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Contents

Intellectual Property Rights	2
Legal Notice	2
Modal verbs terminology.....	2
Foreword.....	7
1 Scope	8
2 References	8
3 Definitions, symbols and abbreviations	9
3.1 Definitions	9
3.2 Abbreviations	10
4 General	11
4.1 Introduction	11
4.2 MAC architecture	11
4.2.1 General.....	11
4.2.2 MAC Entities	11
4.3 Services	13
4.3.1 Services provided to upper layers.....	13
4.3.2 Services expected from physical layer.....	13
4.4 Functions	13
4.5 Channel structure.....	14
4.5.1 General.....	14
4.5.2 Transport Channels	14
4.5.3 Logical Channels	14
4.5.4 Mapping of Transport Channels to Logical Channels	15
4.5.4.1 General	15
4.5.4.2 Uplink mapping	15
4.5.4.3 Downlink mapping	15
4.5.4.4 Sidelink mapping	15
5 MAC procedures	16
5.1 Random Access procedure	16
5.1.1 Random Access procedure initialization.....	16
5.1.1a Initialization of variables specific to Random Access type	20
5.1.2 Random Access Resource selection.....	22
5.1.2a Random Access Resource selection for 2-step RA type	24
5.1.3 Random Access Preamble transmission	26
5.1.3a MSGA transmission.....	27
5.1.4 Random Access Response reception.....	29
5.1.4a MSGB reception and contention resolution for 2-step RA type	31
5.1.5 Contention Resolution	34
5.1.6 Completion of the Random Access procedure.....	36
5.2 Maintenance of Uplink Time Alignment.....	36
5.3 DL-SCH data transfer.....	37
5.3.1 DL Assignment reception	37
5.3.2 HARQ operation.....	39
5.3.2.1 HARQ Entity.....	39
5.3.2.2 HARQ process	39
5.3.3 Disassembly and demultiplexing	40
5.4 UL-SCH data transfer.....	41
5.4.1 UL Grant reception	41
5.4.2 HARQ operation.....	44
5.4.2.1 HARQ Entity.....	44
5.4.2.2 HARQ process	47
5.4.3 Multiplexing and assembly	49
5.4.3.1 Logical Channel Prioritization	49

5.4.3.1.1	General	49
5.4.3.1.2	Selection of logical channels	49
5.4.3.1.3	Allocation of resources.....	50
5.4.3.2	Multiplexing of MAC Control Elements and MAC SDUs	51
5.4.4	Scheduling Request.....	51
5.4.5	Buffer Status Reporting	54
5.4.6	Power Headroom Reporting	56
5.4.7	Pre-emptive Buffer Status Reporting.....	59
5.5	PCH reception	60
5.6	BCH reception.....	60
5.7	Discontinuous Reception (DRX).....	60
5.8	Transmission and reception without dynamic scheduling.....	64
5.8.1	Downlink	64
5.8.2	Uplink	64
5.8.3	Sidelink.....	66
5.9	Activation/Deactivation of SCells.....	68
5.10	Activation/Deactivation of PDCP duplication.....	70
5.11	MAC reconfiguration	70
5.12	MAC Reset.....	71
5.13	Handling of unknown, unforeseen and erroneous protocol data	72
5.14	Handling of measurement gaps	72
5.15	Bandwidth Part (BWP) operation.....	72
5.15.1	Downlink and Uplink.....	72
5.15.2	Sidelink.....	75
5.16	SUL operation	76
5.17	Beam Failure Detection and Recovery procedure.....	76
5.18	Handling of MAC CEs.....	78
5.18.1	General.....	78
5.18.2	Activation/Deactivation of Semi-persistent CSI-RS/CSI-IM resource set	79
5.18.3	Aperiodic CSI Trigger State Subselection	79
5.18.4	Activation/Deactivation of UE-specific PDSCH TCI state	79
5.18.5	Indication of TCI state for UE-specific PDCCH.....	80
5.18.6	Activation/Deactivation of Semi-persistent CSI reporting on PUCCH.....	80
5.18.7	Activation/Deactivation of Semi-persistent SRS and Indication of spatial relation of SP/AP SRS	80
5.18.8	Activation/Deactivation of spatial relation of PUCCH resource	81
5.18.9	Activation/Deactivation of semi-persistent ZP CSI-RS resource set.....	81
5.18.10	Recommended Bit Rate	81
5.18.11	Void	82
5.18.12	Void	82
5.18.13	Void	82
5.18.14	Update of Pathloss Reference RS of SRS.....	82
5.18.15	Update of Pathloss Reference RS of PUSCH	82
5.18.16	Indication of spatial relation of SRS resource for a Serving Cell set.....	82
5.18.17	Activation/Deactivation of Semi-persistent Positioning SRS.....	82
5.18.18	Timing offset adjustment for IAB.....	83
5.18.19	Guard symbols for IAB.....	83
5.19	Data inactivity monitoring.....	83
5.20	Void.....	84
5.21	LBT operation	84
5.21.1	General.....	84
5.21.2	LBT failure detection and recovery procedure	84
5.22	SL-SCH Data transfer	85
5.22.1	SL-SCH Data transmission.....	85
5.22.1.1	SL Grant reception and SCI transmission	85
5.22.1.2	TX resource (re-)selection check	90
5.22.1.3	Sidelink HARQ operation.....	91
5.22.1.3.1	Sidelink HARQ Entity.....	91
5.22.1.3.1a	Sidelink process.....	93
5.22.1.3.2	PSFCH reception.....	95
5.22.1.3.3	HARQ-based Sidelink RLF detection	95
5.22.1.4	Multiplexing and assembly	96
5.22.1.4.1	Logical channel prioritization.....	96

5.22.1.4.1.1	General.....	96
5.22.1.4.1.2	Selection of logical channels.....	97
5.22.1.4.1.3	Allocation of sidelink resources.....	97
5.22.1.4.2	Multiplexing of MAC Control Elements and MAC SDUs.....	98
5.22.1.5	Scheduling Request.....	98
5.22.1.6	Buffer Status Reporting.....	99
5.22.1.7	CSI Reporting	101
5.22.2	SL-SCH Data reception	102
5.22.2.1	SCI reception.....	102
5.22.2.2	Sidelink HARQ operation	102
5.22.2.2.1	Sidelink HARQ Entity.....	102
5.22.2.2.2	Sidelink process.....	103
5.22.2.3	Disassembly and demultiplexing	104
5.23	SL-BCH data transfer.....	104
5.23.1	SL-BCH data transmission	104
5.23.2	SL-BCH data reception.....	104
6	Protocol Data Units, formats and parameters.....	105
6.1	Protocol Data Units	105
6.1.1	General.....	105
6.1.2	MAC PDU (DL-SCH and UL-SCH except transparent MAC and Random Access Response).....	105
6.1.3	MAC Control Elements (CEs).....	108
6.1.3.1	Buffer Status Report MAC CEs	108
6.1.3.2	C-RNTI MAC CE	112
6.1.3.3	UE Contention Resolution Identity MAC CE	112
6.1.3.4	Timing Advance Command MAC CE	112
6.1.3.4a	Absolute Timing Advance Command MAC CE	113
6.1.3.5	DRX Command MAC CE	113
6.1.3.6	Long DRX Command MAC CE	113
6.1.3.7	Configured Grant Confirmation MAC CE	113
6.1.3.8	Single Entry PHR MAC CE.....	113
6.1.3.9	Multiple Entry PHR MAC CE.....	115
6.1.3.10	SCell Activation/Deactivation MAC CEs	117
6.1.3.11	Duplication Activation/Deactivation MAC CE	118
6.1.3.12	SP CSI-RS/CSI-IM Resource Set Activation/Deactivation MAC CE	118
6.1.3.13	Aperiodic CSI Trigger State Subselection MAC CE	119
6.1.3.14	TCI States Activation/Deactivation for UE-specific PDSCH MAC CE	120
6.1.3.15	TCI State Indication for UE-specific PDCCH MAC CE	121
6.1.3.16	SP CSI reporting on PUCCH Activation/Deactivation MAC CE	121
6.1.3.17	SP SRS Activation/Deactivation MAC CE.....	122
6.1.3.18	PUCCH spatial relation Activation/Deactivation MAC CE.....	123
6.1.3.19	SP ZP CSI-RS Resource Set Activation/Deactivation MAC CE	124
6.1.3.20	Recommended bit rate MAC CE	124
6.1.3.21	Timing Delta MAC CE	125
6.1.3.22	Guard Symbols MAC CEs	126
6.1.3.23	BFR MAC CEs	126
6.1.3.24	Enhanced TCI States Activation/Deactivation for UE-specific PDSCH MAC CE	128
6.1.3.25	Enhanced PUCCH Spatial Relation Activation/Deactivation MAC CE	129
6.1.3.26	Enhanced SP/AP SRS Spatial Relation Indication MAC CE.....	130
6.1.3.27	SRS Pathloss Reference RS Update MAC CE.....	131
6.1.3.28	PUSCH Pathloss Reference RS Update MAC CE	132
6.1.3.29	Serving Cell Set based SRS Spatial Relation Indication MAC CE.....	132
6.1.3.30	LBT failure MAC CEs	134
6.1.3.31	Multiple Entry Configured Grant Confirmation MAC CE	134
6.1.3.32	Duplication RLC Activation/Deactivation MAC CE.....	135
6.1.3.33	Sidelink Buffer Status Report MAC CEs	135
6.1.3.34	Sidelink Configured Grant Confirmation MAC CE.....	136
6.1.3.35	Sidelink CSI Reporting MAC CE	136
6.1.3.36	SP Positioning SRS Activation/Deactivation MAC CE.....	137
6.1.4	MAC PDU (transparent MAC).....	140
6.1.5	MAC PDU (Random Access Response).....	140
6.1.5a	MAC PDU (MSGB)	141

6.1.6	MAC PDU (SL-SCH).....	142
6.2	Formats and parameters.....	143
6.2.1	MAC subheader for DL-SCH and UL-SCH.....	143
6.2.2	MAC subheader for Random Access Response.....	145
6.2.2a	MAC subheader for MSGB.....	146
6.2.3	MAC payload for Random Access Response.....	146
6.2.3a	MAC payload for MSGB.....	147
6.2.4	MAC subheader for SL-SCH.....	149
7	Variables and constants.....	149
7.1	RNTI values.....	149
7.2	Backoff Parameter values.....	151
7.3	DELTA_PREAMBLE values.....	151
7.4	PRACH Mask Index values.....	152
Annex A (informative):	Change history	153
History		157

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ETSI TS 138 321 V16.3.0 (2021-01)

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1 Scope

The present document specifies the NR 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 38.300: "NR; Overall description; Stage 2".
- [3] 3GPP TS 38.322: "NR; Radio Link Control (RLC) protocol specification".
- [4] 3GPP TS 38.323: "NR; Packet Data Convergence Protocol (PDCP) protocol specification".
- [5] 3GPP TS 38.331: "NR; Radio Resource Control (RRC); Protocol specification".
- [6] 3GPP TS 38.213: "NR; Physical Layer Procedures for control".
- [7] 3GPP TS 38.214: "NR; Physical Layer Procedures for data".
- [8] 3GPP TS 38.211: "NR; Physical channels and modulation".
- [9] 3GPP TS 38.212: "NR; Multiplexing and channel coding".
- [10] Void.
- [11] 3GPP TS 38.133: "NR; Requirements for support of radio resource management".
- [12] 3GPP TS 36.133: "Evolved Universal Terrestrial Radio Access (E-UTRA); Requirements for support of radio resource management".
- [13] 3GPP TS 26.114: "Technical Specification Group Services and System Aspects; IP Multimedia Subsystem (IMS); Multimedia Telephony; Media handling and interaction".
- [14] 3GPP TS 38.101-1: "NR; User Equipment (UE) radio transmission and reception; Part 1: Range 1 Standalone".
- [15] 3GPP TS 38.101-2: "NR; User Equipment (UE) radio transmission and reception; Part 2: Range 2 Standalone".
- [16] 3GPP TS 38.101-3: "NR; User Equipment (UE) radio transmission and reception; Part 3: Range 1 and Range 2 Interworking operation with other radios".
- [17] 3GPP TS 36.213: "Evolved Universal Terrestrial Radio Access (E-UTRA); Physical Layer Procedures".
- [18] 3GPP TS 37.213: "Physical layer procedures for shared spectrum channel access".
- [19] 3GPP TS 23.287: "Architecture enhancements for 5G System (5GS) to support Vehicle-to-Everything (V2X) services".
- [20] 3GPP TS 23.285: "Architecture enhancements for V2X services".

- [21] 3GPP TS 36.331: "Evolved Universal Terrestrial Radio Access (E-UTRA); Radio Resource Control (RRC); Protocol specification".
- [22] 3GPP TS 36.321: "Evolved Universal Terrestrial Radio Access (E-UTRA); Medium Access Control (MAC); Protocol specification".
- [23] 3GPP TS 37.355: "Evolved Universal Terrestrial Radio Access (E-UTRA); LTE Positioning Protocol (LPP)".
- [24] 3GPP TS 38.215: "NR; Physical layer measurements".

3 Definitions, symbols and abbreviations

3.1 Definitions

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

containing the SpCell of a MAC entity is referred to as Primary Timing Advance Group (PTAG), whereas the term Secondary Timing Advance Group (STAG) refers to other TAGs.

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

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

3.2 Abbreviations

For the purposes of the present document, the abbreviations given in TR 21.905 [1] and the following apply. An abbreviation defined in the present document takes precedence over the definition of the same abbreviation, if any, in TR 21.905 [1].

AP	Aperiodic
BFR	Beam Failure Recovery
BSR	Buffer Status Report
BWP	Bandwidth Part
CE	Control Element
CG	Cell Group
CI-RNTI	Cancellation Indication RNTI
CSI	Channel State Information
CSI-IM	CSI Interference Measurement
CSI-RS	CSI Reference Signal
CS-RNTI	Configured Scheduling RNTI
DAPS	Dual Active Protocol Stack
DCP	DCI with CRC scrambled by PS-RNTI
DL-PRS	DownLink-Positioning Reference Signal
IAB	Integrated Access and Backhaul
INT-RNTI	Interruption RNTI
LBT	Listen Before Talk
LCG	Logical Channel Group
LCP	Logical Channel Prioritization
MCG	Master Cell Group
MPE	Maximum Permissible Exposure
NUL	Normal Uplink
NZP CSI-RS	Non-Zero Power CSI-RS
PDB	Packet Delay Budget
PHR	Power Headroom Report
PS-RNTI	Power Saving RNTI
PTAG	Primary Timing Advance Group
QCL	Quasi-colocation
RS	Reference Signal
SCG	Secondary Cell Group
SFI-RNTI	Slot Format Indication RNTI
SI	System Information
SL-RNTI	Sidelink RNTI
SLCS-RNTI	Sidelink Configured Scheduling RNTI
SpCell	Special Cell
SP	Semi-Persistent
SP-CSI-RNTI	Semi-Persistent CSI RNTI
SPS	Semi-Persistent Scheduling
SR	Scheduling Request
SS	Synchronization Signals
SSB	Synchronization Signal Block
STAG	Secondary Timing Advance Group
SUL	Supplementary Uplink

TAG	Timing Advance Group
TCI	Transmission Configuration Indicator
TPC-SRS-RNTI	Transmit Power Control-Sounding Reference Symbols-RNTI
UCI	Uplink Control Information
V2X	Vehicle-to-Everything
ZP CSI-RS	Zero Power CSI-RS

4 General

4.1 Introduction

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

4.2 MAC architecture

4.2.1 General

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

RRC is in control of the MAC configuration.

4.2.2 MAC Entities

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

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

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

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

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

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

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

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

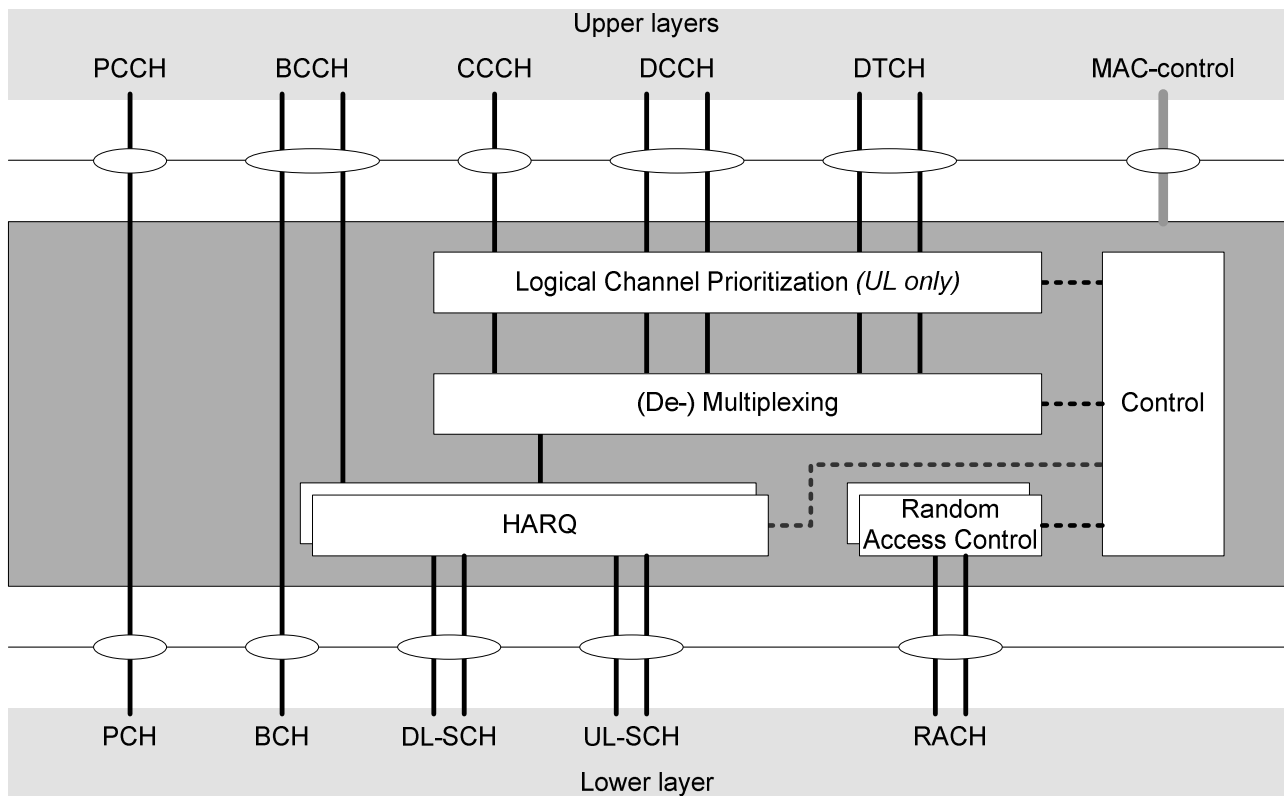


Figure 4.2.2-1: MAC structure overview

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

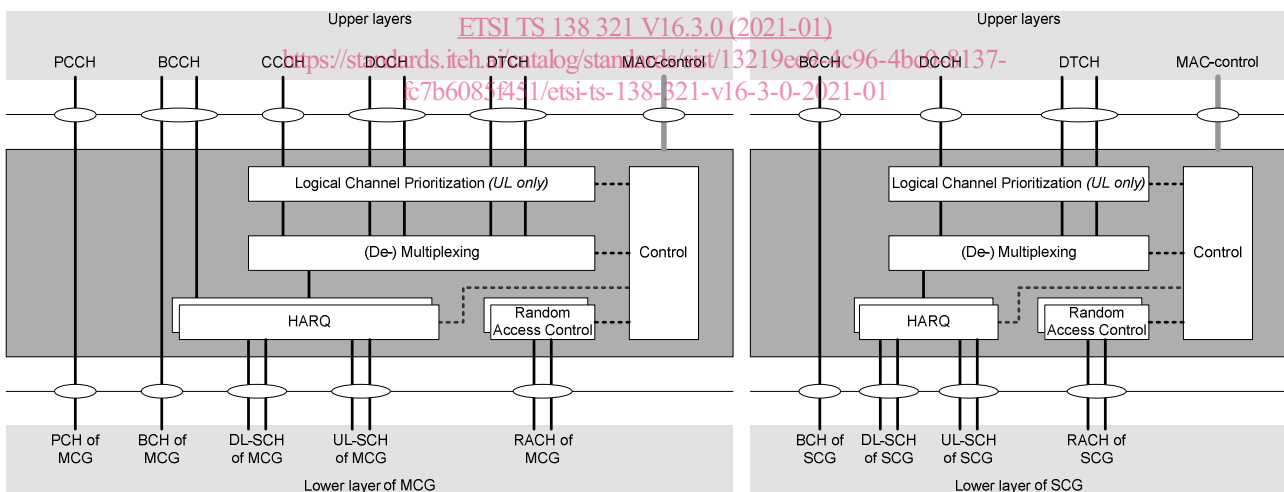


Figure 4.2.2-2: MAC structure overview with two MAC entities

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

- Sidelink Shared Channel (SL-SCH);
- Sidelink Broadcast Channel (SL-BCH).

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

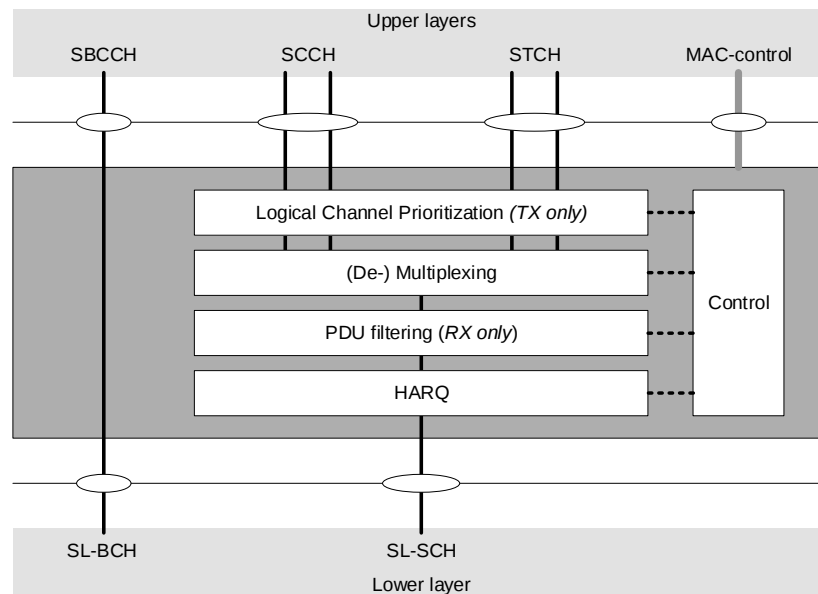


Figure 4.2.2-3: MAC structure overview for sidelink

4.3 Services

4.3.1 Services provided to upper layers

The MAC sublayer provides the following services to upper layers:

- data transfer;
- radio resource allocation.

ETSI TS 138 321 V16.3.0 (2021-01)

<https://standards.iteh.ai/catalog/standards/sist/13219ee9-4c96-4bc0-8137-fc7b6085f451/etsi-ts-138-321-v16-3-0-2021-01>

4.3.2 Services expected from physical layer

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

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

4.4 Functions

The MAC sublayer supports the following functions:

- mapping between logical channels and transport channels;
- multiplexing of MAC SDUs from one or different logical channels onto transport blocks (TB) to be delivered to the physical layer on transport channels;
- demultiplexing of MAC SDUs to one or different logical channels from transport blocks (TB) delivered from the physical layer on transport channels;
- scheduling information reporting;
- error correction through HARQ;
- logical channel prioritisation;

- priority handling between overlapping resources of one UE;
- radio resource selection.

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

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

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

4.5 Channel structure

4.5.1 General

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

4.5.2 Transport Channels

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

Table 4.5.2-1: Transport channels used by MAC

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

4.5.3 Logical Channels

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

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

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