**3GPP TSG-RAN WG2 Meeting #117 Electronic *R2-220xxxx***

**Elbonia, 21 February – 3 March 2022**

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| *CR-Form-v12.1* |
| **CHANGE REQUEST** |
|  |
|  | **38.300** | **CR** | **0416** | **rev** | **1** | **Current version:** | **16.8.0** |  |
|  |
| *For* [***HE******LP***](http://www.3gpp.org/3G_Specs/CRs.htm#_blank)*on using this form: comprehensive instructions can be found at* [*http://www.3gpp.org/Change-Requests*](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 Rel-17 IIoT/URLLC to TS 38.300 |
|  |  |
| ***Source to WG:*** | Nokia, Nokia Shanghai Bell |
| ***Source to TSG:*** | R2 |
|  |  |
| ***Work item code:*** | NR\_IIOT\_URLLC\_enh |  | ***Date:*** | 2022-02 |
|  |  |  |  |  |
| ***Category:*** | **B** |  | ***Release:*** | Rel-17 |
|  | *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-15 (Release 15)Rel-16 (Release 16)Rel-17 (Release 17)Rel-18 (Release 18)* |
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| ***Reason for change:*** | To introduce the features adopted by RAN1 and RAN2 in the Rel-17 WI of IIoT/URLLC to TS 38.300. |
|  |  |
| ***Summary of change:*** | Text change in Clause 3.1, 5.2.5.4, 5.3.3, 5.3.5.5, 16.1.X, and 16.8 to capture features including:* HARQ enhancement
* Sub-slot based PUCCH repetition
* HARQ-ACK multiplexing in PUCCH/PUSCH
* Simultaneous PUCCH and PUSCH transmission
* PUCCH cell switching for TDD cells
* URLLC in unlicensed controlled environments
* Propagation delay compensation for time synchronization
* RAN enhancement for the new QoS requirement of survival time
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| ***Consequences if not approved:*** | The features introduced by Rel-17 NR IIoT/URLLC WI cannot be captured in TS 38.300. |
|  |  |
| ***Clauses affected:*** | 3.1, 5.2.5.4, 5.3.3, 5.3.5.5, 16.1.X, 16.1.Y, 16.8 |
|  |  |
|  | **Y** | **N** |  |  |
| ***Other specs*** |  | **X** |  Other core specifications  | TS/TR ... CR ...  |
| ***affected:*** |  | **X** |  Test specifications | TS/TR ... CR ...  |
| ***(show related CRs)*** |  | **X** |  O&M Specifications | TS/TR ... CR ...  |
|  |  |
| ***Other comments:*** |  |
|  |  |
| ***This CR's revision history:*** |  |

*First Modified Subclause*

## 3.1 Abbreviations

For the purposes of the present document, the abbreviations given in TR 21.905 [1], in TS 36.300 [2] 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] and TS 36.300 [2].

5GC 5G Core Network

5GS 5G System

5QI 5G QoS Identifier

A-CSI Aperiodic CSI

AKA Authentication and Key Agreement

AMBR Aggregate Maximum Bit Rate

AMC Adaptive Modulation and Coding

AMF Access and Mobility Management Function

ARP Allocation and Retention Priority

BA Bandwidth Adaptation

BCH Broadcast Channel

BH Backhaul

BL Bandwidth reduced Low complexity

BPSK Binary Phase Shift Keying

C-RNTI Cell RNTI

CAG Closed Access Group

CAPC Channel Access Priority Class

CBRA Contention Based Random Access

CCE Control Channel Element

CD-SSB Cell Defining SSB

CFRA Contention Free Random Access

CHO Conditional Handover

CIoT Cellular Internet of Things

CLI Cross Link interference

CMAS Commercial Mobile Alert Service

CORESET Control Resource Set

CP Cyclic Prefix

CPC Conditional PSCell Change

DAG Directed Acyclic Graph

DAPS Dual Active Protocol Stack

DFT Discrete Fourier Transform

DCI Downlink Control Information

DCP DCI with CRC scrambled by PS-RNTI

DL-AoD Downlink Angle-of-Departure

DL-SCH Downlink Shared Channel

DL-TDOA Downlink Time Difference Of Arrival

DMRS Demodulation Reference Signal

DRX Discontinuous Reception

E-CID Enhanced Cell-ID (positioning method)

EHC Ethernet Header Compression

ETWS Earthquake and Tsunami Warning System

FS Feature Set

GFBR Guaranteed Flow Bit Rate

HRNN Human-Readable Network Name

IAB Integrated Access and Backhaul

I-RNTI Inactive RNTI

INT-RNTI Interruption RNTI

KPAS Korean Public Alarm System

LDPC Low Density Parity Check

MDBV Maximum Data Burst Volume

MIB Master Information Block

MICO Mobile Initiated Connection Only

MFBR Maximum Flow Bit Rate

MMTEL Multimedia telephony

MNO Mobile Network Operator

MPE Maximum Permissible Exposure

MT Mobile Termination

MU-MIMO Multi User MIMO

Multi-RTT Multi-Round Trip Time

NB-IoT Narrow Band Internet of Things

NCGI NR Cell Global Identifier

NCR Neighbour Cell Relation

NCRT Neighbour Cell Relation Table

NGAP NG Application Protocol

NID Network Identifier

NPN Non-Public Network

NR NR Radio Access

P-MPR Power Management Maximum Power Reduction

P-RNTI Paging RNTI

PCH Paging Channel

PCI Physical Cell Identifier

PDC Propagation Delay Compensation

PDCCH Physical Downlink Control Channel

PDSCH Physical Downlink Shared Channel

PLMN Public Land Mobile Network

PNI-NPN Public Network Integrated NPN

PO Paging Occasion

PRACH Physical Random Access Channel

PRB Physical Resource Block

PRG Precoding Resource block Group

PRS Positioning Reference Signal

PS-RNTI Power Saving RNTI

PSS Primary Synchronisation Signal

PUCCH Physical Uplink Control Channel

PUSCH Physical Uplink Shared Channel

PWS Public Warning System

QAM Quadrature Amplitude Modulation

QFI QoS Flow ID

QPSK Quadrature Phase Shift Keying

RA Random Access

RA-RNTI Random Access RNTI

RACH Random Access Channel

RANAC RAN-based Notification Area Code

REG Resource Element Group

RIM Remote Interference Management

RMSI Remaining Minimum SI

RNA RAN-based Notification Area

RNAU RAN-based Notification Area Update

RNTI Radio Network Temporary Identifier

RQA Reflective QoS Attribute

RQoS Reflective Quality of Service

RS Reference Signal

RSRP Reference Signal Received Power

RSRQ Reference Signal Received Quality

RSSI Received Signal Strength Indicator

RSTD Reference Signal Time Difference

RTT Round Trip Time

SCS SubCarrier Spacing

SD Slice Differentiator

SDAP Service Data Adaptation Protocol

SFI-RNTI Slot Format Indication RNTI

SIB System Information Block

SI-RNTI System Information RNTI

SLA Service Level Agreement

SMC Security Mode Command

SMF Session Management Function

S-NSSAI Single Network Slice Selection Assistance Information

SNPN Stand-alone Non-Public Network

SNPN ID Stand-alone Non-Public Network Identity

SPS Semi-Persistent Scheduling

SR Scheduling Request

SRS Sounding Reference Signal

SRVCC Single Radio Voice Call Continuity

SS Synchronization Signal

SSB SS/PBCH block

SSS Secondary Synchronisation Signal

SST Slice/Service Type

SU-MIMO Single User MIMO

SUL Supplementary Uplink

TA Timing Advance

TPC Transmit Power Control

TRP Transmit/Receive Point

TRS CSI-RS for Tracking

UCI Uplink Control Information

UL-AoA Uplink Angles of Arrival

UL-RTOA Uplink Relative Time of Arrival

UL-SCH Uplink Shared Channel

UPF User Plane Function

URLLC Ultra-Reliable and Low Latency Communications

V2X Vehicle-to-Everything

Xn-C Xn-Control plane

Xn-U Xn-User plane

XnAP Xn Application Protocol

*Next Modified Subclause*

#### 5.2.5.4 HARQ

Asynchronous Incremental Redundancy Hybrid ARQ is supported. The gNB provides the UE with the HARQ-ACK feedback timing either dynamically in the DCI or semi-statically in an RRC configuration. Retransmission of HARQ-ACK feedback is supported by using enhanced dynamic codebook and/or one-shot triggering of HARQ-ACK transmission for (i) all configured CCs and HARQ processes in the PUCCH group, (ii) a configured subset of CCs and/or HARQ processes in the PUCCH group, or (iii) a dynamically indicated HARQ-ACK feedback instance. For HARQ-ACK of SPS PDSCH without associated PDCCH, in case of HARQ-ACK dropping due to TDD specific collisions, the HARQ-ACK feedback can be deferred to a next available PUCCH transmission occasion.

The UE may be configured to receive code block group based transmissions where retransmissions may be scheduled to carry a sub-set of all the code blocks of a TB.

*Next Modified Subclause*

### 5.3.3 Physical uplink control channel

Physical uplink control channel (PUCCH) carries the Uplink Control Information (UCI) from the UE to the gNB. Five formats of PUCCH exist, depending on the duration of PUCCH and the UCI payload size.

- Format #0: Short PUCCH of 1 or 2 symbols with small UCI payloads of up to two bits with UE multiplexing capacity of up to 6 UEs with 1-bit payload in the same PRB;

- Format #1: Long PUCCH of 4-14 symbols with small UCI payloads of up to two bits with UE multiplexing capacity of up to 84 UEs without frequency hopping and 36 UEs with frequency hopping in the same PRB;

- Format #2: Short PUCCH of 1 or 2 symbols with large UCI payloads of more than two bits with no UE multiplexing capability in the same PRBs;

- Format #3: Long PUCCH of 4-14 symbols with large UCI payloads with no UE multiplexing capability in the same PRBs;

- Format #4: Long PUCCH of 4-14 symbols with moderate UCI payloads with multiplexing capacity of up to 4 UEs in the same PRBs.

The short PUCCH format of up to two UCI bits is based on sequence selection, while the short PUCCH format of more than two UCI bits frequency multiplexes UCI and DMRS. The long PUCCH formats time-multiplex the UCI and DMRS. Frequency hopping is supported for long PUCCH formats and for short PUCCH formats of duration of 2 symbols. Short and long PUCCH formats can be repeated over multiple slots or sub-slots, where the repetition factor is either indicated dynamically in the DCI or semi-statically in an RRC configuration.

For operation with shared spectrum channel access, PUCCH Format #0, #1, #2, #3 are extended to use resource in one PRB interlace (up to two interlaces for Format #2 and Format #3) in one RB Set. PUCCH Format #2 and #3 are enhanced to support multiplexing capacity of up to 4 UEs in the same PRB interlace when one interlace is used.

Up to two PUCCH configurations can be configured for a UE per PUCCH group (see TS 38.331 [12]), where the first PUCCH configuration is associated with a PUCCH of priority index 0 (low) and the second PUCCH configuration is associated with a PUCCH of priority index 1 (high).

UCI multiplexing in PUCCH is supported when PUCCH transmissions of UCIs coincide in time, and are associated with the same priority (high/low). In addition, multiplexing of HARQ-ACK of priority index 0 (low) and UCI of priority index 1 (high) in PUCCH of priority index 1 (high) is supported when PUCCH transmissions of HARQ-ACK of priority index 0 and UCI of priority index 1 (high) coincide in time.

UCI multiplexing in PUSCH is supported when UCI and PUSCH transmissions coincide in time, either due to transmission of a UL-SCH transport block or due to triggering of A-CSI transmission without UL-SCH transport block, and are associated with the same priority (high/low). In addition, HARQ-ACK multiplexing of a certain priority in PUSCH of a different priority is supported when HARQ-ACK and PUSCH transmissions coincide in time, either due to transmission of a UL-SCH transport block or due to triggering of A-CSI transmission without UL-SCH transport block:

- UCI carrying HARQ-ACK feedback with 1 or 2 bits is multiplexed by puncturing PUSCH;

- In all other cases UCI is multiplexed by rate matching PUSCH.

UCI consists of the following information:

- CSI;

- ACK/NAK;

- Scheduling request.

Simultaneous transmission of PUCCH and PUSCH associated with different priorities on cells of different bands is supported, where UCI multiplexing in PUCCH associated with the same priority in combination of UCI multiplexing in a PUSCH associated with a different priority is supported.

For operation with shared spectrum channel access, multiplexing of CG-UCI and PUCCH carrying HARQ-ACK feedback can be configured by the gNB. If not configured, when PUCCH overlaps with PUSCH scheduled by a configured grant within a PUCCH group and PUCCH carries HARQ ACK feedback, PUSCH scheduled by configured grant is skipped.

QPSK and π/2 BPSK modulation can be used for long PUCCH with more than 2 bits of information, QPSK is used for short PUCCH with more than 2 bits of information and BPSK and QPSK modulation can be used for long PUCCH with up to 2 information bits.

Transform precoding is applied to PUCCH Format #3 and Format #4.

Channel coding used for uplink control information is described in table 5.3.3-1.

Table 5.3.3-1: Channel coding for uplink control information

|  |  |
| --- | --- |
| Uplink Control Information size including CRC, if present | Channel code |
| 1 | Repetition code |
| 2 | Simplex code |
| 3-11 | Reed Muller code |
| >11 | Polar code |

*Next Modified Subclause*

### 16.1.X URLLC in Unlicensed Controlled Environment

URLLC services can be supported in shared spectrum where LBT failure is assumed to be not frequent. In this case, a channel access procedure for semi-static channel occupancy can be initiated by the gNB or the UE, or the gNB operates in dynamic channel access mode, as described in TS 37.213 [37]. To handle potential LBT failures on configured grants (CG), the CG retransmission timer can be optionally configured to enable autonomous retransmissions, and it may be configured simultaneously with enhanced intra-UE overlapping resource prioritization mechanisms. When the CG retransmission timer is configured, the UE shall select the HARQ process for each CG resource by itself. If the enhanced intra-UE overlapping resource prioritization mechanisms is also configured, the UE may be further configured to select the HARQ process for a CG resource based on logical channel priority.

*Next Modified Subclause*

### 16.1.Y PUCCH cell switching for TDD cells

To reduce the delay for HARQ-ACK feedback for TDD operation with URLLC services, PUCCH cell switching for TDD cells is supported. The UE can be provided in a cell group with an alternative PUCCH SCell (sSCell) that can be used for PUCCH transmission instead of PCell / PSCell / PUCCH SCell. The applicable cell for PUCCH transmission to be either on PCell /PSCell / PUCCH SCell or the PUCCH sSCell at a time is either defined by:

- a higher layer configured time-domain pattern of the applicable cell for PUCCH transmission; or

- dynamic indication of the cell for PUCCH transmission through a PDCCH scheduling a PUCCH transmission.

The PUCCH cell switching is applicable to all UCI types when using the higher layer configured time-domain pattern, but is only applicable to HARQ for the dynamic indication of the cell for PUCCH transmission through a PDCCH scheduling PUCCH.

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## 16.8 Support for Time Sensitive Communications

Time Sensitive Communications (TSC), as defined in TS 23.501 [3], is a communication service that supports deterministic communication and/or isochronous communication with high reliability and availability. Examples of such services are the ones in the area of Industrial Internet of Things, e.g. related to cyber-physical control applications as described in TS 22.104 [39].

To support strict synchronization accuracy requirements of TSC applications, the gNB may signal 5G system time reference information to the UE using unicast or broadcast RRC signalling with a granularity of 10 ns. Uncertainty parameter may be included in reference time information to indicate its accuracy. The UE may indicate to the gNB a preference to be provisioned with reference time information using UE Assistance Information procedure. Propagation delay compensation (PDC) mechanisms may be applied based on RTT or TA, and can be performed at the UE or gNB side. When performed at UE side, the PDC mechanisms are controlled via RRC signalling by the gNB.

The RTT-based PDC mechanism is acheived by using Rx-Tx time difference measurements of a single pair of configured TRS/PRS and SRS. The following figure describes the signalling procedures of UE-side RTT-based PDC:



Figure 16.8-X: Signalling Procedure of UE-side RTT-based PDC

1. The gNB provides measurement configurations to the UE;

2. The gNB transmits TRS or PRS to the UE for measurements;

3. The UE transmits SRS to the gNB for measurement;

4a/b. Both the UE and the gNB perform Rx-Tx time difference measurements;

5. The gNB provides its Rx-Tx time difference measurement to the UE;

6. The UE performs PDC based on Rx-Tx time difference measurements from itself and the gNB.

The following figure describes the signalling procedures of gNB-side RTT-based PDC:



Figure 16.8-Y: Signalling Procedure of gNB-side RTT-based PDC

1. The gNB provides measurement configurations to the UE;

2. The gNB transmits TRS or PRS to the UE for measurements;

3. The UE transmits SRS to the gNB for measurement;

4a/b. Both the UE and the gNB perform Rx-Tx time difference measurements;

5. The UE reports its Rx-Tx time difference measurement to the gNB;

6. The gNB performs PDC based on Rx-Tx time difference measurements from itself and the UE.

The gNB may also receive TSC Assistance Information (TSCAI), see TS 23.501 [3], from the Core Network, e.g. during QoS flow establishment, or from another gNB during handover. TSCAI contains additional information about the traffic flow such as burst arrival time, burst periodicity, and survival time. TSCAI knowledge may be leveraged in the gNB's scheduler to more efficiently schedule periodic, deterministic traffic flows either via Configured Grants, Semi-Persistent Scheduling or with dynamic grants, and/or to improve the associated link reliability to meet the survival time requirement (see TS 22.104 [39]).

To support uplink periodic traffics of services with survival time requirement, configured grant resources can be used such that the mapping relation between the service and the configured grant is known to both gNB and UE, thus allowing the gNB to use configured grant retransmission scheduling (addressed by CS-RNTI) to trigger survival time state entry for the corresponding DRB. Upon survival time state entry, all RLC entities configured for the DRB are activated by the UE for duplication to prevent failure of subsequent messages and hence fulfilling the survival time requirement. If CA or DC duplication for the DRB is already activated, the DRB should enter survival time state when any retransmission grant for any of its active LCH is received in any MAC entity.

*End of Changes*