**3GPP TSG-RAN WG2 #131R2-25xxxxx**

**Bangalore, India, 25-29 August 2025**

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| *CR-Form-v12.3* |
| **CHANGE REQUEST** |
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|  | **36.321** | **CR** | **-** | **rev** | **-** | **Current version:** | **18.4.0** |  |
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| *For* ***[HE](http://www.3gpp.org/3G_Specs/CRs.htm%22%20%5Cl%20%22_blank)******[LP](http://www.3gpp.org/3G_Specs/CRs.htm%22%20%5Cl%20%22_blank)*** *on using this form: comprehensive instructions can be found at <http://www.3gpp.org/Change-Requests>.* |
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| ***Proposed change affects:*** | UICC apps |  | ME | **X** | Radio Access Network | **X** | Core Network |  |

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| ***Title:***  | Introduction of IoT-NTN TDD mode |
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| ***Source to WG:*** | Toyota ITC |
| ***Source to TSG:*** | R2 |
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| ***Work item code:*** | IoT\_NTN\_TDD |  | ***Date:*** | 2025-07-31 |
|  |  |  |  |  |
| ***Category:*** | **B** |  | ***Release:*** | Rel-19 |
|  | *Use one of the following categories:****F*** *(correction)****A*** *(mirror corresponding to a change in an earlier release)****B*** *(addition of feature),* ***C*** *(functional modification of feature)****D*** *(editorial modification)*Detailed explanations of the above categories canbe found in 3GPP [TR 21.900](http://www.3gpp.org/ftp/Specs/html-info/21900.htm). | *Use one of the following releases:Rel-8 (Release 8)Rel-9 (Release 9)Rel-10 (Release 10)Rel-11 (Release 11)…Rel-17 (Release 17)Rel-18 (Release 18)Rel-19 (Release 19) Rel-20 (Release 20)* |
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| ***Reason for change:*** | Introduction of IoT-NTN TDD mode. |
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| ***Summary of change:*** | This CR captures the agreements for the introduction of IoT-NTN TDD mode.Agreements considered for this running CR version:* When the UL SPS overlaps with non-U NB-IoT subframes UE postpones the UL SPS resource to the next valid UL subframe.
* Definition for IoT-NTN TDD mode: allows use of NB-IoT channels with TDD mode for NTN with fixed values of D non-overlapping usable contiguous DL subframes and set of U usable contiguous UL subframes separated by fixed guard period.
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| ***Consequences if not approved:*** | No support for IoT-NTN TDD mode. |
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| ***Clauses affected:*** | 3.1, 4.1, 5.1.4, 5.4.1, 5.10, 5.10.2, 7.3, 7.4 |
|  |  |
|  | **Y** | **N** |  |  |
| ***Other specs*** | **X** |  |  Other core specifications  | TS/TR 36.300, 36.304, 36.306, 36.331 CR  |
| ***affected:*** |  | **X** |  Test specifications | TS/TR ... CR ...  |
| ***(show related CRs)*** |  | **X** |  O&M Specifications | TS/TR ... CR ...  |
|  |  |
| ***Other comments:*** |  |
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| ***This CR's revision history:*** |  |

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| START OF CHANGES |

# 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 clause 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***: Except for NB-IoT UEs, BL UEs or UEs in enhanced coverage, it 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. For NB-IoT UEs, it specifies the number of consecutive PDCCH-subframe(s), after the subframe in which the HARQ RTT timer or UL HARQ RTT timer expires, or after PDCCH indicates a new UL or DL transmission for one TB when the UE is configured with multiple HARQ processes. For NB-IoT UEs in a non-terrestrial network, it specifies the number of consecutive PDCCH-subframe(s) after the subframe as specified in clause 5.7. For BL UEs or UEs in enhanced coverage, it specifies the number of consecutive PDCCH-subframe(s) following the subframe containing the last repetition of the PDCCH reception that indicates an initial UL or DL user data transmission for this MAC entity.

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

***drx-RetransmissionTimerShortTTI***: Specifies the maximum number of consecutive TTI(s) until a DL retransmission is received for HARQ processes scheduled using short TTI.

***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.

***drx-ULRetransmissionTimer***: Specifies the maximum number of consecutive PDCCH-subframe(s) until a grant for UL retransmission or the HARQ feedback is received.

***drx-ULRetransmissionTimeShortTTI***: Specifies the maximum number of consecutive TTI(s) until a grant for UL retransmission is received for HARQ processes scheduled using short TTI.

**Early Data Transmission**: Allows one uplink data transmission optionally followed by one downlink data transmission during the random access procedure as specified in TS 36.300 [20]. The S1 connection is established or resumed upon reception of the uplink data and may be released or suspended along with the transmission of the downlink data. Early data transmission refers to both CP-EDT and UP-EDT.

**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 and for asynchronous UL HARQ and for autonomous UL HARQ, the HARQ information also includes HARQ process ID, except for UEs in NB-IoT configured with a single HARQ process for which this information is not present. 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 assignment for HARQ retransmission is expected by the MAC entity.

**IoT-NTN TDD mode:** allows use of NB-IoT channels with TDD mode for NTN with fixed values of D non-overlapping usable contiguous DL subframes and set of U usable contiguous UL subframes separated by fixed guard period.

**Msg3**:Message transmitted on UL-SCH containing a C-RNTI MAC CE or a CCCH SDU optionally multiplexed with DTCH for the UP-EDT, submitted from upper layer and associated with the UE Contention Resolution Identity, as part of a random access procedure.

**NB-IoT**:NB-IoT allows access to network services via E-UTRA with a channel bandwidth limited to 200 kHz.

**NB-IoT UE**:A UE that uses NB-IoT.

**NR sidelink communication**: AS functionality enabling at least V2X Communication as defined in TS 23.287 [23], between two or more nearby UEs, using NR technology but not traversing any network node.

**Non-terrestrial networks:** An E-UTRAN consisting of eNBs, which provide non-terrestrial LTE access to UEs by means of an NTN payload embarked on a space-borne NTN vehicle and an NTN Gateway.

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

**PDCCH:** Refers to the PDCCH (see TS 36.211 [7]), EPDCCH (in subframes when configured), MPDCCH (see TS 36.213 [2]), for an RN with R-PDCCH configured and not suspended, to the R-PDCCH, for NB-IoT to the NPDCCH or for short TTI to SPDCCH.

**PDCCH period (pp):** Refers to the interval between the start of two consecutive PDCCH occasions and depends on the currently used PDCCH search space, as specified in TS 36.213 [2]. A PDCCH occasion is the start of a search space and is defined by subframe k0 as specified in clause 16.6 of TS 36.213 [2]. The calculation of number of PDCCH-subframes for the timer configured in units of a PDCCH period is done by multiplying the number of PDCCH periods with *npdcch-NumRepetitions-RA* when the UE uses the common search space or by *npdcch-NumRepetitions* when the UE uses the UE specific search space. When counting a timer whose length is calculated in PDCCH-subframes, the UE shall include PDCCH-subframes that will be dropped or not required to be monitored as specified in clause 16.6 of TS 36.213 [2]. The calculation of number of subframes for the timer configured in units of a PDCCH period is done by multiplying the number of PDCCH periods with duration between two consecutive PDCCH occasions.

**PDCCH-subframe:** Refers to a subframe with PDCCH. This represents the union over PDCCH-subframes for all serving cells excluding cells configured with cross carrier scheduling for both uplink and downlink, as specified in TS 36.331 [8]; except if the UE is not capable of simultaneous reception and transmission in the aggregated cells where this instead represents the PDCCH-subframes of the SpCell.

- For FDD serving cells, all subframes represent PDCCH-subframes, unless specified otherwise in this clause.

- For TDD serving cells except for IoT-NTN TDD mode, all downlink subframes and subframes including DwPTS of the TDD UL/DL configuration indicated by *tdd-Config*, as specified in TS 36.331 [8] of the cell represent PDCCH-subframes, unless specified otherwise in this clause.

- For serving cells operating according to Frame structure Type 3, all subframes represent PDCCH-subframes.

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

- For SC-PTM reception on an FDD cell, all subframes except MBSFN subframes represent PDCCH-subframes, unless specified otherwise in this clause.

- For SC-PTM reception on a TDD cell except for IoT-NTN TDD mode, all downlink subframes and subframes including DwPTS of the TDD UL/DL configuration indicated by *tdd-Config*, as specified in TS 36.331 [8] of the cell except MBSFN subframes represent PDCCH-subframes, unless specified otherwise in this clause.

- For BL UE or UE in enhanced coverage, all subframes in which the UE is required to monitor MPDCCH represent PDCCH-subframes among all valid subframes regardless of whether the subframe is dropped, see clause 9.1.5 of TS 36.213 [2].

- For NB-IoT UE, all subframes that are part of the NPDCCH search space represent PDCCH-subframes among all NB-IoT downlink subframes, including those which the UE is not required to monitor as specified in clause 16.6 of TS 36.213 [2].

**PDSCH**: Refers to subframe-PDSCH/slot-PDSCH/subslot-PDSCH or for NB-IoT to NPDSCH.

**PRACH**: Refers to PRACH or for NB-IoT to NPRACH.

**PRACH Resource Index**: The index of a PRACH within a system frame, see TS 36.211 [7]

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

**PUCCH SCell:** An SCell configured with PUCCH/SPUCCH.

**PUSCH**: Refers to subframe-PUSCH/slot-PUSCH/subslot-PUSCH or for NB-IoT to NPUSCH.

***ra-PRACH-MaskIndex*:** Defines in which PRACHs within a system frame the MAC entity can transmit a Random Access Preamble (see clause 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, Group Destination ID (for sidelink communication) and PPPP (for V2X sidelink communication), see TS 36.212 [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, see TS 36.331 [8].

**Short Processing Time**: For 1 ms TTI length, the operation with short processing time in UL data transmission and DL data reception.

**Short TTI**: TTI length based on a slot or a subslot.

**Sidelink:** UE to UE interface for sidelink communication, sidelink discovery and V2X sidelink communication. The sidelink corresponds to the PC5 interface as defined in TS 23.303 [13] for sidelink communication and sidelink discovery, and as defined in TS 23.285 [14] for V2X sidelink communication.

**Sidelink communication**: AS functionality enabling ProSe Direct Communication as defined in TS 23.303 [13], between two or more nearby UEs, using E-UTRA technology but not traversing any network node.

**Sidelink Discovery Gap for Reception:** Time period during which the UE does not receive any channels in DL from any serving cell, except during random access procedure.

**Sidelink Discovery Gap for Transmission:** Time period during which the UE prioritizes transmission of sidelink discovery and associated procedures e.g. re-tuning and synchronisation over transmission of channels in UL, if they occur in the same subframe, except during random access procedure.

**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.

**Transmission using PUR:** Allows one uplink data transmission using preconfigured uplink resource from RRC\_IDLE mode as specified in TS 36.300 [9]. Transmission using PUR refers to both CP transmission using PUR and UP transmission using PUR.

**UE-eNB RTT:** For non-terrestrial networks, the sum of the UE's Timing Advance value (see TS 36.211 [7], clause 8.1) and *k-Mac* in units of subframe, not rounded or truncated toward an integer number of subframes.

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

**V2X sidelink communication**: AS functionality enabling V2X Communication as defined in TS 23.285 [14], 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.

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| NEXT CHANGES |

# 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 except for IoT-NTN TDD mode, UE behaviour follows the TDD UL/DL configuration indicated by *tdd-Config* unless specified otherwise. IoT-NTN TDD mode applies to NB-IoT unless specified otherwise. IoT-NTN TDD mode applies to TDD and TDD mode unless specified otherwise.

The introduction of short TTI allows for more than a single instance of a TTI to occur within a 1ms subframe and as such the use of the term "for each TTI" shall be read as meaning that the associated actions shall be executed for all TTIs also in the case of overlapping TTIs (e.g. a UE may read multiple instances of PDCCH in a downlink subframe).

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| NEXT CHANGES |

### 5.1.4 Random Access Response reception

Once the Random Access Preamble is transmitted and regardless of the possible occurrence of a measurement gap or a Sidelink Discovery Gap for Transmission or a Sidelink Discovery Gap for Reception, and regardless of the prioritization of V2X sidelink communication described in clause 5.14.1.2.2, the MAC entity shall monitor the PDCCH of the SpCell for Random Access Response(s) identified by the RA-RNTI defined below, in the RA Response window which starts at the subframe that contains the end of the preamble transmission,as specified in TS 36.211 [7], plus three subframes and has length *ra-ResponseWindowSize*.

If the UE is a BL UE or a UE in enhanced coverage:

- if the random access preamble was transmitted in a non-terrestrial network:

- RA Response window starts at the subframe that contains the end of the last preamble repetition plus 3 subframes plus UE-eNB RTT and has length *ra-ResponseWindowSize* for the corresponding enhanced coverage level;

- else:

- RA Response window starts at the subframe that contains the end of the last preamble repetition plus three subframes and has length *ra-ResponseWindowSize* for the corresponding enhanced coverage level.

If the UE is an NB-IoT UE:

- if the random access preamble was transmitted in a non-terrestrial network:

- RA Response window starts at the subframe that contains the end of the last preamble repetition plus X subframes plus UE-eNB RTT and has length *ra-ResponseWindowSize* for the corresponding enhanced coverage level, where value X is determined from Table 5.1.4-1 based on the used preamble format and the number of NPRACH repetitions;

- else:

- RA Response window starts at the subframe that contains the end of the last preamble repetition plus X subframes and has length *ra-ResponseWindowSize* for the corresponding enhanced coverage level, where value X is determined from Table 5.1.4-1 based on the used preamble format and the number of NPRACH repetitions.

Table 5.1.4-1: Subframes between preamble transmission and RA Response Window in NB-IoT

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| --- | --- | --- | --- |
| TDD/FDD mode | Preamble format | Number of NPRACH repetitions | X  |
| FDD | 0 or 1 | >= 64 | 41 |
| FDD | 0 or 1 | < 64 | 4 |
| FDD | 2 | >= 16 | 41 |
| FDD | 2 | < 16 | 4 |
| TDD | Any | Any | 4 |

Editor’s Note: Need to confirm if number of NPRACH repetitions ‘Any’ applies to IoT-NTN TDD mode.

The RA-RNTI associated with the PRACH in which the Random Access Preamble is transmitted, is computed as:

RA-RNTI= 1 + t\_id + 10\*f\_id

where t\_id is the index of the first subframe of the specified PRACH (0≤ t\_id <10), and f\_id is the index of the specified PRACH within that subframe, in ascending order of frequency domain (0≤ f\_id< 6) except for NB-IoT UEs, BL UEs or UEs in enhanced coverage. If the PRACH resource is on a TDD carrier, the f\_id is set to , where  is defined in clause 5.7.1 of TS 36.211 [7].

For BL UEs and UEs in enhanced coverage, RA-RNTI associated with the PRACH in which the Random Access Preamble is transmitted, is computed as:

RA-RNTI=1+t\_id + 10\*f\_id + 60\*(SFN\_id mod (Wmax/10))

where t\_id is the index of the first subframe of the specified PRACH (0≤ t\_id <10), f\_id is the index of the specified PRACH within that subframe, in ascending order of frequency domain (0≤ f\_id< 6), SFN\_id is the index of the first radio frame of the specified PRACH, and Wmax is 400, maximum possible RAR window size in subframes for BL UEs or UEs in enhanced coverage. If the PRACH resource is on a TDD carrier, the f\_id is set to , where  is defined in clause 5.7.1 of TS 36.211 [7].

For NB-IoT UEs, the RA-RNTI associated with the PRACH in which the Random Access Preamble is transmitted, is computed as:

RA-RNTI=1 + floor(SFN\_id/4) + 256\*carrier\_id

where SFN\_id is the index of the first radio frame of the specified PRACH and carrier\_id is the index of the UL carrier associated with the specified PRACH. The carrier\_id of the anchor carrier is 0.

For NB-IoT UEs operating in TDD mode, the RA-RNTI associated with the PRACH in which the Random Access Preamble is transmitted, is computed as:

RA-RNTI = 1 + floor(SFN\_id/4) + 256\*(H-SFN mod 2)

Editor’s Note: Need to confirm if the formula above applies to IoT-NTN TDD mode.

where SFN\_id is the index of the first radio frame of the specified PRACH and H-SFN is the index of the first hyper frame of the specified PRACH. The PDCCH transmission and the PRACH resource are on the same carrier.

The MAC entity may stop monitoring for Random Access Response(s) after successful reception of a Random Access Response containing Random Access Preamble identifiers that matches the transmitted Random Access Preamble.

- If a downlink assignment for this TTI has been received on the PDCCH for the RA-RNTI and the received TB is successfully decoded, the MAC entity shall regardless of the possible occurrence of a measurement gap or a Sidelink Discovery Gap for Transmission or a Sidelink Discovery Gap for Reception, and regardless of the prioritization of V2X sidelink communication described in clause 5.14.1.2.2:

- if the Random Access Response contains a Backoff Indicator subheader:

- set the backoff parameter value as indicated by the BI field of the Backoff Indicator subheader and Table 7.2-1, except for NB-IoT where the value from Table 7.2-2 is used.

- else, set the backoff parameter value to 0 ms.

- if the Random Access Response contains a Random Access Preamble identifier corresponding to the transmitted Random Access Preamble (see clause 5.1.3), the MAC entity shall:

- consider this Random Access Response reception successful and apply the following actions for the serving cell where the Random Access Preamble was transmitted:

- process the received Timing Advance Command (see clause 5.2);

- indicate the *preambleInitialReceivedTargetPower* and the amount of power ramping applied to the latest preamble transmission to lower layers (i.e., (PREAMBLE\_TRANSMISSION\_COUNTER – 1) \* *powerRampingStep*);

- if the SCell is configured with *ul-Configuration-r14*, ignore the received UL grant otherwise process the received UL grant value and indicate it to the lower layers;

- if, except for NB-IoT, *ra-PreambleIndex* was explicitly signalled and it was not 000000 (i.e., not selected by MAC):

- consider the Random Access procedure successfully completed.

- else if, the UE is an NB-IoT UE, *ra-PreambleIndex* was explicitly signalled and it was not 000000 (i.e., not selected by MAC) and *ra-CFRA-Config* is configured:

- consider the Random Access procedure successfully completed.

- the UL grant provided in the Random Access Response message is valid only for the configured carrier (i.e. UL carrier used prior to this Random Access procedure).

- else:

- if the Random Access Preamble was selected by the MAC entity; or

- if the UE is an NB-IoT UE, the *ra-PreambleIndex* was explicitly signalled and it was not 000000 and *ra-CFRA-Config* is not configured:

- set the Temporary C-RNTI to the value received in the Random Access Response message no later than at the time of the first transmission corresponding to the UL grant provided in the Random Access Response message;

- if the Random Access Preamble associated with EDT was transmitted and UL grant provided in the Random Access Response message is not for EDT:

- indicate to upper layers that EDT is cancelled due to UL grant not being for EDT;

- for CP-EDT, flush the Msg3 buffer.

- for UP-EDT, update the MAC PDU in the Msg3 buffer in accordance with the uplink grant received in the Random Access Response.

- if the Random Access Preamble associated with EDT was transmitted, the UL grant was received in a Random Access Response for EDT, and there is a MAC PDU in the Msg3 buffer:

- if the TB size according to *edt-SmallTBS-Enabled* and as described in clause 8.6.2 and 16.3.3 of TS 36.213 [2] does not match the size of the MAC PDU in the Msg3 buffer:

- the MAC entity shall update the MAC PDU in the Msg3 buffer in accordance with the TB size.

- if this is the first successfully received Random Access Response within this Random Access procedure; or

- if CP-EDT is cancelled due to the UL grant provided in the Random Access Response message not being for EDT:

- if the transmission is not being made for the CCCH logical channel, indicate to the Multiplexing and assembly entity to include a C-RNTI MAC control element in the subsequent uplink transmission;

- obtain the MAC PDU to transmit from the "Multiplexing and assembly" entity and store it in the Msg3 buffer.

NOTE 1: When an uplink transmission is required, e.g., for contention resolution, the eNB should not provide a grant smaller than 56 bits (or 88 bits for NB-IoT) in the Random Access Response.

NOTE 2: If within a Random Access procedure, an uplink grant provided in the Random Access Response for the same group of Random Access Preambles has a different size than the first uplink grant allocated during that Random Access procedure, the UE behavior is not defined except for EDT.

If no Random Access Response or, for NB-IoT UEs, BL UEs or UEs in enhanced coverage for mode B operation, no PDCCH scheduling Random Access Response is received within the RA Response window, or if none of all received Random Access Responses contains a Random Access Preamble identifier corresponding to the transmitted Random Access Preamble, the Random Access Response reception is considered not successful and the MAC entity shall:

- if the notification of power ramping suspension has not been received from lower layers:

- increment PREAMBLE\_TRANSMISSION\_COUNTER by 1;

- if the UE is an NB-IoT UE, a BL UE or a UE in enhanced coverage:

- if PREAMBLE\_TRANSMISSION\_COUNTER = *preambleTransMax-CE* + 1:

- if the Random Access Preamble is transmitted on the SpCell:

- indicate a Random Access problem to upper layers;

- if NB-IoT:

- consider the Random Access procedure unsuccessfully completed;

- else:

- if PREAMBLE\_TRANSMISSION\_COUNTER = *preambleTransMax* + 1:

- if the Random Access Preamble is transmitted on the SpCell:

- indicate a Random Access problem to upper layers;

- if the Random Access Preamble is transmitted on an SCell:

- consider the Random Access procedure unsuccessfully completed.

- if in this Random Access procedure, the Random Access Preamble was selected by MAC:

- based on the backoff parameter, select a random backoff time according to a uniform distribution between 0 and the Backoff Parameter Value;

- delay the subsequent Random Access transmission by the backoff time;

- else if the SCell where the Random Access Preamble was transmitted is configured with *ul-Configuration-r14*:

- delay the subsequent Random Access transmission until the Random Access Procedure is initiated by a PDCCH order with the same *ra-PreambleIndex and ra-PRACH-MaskIndex*;

- if the UE is an NB-IoT UE, a BL UE or a UE in enhanced coverage:

- increment PREAMBLE\_TRANSMISSION\_COUNTER\_CE by 1;

- if PREAMBLE\_TRANSMISSION\_COUNTER\_CE = *maxNumPreambleAttemptCE* for the corresponding enhanced coverage level+ 1:

- reset PREAMBLE\_TRANSMISSION\_COUNTER\_CE;

- consider to be in the next enhanced coverage level, if it is supported by the Serving Cell and the UE, otherwise stay in the current enhanced coverage level;

- if the UE is an NB-IoT UE:

- if the Random Access Procedure was initiated by a PDCCH order:

- select the PRACH resource in the list of UL carriers providing a PRACH resource for the selected enhanced coverage level for which the carrier index is equal to ((*Carrier Indication* from the PDCCH order) modulo (Number of PRACH resources in the selected enhanced coverage));

- consider the selected PRACH resource as explicitly signalled;

- proceed to the selection of a Random Access Resource (see clause 5.1.2).

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| NEXT CHANGES |

## 5.4 UL-SCH data transfer

### 5.4.1 UL Grant reception

In order to transmit on the UL-SCH the MAC entity must have a valid uplink grant (except for non-adaptive HARQ retransmissions) which it may receive dynamically on the PDCCH or in a Random Access Response or which may be configured semi-persistently or preallocated by RRC or provided by RRC for transmission using PUR (see clause 5.4.7). To perform requested transmissions, the MAC layer receives HARQ information from lower layers. When the physical layer is configured for uplink spatial multiplexing, the MAC layer can receive up to two grants (one per HARQ process) for the same TTI from lower layers.

If the MAC entity has a C-RNTI, a Semi-Persistent Scheduling C-RNTI, a UL Semi-Persistent Scheduling V-RNTI, a AUL C-RNTI, or a Temporary C-RNTI, the MAC entity shall for each TTI and for each Serving Cell belonging to a TAG that has a running *timeAlignmentTimer* and for each grant received for this TTI and for each SPS configuration that is indicated by the PDCCH addressed to UL Semi-Persistent Scheduling V-RNTI; or if the MAC entity has Preconfigured Uplink Resource RNTI, the MAC entity shall for each TTI and for each grant received for this TTI:

- if an uplink grant for this TTI and this Serving Cell has been received on the PDCCH for the MAC entity's C-RNTI, Preconfigured Uplink Resource RNTI or Temporary C-RNTI; or

- if an uplink grant for this TTI has been received in a Random Access Response:

- if the uplink grant is for MAC entity's C-RNTI and if the previous uplink grant delivered to the HARQ entity for the same HARQ process was either an uplink grant received for the MAC entity's Semi-Persistent Scheduling C-RNTI, for the MAC entity's UL Semi-Persistent Scheduling V-RNTI, or a configured uplink grant for which the UL HARQ operation was not autonomous:

- consider the NDI to have been toggled for the corresponding HARQ process regardless of the value of the NDI.

- deliver the uplink grant and the associated HARQ information to the HARQ entity for this TTI.

- else, if an uplink grant for this TTI has been received for this Serving Cell on the PDCCH for the MAC entity's Semi-Persistent Scheduling C-RNTI or for the MAC entity's UL Semi-Persistent Scheduling V-RNTI; or if an uplink grant for this TTI has been received for this Serving Cell on the PDCCH for the MAC entity's AUL C-RNTI:

- if the NDI in the received HARQ information is 1:

- consider the NDI for the corresponding HARQ process not to have been toggled;

- deliver the uplink grant and the associated HARQ information to the HARQ entity for this TTI.

- else if the NDI in the received HARQ information is 0:

- if PDCCH contents indicate AUL release:

- trigger an AUL confirmation;

- if an uplink grant for this TTI has been configured:

- consider the NDI bit for the corresponding HARQ process to have been toggled;

- deliver the configured uplink grant and the associated HARQ information to the HARQ entity for this TTI;

- else if PDCCH contents indicate AUL activation:

- trigger an AUL confirmation;

- store the uplink grant and the associated HARQ information as configured uplink grant;

- initialise (if not active) or re-initialise (if already active) the configured uplink grant to start in this TTI and to recur according to rules in clause 5.23;

- consider the NDI bit for the corresponding HARQ process to have been toggled;

- deliver the configured uplink grant and the associated HARQ information to the HARQ entity for this TTI.

- else if PDCCH contents indicate SPS release:

- if the MAC entity is configured with *skipUplinkTxSPS*:

- trigger an SPS confirmation;

- if an uplink grant for this TTI has been configured:

- consider the NDI bit for the corresponding HARQ process to have been toggled;

- deliver the configured uplink grant and the associated HARQ information to the HARQ entity for this TTI;

- else:

- clear the corresponding configured uplink grant (if any).

- else:

- if the MAC entity is configured with *skipUplinkTxSPS*:

- trigger an SPS confirmation;

- store the uplink grant and the associated HARQ information as configured uplink grant;

- initialise (if not active) or re-initialise (if already active) the configured uplink grant to start in this TTI, or in TTI according to N=0 in clause 5.10.2 for short TTI, and to recur according to rules in clause 5.10.2;

- if UL HARQ operation is asynchronous, set the HARQ Process ID to the HARQ Process ID associated with this TTI;

- consider the NDI bit for the corresponding HARQ process to have been toggled;

- deliver the configured 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 for the Serving Cell and if UL HARQ operation is autonomous for the corresponding HARQ process:

- if the HARQ\_FEEDBACK is set to ACK for the corresponding HARQ process or if there is no uplink grant previously delivered to the HARQ entity for the same HARQ process:

- consider the NDI bit for the corresponding HARQ process to have been toggled.

- if the *aul-RetransmissionTimer* is not running:

- if there is no uplink grant previously delivered to the HARQ entity for the same HARQ process; or

- if the previous uplink grant delivered to the HARQ entity for the same HARQ process was not an uplink grant received for the MAC entity's C-RNTI; or

- if the HARQ\_FEEDBACK is set to ACK for the corresponding HARQ process:

- deliver the configured uplink grant, and the associated HARQ information to the HARQ entity for this TTI.

- else:

- if this Serving Cell is the SpCell and an uplink grant for this TTI has been preallocated for the SpCell; or

- except for preconfigured uplink grant for PUR, if an uplink grant for this TTI has been configured for this Serving Cell:

- if UL HARQ operation is asynchronous, set the HARQ Process ID to the HARQ Process ID associated with this TTI;

- consider the NDI bit for the corresponding HARQ process to have been toggled;

- deliver the configured or preallocated uplink grant, and the associated HARQ information to the HARQ entity for this TTI.

NOTE 1: The period of configured uplink grants is expressed in TTIs.

NOTE 2: If the MAC entity receives both a grant in a Random Access Response and a grant for its C-RNTI or Semi persistent scheduling C-RNTI requiring transmissions on the SpCell in the same UL subframe, the MAC entity may choose to continue with either the grant for its RA-RNTI or the grant for its C-RNTI or Semi persistent scheduling C-RNTI.

NOTE 3: When a configured uplink grant is indicated during a measurement gap and indicates an UL-SCH transmission during a measurement gap, the MAC entity processes the grant but does not transmit on UL-SCH. When a configured uplink grant is indicated during a Sidelink Discovery gap for reception and indicates an UL-SCH transmission during a Sidelink Discovery gap for transmission with a SL-DCH transmission, the MAC entity processes the grant but does not transmit on UL-SCH. When a configured uplink grant indicates an UL-SCH transmission during a V2X sidelink communication transmission and transmission of V2X sidelink communication is prioritized as described in clause 5.14.1.2.2, the MAC entity processes the grant but does not transmit on UL-SCH.

NOTE 4: The NDI transmitted in the PDCCH for the MAC entity's AUL C-RNTI is set to '0' (TS 36.212 [5]).

Except for NB-IoT, for configured uplink grants without *harq-ProcID-offset*, if UL HARQ operation is not autonomous, the HARQ Process ID associated with this TTI is derived from the following equation for asynchronous UL HARQ operation:

- if the TTI is a subframe TTI:

- HARQ Process ID = [floor(CURRENT\_TTI/semiPersistSchedIntervalUL)] modulo numberOfConfUlSPS-Processes,

where CURRENT\_TTI=[(SFN \* 10) + subframe number] and it refers to the subframe where the first transmission of a bundle takes place.

- else:

- HARQ Process ID = [floor(CURRENT\_TTI/*semiPersistSchedIntervalUL-sTTI*)] modulo *numberOfConfUlSPS-Processes-sTTI*,

where CURRENT\_TTI = [(SFN \* 10 \* sTTI\_Number\_Per\_Subframe) + subframe number \* sTTI\_Number\_Per\_Subframe + sTTI\_number] and it refers to the short TTI occasion where the first transmission of a bundle takes place. Refer to 5.10.2 for sTTI\_Number\_Per\_Subframe and sTTI\_number.

For preallocated uplink grants the HARQ Process ID associated with this TTI is derived from the following equation for asynchronous UL HARQ operation:

HARQ Process ID = [floor(CURRENT\_TTI/*ul-SchedInterval*)] modulo *numberOfConfUL-Processes*,

where CURRENT\_TTI=subframe number and it refers to the subframe where the first transmission of a bundle takes place.

For configured uplink grants, if UL HARQ operation is autonomous, the HARQ Process ID associated with this TTI for transmission on this Serving Cell is selected by the UE implementation from the HARQ process IDs that are configured for autonomous UL HARQ operation by upper layers in *aul-HARQ-Processes* (TS 36.331 [8]).

For configured uplink grants with *harq-ProcID-offset*, the HARQ Process ID associated with this TTI is derived from the following equation for asynchronous UL HARQ operation:

- if the TTI is a subframe TTI:

- HARQ Process ID = [floor(CURRENT\_TTI/*semiPersistSchedIntervalUL*)] modulo *numberOfConfUlSPS-Processes* + *harq-ProcID-offset*,

where CURRENT\_TTI = [(SFN \* 10) + subframe number] and it refers to the subframe where the first transmission of a bundle takes place.

- else:

- HARQ Process ID = [floor(CURRENT\_TTI/*semiPersistSchedIntervalUL-sTTI*)] modulo *numberOfConfUlSPS-Processes-sTTI* + harq-ProcID-offset,

where CURRENT\_TTI = [(SFN \* 10 \* sTTI\_Number\_Per\_Subframe) + subframe number \* sTTI\_Number\_Per\_Subframe + sTTI\_number] and it refers to the short TTI occasion where the first transmission of a bundle takes place. Refer to 5.10.2 for sTTI\_Number\_Per\_Subframe and sTTI\_number. For NB-IoT, for configured uplink grants for BSR, the HARQ Process ID is set to 0.

If the MAC entity is configured with Short Processing Time or short TTI and if current\_TTI is a subframe TTI, the HARQ Process ID associated with this TTI is derived from the following equation for synchronous UL HARQ operation:

HARQ Process ID = [SFN \* number\_of\_UL\_PUSCH\_SFs\_per\_radio\_frame + index\_of\_UL\_PUSCH\_SF] modulo number\_of\_UL\_HARQ\_processes.

where number\_of\_UL\_PUSCH\_SFs\_per\_radio\_frame is the number of subframes that can be used for PUSCH (UL PUSCH subframe) per radio frame:

- For FDD serving cells and serving cells operating according to Frame structure Type 3, all 10 subframes in a radio frame represent UL PUSCH subframes;

- For TDD serving cells except for IoT-NTN TDD mode, all uplink subframes of the TDD UL/DL configuration indicated by *tdd-Config*, as specified in TS 36.331 [8] of the cell represent UL PUSCH subframes and additionally the subframes including UpPTS if the cell is configured with *symPUSCH-UpPts-r14*;

- For IoT-NTN TDD mode, uplink and downlink subframe configurations are specified in TS 36.213 [2].

and index\_of\_UL\_PUSCH\_SF is the index of a subframe that can be used for PUSCH within the radio frame, and number\_of\_UL\_HARQ\_processes is the number of parallel HARQ processes per HARQ entity for subframe TTI as specified in TS 36.213 [2], clause 8.

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| NEXT CHANGES |

## 5.10 Semi-Persistent Scheduling

Except for NB-IoT, multiple UL Semi-Persistent Scheduling configurations are supported per Serving Cell. For NB-IoT, UL Semi-Persistent Scheduling configuration is only supported for BSR per Serving Cell. On one Serving Cell, multiple UL configurations can be active simultaneously only for the same TTI length. Multiple UL/DL configurations can also be active simultaneously on different Serving Cells.

When Semi-Persistent Scheduling is enabled by RRC, the following information is provided, as specified in TS 36.331 [8]:

- Semi-Persistent Scheduling C-RNTI or UL Semi-Persistent Scheduling V-RNTI;

- Uplink Semi-Persistent Scheduling interval *semiPersistSchedIntervalUL* if short TTI in UL for the SpCell is not configured or *semiPersistSchedIntervalUL*-*sTTI* in UL for the SpCellifshort TTIis configured and number of empty transmissions before implicit release *implicitReleaseAfter*, if Semi-Persistent Scheduling with Semi-Persistent Scheduling C-RNTI is enabled for the uplink;

- Uplink Semi-Persistent Scheduling interval *semiPersistSchedIntervalUL* and number of empty transmissions before implicit release *implicitReleaseAfter* for each SPS configuration, if Semi-Persistent Scheduling with UL Semi-Persistent Scheduling V-RNTI is enabled for the uplink;

- Whether *twoIntervalsConfig* is enabled or disabled for uplink, only for TDD except IoT-NTN TDD mode;

- Downlink Semi-Persistent Scheduling interval *semiPersistSchedIntervalDL* if short TTI in DL for the SpCell is not configured or *semiPersistSchedIntervalDL*-*sTTI* ifshort TTI in DL for the SpCellis configured and number of configured HARQ processes for Semi-Persistent Scheduling *numberOfConfSPS-Processes*, if Semi-Persistent Scheduling is enabled for the downlink;

- *sTTIStartTimeDl* if short TTI in DL for the SpCell is configured and *sTTIStartTimeUl* if short TTI in UL for the SpCell is configured;

When Semi-Persistent Scheduling for uplink or downlink is disabled by RRC, the corresponding configured grant or configured assignment shall be discarded.

Semi-Persistent Scheduling is not supported for RN communication with the E-UTRAN in combination with an RN subframe configuration.

NOTE: When eIMTA is configured, if a configured uplink grant or a configured downlink assignment occurs on a subframe that can be reconfigured through eIMTA L1 signalling, then the UE behaviour is left unspecified.

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| NEXT CHANGES |

### 5.10.2 Uplink

After a Semi-Persistent Scheduling uplink grant is configured, the MAC entity shall:

- if *twoIntervalsConfig* is enabled by upper layer:

- set the Subframe\_Offset according to Table 7.4-1.

- else:

- set Subframe\_Offset to 0.

- consider sequentially that the Nth grant occurs in the TTI for which:

- subframe SPS is used:

- (10 \* SFN + subframe) = [(10 \* SFNstart time + subframestart time) + N \* *semiPersistSchedIntervalUL* + Subframe\_Offset \* (N modulo 2)] modulo 10240.

- slot or subslot SPS is used:

- (10 \* SFN \* sTTI\_Number\_Per\_Subframe + subframe \* sTTI\_Number\_Per\_Subframe + sTTI\_number) = [(10 \* SFNstart time \* sTTI\_Number\_Per\_Subframe + subframestart time \* sTTI\_Number\_Per\_Subframe + *sTTIStartTimeUl*) + N \**semiPersistSchedIntervalUL-sTTI*+ Subframe\_Offset \* (N modulo 2) \* sTTI\_Number\_Per\_Subframe] modulo (10240 \* sTTI\_Number\_Per\_Subframe).

Where SFNstart time, subframestart time and *sTTIStartTimeUl* are the SFN, subframe and sTTI\_number, respectively, at the time the configured uplink grant were (re-)initialised. The sTTI\_Number\_Per\_Subframe is 6 when subslot TTI is configued and 2 when slot TTI is configured for short TTI operation. sTTI\_number refers to the index of the short TTI, i.e., index of subslot or slot within the subframe.

Except for NB-IoT, for TDD, the MAC entity is configured with *semiPersistSchedIntervalUL* shorter than 10 subframes, the Nth grant shall be ignored if it occurs in a downlink subframe or a special subframe.

Except for NB-IoT, if the MAC entity is not configured with *skipUplinkTxSPS*, the MAC entity shall clear the configured uplink grant immediately after *implicitReleaseAfter*, as specified in TS 36.331 [8], number of consecutive new MAC PDUs each containing zero MAC SDUs have been provided by the Multiplexing and Assembly entity, on the Semi-Persistent Scheduling resource.

If SPS confirmation has been triggered and not cancelled:

- if the MAC entity has UL resources allocated for new transmission for this TTI:

- instruct the Multiplexing and Assembly procedure to generate an SPS confirmation MAC Control Element as defined in clause 6.1.3.11;

- cancel the triggered SPS confirmation.

The MAC entity shall clear the configured uplink grant immediately after first transmission of SPS confirmation MAC Control Element triggered by the SPS release.

NOTE: Retransmissions for Semi-Persistent Scheduling can continue after clearing the configured uplink grant.

For NB-IoT UEs, BL UEs or UEs in enhanced coverage SFNstart time and subframestart time refer to SFN and subframe of the first transmission of PUSCH where configured uplink grant was (re-)initialized.

In the event of a resource conflict between multiple UL SPS configurations configured with Uplink Semi-Persistent Scheduling V-RNTI, the UE behaviour is undefined.

In the event of a resource conflict in the same serving cell between the initial transmision within a configured grant bundle from multiple different UL SPS configurations configured with Uplink Semi-Persistent Scheduling C-RNTI, the UE behaviour is undefined.

For IoT-NTN TDD mode, in the event of a resource conflict between UL SPS and a non-UL NB-IoT subframe, the UE shall postpone the UL SPS resource to the next valid UL subframe.

For NB-IoT UEs, a configured uplink grant shall be used only for BSR or SPS confirmation transmission, and *skipUplinkTxSPS* is implicitly configured.

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| NEXT CHANGES |

## 7.3 PRACH Mask Index values

Table 7.3-1: PRACH Mask Index values

|  |  |  |
| --- | --- | --- |
| PRACH Mask Index | Allowed PRACH (FDD) | Allowed PRACH (TDD) |
| 0 | All | All |
| 1 | PRACH Resource Index 0 | PRACH Resource Index 0 |
| 2 | PRACH Resource Index 1 | PRACH Resource Index 1 |
| 3 | PRACH Resource Index 2 | PRACH Resource Index 2 |
| 4 | PRACH Resource Index 3 | PRACH Resource Index 3 |
| 5 | PRACH Resource Index 4 | PRACH Resource Index 4 |
| 6 | PRACH Resource Index 5 | PRACH Resource Index 5 |
| 7 | PRACH Resource Index 6  | Reserved |
| 8 | PRACH Resource Index 7 | Reserved |
| 9 | PRACH Resource Index 8 | Reserved |
| 10 | PRACH Resource Index 9 | Reserved |
| 11 | Every, in the time domain, even PRACH opportunity1st PRACH Resource Index in subframe | Every, in the time domain, even PRACH opportunity1st PRACH Resource Index in subframe  |
| 12 | Every, in the time domain, odd PRACH opportunity1st PRACH Resource Index in subframe | Every, in the time domain, odd PRACH opportunity1st PRACH Resource Index in subframe |
| 13 | Reserved | 1st PRACH Resource Index in subframe |
| 14 | Reserved | 2nd PRACH Resource Index in subframe |
| 15 | Reserved | 3rd PRACH Resource Index in subframe |

Editor’s Note: Need to confirm if the TDD Allowed PRACH applies to IoT-NTN TDD mode.

7.4 Subframe\_Offset values

Subframe\_Offset values are presented in Table 7.4-1.

**Table 7.4-1: Subframe\_Offset values**

|  |  |  |
| --- | --- | --- |
| **TDD UL/DL configuration**Not applicable to IoT-NTN TDD mode | **Position of initial Semi-Persistent grant** | **Subframe\_Offset value (ms)** |
| 0 | N/A | 0 |
| 1 | Subframes 2 and 7 | 1 |
| Subframes 3 and 8 | -1 |
| 2 | Subframe 2 | 5  |
| Subframe 7 | -5 |
| 3 | Subframes 2 and 3 | 1 |
| Subframe 4 | -2 |
| 4 | Subframe 2 | 1 |
| Subframe 3 | -1 |
| 5 | N/A | 0 |
| 6 | N/A | 0 |

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| END OF CHANGES |