

ETSI TS 138 321 V17.5.0 (2023-07)



5G;
NR;
**Medium Access Control (MAC) protocol specification
(3GPP TS 38.321 version 17.5.0 Release 17)**

[ETSI TS 138 321 V17.5.0 \(2023-07\)](https://standards.iteh.ai/catalog/standards/sist/7d0d6aa5-29e2-47b9-9b7a-01718949b9de/etsi-ts-138-321-v17-5-0-2023-07)

<https://standards.iteh.ai/catalog/standards/sist/7d0d6aa5-29e2-47b9-9b7a-01718949b9de/etsi-ts-138-321-v17-5-0-2023-07>



ReferenceRTS/TSGR-0238321vh50

Keywords5G

ETSI

650 Route des Lucioles
F-06921 Sophia Antipolis Cedex - FRANCE

Tel.: +33 4 92 94 42 00 Fax: +33 4 93 65 47 16

Siret N° 348 623 562 00017 - APE 7112B
Association à but non lucratif enregistrée à la
Sous-Préfecture de Grasse (06) N° w061004871

Important notice

The present document can be downloaded from:

<https://www.etsi.org/standards-search>

The present document may be made available in electronic versions and/or in print. The content of any electronic and/or print versions of the present document shall not be modified without the prior written authorization of ETSI. In case of any existing or perceived difference in contents between such versions and/or in print, the prevailing version of an ETSI deliverable is the one made publicly available in PDF format at www.etsi.org/deliver.

Users of the present document should be aware that the document may be subject to revision or change of status.

Information on the current status of this and other ETSI documents is available at

<https://portal.etsi.org/TB/ETSIDeliverableStatus.aspx>

If you find errors in the present document, please send your comment to one of the following services:

<https://standards-portal.etsi.org/People/CommitteeSupportStaff.aspx> 47b9-9b7a-

If you find a security vulnerability in the present document, please report it through our

Coordinated Vulnerability Disclosure Program:

<https://www.etsi.org/standards/coordinated-vulnerability-disclosure>

Notice of disclaimer & limitation of liability

The information provided in the present deliverable is directed solely to professionals who have the appropriate degree of experience to understand and interpret its content in accordance with generally accepted engineering or other professional standard and applicable regulations.

No recommendation as to products and services or vendors is made or should be implied.

No representation or warranty is made that this deliverable is technically accurate or sufficient or conforms to any law and/or governmental rule and/or regulation and further, no representation or warranty is made of merchantability or fitness for any particular purpose or against infringement of intellectual property rights.

In no event shall ETSI be held liable for loss of profits or any other incidental or consequential damages.

Any software contained in this deliverable is provided "AS IS" with no warranties, express or implied, including but not limited to, the warranties of merchantability, fitness for a particular purpose and non-infringement of intellectual property rights and ETSI shall not be held liable in any event for any damages whatsoever (including, without limitation, damages for loss of profits, business interruption, loss of information, or any other pecuniary loss) arising out of or related to the use of or inability to use the software.

Copyright Notification

No part may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm except as authorized by written permission of ETSI.

The content of the PDF version shall not be modified without the written authorization of ETSI.

The copyright and the foregoing restriction extend to reproduction in all media.

© ETSI 2023.
All rights reserved.

Intellectual Property Rights

Essential patents

IPRs essential or potentially essential to normative deliverables may have been declared to ETSI. The declarations pertaining to these essential IPRs, if any, are publicly available for **ETSI members and non-members**, and can be found in ETSI SR 000 314: *"Intellectual Property Rights (IPRs); Essential, or potentially Essential, IPRs notified to ETSI in respect of ETSI standards"*, which is available from the ETSI Secretariat. Latest updates are available on the ETSI Web server (<https://ipr.etsi.org/>).

Pursuant to the ETSI Directives including the ETSI IPR Policy, no investigation regarding the essentiality of IPRs, including IPR searches, has been carried out by ETSI. No guarantee can be given as to the existence of other IPRs not referenced in ETSI SR 000 314 (or the updates on the ETSI Web server) which are, or may be, or may become, essential to the present document.

Trademarks

The present document may include trademarks and/or tradenames which are asserted and/or registered by their owners. ETSI claims no ownership of these except for any which are indicated as being the property of ETSI, and conveys no right to use or reproduce any trademark and/or tradename. Mention of those trademarks in the present document does not constitute an endorsement by ETSI of products, services or organizations associated with those trademarks.

DECT™, **PLUGTESTS™**, **UMTS™** and the ETSI logo are trademarks of ETSI registered for the benefit of its Members. **3GPP™** and **LTE™** are trademarks of ETSI registered for the benefit of its Members and of the 3GPP Organizational Partners. **oneM2M™** logo is a trademark of ETSI registered for the benefit of its Members and of the oneM2M Partners. **GSM®** and the GSM logo are trademarks registered and owned by the GSM Association.

Legal Notice

This Technical Specification (TS) has been produced by ETSI 3rd Generation Partnership Project (3GPP).

The present document may refer to technical specifications or reports using their 3GPP identities. These shall be interpreted as being references to the corresponding ETSI deliverables.

The cross reference between 3GPP and ETSI identities can be found under <https://webapp.etsi.org/key/queryform.asp>.

Modal verbs terminology

In the present document **"shall"**, **"shall not"**, **"should"**, **"should not"**, **"may"**, **"need not"**, **"will"**, **"will not"**, **"can"** and **"cannot"** are to be interpreted as described in clause 3.2 of the [ETSI Drafting Rules](#) (Verbal forms for the expression of provisions).

"must" and **"must not"** are **NOT** allowed in ETSI deliverables except when used in direct citation.

Contents

Intellectual Property Rights	2
Legal Notice	2
Modal verbs terminology.....	2
Foreword.....	8
1 Scope	9
2 References	9
3 Definitions, symbols and abbreviations	10
3.1 Definitions	10
3.2 Abbreviations	11
4 General	13
4.1 Introduction	13
4.2 MAC architecture	13
4.2.1 General.....	13
4.2.2 MAC Entities	13
4.3 Services	15
4.3.1 Services provided to upper layers.....	15
4.3.2 Services expected from physical layer.....	15
4.4 Functions	15
4.5 Channel structure.....	16
4.5.1 General.....	16
4.5.2 Transport Channels	16
4.5.3 Logical Channels	16
4.5.4 Mapping of Transport Channels to Logical Channels	17
4.5.4.1 General	17
4.5.4.2 Uplink mapping.....	17
4.5.4.3 Downlink mapping.....	17
4.5.4.4 Sidelink mapping	17
5 MAC procedures	18
5.1 Random Access procedure	18
5.1.1 Random Access procedure initialization.....	18
5.1.1a Initialization of variables specific to Random Access type	22
5.1.1b Selection of the set of Random Access resources for the Random Access procedure.....	26
5.1.1c Availability of the set of Random Access resources.....	26
5.1.1d Selection of the set of Random Access resources based on feature prioritization	27
5.1.2 Random Access Resource selection.....	27
5.1.2a Random Access Resource selection for 2-step RA type	30
5.1.3 Random Access Preamble transmission	32
5.1.3a MSGA transmission.....	33
5.1.4 Random Access Response reception.....	35
5.1.4a MSGB reception and contention resolution for 2-step RA type	38
5.1.5 Contention Resolution	40
5.1.6 Completion of the Random Access procedure.....	43
5.2 Maintenance of Uplink Time Alignment.....	43
5.2a Maintenance of UL Synchronization.....	46
5.3 DL-SCH data transfer.....	46
5.3.1 DL Assignment reception	46
5.3.2 HARQ operation.....	48
5.3.2.1 HARQ Entity.....	48
5.3.2.2 HARQ process	49
5.3.3 Disassembly and demultiplexing	50
5.4 UL-SCH data transfer.....	50
5.4.1 UL Grant reception	50
5.4.2 HARQ operation.....	55

5.4.2.1	HARQ Entity.....	55
5.4.2.2	HARQ process	58
5.4.3	Multiplexing and assembly	60
5.4.3.1	Logical Channel Prioritization	60
5.4.3.1.1	General	60
5.4.3.1.2	Selection of logical channels	61
5.4.3.1.3	Allocation of resources.....	61
5.4.3.2	Multiplexing of MAC Control Elements and MAC SDUs	63
5.4.4	Scheduling Request.....	63
5.4.5	Buffer Status Reporting	67
5.4.6	Power Headroom Reporting	70
5.4.7	Pre-emptive Buffer Status Reporting.....	74
5.4.8	Timing Advance Reporting	75
5.5	PCH reception	76
5.6	BCH reception.....	76
5.7	Discontinuous Reception (DRX).....	76
5.7a	Discontinuous Reception (DRX) for MBS Broadcast.....	83
5.7b	Discontinuous Reception (DRX) for MBS Multicast.....	84
5.8	Transmission and reception without dynamic scheduling	86
5.8.1	Downlink	86
5.8.1a	Downlink for Multicast.....	86
5.8.2	Uplink	87
5.8.3	Sidelink.....	90
5.9	Activation/Deactivation of SCells.....	91
5.10	Activation/Deactivation of PDCP duplication.....	93
5.11	MAC reconfiguration	94
5.12	MAC Reset.....	94
5.12a	Void.....	96
5.13	Handling of unknown, unforeseen and erroneous protocol data	96
5.14	Handling of measurement gaps	97
5.15	Bandwidth Part (BWP) operation.....	97
5.15.1	Downlink and Uplink.....	97
5.15.2	Sidelink.....	101
5.16	SUL operation	102
5.17	Beam Failure Detection and Recovery procedure	103
5.18	Handling of MAC CEs	106
5.18.1	General.....	106
5.18.2	Activation/Deactivation of Semi-persistent CSI-RS/CSI-IM resource set	107
5.18.3	Aperiodic CSI Trigger State Subselection	107
5.18.4	Activation/Deactivation of UE-specific PDSCH TCI state	107
5.18.5	Indication of TCI state for UE-specific PDCCH	108
5.18.6	Activation/Deactivation of Semi-persistent CSI reporting on PUCCH	108
5.18.7	Activation/Deactivation of Semi-persistent SRS and Indication of spatial relation of SP/AP SRS	108
5.18.8	Activation/Deactivation of spatial relation of PUCCH resource	109
5.18.9	Activation/Deactivation of semi-persistent ZP CSI-RS resource set.....	109
5.18.10	Recommended Bit Rate	110
5.18.11	Void	110
5.18.12	Void	110
5.18.13	Void	110
5.18.14	Update of Pathloss Reference RS of SRS.....	110
5.18.15	Update of Pathloss Reference RS of PUSCH	110
5.18.16	Indication of spatial relation of SRS resource for a Serving Cell set.....	111
5.18.17	Activation/Deactivation of Semi-Persistent Positioning SRS.....	111
5.18.18	Timing offset adjustments for IAB	111
5.18.19	Guard symbols for IAB.....	111
5.18.20	Positioning Measurement Gap Activation/Deactivation Command	112
5.18.21	PPW Activation/Deactivation Command	113
5.18.22	Update of PUCCH Power Control Set for multiple TRP PUCCH repetition	113
5.18.23	Unified TCI States Activation/Deactivation MAC CE	113
5.18.24	Update of Differential Koffset	114
5.18.25	BFD-RS Indication MAC CE	114
5.18.26	Restricted and recommended beam indication for IAB.....	114

5.18.27	DL TX power adjustment for IAB	114
5.18.28	UL PSD range adjustment for IAB	115
5.18.29	Timing case indication for IAB	115
5.18.30	Case-6 Timing Request	116
5.19	Data inactivity monitoring	116
5.20	Void	116
5.21	LBT operation	116
5.21.1	General	116
5.21.2	LBT failure detection and recovery procedure	116
5.22	SL-SCH Data transfer	118
5.22.1	SL-SCH Data transmission	118
5.22.1.1	SL Grant reception and SCI transmission	118
5.22.1.2	TX resource (re-)selection check	129
5.22.1.2a	Re-evaluation and Pre-emption	130
5.22.1.2b	Re-selection for using a received resource conflict indication	131
5.22.1.3	Sidelink HARQ operation	132
5.22.1.3.1	Sidelink HARQ Entity	132
5.22.1.3.1a	Sidelink process	134
5.22.1.3.2	PSFCH reception	136
5.22.1.3.3	HARQ-based Sidelink RLF detection	137
5.22.1.4	Multiplexing and assembly	137
5.22.1.4.0	General	137
5.22.1.4.1	Logical channel prioritization	137
5.22.1.4.1.1	General	137
5.22.1.4.1.2	Selection of logical channels	138
5.22.1.4.1.3	Allocation of sidelink resources	139
5.22.1.4.2	Multiplexing of MAC Control Elements and MAC SDUs	140
5.22.1.5	Scheduling Request	140
5.22.1.6	Buffer Status Reporting	141
5.22.1.7	CSI Reporting	144
5.22.1.8	Void	144
5.22.1.9	IUC-Request transmission	144
5.22.1.10	IUC-Information Reporting	144
5.22.1.10.1	General	144
5.22.1.10.2	Reception of IUC-Information Reporting	145
5.22.2	SL-SCH Data reception	145
5.22.2.1	SCI reception	145
5.22.2.2	Sidelink HARQ operation	146
5.22.2.2.1	Sidelink HARQ Entity	146
5.22.2.2.2	Sidelink process	146
5.22.2.3	Disassembly and demultiplexing	148
5.23	SL-BCH data transfer	148
5.23.1	SL-BCH data transmission	148
5.23.2	SL-BCH data reception	148
5.24	Handling of PRS Processing Window	148
5.25	Positioning Measurement Gap Activation/Deactivation Request	149
5.26	Positioning SRS transmission in RRC_INACTIVE	149
5.26.1	General	149
5.26.2	TA validation for SRS transmission in RRC_INACTIVE	149
5.27	Small Data Transmission	150
5.27.1	General	150
5.27.2	TA Validation for CG-SDT	151
5.28	Sidelink Discontinuous Reception (DRX)	152
5.28.1	General	152
5.28.2	Behaviour of UE receiving SL-SCH Data	152
5.28.3	Behaviour of UE transmitting SL-SCH Data	155
5.29	Activation/Deactivation of SCG	155
5.30	Handling of FR2 UL gap	156
6	Protocol Data Units, formats and parameters	157
6.1	Protocol Data Units	157
6.1.1	General	157

6.1.2	MAC PDU (DL-SCH and UL-SCH except transparent MAC and Random Access Response).....	157
6.1.3	MAC Control Elements (CEs).....	160
6.1.3.1	Buffer Status Report MAC CEs	160
6.1.3.2	C-RNTI MAC CE	166
6.1.3.3	UE Contention Resolution Identity MAC CE	166
6.1.3.4	Timing Advance Command MAC CE	166
6.1.3.4a	Absolute Timing Advance Command MAC CE.....	167
6.1.3.5	DRX Command MAC CE	167
6.1.3.6	Long DRX Command MAC CE	167
6.1.3.7	Configured Grant Confirmation MAC CE	167
6.1.3.8	Single Entry PHR MAC CE.....	167
6.1.3.9	Multiple Entry PHR MAC CE	169
6.1.3.10	SCell Activation/Deactivation MAC CEs	171
6.1.3.11	Duplication Activation/Deactivation MAC CE.....	172
6.1.3.12	SP CSI-RS/CSI-IM Resource Set Activation/Deactivation MAC CE	172
6.1.3.13	Aperiodic CSI Trigger State Subselection MAC CE	173
6.1.3.14	TCI States Activation/Deactivation for UE-specific PDSCH MAC CE	174
6.1.3.15	TCI State Indication for UE-specific PDCCH MAC CE	175
6.1.3.16	SP CSI reporting on PUCCH Activation/Deactivation MAC CE	175
6.1.3.17	SP SRS Activation/Deactivation MAC CE.....	176
6.1.3.18	PUCCH spatial relation Activation/Deactivation MAC CE.....	177
6.1.3.19	SP ZP CSI-RS Resource Set Activation/Deactivation MAC CE	178
6.1.3.20	Recommended bit rate MAC CE	178
6.1.3.21	Timing Delta MAC CE	179
6.1.3.22	Guard Symbols MAC CEs	180
6.1.3.23	BFR MAC CEs	180
6.1.3.24	Enhanced TCI States Activation/Deactivation for UE-specific PDSCH MAC CE	182
6.1.3.25	Enhanced PUCCH Spatial Relation Activation/Deactivation MAC CE	183
6.1.3.26	Enhanced SP/AP SRS Spatial Relation Indication MAC CE.....	184
6.1.3.27	SRS Pathloss Reference RS Update MAC CE.....	185
6.1.3.28	PUSCH Pathloss Reference RS Update MAC CE	186
6.1.3.29	Serving Cell Set based SRS Spatial Relation Indication MAC CE.....	186
6.1.3.30	LBT failure MAC CEs	188
6.1.3.31	Multiple Entry Configured Grant Confirmation MAC CE	189
6.1.3.32	Duplication RLC Activation/Deactivation MAC CE.....	189
6.1.3.33	Sidelink Buffer Status Report MAC CEs.....	189
6.1.3.34	Sidelink Configured Grant Confirmation MAC CE.....	190
6.1.3.35	Sidelink CSI Reporting MAC CE	191
6.1.3.36	SP Positioning SRS Activation/Deactivation MAC CE.....	191
6.1.3.37	Guard Symbols MAC CEs for Case-6 and Case-7 timing modes	194
6.1.3.38	Case-7 Timing advance offset MAC CE.....	195
6.1.3.39	Case-6 Timing Request MAC CE	195
6.1.3.40	Positioning Measurement Gap Activation/Deactivation Request MAC CE	195
6.1.3.41	Positioning Measurement Gap Activation/Deactivation Command MAC CE	196
6.1.3.42	PPW Activation/Deactivation Command MAC CE.....	196
6.1.3.43	Enhanced BFR MAC CEs.....	197
6.1.3.44	Enhanced TCI States Indication for UE-specific PDCCH MAC CE	200
6.1.3.45	PUCCH spatial relation Activation/Deactivation for multiple TRP PUCCH repetition MAC CE	201
6.1.3.46	PUCCH Power Control Set Update for multiple TRP PUCCH repetition MAC CE	202
6.1.3.47	Unified TCI States Activation/Deactivation MAC CE	203
6.1.3.48	Enhanced Single Entry PHR MAC CE	204
6.1.3.49	Enhanced Multiple Entry PHR MAC CE.....	205
6.1.3.50	Enhanced Single Entry PHR for multiple TRP MAC CE	210
6.1.3.51	Enhanced Multiple Entry PHR for multiple TRP MAC CE	210
6.1.3.52	Sidelink DRX Command MAC CE	213
6.1.3.53	Inter-UE Coordination Information MAC CE	214
6.1.3.54	Inter-UE Coordination Request MAC CE.....	215
6.1.3.55	Enhanced SCell Activation/Deactivation MAC CEs	216
6.1.3.56	Timing Advance Report MAC CE.....	217
6.1.3.57	Differential Koffset MAC CE	218
6.1.3.58	BFD-RS Indication MAC CE	218
6.1.3.59	SP/AP SRS TCI State Indication MAC CE	218

6.1.3.60	Serving Cell Set based SRS TCI State Indication MAC CE	220
6.1.3.61	Child IAB-DU Restricted Beam Indication MAC CE	221
6.1.3.62	IAB-MT Recommended Beam Indication MAC CE	224
6.1.3.63	DL TX Power Adjustment and Desired DL TX Power Adjustment MAC CEs	227
6.1.3.64	Desired IAB-MT PSD range MAC CE	228
6.1.3.65	Timing Case Indication MAC CE	230
6.1.4	MAC PDU (transparent MAC)	231
6.1.5	MAC PDU (Random Access Response)	231
6.1.5a	MAC PDU (MSGB)	232
6.1.6	MAC PDU (SL-SCH)	233
6.2	Formats and parameters	234
6.2.1	MAC subheader for DL-SCH and UL-SCH	234
6.2.2	MAC subheader for Random Access Response	238
6.2.2a	MAC subheader for MSGB	238
6.2.3	MAC payload for Random Access Response	239
6.2.3a	MAC payload for MSGB	240
6.2.4	MAC subheader for SL-SCH	242
7	Variables and constants	242
7.1	RNTI values	242
7.2	Backoff Parameter values	246
7.3	DELTA_PREAMBLE values	246
7.4	PRACH Mask Index values	247
Annex A (informative):	Change history	248
History		254

iteh STANDARD PREVIEW
(standards.iteh.ai)

ETSI TS 138 321 V17.5.0 (2023-07)

<https://standards.iteh.ai/catalog/standards/sist/7d0d6aa5-29e2-47b9-9b7a-01718949b9de/etsi-ts-138-321-v17-5-0-2023-07>

Foreword

This Technical Specification has been produced by the 3rd 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

where:

- 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.

iTeh STANDARD PREVIEW
(standards.iteh.ai)

ETSI TS 138 321 V17.5.0 (2023-07)

<https://standards.iteh.ai/catalog/standards/sist/7d0d6aa5-29e2-47b9-9b7a-01718949b9de/etsi-ts-138-321-v17-5-0-2023-07>

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".
- [25] 3GPP TS 38.306: "NR; User Equipment (UE) radio access capabilities".
- [26] 3GPP TS 23.304: "Proximity based Services (ProSe) in the 5G System (5GS)".
- [27] 3GPP TS 38.473: "NG-RAN; F1 Application Protocol (F1AP)".
- [28] 3GPP TS 24.587: "Technical Specification Group Core Network and Terminals; Vehicle-to-Everything (V2X) services in 5G System (5GS)".
- [29] 3GPP TS 24.554: "Technical Specification Group Core Network and Terminals; Proximity-services (ProSe) in 5G System (5GS) protocol".

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.

Non-terrestrial network: An NG-RAN consisting of gNBs, which provide non-terrestrial NR access to UEs by means of an NTN payload embarked on an airborne or space-borne NTN vehicle and an NTN Gateway.

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] and ProSe communication (including ProSe non-Relay and UE-to-Network Relay communication) as defined in TS 23.304 [26], between two or more nearby UEs, using NR technology but not traversing any network node.

NR sidelink discovery: AS functionality enabling ProSe non-Relay discovery and ProSe UE-to-Network Relay discovery for Proximity based Services as defined in TS 23.304 [26], between two or more nearby UEs, using NR technology but not traversing any network node.

NR sidelink transmission: Any NR Sidelink-based transmission, including both transmission for NR sidelink discovery and transmission for NR sidelink communication.

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.

PRS Processing Window: A time window during which UE may perform PRS measurement inside the active DL BWP with the same numerology as the active DL BWP without measurement gap.

RedCap UE: A UE with reduced capabilities as specified in clause 4.2.21.1 in TS 38.306 [25].

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

Sidelink transmission information: Sidelink transmission information included in an SCI for an 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.

UE-gNB RTT: For non-terrestrial networks, the sum of the UE's Timing Advance value (see TS 38.211 [8] clause 4.3.1) and *k_{mac}*.

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 1: 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.

NOTE 2: In this version of the specification, the SRS in the procedural description includes Positioning SRS except for the Positioning SRS for transmission in RRC_INACTIVE as in clause 5.26. Positioning SRS except for the Positioning SRS for transmission in RRC_INACTIVE is treated the same as SRS by the UE 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
CG-SDT	Configured Grant-based SDT
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
G-CS-RNTI	Group Configured Scheduling RNTI
G-RNTI	Group RNTI
IAB	Integrated Access and Backhaul
INT-RNTI	Interruption RNTI
LBT	Listen Before Talk
LCG	Logical Channel Group
LCP	Logical Channel Prioritization
MBS	Multicast/Broadcast Services
MCCH	MBS Control Channel
MCCH-RNTI	MBS Control Channel RNTI
MCG	Master Cell Group
MPE	Maximum Permissible Exposure
MTCH	MBS Traffic Channel
NCD-SSB	Non Cell Defining SSB
NSAG	Network Slice AS Group
NUL	Normal Uplink
NZP CSI-RS	Non-Zero Power CSI-RS
PDB	Packet Delay Budget
PEI-RNTI	Paging Early Indication RNTI
PHR	Power Headroom Report
PS-RNTI	Power Saving RNTI
PTAG	Primary Timing Advance Group
PTM	Point to Multipoint
PTP	Point to Point
QCL	Quasi-colocation
PPW	PRS Processing Window
PRS	Positioning Reference Signal
RA-SDT	Random Access-based SDT
RS	Reference Signal
SCG	Secondary Cell Group
SDT	Small Data Transmission
SFI-RNTI	Slot Format Indication RNTI
SI	System Information
SL-RNTI	Sidelink RNTI
SLCS-RNTI	Sidelink Configured Scheduling RNTI
SpCell	Special Cell
SP	Semi-Persistent
SP-CSI-RNTI	Semi-Persistent CSI RNTI
SPS	Semi-Persistent Scheduling
SR	Scheduling Request
SS	Synchronization Signals
SSB	Synchronization Signal Block
STAG	Secondary Timing Advance Group
SUL	Supplementary Uplink
TAG	Timing Advance Group
TCI	Transmission Configuration Indicator
TPC-SRS-RNTI	Transmit Power Control-Sounding Reference Signal-RNTI
TRIV	Time Resource Indicator Value
TRP	Transmit/Receive Point
TRS	CSI-RS for tracking
U2N	UE-to-Network
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.

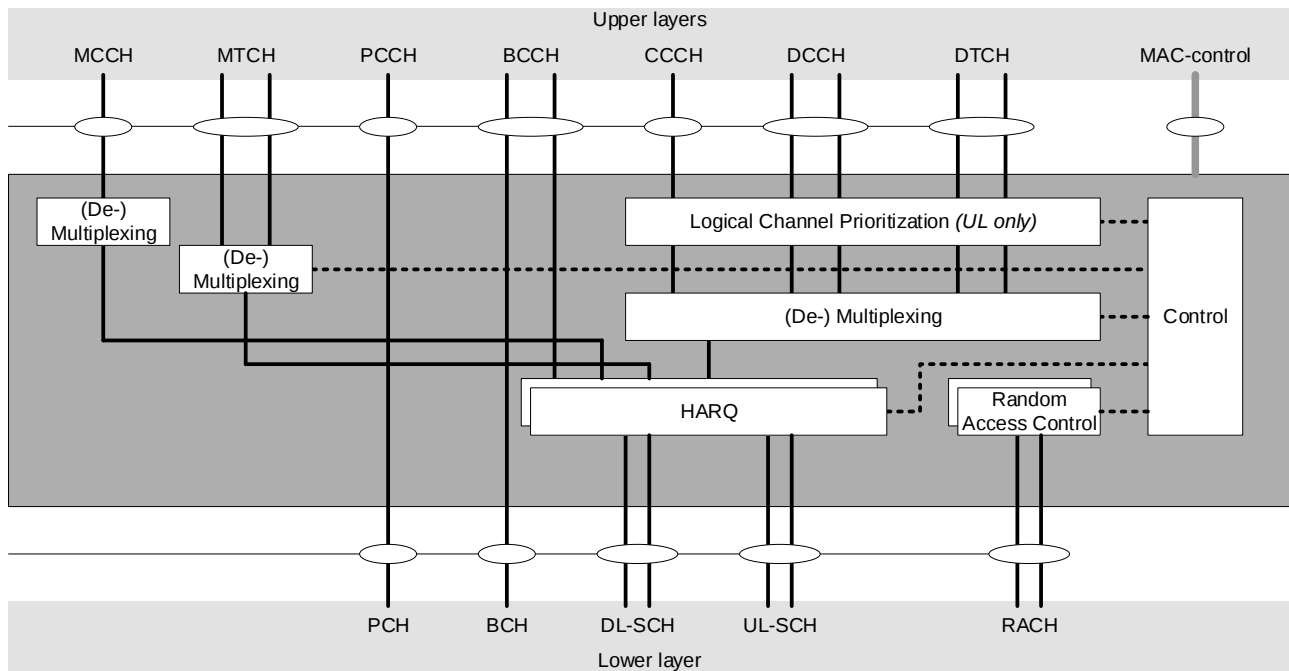


Figure 4.2.2-1: MAC structure overview

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

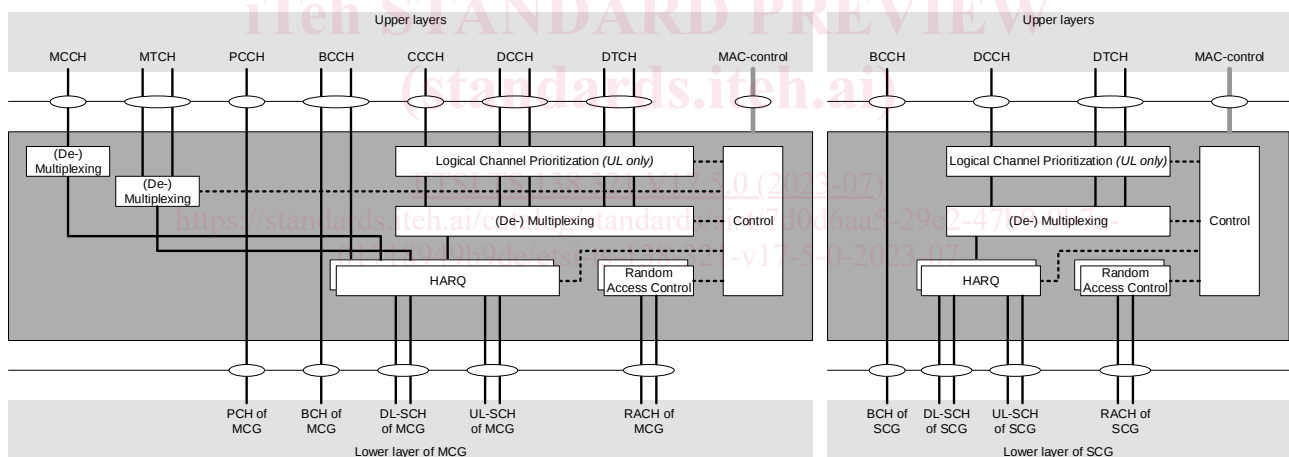


Figure 4.2.2-2: MAC structure overview with two MAC entities

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.