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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:

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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.
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[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".

[30] 3GPP TS 23.586: "Technical Specification Group Services and System Aspects; Architectural Enhancements to support Ranging based services and Sidelink Positioning".

[31] 3GPP TS 23.256: "Support of Uncrewed Aerial Systems (UAS) connectivity, identification and tracking; Stage 2".

[32] 3GPP TS 23.501: "Technical Specification Group Services and System Aspects; System Architecture for the 5G System (5GS); Stage 2".

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].

A2X communication: A communication to support A2X services leveraging PC5 reference points, as defined in TS 23.256 [31]. A2X services are realized by various types of A2X applications, e.g., BRID or DAA.

Air to Ground network: An NG-RAN consisting of ground-based gNBs, which provide cell towers that send signals up to an aircraft's antenna(s) of onboard ATG terminal, with typical vertical altitude of around 10,000 m and take-off/landing altitudes down to 3000 m.

BWP for SRS for positioning Tx frequency hopping: For SRS for positioning Tx frequency hopping, separate BWP configuration outside BWP configuration for data transmission.

CLTM candidate cell: A candidate cell configured for conditional LTM as defined in TS 38.331 [5].

Dedicated SL-PRS resource pool: A sidelink resource pool which can be used for the transmission of SL-PRS and cannot be used for the transmission of PSSCH.

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.

eRedCap UE: A UE with enhanced reduced capabilities as specified in clause 4.2.22.1 of TS 38.306 [25].

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].

LTM candidate cell: A candidate cell configured for LTM as defined in TS 38.331 [5].

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.

Multi-path: Mode of operation of a UE in RRC_CONNECTED configured with one direct path on which the UE connects to gNB using NR Uu, and one indirect path on which the UE connects to the same gNB via another UE using PC5 unicast link or non-3GPP connection (N3C).

Multi-PUSCH configured grant: A configured grant configuration configured with *nrOfSlotsInCG-Period* (see TS 38.331 [5]). It includes multiple consecutive configured uplink grants within a single periodicity.

N3C indirect path: In Multi-path, the indirect path using Non-3GPP Connection between a remote UE and one or more relay UE(s).

NCR-Fwd: NCR-node function, which performs amplifying-and-forwarding of UL/DL RF signals between gNB and UE. The behavior of the NCR-Fwd is controlled according to the side control information received by the NCR-MT from a gNB.

NCR-MT: NCR-node entity which communicates with a gNB via a control link to receive side control information. The control link is based on NR Uu interface.

NCR-node: RAN node comprising NCR-MT and NCR-Fwd.

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, single-hop UE-to-Network Relay, Multihop L2 UE-to-Network Relay, and UE-to-UE Relay communication (including ProSe UE-to-UE Relay communication with integrated discovery)) 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, ProSe UE-to-Network Relay discovery, ProSe Multihop L2 UE-to-Network Relay discovery, and ProSe UE-to-UE 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 transmission for NR sidelink discovery, transmission for NR sidelink communication, transmission for Ranging/Sidelink Positioning, and transmission for A2X 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.

Positioning SRS Bandwidth Aggregation: Transmission of positioning SRS on multiple carriers in RRC_CONNECTED and RRC_INACTIVE where the positioning SRS resources are linked in RRC configuration as defined in TS 38.331 [5].

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.

Ranging/Sidelink Positioning: AS functionality enabling ranging-based services and sidelink positioning as specified in TS 23.586 [30].

RB set: A RB set refers to a contiguous set of resource blocks (RBs) on which a channel access procedure is performed in shared spectrum as defined in TS 37.213 [18].

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].

Shared SL-PRS resource pool: A sidelink resource pool which can be used for the transmission of both SL-PRS and PSSCH.

Sidelink transmission information: Sidelink transmission information included in an SCI for an SL-SCH transmission or SL-PRS transmission with or without SL-SCH transmission on Shared SL-PRS resource pool 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, SL-PRS request, SL-PRS resource ID, a priority, a communication range requirement and Zone ID and COT sharing information.

SL-PRS delay budget: Delay budget before which the SL-PRS is expected to be transmitted by the Tx UE.

SL-PRS transmission information on Dedicated SL-PRS resource pool: SL-PRS transmission information on Dedicated SL-PRS resource pool is included in an SCI for an SL-PRS transmission on Dedicated SL-PRS resource pool, as specified in TS 38.212 [9], consisting of

- SL-PRS identification information, including cast type indicator, source ID and destination ID;
- SL-PRS transmission other information, including SL-PRS priority, SL-PRS request, SL-PRS resource ID and resource reservation period.

SRS positioning validity area: An area consisting of a list of cells within which the corresponding positioning SRS configuration is considered as valid.

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 *kmac*.

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].

A2X	Aircraft-to-Everything
AP	Aperiodic
BFR	Beam Failure Recovery
BRID	Broadcast Remote Identification
BSR	Buffer Status Report
BWP	Bandwidth Part
CE	Control Element
CG	Cell Group
CG-SDT	Configured Grant-based SDT
CI-RNTI	Cancellation Indication RNTI
CLTM	Conditional L1/L2 Triggered Mobility
CSI	Channel State Information
CSI-IM	CSI Interference Measurement
CSI-RS	CSI Reference Signal
CS-RNTI	Configured Scheduling RNTI
DAA	Detect And Avoid
DAPS	Dual Active Protocol Stack
DCP	DCI with CRC scrambled by PS-RNTI
DL-PRS	DownLink-Positioning Reference Signal
DSR	Delay Status Report
DTX	Discontinuous Transmission
FDM	Frequency Division Multiplexing
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
LP-WUS	Low Power Wake-Up Signal
LTM	L1/L2 Triggered Mobility
MBS	Multicast/Broadcast Services
MCCH	MBS Control Channel
MCCH-RNTI	MBS Control Channel RNTI
MCG	Master Cell Group
MO-SDT	Mobile Originated SDT
MPE	Maximum Permissible Exposure
MR	Main Receiver
MTCH	MBS Traffic Channel
MT-SDT	Mobile Terminated SDT
N3C	Non-3GPP Connection
NCC	Next Hop Chaining Counter
NCD-SSB	Non Cell Defining SSB
NCR	Network-Controlled Repeater
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
PQI	PC5 QoS Identifier
PS-RNTI	Power Saving RNTI
PSI	PDU Set Importance
PTAG	Primary Timing Advance Group
PTM	Point to Multipoint