term, if any, in TR 21.905 [1].

**Dormant BWP:** The dormant BWP is one of downlink BWPs configured by the network via dedicated RRC signaling. In the dormant BWP, the UE stop monitoring PDCCH on/for the SCell, but continues performing CSI measurements, Automatic Gain Control (AGC) and beam management, if configured.

**DRX group:** A group of Serving Cells that is configured by RRC and that have the same DRX Active Time.

**HARQ information:** HARQ information for DL-SCH, for UL-SCH, or for SL-SCH transmissions consists of New Data Indicator (NDI), Transport Block size (TBS), Redundancy Version (RV), and HARQ process ID.

**IAB-donor:** gNB that provides network access to UEs via a network of backhaul and access links.

**IAB-node:** RAN node that supports NR access links to UEs and NR backhaul links to parent nodes and child nodes.

**Listen Before Talk**: A procedure according to which transmissions are not performed if the channel is identified as being occupied, see TS 37.213 [18].

**Msg3**: Message transmitted on UL-SCH containing a C-RNTI MAC CE or CCCH SDU, submitted from upper layer and associated with the UE Contention Resolution Identity, as part of a Random Access procedure.

**NR backhaul link:** NR link used for backhauling between an IAB-node and an IAB-donor, and between IAB-nodes in case of a multi-hop backhauling.

**NR sidelink communication**: AS functionality enabling at least V2X Communication as defined in TS 23.287 [19], between two or more nearby UEs, using NR technology but not traversing any network node.

**PDCCH occasion**: A time duration (i.e. one or a consecutive number of symbols) during which the MAC entity is configured to monitor the PDCCH.

**Serving Cell:** A PCell, a PSCell, or an SCell in TS 38.331 [5].

**Sidelink transmission information:** Sidelink transmission information included in a SCI for a SL-SCH transmission as specified in clause 8.3 and 8.4 of TS 38.212 [9] consists of Sidelink HARQ information including NDI, RV, Sidelink process ID, HARQ feedback enabled/disabled indicator, Sidelink identification information including cast type indicator, Source Layer-1 ID and Destination Layer-1 ID, and Sidelink other information including CSI request, a priority, a communication range requirement and Zone ID.

**Special Cell:** For Dual Connectivity operation the term Special Cell refers to the PCell of the MCG or the PSCell of the SCG depending on if the MAC entity is associated to the MCG or the SCG, respectively. Otherwise the term Special Cell refers to the PCell. A Special Cell supports PUCCH transmission and contention-based Random Access, and is always activated.

**Timing Advance Group:** A group of Serving Cells that is configured by RRC and that, for the cells with a UL configured, using the same timing reference cell and the same Timing Advance value. A Timing Advance Group containing the SpCell of a MAC entity is referred to as Primary Timing Advance Group (PTAG), whereas the term Secondary Timing Advance Group (STAG) refers to other TAGs.

**V2X sidelink communication**: AS functionality enabling V2X Communication as defined in TS 23.285 [20], between nearby UEs, using E-UTRA technology but not traversing any network node.

NOTE: A timer is running once it is started, until it is stopped or until it expires; otherwise it is not running. A timer can be started if it is not running or restarted if it is running. A Timer is always started or restarted from its initial value. The duration of a timer is not updated until it is stopped or expires (e.g. due to BWP switching). When the MAC entity applies zero value for a timer, the timer shall be started and immediately expire unless explicitly stated otherwise.

Editor’s note: The definitions/acronyms related to MBS need to be agreed and aligned between TS 38.331 and TS 38.300.

## 3.2 Abbreviations

For the purposes of the present document, the abbreviations given in TR 21.905 [1] 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].

AP Aperiodic

BFR Beam Failure Recovery

BSR Buffer Status Report

BWP Bandwidth Part

CE Control Element

CG Cell Group

CI-RNTI Cancellation Indication RNTI

CSI Channel State Information

CSI-IM CSI Interference Measurement

CSI-RS CSI Reference Signal

CS-RNTI Configured Scheduling RNTI

DAPS Dual Active Protocol Stack

DCP DCI with CRC scrambled by PS-RNTI

DL-PRS DownLink-Positioning Reference Signal

GC-PDCCH Group Common PDCCH

G-RNTI Group RNTI

IAB Integrated Access and Backhaul

INT-RNTI Interruption RNTI

LBT Listen Before Talk

LCG Logical Channel Group

LCP Logical Channel PrioritizationMBS Multicast/ Broadcast Services

MCCH MBS Control Channel

MCG Master Cell Group

MPE Maximum Permissible Exposure

MTCH MBS Traffic Channel

NUL Normal Uplink

NZP CSI-RS Non-Zero Power CSI-RS

PDB Packet Delay Budget

PHR Power Headroom Report

PS-RNTI Power Saving RNTI

PTAG Primary Timing Advance Group

PTM Point to Multipoint

PTP Point to Point

QCL Quasi-colocation

RS Reference Signal

SCG Secondary Cell Group

SFI-RNTI Slot Format Indication RNTI

SI System Information

SL-RNTI Sidelink RNTI

SLCS-RNTI Sidelink Configured Scheduling RNTI

SpCell Special Cell

SP Semi-Persistent

SP-CSI-RNTI Semi-Persistent CSI RNTI

SPS Semi-Persistent Scheduling

SR Scheduling Request

SS Synchronization Signals

SSB Synchronization Signal Block

STAG Secondary Timing Advance Group

SUL Supplementary Uplink

TAG Timing Advance Group

TCI Transmission Configuration Indicator

TPC-SRS-RNTI Transmit Power Control-Sounding Reference Signal-RNTI

UCI Uplink Control Information

V2X Vehicle-to-Everything

ZP CSI-RS Zero Power CSI-RS

Editor’s note: FFS to name/definition of RNTI for MBS.

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# 4 General

## 4.1 Introduction

The objective of this clause is to describe the MAC architecture and the MAC entity of the UE from a functional point of view.

## 4.2 MAC architecture

### 4.2.1 General

This clause describes a model of the MAC i.e. it does not specify or restrict implementations.

RRC is in control of the MAC configuration.

### 4.2.2 MAC Entities

The MAC entity of the UE handles the following transport channels:

- Broadcast Channel (BCH);

- Downlink Shared Channel(s) (DL-SCH);

- Paging Channel (PCH);

- Uplink Shared Channel(s) (UL-SCH);

- Random Access Channel(s) (RACH).

When the UE is configured with SCG, two MAC entities are configured to the UE: one for the MCG and one for the SCG.

When the UE is configured with DAPS handover, two MAC entities are used by the UE: one for the source cell (source MAC entity) and one for the target cell (target MAC entity).

The functions of the different MAC entities in the UE operate independently unless otherwise specified. The timers and parameters used in each MAC entity are configured independently unless otherwise specified. The Serving Cells, C-RNTI, radio bearers, logical channels, upper and lower layer entities, LCGs, and HARQ entities considered by each MAC entity refer to those mapped to that MAC entity unless otherwise specified.

If the MAC entity is configured with one or more SCells, there are multiple DL-SCH and there may be multiple UL-SCH as well as multiple RACH per MAC entity; one DL-SCH, one UL-SCH, and one RACH on the SpCell, one DL-SCH, zero or one UL-SCH and zero or one RACH for each SCell.

If the MAC entity is not configured with any SCell, there is one DL-SCH, one UL-SCH, and one RACH per MAC entity.

Figure 4.2.2-1 illustrates one possible structure of the MAC entity when SCG is not configured and for each MAC entity during DAPS handover.



Figure 4.2.2-1: MAC structure overview

Figure 4.2.2-2 illustrates one possible structure for the MAC entities when MCG and SCG are configured.

Editor’s note: FFS to MR-DC case for MBS.



Figure 4.2.2-2: MAC structure overview with two MAC entities

In addition, the MAC entity of the UE handles the following transport channel for sidelink:

- Sidelink Shared Channel (SL-SCH);

- Sidelink Broadcast Channel (SL-BCH).

Figure 4.2.2-3 illustrates one possible structure for the MAC entity when sidelink is configured.



Figure 4.2.2-3: MAC structure overview for sidelink

## 4.3 Services

### 4.3.1 Services provided to upper layers

The MAC sublayer provides the following services to upper layers:

- data transfer;

- radio resource allocation.

### 4.3.2 Services expected from physical layer

The MAC sublayer expects the following services from the physical layer:

- data transfer services;

- signalling of HARQ feedback;

- signalling of Scheduling Request;

- measurements (e.g. Channel Quality Indication (CQI)).

## 4.4 Functions

The MAC sublayer supports the following functions:

- mapping between logical channels and transport channels;

- multiplexing of MAC SDUs from one or different logical channels onto transport blocks (TB) to be delivered to the physical layer on transport channels;

- demultiplexing of MAC SDUs to one or different logical channels from transport blocks (TB) delivered from the physical layer on transport channels;

- scheduling information reporting;

- error correction through HARQ;

- logical channel prioritization;

- priority handling between overlapping resources of one UE;

- radio resource selection.

The relevance of MAC functions for uplink, downlink, and sidelink is indicated in Table 4.4-1.

Table 4.4-1: The link direction association of MAC functions.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| MAC function | Downlink | Uplink | Sidelink TX | Sidelink RX |
| Mapping between logical channels and transport channels | X | X | X | X |
| Multiplexing |  | X | X |  |
| Demultiplexing | X |  |  | X |
| Scheduling information reporting |  | X | X |  |
| Error correction through HARQ | X | X | X | X |
| Logical Channel prioritization |  | X | X |  |
| Radio resource selection |  |  | X |  |

## 4.5 Channel structure

### 4.5.1 General

The MAC sublayer operates on the channels defined below; transport channels are SAPs between MAC and Layer 1, logical channels are SAPs between MAC and RLC.

### 4.5.2 Transport Channels

The MAC sublayer uses the transport channels listed in Table 4.5.2-1 below.

Table 4.5.2-1: Transport channels used by MAC

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Transport channel name | Acronym | Downlink | Uplink | Sidelink |
| Broadcast Channel | BCH | X |  |  |
| Downlink Shared Channel | DL-SCH | X |  |  |
| Paging Channel | PCH | X |  |  |
| Uplink Shared Channel | UL-SCH |  | X |  |
| Random Access Channel | RACH |  | X |  |
| Sidelink Broadcast Channel | SL-BCH |  |  | X |
| Sidelink Shared Channel | SL-SCH |  |  | X |

### 4.5.3 Logical Channels

The MAC sublayer provides data transfer services on logical channels. To accommodate different kinds of data transfer services, multiple types of logical channels are defined i.e. each supporting transfer of a particular type of information.

Each logical channel type is defined by what type of information is transferred.

The MAC sublayer provides the control and traffic channels listed in Table 4.5.3-1 below.

Table 4.5.3-1: Logical channels provided by MAC.

|  |  |  |  |
| --- | --- | --- | --- |
| Logical channel name | Acronym | Control channel | Traffic channel |
| Broadcast Control Channel | BCCH | X |  |
| Paging Control Channel | PCCH | X |  |
| Common Control Channel | CCCH | X |  |
| Dedicated Control Channel | DCCH | X |  |
| Dedicated Traffic Channel | DTCH |  | X |
| Sidelink Broadcast Control Channel | SBCCH | X |  |
| Sidelink Control Channel | SCCH | X |  |
| Sidelink Traffic Channel | STCH |  | X |
| MBS Control Channel | MCCH | X |  |
| MBS Trafic Channel | MTCH |  | X |

### 4.5.4 Mapping of Transport Channels to Logical Channels

#### 4.5.4.1 General

The MAC entity is responsible for mapping logical channels onto transport channels. This mapping depends on the multiplexing that is configured by RRC.

#### 4.5.4.2 Uplink mapping

The uplink logical channels can be mapped as described in Table 4.5.4.2-1.

Table 4.5.4.2-1: Uplink channel mapping.

|  |  |  |
| --- | --- | --- |
| Transport channel  Logical channel | UL-SCH | RACH |
| CCCH | X |  |
| DCCH | X |  |
| DTCH | X |  |

#### 4.5.4.3 Downlink mapping

The downlink logical channels can be mapped as described in Table 4.5.4.3-1.

Table 4.5.4.3-1: Downlink channel mapping.

|  |  |  |  |
| --- | --- | --- | --- |
| Transport channel  Logical channel | BCH | PCH | DL-SCH |
| BCCH | X |  | X |
| PCCH |  | X |  |
| CCCH |  |  | X |
| DCCH |  |  | X |
| DTCH |  |  | X |
| MCCH |  |  | X |
| MTCH |  |  | X |

#### 4.5.4.4 Sidelink mapping

The sidelink logical channels can be mapped as described in Table 4.5.4.4-1.

Table 4.5.4.4-1: Sidelink channel mapping.

|  |  |  |
| --- | --- | --- |
| Transport channel  Logical channel | SL-BCH | SL-SCH |
| SBCCH | X |  |
| SCCH |  | X |
| STCH |  | X |

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## 5.3 DL-SCH data transfer

### 5.3.1 DL Assignment reception

Editor’s note: FFS to DL assignament and HARQ process related issue. Wait for RAN1 to input more.

Downlink assignments received on the PDCCH both indicate that there is a transmission on a DL-SCH for a particular MAC entity and provide the relevant HARQ information.

When the MAC entity has a C-RNTI, Temporary C-RNTI, or CS-RNTI, the MAC entity shall for each PDCCH occasion during which it monitors PDCCH and for each Serving Cell:

1> if a downlink assignment for this PDCCH occasion and this Serving Cell has been received on the PDCCH for the MAC entity's C-RNTI, or Temporary C‑RNTI:

2> if this is the first downlink assignment for this Temporary C-RNTI:

3> consider the NDI to have been toggled.

2> if the downlink assignment is for the MAC entity's C-RNTI, and if the previous downlink assignment indicated to the HARQ entity of the same HARQ process was either a downlink assignment received for the MAC entity's CS-RNTI or a configured downlink assignment:

3> consider the NDI to have been toggled regardless of the value of the NDI.

2> indicate the presence of a downlink assignment and deliver the associated HARQ information to the HARQ entity.

1> else if a downlink assignment for this PDCCH occasion has been received for this Serving Cell on the PDCCH for the MAC entity's CS-RNTI:

2> if the NDI in the received HARQ information is 1:

3> consider the NDI for the corresponding HARQ process not to have been toggled;

3> indicate the presence of a downlink assignment for this Serving Cell and deliver the associated HARQ information to the HARQ entity.

2> if the NDI in the received HARQ information is 0:

3> if PDCCH contents indicate SPS deactivation:

4> clear the configured downlink assignment for this Serving Cell (if any);

4> if the *timeAlignmentTimer*, associated with the TAG containing the Serving Cell on which the HARQ feedback is to be transmitted, is running:

5> indicate a positive acknowledgement for the SPS deactivation to the physical layer.

3> else if PDCCH content indicates SPS activation:

4> store the downlink assignment for this Serving Cell and the associated HARQ information as configured downlink assignment;

4> initialise or re-initialise the configured downlink assignment for this Serving Cell to start in the associated PDSCH duration and to recur according to rules in clause 5.8.1;

For each Serving Cell and each configured downlink assignment, if configured and activated, the MAC entity shall:

1> if the PDSCH duration of the configured downlink assignment does not overlap with the PDSCH duration of a downlink assignment received on the PDCCH for this Serving Cell:

2> instruct the physical layer to receive, in this PDSCH duration, transport block on the DL-SCH according to the configured downlink assignment and to deliver it to the HARQ entity;

2> set the HARQ Process ID to the HARQ Process ID associated with this PDSCH duration;

2> consider the NDI bit for the corresponding HARQ process to have been toggled;

2> indicate the presence of a configured downlink assignment and deliver the stored HARQ information to the HARQ entity.

For configured downlink assignments without *harq-ProcID-Offset*, the HARQ Process ID associated with the slot where the DL transmission starts is derived from the following equation:

HARQ Process ID = [floor (CURRENT\_slot × 10 / (*numberOfSlotsPerFrame* × *periodicity*))] modulo *nrofHARQ-Processes*

where CURRENT\_slot = [(SFN × *numberOfSlotsPerFrame*) + slot number in the frame] and *numberOfSlotsPerFrame* refers to the number of consecutive slots per frame as specified in TS 38.211 [8].

For configured downlink assignments with *harq-ProcID-Offset*, the HARQ Process ID associated with the slot where the DL transmission starts is derived from the following equation:

HARQ Process ID = [floor (CURRENT\_slot × 10 / (*numberOfSlotsPerFrame* × *periodicity*))] modulo *nrofHARQ-Processes* + *harq-ProcID-Offset*

where CURRENT\_slot = [(SFN × *numberOfSlotsPerFrame*) + slot number in the frame] and *numberOfSlotsPerFrame* refers to the number of consecutive slots per frame as specified in TS 38.211 [8].

NOTE 1: In case of unaligned SFN across carriers in a cell group, the SFN of the concerned Serving Cell is used to calculate the HARQ Process ID used for configured downlink assignments.

NOTE 2: CURRENT\_slot refers to the slot index of the first transmission occasion of a bundle of configured downlink assignment.

When the MAC entity needs to read BCCH, the MAC entity may, based on the scheduling information from RRC:

1> if a downlink assignment for this PDCCH occasion has been received on the PDCCH for the SI-RNTI;

2> indicate a downlink assignment and redundancy version for the dedicated broadcast HARQ process to the HARQ entity.

### 5.3.2 HARQ operation

#### 5.3.2.1 HARQ Entity

The MAC entity includes a HARQ entity for each Serving Cell, which maintains a number of parallel HARQ processes. Each HARQ process is associated with a HARQ process identifier. The HARQ entity directs HARQ information and associated TBs received on the DL-SCH to the corresponding HARQ processes (see clause 5.3.2.2).

The number of parallel DL HARQ processes per HARQ entity is specified in TS 38.214 [7]. The dedicated broadcast HARQ process is used for BCCH.

The HARQ process supports one TB when the physical layer is not configured for downlink spatial multiplexing. The HARQ process supports one or two TBs when the physical layer is configured for downlink spatial multiplexing.

When the MAC entity is configured with *pdsch-AggregationFactor* > 1, the parameter *pdsch-AggregationFactor* provides the number of transmissions of a TB within a bundle of the downlink assignment. Bundling operation relies on the HARQ entity for invoking the same HARQ process for each transmission that is part of the same bundle. After the initial transmission, *pdsch-AggregationFactor* – 1 HARQ retransmissions follow within a bundle.

The MAC entity shall:

1> if a downlink assignment has been indicated:

2> allocate the TB(s) received from the physical layer and the associated HARQ information to the HARQ process indicated by the associated HARQ information.

1> if a downlink assignment has been indicated for the broadcast HARQ process:

2> allocate the received TB to the broadcast HARQ process.

#### 5.3.2.2 HARQ process

When a transmission takes place for the HARQ process, one or two (in case of downlink spatial multiplexing) TBs and the associated HARQ information are received from the HARQ entity.

For each received TB and associated HARQ information, the HARQ process shall:

1> if the NDI, when provided, has been toggled compared to the value of the previous received transmission corresponding to this TB; or

1> if the HARQ process is equal to the broadcast process, and this is the first received transmission for the TB according to the system information schedule indicated by RRC; or

1> if this is the very first received transmission for this TB (i.e. there is no previous NDI for this TB):

2> consider this transmission to be a new transmission.

1> else:

2> consider this transmission to be a retransmission.

The MAC entity then shall:

1> if this is a new transmission:

2> attempt to decode the received data.

1> else if this is a retransmission:

2> if the data for this TB has not yet been successfully decoded:

3> instruct the physical layer to combine the received data with the data currently in the soft buffer for this TB and attempt to decode the combined data.

1> if the data which the MAC entity attempted to decode was successfully decoded for this TB; or

1> if the data for this TB was successfully decoded before:

2> if the HARQ process is equal to the broadcast process:

3> deliver the decoded MAC PDU to upper layers.

2> else if this is the first successful decoding of the data for this TB:

3> deliver the decoded MAC PDU to the disassembly and demultiplexing entity.

1> else:

2> instruct the physical layer to replace the data in the soft buffer for this TB with the data which the MAC entity attempted to decode.

1> if the HARQ process is associated with a transmission indicated with a Temporary C-RNTI and the Contention Resolution is not yet successful (see clause 5.1.5); or

1> if the HARQ process is associated with a transmission indicated with a MSGB-RNTI and the Random Access procedure is not yet successfully completed (see clause 5.1.4a); or

1> if the HARQ process is equal to the broadcast process; or

1> if the *timeAlignmentTimer*, associated with the TAG containing the Serving Cell on which the HARQ feedback is to be transmitted, is stopped or expired:

2> not instruct the physical layer to generate acknowledgement(s) of the data in this TB.

1> else:

2> instruct the physical layer to generate acknowledgement(s) of the data in this TB.

The MAC entity shall ignore NDI received in all downlink assignments on PDCCH for its Temporary C-RNTI when determining if NDI on PDCCH for its C-RNTI has been toggled compared to the value in the previous transmission.

NOTE: If the MAC entity receives a retransmission with a TB size different from the last TB size signalled for this TB, the UE behavior is left up to UE implementation.

### 5.3.3 Disassembly and demultiplexing

The MAC entity shall disassemble and demultiplex a MAC PDU as defined in clauses 6.1.2 and 6.1.5a.

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| *The next of change* |

## 5.7a Discontinuous Reception (DRX) for Broadcast MBS

Each G-RNTI of the MAC entity may be configured by RRC with a broadcast DRX functionality that controls the UE’s PDCCH monitoring activity for this G-RNTI as specified in TS 38.331[5]. When in RRC\_IDLE or RRC\_INACTIVE or RRC\_CONNECTED, if broadcast DRX is configured for a G-RNTI, the MAC entity is allowed to monitor the PDCCH for this G-RNTI discontinuously using the broadcast DRX operation specified in this subclause; otherwise the MAC entity monitors the PDCCH for this G-RNTI as specified in TS 38.213[6]. The broadcast DRX operation specified in this subclause is performed independently for each G-RNTI and independently from the DRX operation specified in subcaluse 5.7 and 5.7b.

Editor’s note: FFS how to model broadcast reception.

RRC controls broadcast DRX operation by configuring the following parameters:

- *drx-onDurationTimerPTM*: the duration at the beginning of a DRX cycle;

- *drx-SlotOffsetPTM*: the delay before starting the *drx-onDurationTimerPTM*;

- *drx-InactivityTimerPTM*: the duration after the GC-PDCCH occasion in which a GC-PDCCH indicates a new DL broadcast transmission for the MAC entity;

- *drx-LongCycleStartOffsetPTM*: the long DRX cycle and *drx-StartOffsetPTM* which defines the subframe where the DRX cycle starts;

When broadcast DRX is configured for a G-RNTI, the Active Time includes the time while:

*- drx-onDurationTimerPTM* or *drx-InactivityTimerPTM* for this G-RNTI is running.

When broadcast DRX is configured for a G-RNTI, the MAC entity shall for this G-RNTI:

1> if [(SFN × 10) + subframe number] modulo (*drx-LongCycleStartOffsetPTM*) = *drx-StartOffsetPTM*:

2> start *drx-onDurationTimerPTM* after *drx-SlotOffsetPTM* from the beginning of the subframe.

1> during the Active Time:

2> monitor the GC-PDCCH;

2> if the GC-PDCCH indicates a DL broadcast transmission:

3> start or restart *drx-InactivityTimerPTM* in the first symbol after the end of the GC-PDCCH reception.

Editor’s note: FFS impact on DRX operation due to MCCH RNTI.

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| *The next of change* |

## 5.7b Discontinuous Reception (DRX) for Multicast MBS

For multicast, the MAC entity may be configured by RRC with a DRX functionality per G-RNTI or per G-CS-RNTI that controls the UE's PDCCH monitoring activity for the MAC entity's G-RNTI(s) and G-CS-RNTI(s) as specified in TS 38.331[5].]. When in RRC\_CONNECTED, if multicast DRX is configured, the MAC entity is allowed to monitor the PDCCH for this G-RNTI or G-CS-RNTI discontinuously using the multicast DRX operation specified in this subclause; otherwise the MAC entity monitors the PDCCH for this G-RNTI or G-CS-RNTI as specified in TS 38.213[6]. The multicast DRX operation specified in this subclause is performed independently for each G-RNTI or G-CS-RNTI and independently from the DRX operation specified in subcaluse 5.7 and 5.7a.

Editor’s note: FFS how to handle the PTP only for PTM retranmission case.

RRC controls multicast DRX operation per G-RNTI or per G-CS-RNTI by configuring the following parameters:

- *drx-onDurationTimerPTM*: the duration at the beginning of a DRX cycle;

- *drx-SlotOffsetPTM*: the delay before starting the *drx-onDurationTimerPTM*;

- *drx-InactivityTimerPTM*: the duration after the PDCCH occasion in which a PDCCH indicates a new DL multicast transmission for the MAC entity;

- *drx-LongCycleStartOffsetPTM*: the long DRX cycle and *drx-StartOffsetPTM* which defines the subframe where the long DRX cycle starts;

- *drx-RetransmissionTimerDL-PTM* (per DL HARQ process for multicast MBS): the maximum duration until a DL multicast retransmission is received;

- *drx-HARQ-RTT-TimerDL-PTM* (per DL HARQ process for multicast MBS): the minimum duration before a DL multicast assignment for HARQ retransmission is expected by the MAC entity;

When multicast DRX is configured for a G-RNTI, the Active Time includes the time while:

- *drx-onDurationTimerPTM* or *drx-InactivityTimerPTM* or *drx-RetransmissionTimerDL-PTM* for this G-RNTI or G-CS-RNTI is running;

Editor’s note: FFS other condition to define the Active Time.

When multicast DRX is configured for a G-RNTI or G-CS-RNTI, the MAC entity shall for this G-RNTI or G-CS-RNTI:

1> if a MAC PDU is received in a configured downlink multicast assignment:

2> start the *drx-HARQ-RTT-TimerDL-PTM* for the corresponding HARQ process in the first symbol after the end of the corresponding multicast transmission carrying the DL multicast HARQ feedback;

2> stop the *drx-RetransmissionTimerDL-PTM* for the corresponding multicast HARQ process.

1> if a *drx-HARQ-RTT-TimerDL-PTM* expires:

2> if the data of the corresponding multicast HARQ process was not successfully decoded:

3> start the *drx-RetransmissionTimerDL-PTM* for the corresponding multicast HARQ process in the first symbol after the expiry of *drx-HARQ-RTT-TimerDL-PTM*.

Editor’s note: FFS to support DRX Command MAC CE for MBS DRX.

Editor’s note: FFS to support short DRX for MBS.

1> if *drx-InactivityTimerPTM* expires, and [(SFN × 10) + subframe number] modulo (*drx-LongCyclePTM*) = *drx-StartOffsetPTM*:

2> start *drx-onDurationTimerPTM* for this multicast DRXafter *drx-SlotOffsetPTM* from the beginning of the subframe.

NOTE 1: In case of unaligned SFN across carriers in a cell group, the SFN of the SpCell is used to calculate the DRX duration.

1> if the MAC entity is in Active Time:

2> monitor the GC-PDCCH as specified in TS 38.213 [6];

2> if the GC-PDCCH indicates a DL multicast transmission:

3> start the *drx-HARQ-RTT-TimerDL-PTM* for the corresponding multicast HARQ process in the first symbol after the end of the corresponding multicast transmission carrying the DL multicast HARQ feedback;

3> stop the *drx-RetransmissionTimerDL-PTM* for the corresponding multicast HARQ process.

2> if the GC-PDCCH indicates a new transmission for this G-RNTI or G-CS-RNTI:

3> start or restart *drx-InactivityTimerPTM* for this multicast DRX in the first symbol after the end of the GC-PDCCH reception.

NOTE 2: A GC-PDCCH indicating activation of multicast SPS is considered to indicate a new transmission.

Editor’s note: FFS to CSI and SRS reporting due to MBS DRX.

Editor’s note: FFS to HARQ disable or HARQ is not configured case for MBS.

The MAC entity needs not to monitor the GC-PDCCH if it is not a complete PDCCH occasion (e.g. the Active Time starts or ends in the middle of a PDCCH occasion).

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| *The next of change* |

## 5.8 Transmission and reception without dynamic scheduling

### 5.8.1 Downlink

Editor’s note: FFS on SPS impact due to MBS.

Semi-Persistent Scheduling (SPS) is configured by RRC for a Serving Cell per BWP. Multiple assignments can be active simultaneously in the same BWP. Activation and deactivation of the DL SPS are independent among the Serving Cells.

For the DL SPS, a DL assignment is provided by PDCCH, and stored or cleared based on L1 signalling indicating SPS activation or deactivation.

RRC configures the following parameters when the SPS is configured:

- *cs-RNTI*: CS-RNTI for activation, deactivation, and retransmission;

- *nrofHARQ-Processes*: the number of configured HARQ processes for SPS;

- *harq-ProcID-Offset*: Offset of HARQ process for SPS;

- *periodicity*: periodicity of configured downlink assignment for SPS.

When the SPS is released by upper layers, all the corresponding configurations shall be released.

After a downlink assignment is configured for SPS, the MAC entity shall consider sequentially that the Nth downlink assignment occurs in the slot for which:

(*numberOfSlotsPerFrame* × SFN + slot number in the frame) =  
[(*numberOfSlotsPerFrame* × SFNstart time + slotstart time) + N × *periodicity* × *numberOfSlotsPerFrame* / 10] modulo (1024 × *numberOfSlotsPerFrame*)

where SFNstart time and slotstart time are the SFN and slot, respectively, of the first transmission of PDSCH where the configured downlink assignment was (re-)initialised.

NOTE: In case of unaligned SFN across carriers in a cell group, the SFN of the concerned Serving Cell is used to calculate the occurrences of configured downlink assignments.

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| *The next of change* |

## 5.19 Data inactivity monitoring

The UE may be configured by RRC with a Data inactivity monitoring functionality, when in RRC\_CONNECTED. RRC controls Data inactivity operation by configuring the timer *dataInactivityTimer*.

When *dataInactivityTimer* is configured, the UE shall:

1> if any MAC entity receives a MAC SDU for DTCH logical channel, DCCH logical channel, CCCH logical channel, or MTCH for multicast MBS; or

1> if any MAC entity transmits a MAC SDU for DTCH logical channel, or DCCH logical channel:

2> start or restart *dataInactivityTimer*.

1> if the *dataInactivityTimer* expires:

2> indicate the expiry of the *dataInactivityTimer* to upper layers.

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| *The next of change* |

## 6.2 Formats and parameters

### 6.2.1 MAC subheader for DL-SCH and UL-SCH

The MAC subheader consists of the following fields:

- LCID: The Logical Channel ID field identifies the logical channel instance of the corresponding MAC SDU or the type of the corresponding MAC CE or padding as described in Tables 6.2.1-1 and 6.2.1-2 for the DL-SCH and UL-SCH respectively. There is one LCID field per MAC subheader. The size of the LCID field is 6 bits. If the LCID field is set to 34, one additional octet is present in the MAC subheader containing the eLCID field and follow the octet containing LCID field. If the LCID field is set to 33, two additional octets are present in the MAC subheader containing the eLCID field and these two additional octets follow the octet containing LCID field;

- eLCID: The extended Logical Channel ID field identifies the logical channel instance of the corresponding MAC SDU or the type of the corresponding MAC CE as described in tables 6.2.1-1a, 6.2.1-1b, 6.2.1-2a and 6.2.1-2b for the DL-SCH and UL-SCH respectively. The size of the eLCID field is either 8 bits or 16 bits.

NOTE: The extended Logical Channel ID space using two-octet eLCID and the relevant MAC subheader format is used, only when configured, on the NR backhaul links between IAB nodes or between IAB node and IAB Donor.

- L: The Length field indicates the length of the corresponding MAC SDU or variable-sized MAC CE in bytes. There is one L field per MAC subheader except for subheaders corresponding to fixed-sized MAC CEs, padding, and MAC SDUs containing UL CCCH. The size of the L field is indicated by the F field;

- F: The Format field indicates the size of the Length field. There is one F field per MAC subheader except for subheaders corresponding to fixed-sized MAC CEs, padding, and MAC SDUs containing UL CCCH. The size of the F field is 1 bit. The value 0 indicates 8 bits of the Length field. The value 1 indicates 16 bits of the Length field;

- R: Reserved bit, set to 0.

The MAC subheader is octet aligned.

Table 6.2.1-1 Values of LCID for DL-SCH

|  |  |
| --- | --- |
| Codepoint/Index | LCID values |
| 0 | CCCH |
| 1–32 | Identity of the logical channel |
| 33 | Extended logical channel ID field (two-octet eLCID field) |
| 34 | Extended logical channel ID field (one-octet eLCID field) |
| 35–46 | Reserved |
| 47 | Recommended bit rate |
| 48 | SP ZP CSI-RS Resource Set Activation/Deactivation |
| 49 | PUCCH spatial relation Activation/Deactivation |
| 50 | SP SRS Activation/Deactivation |
| 51 | SP CSI reporting on PUCCH Activation/Deactivation |
| 52 | TCI State Indication for UE-specific PDCCH |
| 53 | TCI States Activation/Deactivation for UE-specific PDSCH |
| 54 | Aperiodic CSI Trigger State Subselection |
| 55 | SP CSI-RS/CSI-IM Resource Set Activation/Deactivation |
| 56 | Duplication Activation/Deactivation |
| 57 | SCell Activation/Deactivation (four octets) |
| 58 | SCell Activation/Deactivation (one octet) |
| 59 | Long DRX Command |
| 60 | DRX Command |
| 61 | Timing Advance Command |
| 62 | UE Contention Resolution Identity |
| 63 | Padding |

Editor’s note: FFS whether eLCID is used for MBS.

Table 6.2.1-1a Values of two-octet eLCID for DL-SCH

|  |  |  |
| --- | --- | --- |
| Codepoint | Index | LCID values |
| 0 to (216 – 1) | 320 to (216 + 319) | Identity of the logical channel |

Table 6.2.1-1b Values of one-octet eLCID for DL-SCH

|  |  |  |
| --- | --- | --- |
| Codepoint | Index | LCID values |
| 0 to 244 | 64 to 308 | Reserved |
| 245 | 309 | Serving Cell Set based SRS Spatial Relation Indication |
| 246 | 310 | PUSCH Pathloss Reference RS Update |
| 247 | 311 | SRS Pathloss Reference RS Update |
| 248 | 312 | Enhanced SP/AP SRS Spatial Relation Indication |
| 249 | 313 | Enhanced PUCCH Spatial Relation Activation/Deactivation |
| 250 | 314 | Enhanced TCI States Activation/Deactivation for UE-specific PDSCH |
| 251 | 315 | Duplication RLC Activation/Deactivation |
| 252 | 316 | Absolute Timing Advance Command |
| 253 | 317 | SP Positioning SRS Activation/Deactivation |
| 254 | 318 | Provided Guard Symbols |
| 255 | 319 | Timing Delta |

Table 6.2.1-1c Values of LCID for NR broadcast MBS on DL-SCH

|  |  |
| --- | --- |
| Codepoint/Index | LCID values |
| 0 | MCCH |
| 1–32 | Identity of the logical channel for PTM MTCH via broadcast |
| 33–63 | Reserved |

Editor’s note: FFS new table for broadcast MBS and the maximal value.

Table 6.2.1-2 Values of LCID for UL-SCH

|  |  |
| --- | --- |
| Codepoint/Index | LCID values |
| 0 | CCCH of size 64 bits (referred to as "CCCH1" in TS 38.331 [5]) |
| 1–32 | Identity of the logical channel |
| 33 | Extended logical channel ID field (two-octet eLCID field) |
| 34 | Extended logical channel ID field (one-octet eLCID field) |
| 35–44 | Reserved |
| 45 | Truncated Sidelink BSR |
| 46 | Sidelink BSR |
| 47 | Reserved |
| 48 | LBT failure (four octets) |
| 49 | LBT failure (one octet) |
| 50 | BFR (one octet Ci) |
| 51 | Truncated BFR (one octet Ci) |
| 52 | CCCH of size 48 bits (referred to as "CCCH" in TS 38.331 [5]) |
| 53 | Recommended bit rate query |
| 54 | Multiple Entry PHR (four octets Ci) |
| 55 | Configured Grant Confirmation |
| 56 | Multiple Entry PHR (one octet Ci) |
| 57 | Single Entry PHR |
| 58 | C-RNTI |
| 59 | Short Truncated BSR |
| 60 | Long Truncated BSR |
| 61 | Short BSR |
| 62 | Long BSR |
| 63 | Padding |

Table 6.2.1-2a Values of two-octet eLCID for UL-SCH

|  |  |  |
| --- | --- | --- |
| Codepoint | Index | LCID values |
| 0 to (216 – 1) | 320 to (216 + 319) | Identity of the logical channel |

Table 6.2.1-2b Values of one-octet eLCID for UL-SCH

|  |  |  |
| --- | --- | --- |
| Codepoint | Index | LCID values |
| 0 to 249 | 64 to 313 | Reserved |
| 250 | 314 | BFR (four octets Ci) |
| 251 | 315 | Truncated BFR (four octets Ci) |
| 252 | 316 | Multiple Entry Configured Grant Confirmation |
| 253 | 317 | Sidelink Configured Grant Confirmation |
| 254 | 318 | Desired Guard Symbols |
| 255 | 319 | Pre-emptive BSR |

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| *The next of change* |

## 7.1 RNTI values

RNTI values are presented in Table 7.1-1.

Table 7.1-1: RNTI values.

|  |  |
| --- | --- |
| Value (hexa-decimal) | RNTI |
| 0000 | N/A |
| 0001–FFF2 | RA-RNTI, MSGB-RNTI, Temporary C-RNTI, C-RNTI, CI-RNTI, MCS-C-RNTI, CS-RNTI, TPC-PUCCH-RNTI, TPC-PUSCH-RNTI, TPC-SRS-RNTI, INT-RNTI, SFI-RNTI, SP-CSI-RNTI, PS-RNTI, SL-RNTI, SLCS-RNTI SL Semi-Persistent Scheduling V-RNTI, AI-RNTI, G-RNTI and G-CS-RNTI |
| FFF3–FFFD | Reserved |
| FFFE | P-RNTI |
| FFFF | SI-RNTI |

Table 7.1-2: RNTI usage.

|  |  |  |  |
| --- | --- | --- | --- |
| RNTI | Usage | Transport Channel | Logical Channel |
| P-RNTI | Paging and System Information change notification | PCH | PCCH |
| SI-RNTI | Broadcast of System Information | DL-SCH | BCCH |
| RA-RNTI | Random Access Response | DL-SCH | N/A |
| MSGB-RNTI | Random Access Response for 2-step RA type | DL-SCH | CCCH, DCCH |
| Temporary C-RNTI | Contention Resolution (when no valid C-RNTI is available) | DL-SCH | CCCH, DCCH |
| Temporary C-RNTI | Msg3 transmission | UL-SCH | CCCH, DCCH, DTCH |
| C-RNTI, MCS-C-RNTI | Dynamically scheduled unicast transmission | UL-SCH | DCCH, DTCH |
| C-RNTI | Dynamically scheduled unicast transmission | DL-SCH | CCCH, DCCH, DTCH |
| MCS-C-RNTI | Dynamically scheduled unicast transmission | DL-SCH | DCCH, DTCH |
| C-RNTI | Triggering of PDCCH ordered random access | N/A | N/A |
| CS-RNTI | Configured scheduled unicast transmission (activation, reactivation and retransmission) | DL-SCH, UL-SCH | DCCH, DTCH |
| CS-RNTI | Configured scheduled unicast transmission (deactivation) | N/A | N/A |
| TPC-PUCCH-RNTI | PUCCH power control | N/A | N/A |
| TPC-PUSCH-RNTI | PUSCH power control | N/A | N/A |
| TPC-SRS-RNTI | SRS trigger and power control | N/A | N/A |
| INT-RNTI | Indication pre-emption in DL | N/A | N/A |
| SFI-RNTI | Slot Format Indication on the given cell | N/A | N/A |
| SP-CSI-RNTI | Activation of Semi-persistent CSI reporting on PUSCH | N/A | N/A |
| CI-RNTI | Cancellation indication in UL | N/A | N/A |
| PS-RNTI | DCP to indicate whether to start *drx-onDurationTimer* for associated DRX cycle | N/A | N/A |
| SL-RNTI | Dynamically scheduled sidelink transmission | SL-SCH | SCCH, STCH |
| SLCS-RNTI | Configured scheduled sidelink transmission (activation, reactivation and retransmission) | SL-SCH | SCCH, STCH |
| SLCS-RNTI | Configured scheduled sidelink transmission (deactivation) | N/A | N/A |
| SL Semi-Persistent Scheduling V-RNTI (NOTE 2) | Semi-Persistently scheduled sidelink transmission for V2X sidelink communication  (activation, reactivation and retransmission) | SL-SCH | STCH |
| SL Semi-Persistent Scheduling V-RNTI  (NOTE 2) | Semi-Persistently scheduled sidelink transmission for V2X sidelink communication  (deactivation) | N/A | N/A |
| AI-RNTI | Availability indication on the given cell | N/A | N/A |
| G-RNTI | Dynamically scheduled MBS transmission via PTM | DL-SCH | MTCH |
| G-CS-RNTI | Configured scheduled multicast transmission (activation, reactivation and retransmission) | DL-SCH | MTCH |
| G-CS-RNTI | Configured scheduled multicast transmission (deactivation) | N/A | N/A |
| NOTE 1: The usage of MCS-C-RNTI is equivalent to that of C-RNTI in MAC procedures (except for the C-RNTI MAC CE).  NOTE 2: The MAC entity uses SL Semi-Persistent Scheduling V-RNTI to control semi-persistently scheduled sidelink transmission on SL-SCH for V2X sidelink communication as specified in clause 5.14.1.1 of TS 36.321 [22]. | | | |

Editor’s note: FFS to name/definition of RNTI for MBS.

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| *The end of change* |