**3GPP TSG-RAN WG2 Meeting #109-e R2-2002225**

**E-meeting, February 2020**

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| *CR-Form-v11.4* | | | | | | | | |
| **CHANGE REQUEST** | | | | | | | | |
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|  | **38.321** | **CR** | **0677** | **rev** | **4** | **Current version:** | **15.8.0** |  |
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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 to 38.321 on Integrated Access and Backhaul for NR | | | | | | | | | |
|  |  | | | | | | | | | |
| ***Source to WG:*** | Samsung | | | | | | | | | |
| ***Source to TSG:*** | R2 | | | | | | | | | |
|  |  | | | | | | | | | |
| ***Work item code:*** | NR\_IAB | | | | |  | ***Date:*** | | | 2020-03-05 |
|  |  | | | |  | |  | | |  |
| ***Category:*** | **B** |  | | | | | ***Release:*** | | | Rel-16 |
|  | *Use one of the following categories:* ***F*** *(correction)* ***A*** *(mirror corresponding to a change in an earlier release)* ***B*** *(addition of feature),* ***C*** *(functional modification of feature)* ***D*** *(editorial modification)*  Detailed explanations of the above categories can be found in 3GPP [TR 21.900](http://www.3gpp.org/ftp/Specs/html-info/21900.htm). | | | | | | | | *Use one of the following releases: Rel-8 (Release 8) Rel-9 (Release 9) Rel-10 (Release 10) Rel-11 (Release 11) Rel-12 (Release 12)* *Rel-13 (Release 13) Rel-14 (Release 14) Rel-15 (Release 15) Rel-16 (Release 16)* | |
|  |  | | | | | | | | | |
| ***Reason for change:*** | | Ensure support for IAB by making necessary changes to the NR MAC specification. | | | | | | | | |
|  | |  | | | | | | | | |
| ***Summary of change:*** | | (Rev 1)   * Added definitions of IAB node, IAB donor, and NR backhaul link (from 38.300) * Introduced the extended LCID space into the spec, based on RAN2#107-Bis agreements, mainly by reusing relevant text (and approach) from 36.321 * Clarified the scope of this extension using a NOTE * Highlighted FFSs (in Editor’s Notes) required to be resolved for this extension to be implementable   (Rev 2)   * Implemented agreement stating that 33 (dec) shall be used to indicate use of eLCID, both on UL and DL   + The final value may be changed by the NR MAC spec rapporteur depending on the reserved values used by other Rel-16 WIs and any potential clashes; if different value is chosen by MAC rapporteur, we prefer that as a minimum the same value is used for UL and DL if possible * Added a NOTE specifying code points (binary) for the eLCID space (i.e. the mapping of code points to indices) * 128 values in the top of the eLCID space have been set aside as reserved * Introduced T\_delta MAC CE and the relevant LCID value to identify this MAC CE * Introduced pre-emptive BSR, the events/conditions that may trigger it, explained what the content of the relevant MAC CE indicates, and which LCID value is used to identify this MAC CE   (Rev 3)   * Corrected typos in the cover sheet (unticked ‘Core Network’, ticked ‘ME’, and corrected revision numbers – they used to start at 0)   (Rev 4)   * Implemented agreements from RAN2#109-e. | | | | | | | | |
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| ***Consequences if not approved:*** | | Rel-16 will not support IAB. | | | | | | | | |
|  | |  | | | | | | | | |
| ***Clauses affected:*** | | 3 Definitions, symbols and abbreviations  5 MAC procedures  5.4.3.1.3 Allocation of resources  5.4.4 Scheduling Request  5.4.5 Buffer Status Reporting  6.1 Protocol Data Units  6.2 Formats and parameters | | | | | | | | |
|  | |  | | | | | | | | |
|  | | **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:*** | See Summary of change |

FIRST CHANGE

# 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].

**HARQ information:** HARQ information for DL-SCH or for UL-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.

**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-gNB, and between IAB-nodes in case of a multi-hop backhauling.

**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].

**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.

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 they are stopped or expires (e.g. due to BWP switching).

## 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].

BSR Buffer Status Report

BWP Bandwidth Part

CE Control Element

CSI Channel State Information

CSI-IM CSI Intereference Measurement

CSI-RS CSI Reference Signal

CS-RNTI Configured Scheduling RNTI

IAB Integrated Access and Backhaul

INT-RNTI Interruption RNTI

LCG Logical Channel Group

LCP Logical Channel Prioritization

MCG Master Cell Group

NUL Normal Uplink

NZP CSI-RS Non-Zero Power CSI-RS

PHR Power Headroom Report

PTAG Primary Timing Advance Group

QCL Quasi-colocation

RS Reference Signal

SCG Secondary Cell Group

SFI-RNTI Slot Format Indication RNTI

SI System Information

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 Symbols-RNTI

UCI Uplink Control Information

ZP CSI-RS Zero Power CSI-RS

START OF CHANGE

# 5 MAC procedures

## 5.x Guard symbols for IAB

For IAB operation, the MAC entity on the IAB-DU or IAB-donor DU should reserve a sufficient number of symbols at the beginning and the end of each slot to allow the child IAB-node to switch operation from its IAB-DU to its IAB- MT function and operation from its IAB-MT function to its IAB-DU. The MAC entity on the IAB-DU or IAB-donor DU informs the child node about the number of guard symbols it provides via the Provided Guard Symbol MAC CE. The IAB-MT on the child node can inform the IAB-DU or IAB-donor DU about the number of guard symbols desired via the Desired Guard Symbol MAC CE.

Upon reception of a Provided Guard Symbol MAC CE the MAC entity shall:

- indicate to lower layers the number of provided guard symbols and the SCS configuration.

The MAC entity may:

1> if a Desired Guard Symbol query has not been triggered:

2> trigger a Desired Guard Symbol query.

If the MAC entity has UL resources allocated for new transmission the MAC entity shall:

1> for each Desired Guard Symbol query that the Desired Guard Symbol procedure determines has been triggered and not cancelled:

2> if the MAC entity has Desired resources allocated for new transmission and the allocated UL resources can accommodate a Desired Guard Symbol MAC CE plus its subheader as a result of LCP as defined in clause 5.4.3.1:

3> instruct the Multiplexing and Assembly procedure to generate the Desired Guard Symbol MAC CE;

3> cancel this Desired Guard Symbol query.

A separate value for the number of guard symbols is specified for each of the following eight switching scenarios (see Table 5.x-1).

**Table 5.x-1: Switching scenarios and relevant guard symbols**

|  |  |  |
| --- | --- | --- |
| **Switching scenario** | | **Field for number of guard symbols in MAC CE** |
| IAB-MT operation to IAB-DU operation | DL Rx to DL Tx | NmbGS1 |
| DL Rx to UL Rx | NmbGS2 |
| UL Tx to DL Tx | NmbGS3 |
| UL Tx to UL Rx | NmbGS4 |
| IAB-DU operation to IAB-MT operation | DL Rx to DL Tx | NmbGS5 |
| DL Rx to UL Rx | NmbGS6 |
| UL Tx to DL Tx | NmbGS7 |
| UL Tx to UL Rx | NmbGS8 |

NEXT CHANGE

##### 5.4.3.1.3 Allocation of resources

The MAC entity shall, when a new transmission is performed:

1> allocate resources to the logical channels as follows:

2> logical channels selected in clause 5.4.3.1.2 for the UL grant with *Bj* > 0 are allocated resources in a decreasing priority order. If the PBR of a logical channel is set to *infinity*, the MAC entity shall allocate resources for all the data that is available for transmission on the logical channel before meeting the PBR of the lower priority logical channel(s);

2> decrement *Bj* by the total size of MAC SDUs served to logical channel *j* above;

2> if any resources remain, all the logical channels selected in clause 5.4.3.1.2 are served in a strict decreasing priority order (regardless of the value of *Bj*) until either the data for that logical channel or the UL grant is exhausted, whichever comes first. Logical channels configured with equal priority should be served equally.

NOTE: The value of *Bj* can be negative.

If the MAC entity is requested to simultaneously transmit multiple MAC PDUs, or if the MAC entity receives the multiple UL grants within one or more coinciding PDCCH occasions (i.e. on different Serving Cells), it is up to UE implementation in which order the grants are processed.

The UE shall also follow the rules below during the scheduling procedures above:

- the UE should not segment an RLC SDU (or partially transmitted SDU or retransmitted RLC PDU) if the whole SDU (or partially transmitted SDU or retransmitted RLC PDU) fits into the remaining resources of the associated MAC entity;

- if the UE segments an RLC SDU from the logical channel, it shall maximize the size of the segment to fill the grant of the associated MAC entity as much as possible;

- the UE should maximise the transmission of data;

- if the MAC entity is given a UL grant size that is equal to or larger than 8 bytes while having data available and allowed (according to clause 5.4.3.1) for transmission, the MAC entity shall not transmit only padding BSR and/or padding.

The MAC entity shall not generate a MAC PDU for the HARQ entity if the following conditions are satisfied:

- the MAC entity is configured with *skipUplinkTxDynamic* with value *true* and the grant indicated to the HARQ entity was addressed to a C-RNTI, or the grant indicated to the HARQ entity is a configured uplink grant; and

- there is no aperiodic CSI requested for this PUSCH transmission as specified in TS 38.212 [9]; and

- the MAC PDU includes zero MAC SDUs; and

- the MAC PDU includes only the periodic BSR and there is no data available for any LCG, or the MAC PDU includes only the padding BSR.

Logical channels shall be prioritised in accordance with the following order (highest priority listed first):

- C-RNTI MAC CE or data from UL-CCCH;

- Configured Grant Confirmation MAC CE;

- MAC CE for BSR, with exception of BSR included for padding;

- Single Entry PHR MAC CE or Multiple Entry PHR MAC CE;

- MAC CE for the number of Desired Guard Symbols;

- MAC CE for pre-emptive BSR;

- data from any Logical Channel, except data from UL-CCCH;

- MAC CE for Recommended bit rate query;

- MAC CE for BSR included for padding.

NEXT CHANGE

### 5.4.4 Scheduling Request

The Scheduling Request (SR) is used for requesting UL-SCH resources for new transmission.

The MAC entity may be configured with zero, one, or more SR configurations. An SR configuration consists of a set of PUCCH resources for SR across different BWPs and cells. For a logical channel, at most one PUCCH resource for SR is configured per BWP.

Each SR configuration corresponds to one or more logical channels. Each logical channel may be mapped to zero or one SR configuration, which is configured by RRC. The SR configuration of the logical channel that triggered a BSR other than pre-emptive BSR (clause 5.4.5) (if such a configuration exists) is considered as corresponding SR configuration for the triggered SR. Any SR configuration may be used for an SR triggered by pre-emptive BSR (clause 5.4.5).

RRC configures the following parameters for the scheduling request procedure:

- *sr-ProhibitTimer* (per SR configuration);

- *sr-TransMax* (per SR configuration).

The following UE variables are used for the scheduling request procedure:

- *SR\_COUNTER* (per SR configuration).

If an SR is triggered and there are no other SRs pending corresponding to the same SR configuration, the MAC entity shall set the *SR\_COUNTER* of the corresponding SR configuration to 0.

When an SR is triggered, it shall be considered as pending until it is cancelled. All pending SR(s) triggered prior to the MAC PDU assembly shall be cancelled and each respective *sr-ProhibitTimer* shall be stopped when the MAC PDU is transmitted and this PDU includes a Long or Short BSR MAC CE which contains buffer status up to (and including) the last event that triggered a BSR (see clause 5.4.5) prior to the MAC PDU assembly. All pending SR(s) shall be cancelled and each respective *sr-ProhibitTimer* shall be stopped when the UL grant(s) can accommodate all pending data available for transmission.

Only PUCCH resources on a BWP which is active at the time of SR transmission occasion are considered valid.

As long as at least one SR is pending, the MAC entity shall for each pending SR:

1> if the MAC entity has no valid PUCCH resource configured for the pending SR:

2> initiate a Random Access procedure (see clause 5.1) on the SpCell and cancel the pending SR.

1> else, for the SR configuration corresponding to the pending SR:

2> when the MAC entity has an SR transmission occasion on the valid PUCCH resource for SR configured; and

2> if *sr-ProhibitTimer* is not running at the time of the SR transmission occasion; and

2> if the PUCCH resource for the SR transmission occasion does not overlap with a measurement gap; and

2> if the PUCCH resource for the SR transmission occasion does not overlap with a UL-SCH resource:

3> if *SR\_COUNTER* < *sr-TransMax*:

4> increment *SR\_COUNTER* by 1;

4> instruct the physical layer to signal the SR on one valid PUCCH resource for SR;

4> start the *sr-ProhibitTimer*.

3> else:

4> notify RRC to release PUCCH for all Serving Cells;

4> notify RRC to release SRS for all Serving Cells;

4> clear any configured downlink assignments and uplink grants;

4> clear any PUSCH resources for semi-persistent CSI reporting;

4> initiate a Random Access procedure (see clause 5.1) on the SpCell and cancel all pending SRs.

NOTE 1: The selection of which valid PUCCH resource for SR to signal SR on when the MAC entity has more than one overlapping valid PUCCH resource for the SR transmission occasion is left to UE implementation.

NOTE 2: If more than one individual SR triggers an instruction from the MAC entity to the PHY layer to signal the SR on the same valid PUCCH resource, the SR\_COUNTER for the relevant SR configuration is incremented only once.

The MAC entity may stop, if any, ongoing Random Access procedure due to a pending SR which has no valid PUCCH resources configured, which was initiated by MAC entity prior to the MAC PDU assembly. Such a Random Access procedure may be stopped when the MAC PDU is transmitted using a UL grant other than a UL grant provided by Random Access Response, and this PDU includes a BSR MAC CE which contains buffer status up to (and including) the last event that triggered a BSR (see clause 5.4.5) prior to the MAC PDU assembly, or when the UL grant(s) can accommodate all pending data available for transmission.

NEXT CHANGE

5.4.5 Buffer Status Reporting

The Buffer Status reporting (BSR) procedure is used to provide the serving gNB with information about UL data volume in the MAC entity. In the case of IAB, it is additionally used by an IAB-MT to provide its parent IAB-DU with the information about the amount of the data expected to arrive at the MT of the IAB node from its child node(s) and or UE(s) connected to it. This BSR is referred to as pre-emptive BSR.

For BSR other than pre-emptive BSR, RRC configures the following parameters to control the BSR:

- *periodicBSR-Timer*;

- *retxBSR-Timer*;

- *logicalChannelSR-DelayTimerApplied*;

- *logicalChannelSR-DelayTimer*;

- *logicalChannelSR-Mask*;

- *logicalChannelGroup*.

Each logical channel may be allocated to an LCG using the *logicalChannelGroup*. The maximum number of LCGs is eight.

The MAC entity determines the amount of UL data available for a logical channel according to the data volume calculation procedure in TSs 38.322 [3] and 38.323 [4].

A BSR other than pre-emptive BSR shall be triggered if any of the following events occur:

- UL data, for a logical channel which belongs to an LCG, becomes available to the MAC entity; and either

- this UL data belongs to a logical channel with higher priority than the priority of any logical channel containing available UL data which belong to any LCG; or

- none of the logical channels which belong to an LCG contains any available UL data.

in which case the BSR is referred below to as 'Regular BSR';

- UL resources are allocated and number of padding bits is equal to or larger than the size of the Buffer Status Report MAC CE plus its subheader, in which case the BSR is referred below to as 'Padding BSR';

- *retxBSR-Timer* expires, and at least one of the logical channels which belong to an LCG contains UL data, in which case the BSR is referred below to as 'Regular BSR';

- *periodicBSR-Timer* expires, in which case the BSR is referred below to as 'Periodic BSR'.

NOTE: When Regular BSR triggering events occur for multiple logical channels simultaneously, each logical channel triggers one separate Regular BSR.

If configured, pre-emptive BSR may be triggered for the specific case of an IAB-MT if any of the following events occur:

- UL grant is provided to child IAB node or UE;

- BSR is received from child IAB node or UE.

For Regular BSR, the MAC entity shall:

1> if the BSR is triggered for a logical channel for which *logicalChannelSR-DelayTimerApplied* with value *true* is configured by upper layers:

2> start or restart the *logicalChannelSR-DelayTimer*.

1> else:

2> if running, stop the *logicalChannelSR-DelayTimer*.

For Regular and Periodic BSR, the MAC entity shall:

1> if more than one LCG has data available for transmission when the MAC PDU containing the BSR is to be built:

2> report Long BSR for all LCGs which have data available for transmission.

1> else:

2> report Short BSR.

For Padding BSR, the MAC entity shall:

1> if the number of padding bits is equal to or larger than the size of the Short BSR plus its subheader but smaller than the size of the Long BSR plus its subheader:

2> if more than one LCG has data available for transmission when the BSR is to be built:

3> if the number of padding bits is equal to the size of the Short BSR plus its subheader:

4> report Short Truncated BSR of the LCG with the highest priority logical channel with data available for transmission.

3> else:

4> report Long Truncated BSR of the LCG(s) with the logical channels having data available for transmission following a decreasing order of the highest priority logical channel (with or without data available for transmission) in each of these LCG(s), and in case of equal priority, in increasing order of LCGID.

2> else:

3> report Short BSR.

1> else if the number of padding bits is equal to or larger than the size of the Long BSR plus its subheader:

2> report Long BSR for all LCGs which have data available for transmission.

For pre-emptive BSR, the MAC entity shall:

1> report Pre-emptive BSR.

For BSR triggered by *retxBSR-Timer* expiry, the MAC entity considers that the logical channel that triggered the BSR is the highest priority logical channel that has data available for transmission at the time the BSR is triggered.

The MAC entity shall:

1> if the Buffer Status reporting procedure determines that at least one BSR has been triggered and not cancelled:

2> if a BSR other than pre-emptive BSR has been triggered:

2> if UL-SCH resources are available for a new transmission and the UL-SCH resources can accommodate the BSR MAC CE plus its subheader as a result of logical channel prioritization:

3> instruct the Multiplexing and Assembly procedure to generate the BSR MAC CE(s);

3> start or restart *periodicBSR-Timer* except when all the generated BSRs are long or short Truncated BSRs;

3> start or restart *retxBSR-Timer*.

2> if a Regular BSR has been triggered and *logicalChannelSR-DelayTimer* is not running:

3> if there is no UL-SCH resource available for a new transmission; or

3> if the MAC entity is configured with configured uplink grant(s) and the Regular BSR was triggered for a logical channel for which *logicalChannelSR-Mask* is set to *false*; or

3> if the UL-SCH resources available for a new transmission do not meet the LCP mapping restrictions (see clause 5.4.3.1) configured for the logical channel that triggered the BSR:

4> trigger a Scheduling Request.

2> if a pre-emptive BSR has been triggered:

2> if UL-SCH resources are available for a new transmission and the UL-SCH resources can accommodate the pre-emptive BSR MAC CE plus its subheader as a result of logical channel prioritization:

3> instruct the Multiplexing and Assembly procedure to generate the pre-emptive BSR MAC CE;

2> else:

3> trigger a Scheduling Request.

NOTE: UL-SCH resources are considered available if the MAC entity has an active configuration for either type of configured uplink grants, or if the MAC entity has received a dynamic uplink grant, or if both of these conditions are met. If the MAC entity has determined at a given point in time that UL-SCH resources are available, this need not imply that UL-SCH resources are available for use at that point in time.

For the case when pre-emptive BSR is being sent, a MAC PDU may contain one BSR MAC CE for pre-emptive BSR, and one BSR MAC CE for BSR other than pre-emptive BSR. A MAC PDU not containing a BSR MAC CE for pre-emptive BSR shall contain at most one BSR MAC CE, even when multiple events have triggered a BSR. The Regular BSR and the Periodic BSR shall have precedence over the padding BSR.

The MAC entity shall restart *retxBSR-Timer* upon reception of a grant for transmission of new data on any UL-SCH.

All triggered BSRs other than pre-emptive BSR may be cancelled when the UL grant(s) can accommodate all pending data available for transmission but is not sufficient to additionally accommodate the BSR MAC CE plus its subheader. All BSRs other than pre-emptive BSR triggered prior to MAC PDU assembly shall be cancelled when a MAC PDU is transmitted and this PDU includes a Long or Short BSR MAC CE which contains buffer status up to (and including) the last event that triggered a BSR prior to the MAC PDU assembly. A pre-emptive BSR shall be cancelled when a MAC PDU is transmitted and this PDU includes the corresponding pre-emptive BSR MAC CE.

NOTE: MAC PDU assembly can happen at any point in time between uplink grant reception and actual transmission of the corresponding MAC PDU. BSR and SR can be triggered after the assembly of a MAC PDU which contains a BSR MAC CE, but before the transmission of this MAC PDU. In addition, BSR and SR can be triggered during MAC PDU assembly.

NOTE: Pre-emptive BSR may be used for the case of dual-connected IAB node. It is up to network implementation to work out the associated MAC entity or entities, and the associated expected amount of data. For the case of dual-connected IAB node, there may be ambiguity in pre-emptive BSR calculations and interpretation by the receiving nodes in case where BH RLC channels mapped to different egress Cell Groups are not mapped to different ingress LCGs.

NEXT CHANGE

# 6 Protocol Data Units, formats and parameters

## 6.1 Protocol Data Units

### 6.1.1 General

A MAC PDU is a bit string that is byte aligned (i.e. multiple of 8 bits) in length. In the figures in clause 6, bit strings are represented by tables in which the most significant bit is the leftmost bit of the first line of the table, the least significant bit is the rightmost bit on the last line of the table, and more generally the bit string is to be read from left to right and then in the reading order of the lines. The bit order of each parameter field within a MAC PDU is represented with the first and most significant bit in the leftmost bit and the last and least significant bit in the rightmost bit.

A MAC SDU is a bit string that is byte aligned (i.e. multiple of 8 bits) in length. A MAC SDU is included into a MAC PDU from the first bit onward.

A MAC CE is a bit string that is byte aligned (i.e. multiple of 8 bits) in length.

A MAC subheader is a bit string that is byte aligned (i.e. multiple of 8 bits) in length. Each MAC subheader is placed immediately in front of the corresponding MAC SDU, MAC CE, or padding.

The MAC entity shall ignore the value of the Reserved bits in downlink MAC PDUs.

### 6.1.2 MAC PDU (DL-SCH and UL-SCH except transparent MAC and Random Access Response)

A MAC PDU consists of one or more MAC subPDUs. Each MAC subPDU consists of one of the following:

- A MAC subheader only (including padding);

- A MAC subheader and a MAC SDU;

- A MAC subheader and a MAC CE;

- A MAC subheader and padding.

The MAC SDUs are of variable sizes.

Each MAC subheader corresponds to either a MAC SDU, a MAC CE, or padding.

A MAC subheader except for fixed sized MAC CE, padding, and a MAC SDU containing UL CCCH consists of the header fields R/F/LCID/(eLCID)/L. A MAC subheader for fixed sized MAC CE, padding, and a MAC SDU containing UL CCCH consists of the two header fields R/LCID.





Figure 6.1.2-1: R/F/LCID/(eLCID)/L MAC subheader with 8-bit L field





Figure 6.1.2-2: R/F/LCID/(eLCID)/L MAC subheader with 16-bit L field



Figure 6.1.2-3: R/LCID MAC subheader

MAC CEs are placed together. DL MAC subPDU(s) with MAC CE(s) is placed before any MAC subPDU with MAC SDU and MAC subPDU with padding as depicted in Figure 6.1.2-4. UL MAC subPDU(s) with MAC CE(s) is placed after all the MAC subPDU(s) with MAC SDU and before the MAC subPDU with padding in the MAC PDU as depicted in Figure 6.1.2-5. The size of padding can be zero.



Figure 6.1.2-4: Example of a DL MAC PDU



Figure 6.1.2-5: Example of a UL MAC PDU

A maximum of one MAC PDU can be transmitted per TB per MAC entity.

6.1.3 MAC Control Elements (CEs)

6.1.3.1 Buffer Status Report MAC CEs

Buffer Status Report (BSR) MAC CEs consist of either:

- Short BSR format (fixed size); or

- Long BSR format (variable size); or

- Short Truncated BSR format (fixed size);

- Long Truncated BSR format (variable size); or

- Pre-emptive BSR format (fixed size).

The BSR formats are identified by MAC subheaders with LCIDs as specified in Table 6.2.1-2.

The fields in the BSR MAC CE are defined as follows:

- LCG ID: The Logical Channel Group ID field identifies the group of logical channel(s) whose buffer status is being reported. The length of the field is 3 bits;

- LCGi: For the Long BSR format, this field indicates the presence of the Buffer Size field for the logical channel group i. The LCGi field set to 1 indicates that the Buffer Size field for the logical channel group i is reported. The LCGi field set to 0 indicates that the Buffer Size field for the logical channel group i is not reported. For the Long Truncated BSR format, this field indicates whether logical channel group i has data available. The LCGi field set to 1 indicates that logical channel group i has data available. The LCGi field set to 0 indicates that logical channel group i does not have data available;

- Buffer Size: The Buffer Size field identifies the total amount of data available according to the data volume calculation procedure in TSs 38.322 [3] and 38.323 [4] across all logical channels of a logical channel group after the MAC PDU has been built (i.e. after the logical channel prioritization procedure, which may result the value of the Buffer Size field to zero). The amount of data is indicated in number of bytes. The size of the RLC and MAC headers are not considered in the buffer size computation. The length of this field for the Short BSR format and the Short Truncated BSR format is 5 bits. The length of this field for the Long BSR format and the Long Truncated BSR format is 8 bits. The values for the 5-bit and 8-bit Buffer Size fields are shown in Tables 6.1.3.1-1 and 6.1.3.1-2, respectively. For the Long BSR format and the Long Truncated BSR format, the Buffer Size fields are included in ascending order based on the LCGi. For the Long Truncated BSR format the number of Buffer Size fields included is maximised, while not exceeding the number of padding bits. For the pre-emptive BSR, the Buffer Size field identifies the total amount of the data expected to arrive at the IAB-MT of the node where the pre-emptive BSR is triggered. Pre-emptive BSR is identical to the Long BSR format.

NOTE: For the pre-emptive BSR, if configured, the LCGs to be reported, the expected data volume calculation, the exact time to report pre-emptive BSR and the associated LCH are left to implementation.

NOTE: The mapping of LCGs between the ingress and egress links of an IAB node for purposes of determining expected change in occupancy of IAB-MT buffers (to be reported as pre-emptive BSR) is left to implementation.

NOTE: The number of the Buffer Size fields in the Long BSR and Long Truncated BSR format can be zero.

****

**Figure 6.1.3.1-1: Short BSR and Short Truncated BSR MAC CE**

****

**Figure 6.1.3.1-2: Long BSR and, Long Truncated BSR and pre-emptive BSR MAC CE**

**Skip>>>>**

#### 6.1.3.x Timing Delta MAC CE

The Timing Delta MAC CE is identified by MAC subheader with LCID as specified in Table 6.2.1-1.

It has a fixed size and consists of two octets defined as follows (Figure 6.1.3.x-1):

- R: Reserved bit, set to 0;

- T\_delta: This field indicates the index value of *Tdelta* (0, 1, 2… 1199) used to control the amount of timing adjustment that MAC entity indicates (as specified in TS 38.xxx). The length of the field is 11 bits.



Figure 6.1.3.x-1: Timing Delta MAC CE

Editors Note: It is FFS whether the SCS should be indicated in the Timing Delta MAC CE. RAN2 needs to confirm with RAN1.

NEXT CHANGE

#### 6.1.3.x Guard Symbols MAC CE

The Guard Symbols MAC CE is identified by the MAC subheader LCIDs as specified in Table 6.2.1-1 for DL-SCH and in Table 6.2.1-2 for UL-SCH.

It has fixed size and consists of four octets defined as follows (Figure 6.1.3.x-1):

- R: Reserved bit, set to 0;

- Sub-carrier spacing (SCS): This field indicates the subcarrier spacing used as reference for the guard spacing. The length of this field is 2bits. The values for the SCS field are shown in Table 6.1.3.x-2.

- Number of Guard Symbols (NmbGSi): This field indicates the number of guard symbols for the switching scenario shown in Table 5.x-1. The number of guard symbols can take values within the range of 0..4. Higher values 5-7 are reserved.



Figure 6.1.3.x-1: Guard Symbol MAC CE

**Table 6.1.3.x-2: Subcarrier spacing for Guard Symbols MAC CE**

|  |  |
| --- | --- |
| **Subcarrier spacing** | **SCS value** |
| 15kHz | 00 |
| 30kHz | 01 |
| 60kHz | 10 |
| 120kHz | 11 |

NEXT 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 LCID field size is 6 bits. If the LCID field is set to “100001”, 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 as described in tables 6.2.1-1a and 6.2.1-2a for the DL-SCH and UL-SCH respectively. The size of the eLCID field is 16 bits.

NOTE: The extended Logical Channel ID space 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.

Editors Note: The NOTE immediately above may need to be updated depending on the progress of other Rel-16 WIs and whether the extended LCID space is used for any other Rel-16 feature apart from IAB.

- 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

|  |  |
| --- | --- |
| Index | LCID values |
| 0 | CCCH |
| 1–32 | Identity of the logical channel |
| 33 | Extended logical channel ID field |
| 34-44 | Reserved |
| 45 | Number of Provided Guard Symbols |
| 46 | Timing Delta |
| 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 |

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

|  |  |
| --- | --- |
| Index | LCID values |
| 64–(216-65) | Identity of the logical channel |
| (216-64)–(216+63) | Reserved |

Table 6.2.1-2 Values of LCID for UL-SCH

|  |  |
| --- | --- |
| 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 |
| 34–49 | Reserved |
| 50 | Number of Desired Guard Symbols |
| 51 | Pre-emptive BSR |
| 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 eLCID for UL-SCH

|  |  |
| --- | --- |
| Index | LCID values |
| 64–(216-65) | Identity of the logical channel |
| (216-64)–(216+63) | Reserved |

NOTE: For the eLCID space, the 16-bit codepoint 000…00 (all zeros) corresponds to the index value of 64, while the 16-bit codepoint 111…11 (all ones) corresponds to the index value of 216+63.