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Evolved Universal Terrestrial Radio Access (E-UTRA);
Medium Access Control (MAC) protocol specification
(3GPP TS 36.321 version 12.8.0 Release 12)

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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".
- [2] 3GPP TS 36.213: "Evolved Universal Terrestrial Radio Access (E-UTRA); Physical Layer Procedures".
- [3] 3GPP TS 36.322: 'Evolved Universal Terrestrial Radio Access (E-UTRA); Radio Link Control (RLC) protocol specification'.
- [4] 3GPP TS 36.323: 'Evolved Universal Terrestrial Radio Access (E-UTRA); Packet Data Convergence Protocol (PDCP) Specification'.
- [5] 3GPP TS 36.212: 'Evolved Universal Terrestrial Radio Access (E-UTRA); Multiplexing and channel coding'.
- [6] 3GPP TS 36.214: 'Evolved Universal Terrestrial Radio Access (E-UTRA); Physical layer; Measurements'.
- [7] 3GPP TS 36.211: 'Evolved Universal Terrestrial Radio Access (E-UTRA); Physical Channels and Modulation'.
- [8] 3GPP TS 36.331: 'Evolved Universal Terrestrial Radio Access (E-UTRA); Radio Resource Control (RRC); Protocol specification'.
- [9] 3GPP TS 36.133: "Evolved Universal Terrestrial Radio Access (E-UTRA); Requirements for support of radio resource management".
- [10] 3GPP TS 36.101: "Evolved Universal Terrestrial Radio Access (E-UTRA); User Equipment (UE) radio transmission and reception".
- [11] 3GPP TS 36.216: "Evolved Universal Terrestrial Radio Access (E-UTRA); Physical layer for relaying operation".
- [12] 3GPP TS 36.306: "Evolved Universal Terrestrial Radio Access (E-UTRA); User Equipment (UE) radio access capabilities".
- [13] 3GPP TS 23.303: "Proximity-based services (ProSe); Stage 2".

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 related to DRX operation, as defined in subclause 5.7, during which the MAC entity monitors the PDCCH.

mac-ContentionResolutionTimer: Specifies the number of consecutive subframe(s) during which the MAC entity shall monitor the PDCCH after Msg3 is transmitted.

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

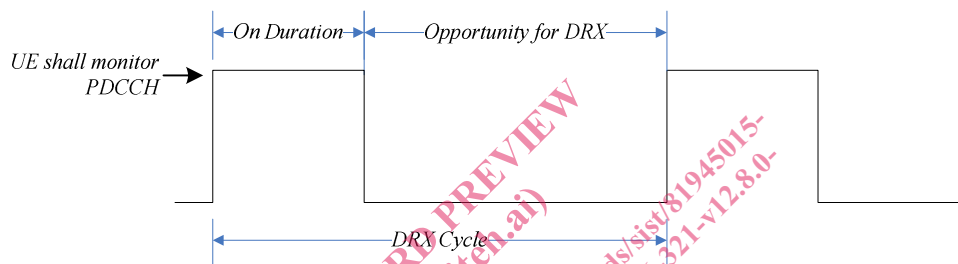


Figure 3.1-1: DRX Cycle

drx-InactivityTimer: Specifies the number of consecutive PDCCH-subframe(s) after the subframe in which a PDCCH indicates an initial UL, DL or SL user data transmission for this MAC entity.

drx-RetransmissionTimer: Specifies the maximum number of consecutive PDCCH-subframe(s) until a DL retransmission is received.

drxShortCycleTimer: Specifies the number of consecutive subframe(s) the MAC entity shall follow the Short DRX cycle.

drxStartOffset: Specifies the subframe where the DRX Cycle starts.

HARQ information: HARQ information for DL-SCH or for UL-SCH transmissions consists of New Data Indicator (NDI), Transport Block (TB) size. For DL-SCH transmissions the HARQ information also includes HARQ process ID. For UL-SCH transmission the HARQ information also includes Redundancy Version (RV). In case of spatial multiplexing on DL-SCH the HARQ information comprises a set of NDI and TB size for each transport block. HARQ information for SL-SCH and SL-DCH transmissions consists of TB size only.

HARQ RTT Timer: This parameter specifies the minimum amount of subframe(s) before a DL HARQ retransmission is expected by the MAC entity.

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.

onDurationTimer: Specifies the number of consecutive PDCCH-subframe(s) at the beginning of a DRX Cycle.

PDCCH: Refers to the PDCCH [7], EPDCCH (in subframes when configured) or, for an RN with R-PDCCH configured and not suspended, to the R-PDCCH.

PDCCH-subframe: Refers to a subframe with PDCCH. For a MAC entity configured with only FDD serving cell(s), this represents any subframe; for a MAC entity configured with at least one TDD serving cell, if a MAC entity is capable of simultaneous reception and transmission in the aggregated cells, this represents the union over all serving cells of downlink subframes and subframes including DwPTS of the TDD UL/DL configuration indicated by *tdd-Config* [8], except serving cells that are configured with *schedulingCellId* [8]; otherwise, this represents the subframes where the SpCell is configured with a downlink subframe or a subframe including DwPTS of the TDD UL/DL

configuration indicated by *tdd-Config* [8].

For RNs with an RN subframe configuration configured and not suspended, in its communication with the E-UTRAN, this represents all downlink subframes configured for RN communication with the E-UTRAN.

PRACH Resource Index: The index of a PRACH within a system frame [7]

Primary Timing Advance Group: Timing Advance Group containing the SpCell.

ra-PRACH-MaskIndex: Defines in which PRACHs within a system frame the MAC entity can transmit a Random Access Preamble (see subclause 7.3).

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 MAC entity to transmit the Random Access preamble.

SC Period: Sidelink Control period, the time period consisting of transmission of SCI and its corresponding data.

SCI: The Sidelink Control Information contains the sidelink scheduling information such as resource block assignment, modulation and coding scheme and Group Destination ID [5].

Secondary Timing Advance Group: Timing Advance Group not containing the SpCell. A Secondary Timing Advance Group contains at least one Serving Cell with an UL configured.

Serving Cell: A Primary or a Secondary Cell [8].

Sidelink: UE to UE interface for sidelink communication and sidelink discovery. The sidelink corresponds to the PC5 interface as defined in [13].

Special Cell: For Dual Connectivity operation the term Special Cell refers to the PCell of the MCG or the PSCell of the SCG, otherwise the term Special Cell refers to the PCell.

Timing Advance Group: A group of Serving Cells that is configured by RRC and that, for the cells with an UL configured, using the same timing reference cell and the same Timing Advance value.

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.

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
C-RNTI	Cell RNTI
CQI	Channel Quality Indicator
eIMTA	Enhanced Interference Management and Traffic Adaptation
eIMTA-RNTI	Enhanced Interference Management and Traffic Adaptation - RNTI
E-UTRA	Evolved UMTS Terrestrial Radio Access
E-UTRAN	Evolved UMTS Terrestrial Radio Access Network
MAC	Medium Access Control
MCG	Master Cell Group
M-RNTI	MBMS RNTI
LCG	Logical Channel Group
PCell	Primary Cell
PSCell	Primary Secondary Cell
PHR	Power Headroom Report
PMI	Precoding Matrix Index
P-RNTI	Paging RNTI
ProSe	Proximity-based Services
pTAG	Primary Timing Advance Group
PTI	Precoding Type Indicator
RA-RNTI	Random Access RNTI

RI	Rank Indicator
RN	Relay Node
RNTI	Radio Network Temporary Identifier
SCell	Secondary Cell
SCG	Secondary Cell Group
SCI	Sidelink Control Information
SI-RNTI	System Information RNTI
SL	Sidelink
SL-RNTI	Sidelink RNTI
SR	Scheduling Request
SRS	Sounding Reference Symbols
SpCell	Special Cell
sTAG	Secondary Timing Advance Group
TAG	Timing Advance Group
TB	Transport Block
TPC-PUCCH-RNTI	Transmit Power Control-Physical Uplink Control Channel-RNTI
TPC-PUSCH-RNTI	Transmit Power Control-Physical Uplink Shared Channel-RNTI

4 General

4.1 Introduction

The objective is to describe the MAC architecture and the MAC entity from a functional point of view. Functionality specified for the UE equally applies to the RN for functionality necessary for the RN. There is also functionality which is only applicable to the RN, in which case the specification denotes the RN instead of the UE. RN-specific behaviour is not applicable to the UE. For TDD operation, UE behaviour follows the TDD UL/DL configuration indicated by *tdd-Config* unless specified otherwise.

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(s) (DL-SCH);
- Paging Channel (PCH);
- Uplink Shared Channel(s) (UL-SCH);
- Random Access Channel(s) (RACH);
- Multicast Channel(s) (MCH);
- Sidelink Broadcast Channel (SL-BCH);
- Sidelink Discovery Channel (SL-DCH);
- Sidelink Shared Channel (SL-SCH).

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

The RN includes both types of MAC entities; one type for communication with UEs and one type for communication with the E-UTRAN.

In Dual Connectivity, two MAC entities are configured in the UE: one for the MCG and one for the SCG. Each MAC entity is configured by RRC with a serving cell supporting PUCCH transmission and contention based Random Access. In this specification, the term SpCell refers to such cell, whereas the term SCell refers to other serving cells. The term SpCell either refers to the PCell of the MCG or the PCell of the SCG depending on if the MAC entity is associated to the MCG or the SCG, respectively. A Timing Advance Group containing the SpCell of a MAC entity is referred to as pTAG, whereas the term sTAG refers to other TAGs.

The functions of the different MAC entities in the UE operate independently if not otherwise indicated. The timers and parameters used in each MAC entity are configured independently if not otherwise indicated. 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 if not otherwise indicated.

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

Figure 4.2.1-1 illustrates one possible structure for the UE side MAC entity when SCG is not configured, and it should not restrict implementation.

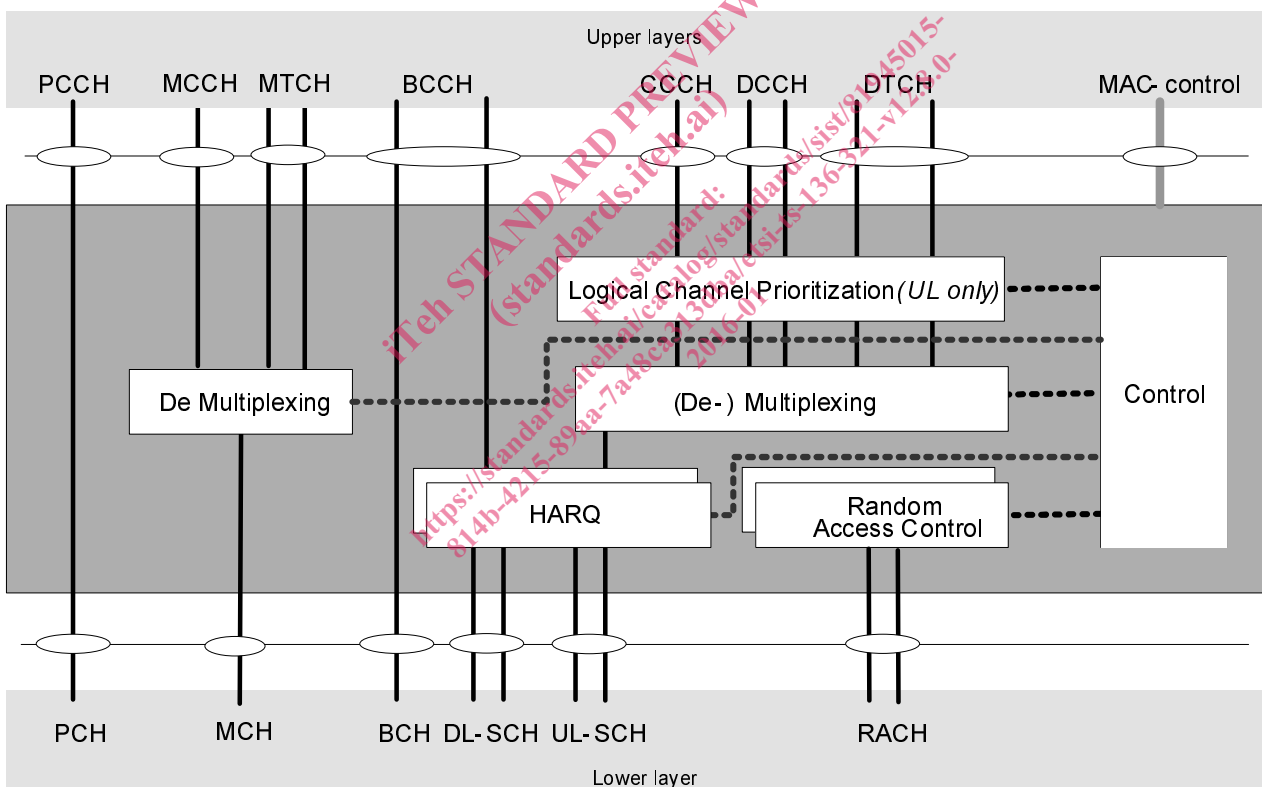


Figure 4.2.1-1: MAC structure overview, UE side

Figure 4.2.1-2 illustrates one possible structure for the UE side MAC entities when MCG and SCG are configured, and it should not restrict implementation. MBMS reception is excluded from this figure for simplicity.

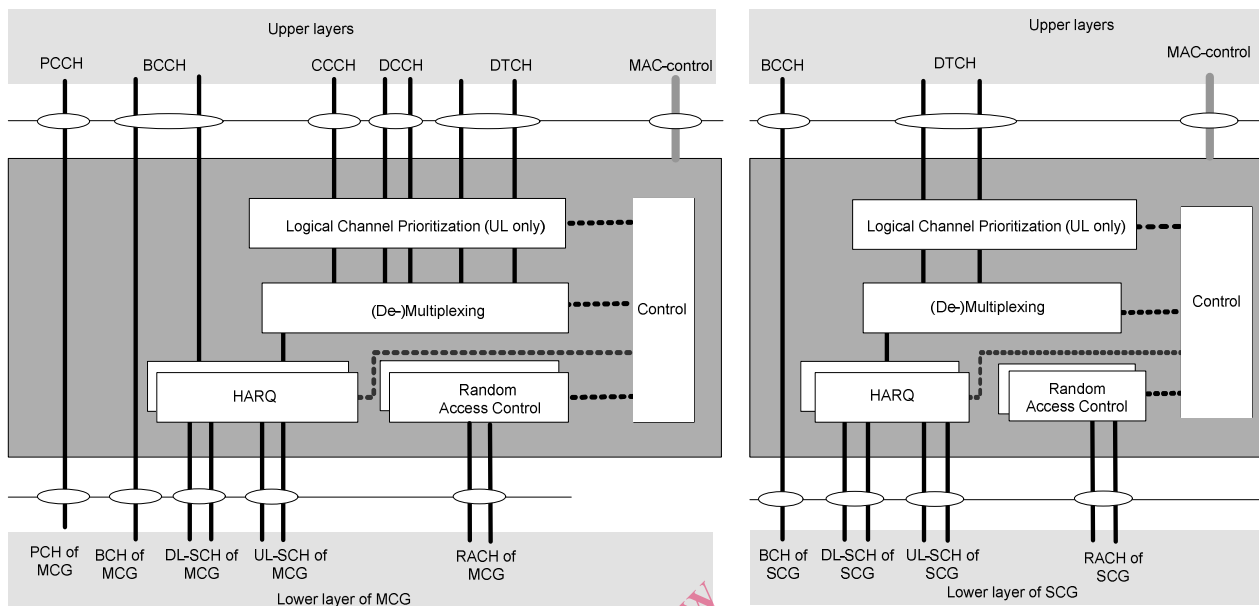


Figure 4.2.1-2: MAC structure overview with two MAC entities, UE side

Figure 4.2.1-3 illustrates one possible structure for the UE side MAC entity when sidelink is configured, and it should not restrict implementation.

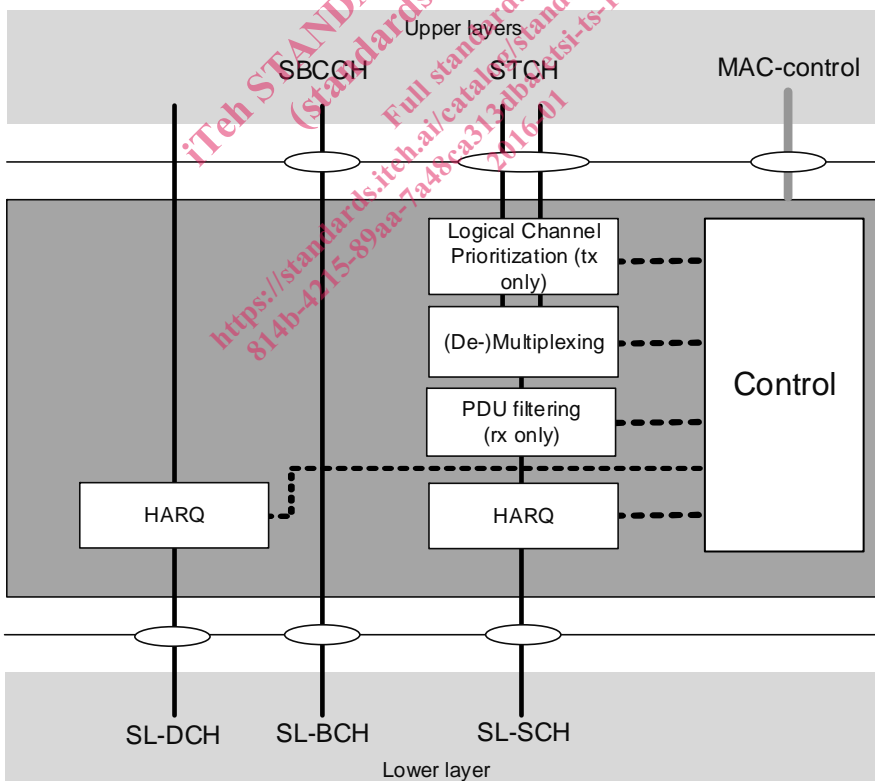


Figure 4.2.1-3: MAC structure overview for sidelink, UE side