

**3rd Generation Partnership Project;  
Technical Specification Group Radio Access Network;  
Evolved Universal Terrestrial Radio Access (E-UTRA)  
Medium Access Control (MAC) protocol specification  
(Release 8)**



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Postal address

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3GPP support office address

650 Route des Lucioles - Sophia Antipolis  
Valbonne - FRANCE  
Tel.: +33 4 92 94 42 00 Fax: +33 4 93 65 47 16

---

Internet

<http://www.3gpp.org>

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# Contents

|                                                                      |    |
|----------------------------------------------------------------------|----|
| Foreword.....                                                        | 5  |
| 1 Scope.....                                                         | 6  |
| 2 References.....                                                    | 6  |
| 3 Definitions and abbreviations.....                                 | 6  |
| 3.1 Definitions.....                                                 | 6  |
| 3.2 Abbreviations.....                                               | 7  |
| 4 General.....                                                       | 7  |
| 4.1 Introduction.....                                                | 7  |
| 4.2 MAC architecture.....                                            | 7  |
| 4.2.1 MAC Entities.....                                              | 7  |
| 4.3 Services.....                                                    | 7  |
| 4.3.1 Services provided to upper layers.....                         | 7  |
| 4.3.2 Services expected from physical layer.....                     | 8  |
| 4.4 Functions.....                                                   | 8  |
| 4.5 Channel structure.....                                           | 9  |
| 4.5.1 Transport Channels.....                                        | 9  |
| 4.5.2 Logical Channels.....                                          | 9  |
| 4.5.3 Mapping of Transport Channels to Logical Channels.....         | 10 |
| 4.5.3.1 Uplink mapping.....                                          | 10 |
| 4.5.3.2 Downlink mapping.....                                        | 10 |
| 5 MAC procedures.....                                                | 11 |
| 5.1 Random Access procedure.....                                     | 11 |
| 5.1.1 Random Access Procedure initialization.....                    | 11 |
| 5.1.2 Random Access Resource selection.....                          | 11 |
| 5.1.3 Random Access Preamble transmission.....                       | 12 |
| 5.1.4 Random Access Response reception.....                          | 12 |
| 5.2 Maintenance of Uplink Time Alignment.....                        | 13 |
| 5.3 DL-SCH data transfer.....                                        | 13 |
| 5.3.1 DL Assignment reception.....                                   | 13 |
| 5.3.2 HARQ operation.....                                            | 13 |
| 5.3.2.1 HARQ Entity.....                                             | 13 |
| 5.3.2.2 HARQ process.....                                            | 14 |
| 5.3.3 Disassembly and demultiplexing.....                            | 14 |
| 5.4 UL-SCH data transfer.....                                        | 14 |
| 5.4.1 UL Grant reception.....                                        | 14 |
| 5.4.2 HARQ operation.....                                            | 15 |
| 5.4.2.1 HARQ entity.....                                             | 15 |
| 5.4.2.2 HARQ process.....                                            | 15 |
| 5.4.3 Multiplexing and assembly.....                                 | 16 |
| 5.4.3.1 Logical channel prioritization.....                          | 16 |
| 5.4.3.2 Multiplexing of MAC SDUs.....                                | 17 |
| 5.4.4 Scheduling Request.....                                        | 17 |
| 5.4.5 Buffer Status reporting.....                                   | 17 |
| 5.5 PCH reception.....                                               | 17 |
| 5.6 BCH reception.....                                               | 18 |
| 5.7 Discontinuous Reception (DRX).....                               | 18 |
| 5.8 MAC reconfiguration.....                                         | 19 |
| 5.9 MAC Reset.....                                                   | 19 |
| 5.X Handling of unknown, unforeseen and erroneous protocol data..... | 19 |
| 6 Protocol Data Units, formats and parameters.....                   | 19 |
| 6.1 Protocol Data Units.....                                         | 19 |
| 6.1.1 General.....                                                   | 19 |
| 6.1.2 MAC PDU (DL-SCH and UL-SCH).....                               | 19 |

|                               |                                             |           |
|-------------------------------|---------------------------------------------|-----------|
| 6.1.3                         | MAC Control Elements.....                   | 20        |
| 6.1.3.1                       | Buffer Status Report Control Elements ..... | 20        |
| 6.2                           | Formats and parameters .....                | 21        |
| 6.2.1                         | MAC header for DL-SCH and UL-SCH.....       | 21        |
| 7                             | Variables and constants.....                | 22        |
| <b>Annex A (informative):</b> | <b>Change history .....</b>                 | <b>23</b> |

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## Foreword

This Technical Specification has been produced by the 3<sup>rd</sup> Generation Partnership Project (3GPP).

The contents of the present document are subject to continuing work within the TSG and may change following formal TSG approval. Should the TSG modify the contents of the present document, it will be re-released by the TSG with an identifying change of release date and an increase in version number as follows:

Version x.y.z

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- x the first digit:
  - 1 presented to TSG for information;
  - 2 presented to TSG for approval;
  - 3 or greater indicates TSG approved document under change control.
- y the second digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.
- z the third digit is incremented when editorial only changes have been incorporated in the document.

# 1 Scope

The present document specifies the E-UTRA MAC protocol.

## 2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.

[1] 3GPP TR 21.905: "Vocabulary for 3GPP Specifications".

## 3 Definitions 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].

**Active Time:** time that the UE is awake. When DRX is configured by higher layer, this includes the On Duration, the time UE is continuously monitoring the PDCCH while the DRX Inactivity Timer has not expired and the time UE is continuously monitoring the PDCCH while the DRX Retransmission Timer has not expired.

**DRX Cycle:** Specifies the periodic repetition of the On Duration followed by a possible period of inactivity (see figure 3.1-1 below).

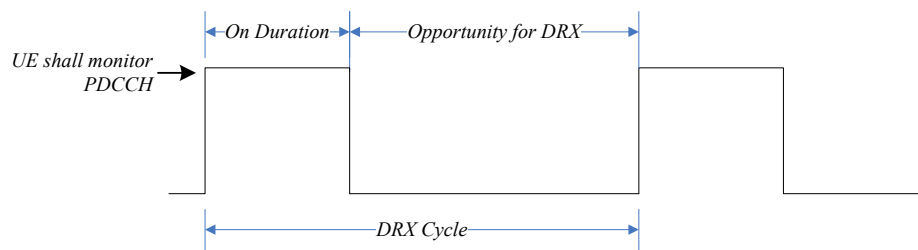


**Figure 3.1-1: DRX Cycle**

**DRX Inactivity Timer:** Specifies the number of consecutive TTIs during which the UE shall monitor the PDCCH after successfully decoding a PDCCH indicating an initial UL or DL user data transmission for this UE.

**DRX Retransmission Timer:** Specifies the number of consecutive TTIs the UE shall monitor the PDCCH for as soon as a DL retransmission is expected by the UE.

**DRX Short Cycle Timer:** This parameter specifies the number of consecutive TTIs the UE shall follow the short DRX cycle after the DRX Inactivity Timer has expired.

**HARQ RTT Timer:** This parameter specifies the minimum amount of TTIs before a DL HARQ retransmission is expected by the UE.

**On Duration Timer:** Specifies the number of consecutive TTIs during which the UE shall monitor the PDCCH for possible allocations. The On Duration Timer is a part of a DRX Cycle.

**RA-RNTI:** The Random Access RNTI is used on the [PDCCH] when Random Access Response messages are transmitted. It unambiguously identifies which time-frequency resource was utilized by the UE to transmit the Random Access preamble.

## 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].

|         |                                               |
|---------|-----------------------------------------------|
| C-RNTI  | Cell RNTI                                     |
| E-UTRA  | Evolved UMTS Terrestrial Radio Access         |
| E-UTRAN | Evolved UMTS Terrestrial Radio Access Network |
| MAC     | Medium Access Control                         |
| RA-RNTI | Random Access RNTI                            |
| RNTI    | Radio Network Temporary Identifier            |
| SR      | Scheduling Request                            |

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# 4 General

## 4.1 Introduction

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

## 4.2 MAC architecture

The description in this sub clause is a model and does not specify or restrict implementations.

RRC is in control of configuration of MAC.

### 4.2.1 MAC Entities

E-UTRA defines two MAC entities; one in the UE and one in the E-UTRAN. These MAC entities handle the following transport channels:

- Broadcast Channel (BCH)
- Downlink Shared Channel (DL-SCH)
- Paging Channel (PCH)
- Multicast Channel (MCH)
- Uplink Shared Channel (UL-SCH)
- Random Access Channel(s) (RACH)

The exact functions performed by the MAC entities are different in the UE from those performed in the E-UTRAN.

## 4.3 Services

### 4.3.1 Services provided to upper layers

This clause describes the different services provided by MAC sub layer to upper layers.

- Data transfer
- Radio resource allocation

### 4.3.2 Services expected from physical layer

The physical layer provides the following services to MAC:

- data transfer services;
- signalling of HARQ feedback;
- signalling of Scheduling Request;
- measurements (e.g. Channel Quality Indication (CQI)).

The access to the data transfer services is through the use of transport channels. The characteristics of a transport channel are defined by its transport format (or format set), specifying the physical layer processing to be applied to the transport channel in question, such as channel coding and interleaving, and any service-specific rate matching as needed.

## 4.4 Functions

The following functions are supported by MAC sub layer:

- 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 from one or different logical channels from transport blocks (TB) delivered from the physical layer on transport channels;
- Scheduling information reporting;
- Error correction through HARQ;
- Priority handling between UEs by means of dynamic scheduling;
- Priority handling between logical channels of one UE;
- Logical Channel prioritisation;
- Transport format selection;

NOTE: How the multiplexing relates to the QoS of the multiplexed logical channels is FFS.

The location of the different functions and their relevance for uplink and downlink respectively is illustrated in Table 4.4-1.

**Table 4.4-1: MAC function location and link direction association.**

| MAC function                                            | UE | eNB | Downlink | Uplink |
|---------------------------------------------------------|----|-----|----------|--------|
| Mapping between logical channels and transport channels | X  |     | X        | X      |
|                                                         |    | X   | X        | X      |
| Multiplexing                                            | X  |     |          | X      |
|                                                         |    | X   | X        |        |
| Demultiplexing                                          | X  |     | X        |        |
|                                                         |    | X   |          | X      |
| Error correction through HARQ                           | X  |     | X        | X      |
|                                                         |    | X   | X        | X      |
| Transport Format Selection                              |    | X   | X        | X      |
| Priority handling between UEs                           |    | X   | X        | X      |
| Priority handling between logical channels of one UE    |    | X   | X        | X      |
| Logical Channel prioritisation                          | X  |     |          | X      |
| Scheduling information reporting                        | X  |     |          | X      |

## 4.5 Channel structure

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

### 4.5.1 Transport Channels

The transport channels used by MAC are described in Table 4.5.1-1 below.

**Table 4.5.1-1: Transport channels used by MAC**

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

### 4.5.2 Logical Channels

The MAC layer provides data transfer services on logical channels. A set of logical channel types is defined for different kinds of data transfer services as offered by MAC.

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

MAC provides the control and traffic channels listed in Table 4.5.2-1 below. When MAC uses the [L1/L2 control channel (name FFS)] to indicate radio resource allocation, the RNTI that is mapped on the [L1/L2 control channel (name FFS)] depends on the logical channel type.

Table 4.5.2-1: 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               |                 |
| Multicast Control Channel | MCCH    | X               |                 |
| Dedicated Control Channel | DCCH    | X               |                 |
| Dedicated Traffic Channel | DTCH    |                 | X               |
| Multicast Traffic Channel | MTCH    |                 | X               |

4.5.3 Mapping of Transport Channels to Logical Channels

The mapping of logical channels on transport channels depends on the multiplexing that is configured by RRC.

4.5.3.1 Uplink mapping

The MAC entity is responsible for mapping logical channels for the uplink onto uplink transport channels. The uplink logical channels can be mapped as described in Figure 4.5.3.1-1 and Table 4.5.3.1-1.

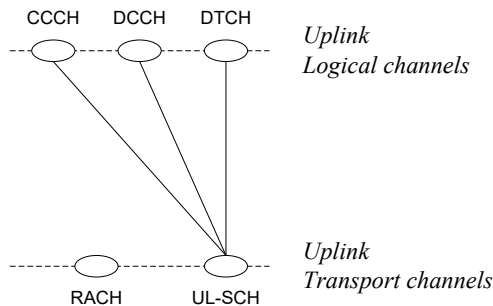


Figure 4.5.3.1-1

Table 4.5.3.1-1: Uplink channel mapping.

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

4.5.3.2 Downlink mapping

The MAC entity is responsible for mapping the downlink logical channels to downlink transport channels. The downlink logical channels can be mapped as described in Figure 4.5.3.2-1 and Table 4.5.3.2-1.

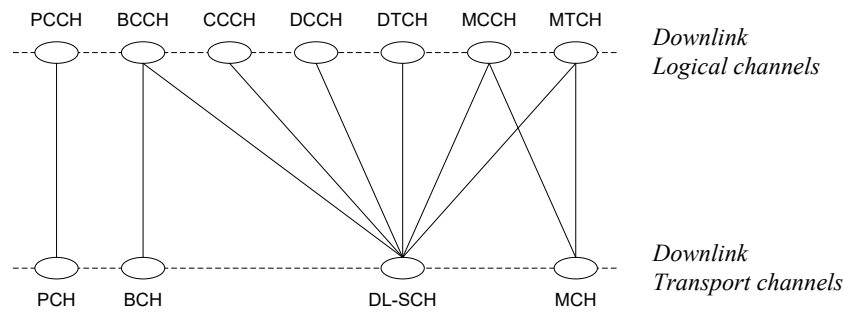


Figure 4.5.3.2-1

Table 4.5.3.2-1: Downlink channel mapping.

| <div>Transport channel</div> <div>Logical channel</div> | BCH | PCH | MCH | DL-SCH |
|---------------------------------------------------------|-----|-----|-----|--------|
| BCCH                                                    | X   |     |     | X      |
| PCCH                                                    |     | X   |     |        |
| CCCH                                                    |     |     |     | X      |
| MCCH                                                    |     |     | X   | X      |
| DCCH                                                    |     |     |     | X      |
| DTCH                                                    |     |     |     | X      |
| MTCH                                                    |     |     | X   | X      |

## 5 MAC procedures

### 5.1 Random Access procedure

#### 5.1.1 Random Access Procedure initialization

The Random Access procedure described in this subclause is initiated upon request from higher layer or by the MAC sublayer itself.

Before the procedure can be initiated, the following information is assumed to be available:

- The available set of PRACH resources for the transmission of the Random Access Preamble and their corresponding RA-RNTIs.
- The groups of Random Access Preambles and the set of available Random Access Preambles in each group.
- The thresholds required for selecting one of the two groups of Random Access Preambles.
- The parameters required to derive the TTI window described in subclause 5.1.4.
- The power-ramping factor `POWER_RAMP_STEP` [integer ≥ 0].
- The parameter `PREAMBLE_TRANS_MAX` [integer > 0].
- The initial preamble power `PREAMBLE_INITIAL_POWER`.

[Note that the above parameters may be updated from higher layers before each Random Access procedure is initiated.]

The Random Access procedure shall be performed as follows:

- Set the `PREAMBLE_TRANSMISSION_COUNTER` to 1;
- proceed to the selection of the Random Access Resource (see subclause 5.1.2).

### 5.1.2 Random Access Resource selection

The Random Access Preamble can either be provided to MAC through explicit signalling (from RRC or from L1/L2 control channel (name FFS) [FFS] or a MAC control PDU [FFS]) or must be selected by MAC itself.

If the Random Access Preamble and PRACH resource are explicitly signalled it can directly proceed to its transmission (see subclause 5.1.3).

If the Random Access Preamble must be selected by MAC, the UE shall:

- depending on the size of the message to be transmitted on the UL or the requested resource blocks [FFS] [the selection also depends on radio conditions], select one of the two groups of Random Access Preambles configured by RRC;
- randomly select a Random Access Preamble within the selected group. The random function shall be such that each of the allowed selections can be chosen with equal probability;
- if more than one PRACH resources are available in the same subframe (TDD), randomly select one. The random function shall be such that each of the allowed selections can be chosen with equal probability;
- proceed to the transmission of the Random Access Preamble (see subclause 5.1.3).

### 5.1.3 Random Access Preamble transmission

The random-access procedure shall be performed as follows:

[- Set the parameter PREAMBLE\_TRANSMISSION\_POWER to PREAMBLE\_INITIAL\_POWER + (PREAMBLE\_TRANSMISSION\_COUNTER-1) \* POWER\_RAMP\_STEP.]

[- If the PREAMBLE\_TRANSMISSION\_POWER is below the minimum power level, set the PREAMBLE\_TRANSMISSION\_POWER to the minimum power level.]

[- If the PREAMBLE\_TRANSMISSION\_POWER is above the maximum power level, set the PREAMBLE\_TRANSMISSION\_POWER to the maximum power level.]

- If PREAMBLE\_TRANSMISSION\_COUNTER = 1, determine the next available Random Access occasion. If PREAMBLE\_TRANSMISSION\_COUNTER > 1, the Random Access occasion is determined by the back-off procedure.
- Instruct the physical layer to transmit a preamble using the selected PRACH resource, corresponding RA-RNTI, preamble index and PREAMBLE\_TRANSMISSION\_POWER.

### 5.1.4 Random Access Response reception

Once the Random Access Preamble is transmitted, the UE shall monitor the [PDCCH] in the TTI window [RA\_WINDOW\_BEGIN—RA\_WINDOW\_END] for Random Access Response(s). The UE may stop monitoring for Random Access Response(s) after successful reception of a Random Access Response corresponding to the Random Access Preamble transmission.

- If notification of a reception of the Random Access Response is received from lower layers, the UE shall:
  - if the Random Access Response contains a Random Access Preamble identifier corresponding to the transmitted Random Access Preamble (see subclause 5.1.3)
  - the UE shall:
    - consider this Random Access Response reception successful and provide an indication to the higher layers;
    - process the received Timing Alignment value (see subclause 5.2);
    - if an UL grant was received, process the UL grant value;

- if the UE does not have a C-RNTI, Temporary C-RNTI shall be set to the value received in the Random Access Response message.

If no Random Access Response is received within the TTI window [RA\_WINDOW\_BEGIN—RA\_WINDOW\_END], or if all received Random Access Responses contain Random Access Preamble identifiers that do not match the transmitted Random Access Preamble, the Random Access Response reception is considered not successful and the UE shall:

- If the PREAMBLE\_TRANSMISSION\_COUNTER is less than PREAMBLE\_TRANS\_MAX
  - increment PREAMBLE\_TRANSMISSION\_COUNTER by 1;
  - [compute a backoff value indicating when a new Random Access transmission shall be attempted];
  - proceed to the selection of a Random Access Resource (see subclause 5.1.2).
- Else if PREAMBLE\_TRANSMISSION\_COUNTER is equal to PREAMBLE\_TRANS\_MAX
  - indicate to the higher layer that the random access procedure failed.

## 5.2 Maintenance of Uplink Time Alignment

The UE has a configurable Time Alignment Timer. The Time Alignment Timer is valid only in the cell for which it was configured and started.

If the Time Alignment Timer has been configured, the UE shall:

- when a Time Alignment Command is received:
  - apply the Time Alignment Command;
  - start the Time Alignment Timer (if it is not running) or restart the Time Alignment Timer (if it was already running)
- when the Time Alignment Timer has expired or is not running:
  - prior to any uplink transmission, use the Random Access procedure in order to obtain uplink Time Alignment
- when the Time Alignment Timer expires:
  - release all PUCCH resources.

## 5.3 DL-SCH data transfer

### 5.3.1 DL Assignment reception

When the UE has a C-RNTI, Temporary C-RNTI or RA-RNTI, the UE shall for each TTI during Active Time, for each TTI when a Random Access Response or Contention Resolution is expected and for each TTI for which a DL assignment has been configured:

- If a downlink assignment for this TTI has been received on the [PDCCH] for the UE's C-RNTI, Temporary C-RNTI or RA-RNTI:
  - Indicate a downlink assignment and the associated HARQ information to the HARQ entity for this TTI;
- else, if a downlink assignment for this TTI has been configured and a downlink assignment for this TTI has not been received on the [PDCCH] for the UE's C-RNTI, Temporary C-RNTI or RA-RNTI:
  - Indicate a downlink assignment, for a new transmission, and the associated HARQ information to the HARQ entity for this TTI;

When the UE needs to read BCCH, the UE shall:

- If a downlink assignment for this TTI has been received on the [PDCCH] for the [broadcast identity];

- Indicate a downlink assignment for the dedicated broadcast HARQ process to the HARQ entity for this TTI;

NOTE: Downlink assignments for both C-RNTI and [broadcast identity] can be received in the same TTI

## 5.3.2 HARQ operation

NOTE: Additional optimisations (e.g. less adaptive/synchronous) are FFS

### 5.3.2.1 HARQ Entity

There is one HARQ entity at the UE which processes the HARQ process identifiers indicated by the HARQ information associated with TBs received on the DL-SCH.

A number of parallel HARQ processes are used in the UE to support the HARQ entity. [The number of HARQ processes is FFS].

For a received TB the UE shall:

- If a downlink assignment has been indicated or configured for this TTI:
  - allocate the received TB to the HARQ process indicated by the associated HARQ information.

NOTE: In case of BCCH a dedicated broadcast HARQ process will be used

### 5.3.2.2 HARQ process

The HARQ process processes the New Data Indicator (name FFS) indicated from the HARQ entity for each received MAC PDU.

The UE shall:

- if a new transmission is indicated for this HARQ process:
  - replace the data currently in the soft buffer for this HARQ process with the received data.
- if a retransmission is indicated for this HARQ process:
  - if the data has not yet been successfully decoded:
    - combine the received data with the data currently in the soft buffer for this HARQ process.
  - if the transport block size is different from the last valid transport block size signalled for this HARQ process:
    - the UE may replace the data currently in the soft buffer for this HARQ process with the received data.
- if the data in the soft buffer has been successfully decoded:
  - deliver the decoded MAC PDU to the disassembly and demultiplexing entity;
  - generate a positive acknowledgement (ACK) of the data in this HARQ process.
- else:
  - generate a negative acknowledgement (NACK) of the data in this HARQ process;
- if the HARQ process is associated with a transmission indicated with an RA-RNTI; or
- if the HARQ process is associated with a transmission indicated with a Temporary C-RNTI and a Random Access Identity match is not indicated; or
- if the HARQ process is equal to the broadcast process:
  - do not indicate the generated positive or negative acknowledgement to the physical layer
- otherwise

- indicate the generated positive or negative acknowledgement to the physical layer.

### 5.3.3 Disassembly and demultiplexing

## 5.4 UL-SCH data transfer

### 5.4.1 UL Grant reception

The UE shall for each TTI:

- If an uplink grant for this TTI has been received on the [PDCCH]; or
- if an uplink grant for this TTI has been received in a Random Access Response:
  - Indicate a valid uplink grant and the associated HARQ information to the HARQ entity for this TTI;
- else, if an uplink grant for this TTI has been configured and an uplink grant for this TTI has not been received on the [PDCCH], nor in a Random Access Response:
  - Indicate an uplink grant, valid for new transmission, and the associated HARQ information to the HARQ entity for this TTI.

NOTE: The period of configured uplink grants is expressed in TTIs.

### 5.4.2 HARQ operation

NOTE: Whether resource allocation and modulation and coding scheme can be adapted for retransmissions is FFS.

#### 5.4.2.1 HARQ entity

There is one HARQ entity at the UE. A number of parallel HARQ processes are used in the UE to support the HARQ entity, allowing transmissions to take place continuously while waiting for the feedback on the successful or unsuccessful reception of previous transmissions.

At a given TTI, if an uplink grant is indicated for the TTI, the HARQ entity identifies the HARQ process for which a transmission should take place. It also routes the receiver feedback (ACK/NACK information), relayed by the physical layer, to the appropriate HARQ process.

The number of HARQ processes is equal to [X] [FFS]. Each process is associated with a number from 0 to [X-1].

At the given TTI, the HARQ entity shall:

- if an uplink grant, indicating a new transmission, is indicated for this TTI:
  - notify the "uplink prioritisation" entity that the TTI is available for a new transmission;
  - if the "uplink prioritisation" entity indicates the need for a new transmission:
    - obtain the MAC PDU to transmit from the "Multiplexing and assembly" entity;
    - instruct the HARQ process corresponding to this TTI to trigger the transmission of this new payload using the identified parameters.
  - else:
    - flush the HARQ buffer.
- else:
  - if an uplink grant, indicating a re-transmission, is indicated for this TTI; or
  - if the HARQ buffer of the HARQ process corresponding to this TTI is not empty:

- instruct the HARQ process to generate a re-transmission.

NOTE: Adaptive retransmissions are ‘sticky’; i.e., when parameters are modified for a retransmission, previous parameters no longer apply for subsequent retransmissions.

#### 5.4.2.2 HARQ process

Each HARQ process is associated with a HARQ buffer.

Each HARQ process shall maintain a state variable `CURRENT_TX_NB`, which indicates the number of transmissions that have taken place for the MAC PDU currently in the buffer. When the HARQ process is established, `CURRENT_TX_NB` shall be initialized to 0.

In case of dynamically scheduled transmissions, the UE is configured with a maximum number of transmissions that is identical across all HARQ Processes and all Logical Channels.

If the HARQ entity provides a new PDU, the HARQ process shall:

- set `CURRENT_TX_NB` to 0;
- set `CURRENT_IRV` to 0;
- store the MAC PDU in the associated HARQ buffer;
- generate a transmission as described below.

If the HARQ entity requests a re-transmission, the HARQ process shall:

- if an uplink grant for this was received on [PDCCH]:
  - set `CURRENT_IRV` to the value indicated in the uplink grant;
- generate a transmission as described below.

To generate a transmission, the HARQ process shall:

- instruct the physical layer to generate a transmission with the redundancy version corresponding to the `CURRENT_IRV` value and the transmission timing;
- if `CURRENT_IRV` < [Y] [FFS]:
  - increment `CURRENT_IRV` by 1;
- increment `CURRENT_TX_NB` by 1;

The HARQ process shall:

- if a HARQ ACK is received; or
- if `CURRENT_TX_NB` ≥ maximum number of transmissions configured:
  - flush the HARQ buffer.

The HARQ process shall also:

- if `CURRENT_TX_NB` = maximum number of transmissions configured; and
- no HARQ ACK is received for this process:
  - notify the relevant ARQ entities in the upper layer that the transmission of the corresponding RLC PDUs failed.

## 5.4.3 Multiplexing and assembly

### 5.4.3.1 Logical channel prioritization

The Logical Channel Prioritization procedure shall be applied when a new transmission is performed.

RRC can control the scheduling of uplink data by giving each logical channel a priority where increasing priority values indicate lower priority levels. In addition, each logical channel is given a Prioritized Bit Rate (PBR) and optionally, a Maximum Bit Rate (MBR) is also provided. The Logical Channel Prioritization procedure ensures that the UE serves the logical channels in the following sequence:

- All the logical channels are served in a decreasing priority order up to their configured PBR;
- if any resources remain, all the logical channels are served in a strict decreasing priority order up to their configured MBR. In case no MBR is configured the logical channel is served until either the data for that logical channel or the UL grant is exhausted, whichever comes first.

Logical channels configured with the same priority shall be served equally by the UE.

### 5.4.3.2 Multiplexing of MAC SDUs

## 5.4.4 Scheduling Request

The Scheduling Request is for requesting UL resources.

If a Scheduling Request is triggered, the UE shall, for each TTI:

- If no UL resources were allocated in this TTI, and Scheduling Request has been mapped on PUCCH, instruct the physical layer to signal the Scheduling Request on PUCCH;
- If no UL resources were allocated in this TTI and Scheduling Request has not been mapped on PUCCH, instruct the Random Access procedure (see subclause 5.1) to initiate a Random Access procedure.

A triggered Scheduling Request shall be considered pending until UL resources are granted.

## 5.4.5 Buffer Status reporting

The Buffer Status reporting procedure is used to provide the serving eNB with information about the amount of data in the UL buffers of the UE.

A Buffer Status report shall be triggered if any of the following events occur:

- UL data arrives in the UE transmission buffer and the data belongs to a logical channel group with higher priority than those for which data already existed in the UE transmission buffer;
- UL resources are allocated and number of padding bits is larger than the size of the [Short/Long] Buffer Status Report MAC control element;
- a serving cell change occurs.

If the Buffer Status reporting procedure determines that a Buffer Status report is pending:

- if the UE has UL resources allocated for this TTI, instruct the Multiplexing and Assembly procedure to generate a [Short/Long] Buffer Status Report MAC control element;
- else:
  - a Scheduling Request shall be triggered

NOTE: Even if multiple events occur by the time a Buffer Status Report can be transmitted, only one Buffer Status Report will be included in the MAC PDU.

A pending Buffer Status report is cancelled in case the UL grant can accommodate all pending data but is not sufficient to accommodate the [Short/Long] Buffer Status Report MAC control element in addition.

## 5.5 PCH reception

When in RRC\_IDLE, the UE shall at its paging occasions:

- If a PCH assignment has been received on the [PDCCH] with the Paging RNTI:
  - attempt to decode the TB on the PCH as indicated by the [PDCCH] information;
- If a TB on the PCH has been successfully decoded:
  - deliver the decoded MAC PDU to higher layers.

## 5.6 BCH reception

When the UE needs to receive BCH, the UE shall:

- receive and attempt to decode the BCH;
- if a TB on the BCH has been successfully decoded:
  - deliver the decoded MAC PDU to higher layers;

## 5.7 Discontinuous Reception (DRX)

The UE may be configured [by RRC/MAC] with a DRX functionality that allows it to stop monitoring PDCCH during some period of time.

The DRX functionality consists of a Long DRX cycle, a DRX Inactivity Timer, a DRX Retransmission Timer and optionally a Short DRX Cycle and a DRX Short Cycle Timer all defined in subclause 3.1.

When a DRX cycle has been configured, the UE shall for each TTI:

- Whenever a new DRX Cycle begins, the On Duration Timer is started.
- If a DL assignment has been configured for this TTI start the HARQ RTT Timer.
- If the On Duration Timer or DRX Inactivity Timer or DRX Retransmission Timer is running; or
- if an UL grant for a retransmission can occur:
  - UE shall monitor the PDCCH;
  - if the PDCCH is successfully decoded:
    - if the PDCCH indicates a DL transmission:
      - start the HARQ RTT Timer.
    - If On Duration Timer or DRX Inactivity Timer is running and the PDCCH indicates a new transmission:
      - start or restart the DRX Inactivity Timer.
- If the DRX Inactivity Timer expires in this TTI:
  - start DRX Short Cycle Timer if configured;
  - use the short DRX cycle if configured else use the long DRX cycle.
- If DRX Short Cycle Timer or the On Duration Timer expires in this TTI:
  - use the long DRX cycle.

- If HARQ RTT Timer expires in this TTI:
  - UE shall start or restart the DRX Retransmission Timer.

Regardless of whether the UE is monitoring PDCCH or not the UE receives and transmits HARQ feedback when such is expected.

## 5.8 MAC reconfiguration

## 5.9 MAC Reset

## 5.X Handling of unknown, unforeseen and erroneous protocol data

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# 6 Protocol Data Units, formats and parameters

## 6.1 Protocol Data Units

### 6.1.1 General

### 6.1.2 MAC PDU (DL-SCH and UL-SCH)

A MAC PDU consists of a MAC header, zero or more MAC Service Data Units (MAC SDU), zero, or more MAC Control elements, and optionally padding; as described in figure 6.1.2-3.

Both the MAC header and the MAC SDUs are of variable sizes.

A MAC PDU header consists of one or more MAC PDU sub-headers; each sub-header corresponding to either a MAC SDU, a MAC Control element or padding.

A MAC PDU sub-header corresponding to a MAC SDU consists of the six header fields LCID/E/R/R/F/L (as described in figure 6.1.2-1) but for the last sub-header in the MAC PDU which consists solely of the four header fields LCID/E/R/R (as described in figure 6.1.2-2).

A MAC PDU sub-header corresponding to a MAC Control element consists of the six header fields LCID/E/R/R/F/L but for the last sub-header in the MAC PDU and for fixed sized MAC Control elements which consist solely of the four header fields LCID/E/R/R.

A MAC PDU sub-header corresponding to padding consists of the four header fields LCID/E/R/R.

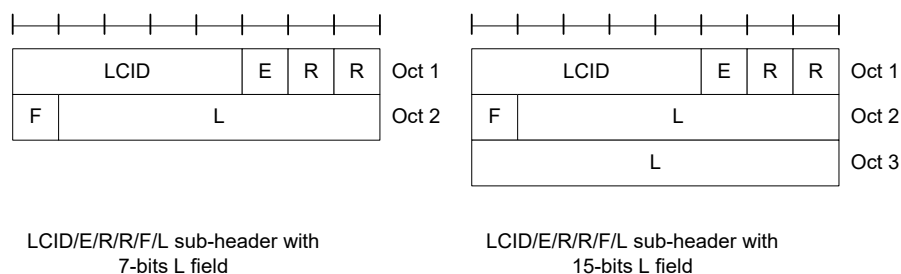


Figure 6.1.2-1: LCID/E/R/R/F/L MAC sub-header

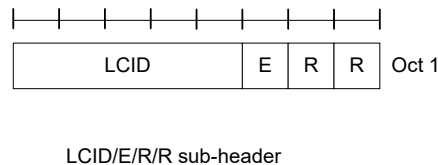


**Figure 6.1.2-2: LCID/E/R/R MAC sub-header**

MAC PDU sub-headers have the same order as the corresponding MAC SDUs, MAC Control elements and padding.

MAC Control elements are always placed before any MAC SDU and padding occurs at the end of the MAC PDU.

A maximum of one MAC PDU can be transmitted per TB per UE. [Depending on the physical layer category], one or two TBs can be transmitted per TTI per UE.

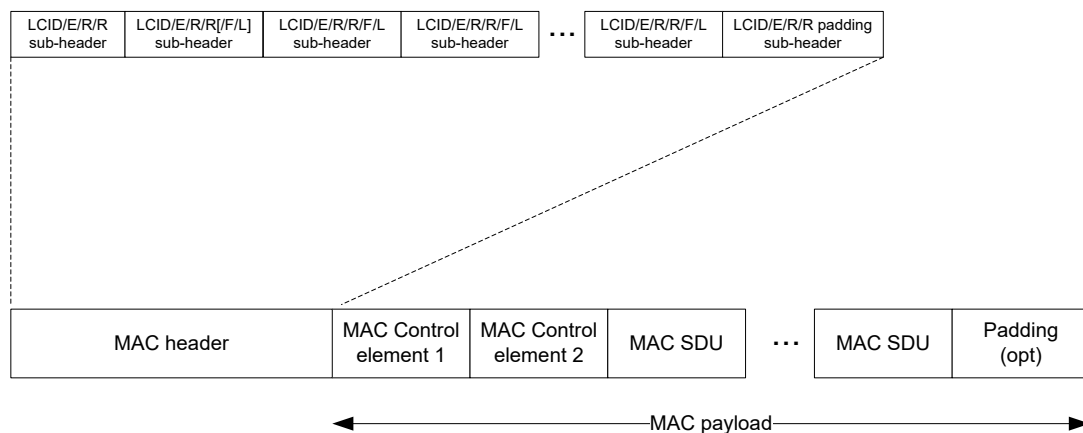


**Figure 6.1.2-3: MAC PDU consisting of MAC header, MAC Control elements, MAC SDUs and padding**

## 6.1.3 MAC Control Elements

### 6.1.3.1 Buffer Status Report Control Elements

Buffer Status Report (BSR) Control Elements consist of either:

- Short BSR format: one LCG ID field and one corresponding BS field (figure 6.1.3.1-1); or
- Long BSR format: four Buffer Size fields, corresponding to LCG IDs #1 through #4 (figure 6.1.3.1-2).

The BSR formats are identified by MAC PDU subheaders with LCIDs as specified in table 6.2.1.-1.

The fields LCG ID and BS are defined as follow:

- LCG ID: The Logical Channel Group ID field identifies the group of logical channel(s) which buffer status is being reported. The length of the field is 2 bits.
- Buffer Size: The Buffer Size field identifies the total amount of data available across all logical channels of a logical channel group after the MAC PDU has been built. The amount of data is indicated in number of bytes. The length of this field is 6 bits. The values taken by the Buffer Size field are shown in [Table 6.1.2.1-1].

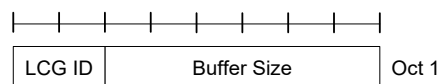


**Figure 6.1.3.1-1: Short Buffer Status MAC control element**

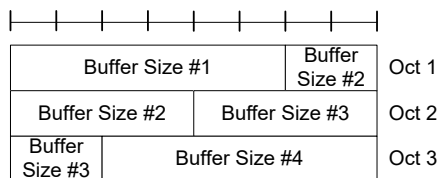


Figure 6.1.3.1-2: Long Buffer Status MAC control element

## 6.2 Formats and parameters

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

The MAC header is of variable size and 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 Control element or padding as described in tables 6.2.1-1 and 6.2.1-2 for the DL and UL-SCH respectively. There is one LCID field for each MAC SDU, MAC Control element or padding included in the MAC PDU. The LCID field size is 5 bits.
- L: The Length field indicates the length of the corresponding MAC SDU or MAC Control element in bytes. There is one L field per MAC SDU included in the MAC PDU except for the last MAC SDU. For MAC Control elements, the presence of an L field depends on the type of MAC Control element. The size of the L field is indicated by the F field.
- F: The Format field indicates the size of the Length field as indicated in table 6.2.1-3. There is one F field per MAC SDU included in the MAC PDU except for the last MAC SDU. The size of the F field is 1 bit.
- E: The Extension field is a flag indicating if more fields are present in the MAC header or not. The E field is set to "1" to indicate another set of at least LCID/E/R/R fields. The E field is set to "0" to indicate that either a MAC SDU, a MAC control element or padding starts at the next byte
- R: Reserved bits.

The MAC header and sub-headers are octet aligned.

Table 6.2.1-1 Values of LCID for DL-SCH;

| Index       | LCID values                     |
|-------------|---------------------------------|
| 00000-xxxxx | Identity of the logical channel |
| xxxxx-11011 | reserved                        |
| 11100       | [RACH Message 2]                |
| 11101       | [Timing Advance]                |
| 11110       | [DRX]                           |
| 11111       | Padding                         |

Table 6.2.1-2 Values of LCID for UL-SCH;

| Index       | LCID values                     |
|-------------|---------------------------------|
| 00000-yyyyy | Identity of the logical channel |
| yyyyy-11100 | reserved                        |

|       |                            |
|-------|----------------------------|
| 11101 | Short Buffer Status Report |
| 11110 | Long Buffer Status Report  |
| 11111 | Padding                    |

**Table 6.2.1-3 Values of F field:**

| <b>Index</b> | <b>Size of Length field (in bits)</b> |
|--------------|---------------------------------------|
| 0            | 7                                     |
| 1            | 15                                    |

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## 7 Variables and constants

## Annex A (informative): Change history

| Change history |             |           |    |     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |       |       |
|----------------|-------------|-----------|----|-----|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|-------|
| Date           | TSG #       | TSG Doc.  | CR | Rev | Subject/Comment                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Old   | New   |
| 2007-06        | RAN2#58 bis | R2-072710 |    |     | MAC Protocol Specification Baseline                                                                                                                                                                                                                                                                                                                                                                                                                                          | -     |       |
| 2007-06        | RAN2#58 bis | R2-072912 |    |     | Text Proposal for UL HARQ (Tdoc R2-072708)<br>Text Proposal for DL HARQ (Tdoc R2-072707)<br>Text Proposal for RACH procedure (Tdoc R2-072640)<br>Text Proposal for Logical Channel prioritization (Tdoc R2-072643)                                                                                                                                                                                                                                                           |       | 0.1.0 |
| 2007-06        | RAN2#58 bis | R2-072994 |    |     | Basic MAC PDU structure (Tdoc R2-072983) with updates<br>Agreements on time-frequency resource configuration (Tdoc R2-072993)<br>Agreement on RA-RNTI association (Tdoc R2-072993)<br>Clarification on RA Response reception (Tdoc R2-072993)                                                                                                                                                                                                                                | 0.1.0 | 0.1.1 |
| 2007-08        | RAN2#59     | R2-073715 |    |     | Removed reference to non-existing table (Tdoc R2-073473)<br>Incorrect mapping of logical to transport channel (Tdoc R2-073473)<br>Un-necessary error checking in HARQ process procedure (Tdoc R2-073473)<br>Removal of reference to timing relation for HARQ feedback (Tdoc R2-073473)<br>Correction of Internal variable name (Tdoc R2-073473)<br>Correction of procedure in case of successful HARQ reception (Tdoc R2-073473)                                             | 0.1.1 | 0.2.0 |
| 2007-09        | RAN2#59     | R2-073885 |    |     | Text proposal for Random Access procedure<br>Text proposal on HARQ clarification for TDD<br>Text proposal on HARQ for grants                                                                                                                                                                                                                                                                                                                                                 | 0.2.0 | 0.2.1 |
| 2007-09        | RAN#37      | RP-070688 |    |     | Clean version for information                                                                                                                                                                                                                                                                                                                                                                                                                                                | 0.2.1 | 1.0.0 |
| 2007-10        | RAN2#59 bis | R2-074530 |    |     | Editorial update with Editor's notes (Tdoc R2-074211).                                                                                                                                                                                                                                                                                                                                                                                                                       | 1.0.0 | 1.1.0 |
| 2007-11        | RAN2#60     | R2-075093 |    |     | Agreements on MAC PDU format (R2-074536)<br>Corrections on Random Access Procedure (R2-074536)                                                                                                                                                                                                                                                                                                                                                                               | 1.1.0 | 1.1.1 |
| 2007-11        | RAN2#60     | R2-075243 |    |     | Endorsement of v1.1.1<br>Removal of FFS on DL CCCH existence                                                                                                                                                                                                                                                                                                                                                                                                                 | 1.1.1 | 1.2.0 |
| 2007-11        | RAN2#60     | R2-075488 |    |     | Agreement on identity used Random Access Response (R2-075038)<br>Agreement on Local Nack1 (R2-074949)<br>PUCCH Resource handling (R2-075432)<br>UL HARQ agreements (R2-075432)<br>Agreements on semi-persistent scheduling (R2-075432, 36.300)<br>Agreements on BSR/SR triggers (R2-075432)<br>Agreements on BSR contents (R2-075432)<br>Agreements on Timing Advance principles (36.300)<br>Agreements on DRX control (36.300)<br>Handling of P-BCH, D-BCH, PCH (R2-075246) | 1.2.0 | 1.3.0 |
| 2007-11        | RAN#38      | RP-070917 |    |     | Clean version, presented at TSG RAN-38 for approval                                                                                                                                                                                                                                                                                                                                                                                                                          | 1.3.0 | 2.0.0 |
| 2007-12        | RAN#38      | -         |    |     | Approved at TSG RAN-38 and placed under change control                                                                                                                                                                                                                                                                                                                                                                                                                       | 2.0.0 | 8.0.0 |