**3GPP TSG-RAN WG2 Meeting #129 *R2-2500489***

**Athens, Greece, 17 – 21 February 2025**

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| *CR-Form-v12.3* | | | | | | | | |
| **DRAFT CHANGE REQUEST** | | | | | | | | |
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|  |  | **CR** |  | **rev** |  | **Current version:** |  |  |
|  | | | | | | | | |
| *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 XR Enhancements Phase 3 | | | | | | | | | |
|  |  | | | | | | | | | |
| ***Source to WG:*** | Nokia | | | | | | | | | |
| ***Source to TSG:*** | R2 | | | | | | | | | |
|  |  | | | | | | | | | |
| ***Work item code:*** | NR\_XR\_Ph3-Core | | | | |  | ***Date:*** | | | 2025-02 |
|  |  | | | |  | |  | | |  |
| ***Category:*** |  |  | | | | | ***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 can be 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)* | |
|  |  | | | | | | | | | |
| ***Reason for change:*** | | For the Phase 3 of XR Enhancements, the following was agreed:   1. By SA2: provision of MMSID by 5GC. 2. By SA2: provision of TTNB and Burst Size in GTP-U header. 3. A refined DSR to convey multiple pairs of amount of data buffered and shortest remaining time for that data 4. In LCP, prioritisation of with data with remaining time before discard going below a configured threshold 5. A rate control mechanism to cope with congestion 6. For RLC AM, new mechanisms to ensure timely RLC retransmissions and avoiding unnecessery RLC retransmisions. 7. Measurement gap handling enhancement to enable transmission/reception in gaps/restrictions that are caused by RRM measurements | | | | | | | | |
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| ***Summary of change:*** | | New mechanims for the Phase 3 of XR Enhancements are introduced:   1. The provision of MMSID, Burst Size and TTNB by 5GC 2. Refined DSR 3. Delay-aware LCP 4. Rate control mechanism 5. RLC AM enhancements 6. Measurement gaps handling enhancements | | | | | | | | |
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| ***Consequences if not approved:*** | | The new mechanims agreed for the Phase 3 of XR Enhancements are not captured in the Stage 2. | | | | | | | | |
|  | |  | | | | | | | | |
| ***Clauses affected:*** | | 3.1, 16.15 | | | | | | | | |
|  | |  | | | | | | | | |
|  | | **Y** | **N** |  | | | |  | | |
| ***Other specs*** | | **X** |  | Other core specifications | | | | TS 38.321 CR TBD  TS 38.322 CR TBD  TS 38.323 CR TBD  TS 38.331 CR TBD | | |
| ***affected:*** | |  | **X** | Test specifications | | | |  | | |
| ***(show related CRs)*** | |  | **X** | O&M Specifications | | | |  | | |
|  | |  | | | | | | | | |
| ***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

A2X Aircraft-to-Everything

A-CSI Aperiodic CSI

AGC Automatic Gain Control

AI Artificial Intelligence

AKA Authentication and Key Agreement

AMBR Aggregate Maximum Bit Rate

AMC Adaptive Modulation and Coding

AMF Access and Mobility Management Function

AR Augmented Reality

ARP Allocation and Retention Priority

ATG Air to Ground

BA Bandwidth Adaptation

BCCH Broadcast Control Channel

BCH Broadcast Channel

BFD Beam Failure Detection

BH Backhaul

BL Bandwidth reduced Low complexity

BPSK Binary Phase Shift Keying

BRID Broadcast Remote Identification

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

cellDTRX-RNTI Cell Discontinuous Transmission and Reception RNTI

CFR Common Frequency Resource

CFRA Contention Free Random Access

CG Configured Grant

CHO Conditional Handover

CIoT Cellular Internet of Things

CLI Cross Link interference

CMAS Commercial Mobile Alert Service

CORESET Control Resource Set

CP Cyclic Prefix

CPA Conditional PSCell Addition

CPC Conditional PSCell Change

DAA Detect And Avoid

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

DCR Direct Communication Request

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

DSR Delay Status Report

DTX Discontinuous Transmission

E-CID Enhanced Cell-ID (positioning method)

EC Energy Cost

EHC Ethernet Header Compression

ePWS enhancements of Public Warning System

ETWS Earthquake and Tsunami Warning System

FS Feature Set

FSA ID Frequency Selection Area Identity

G-CS-RNTI Group Configured Scheduling RNTI

G-RNTI Group RNTI

GFBR Guaranteed Flow Bit Rate

GIN Group ID for Network selection

GNSS Global Navigation Satellite System

GSO Geosynchronous Orbit

H-SFN Hyper System Frame Number

HAPS High Altitude Platform Station

HRNN Human-Readable Network Name

IAB Integrated Access and Backhaul

IFRI Intra Frequency Reselection Indication

I-RNTI Inactive RNTI

INT-RNTI Interruption RNTI

KPAS Korean Public Alarm System

L2 Layer-2

L3 Layer-3

LBT Listen Before Talk

LDPC Low Density Parity Check

LEO Low Earth Orbit

LTM L1/L2 Triggered Mobility

MBS Multicast/Broadcast Services

MCE Measurement Collection Entity

MCCH MBS Control Channel

MDBV Maximum Data Burst Volume

MEO Medium Earth Orbit

MIB Master Information Block

MICO Mobile Initiated Connection Only

MFBR Maximum Flow Bit Rate

ML Machine Learning

MMSID Multi-modal Service ID

MMTEL Multimedia telephony

MNO Mobile Network Operator

MO-SDT Mobile Originated SDT

MP Multi-Path

MPE Maximum Permissible Exposure

MRB MBS Radio Bearer

MT Mobile Termination

MT-SDT Mobile Terminated SDT

MTCH MBS Traffic Channel

MTSI Multimedia Telephony Service for IMS

MU-MIMO Multi User MIMO

Multi-RTT Multi-Round Trip Time

MUSIM Multi-Universal Subscriber Identity Module

N3C Non-3GPP Connection

NB-IoT Narrow Band Internet of Things

NCD-SSB Non Cell Defining SSB

NCGI NR Cell Global Identifier

NCL Neighbour Cell List

NCR Neighbour Cell Relation

NCRT Neighbour Cell Relation Table

NES Network Energy Savings

NGAP NG Application Protocol

NGSO Non-Geosynchronous Orbit

NID Network Identifier

NPN Non-Public Network

NR NR Radio Access

NSAG Network Slice AS Group

NTN Non-Terrestrial Network

P-MPR Power Management Maximum Power Reduction

P-RNTI Paging RNTI

PCH Paging Channel

PCI Physical Cell Identifier

PDB Packet Delay Budget

PDC Propagation Delay Compensation

PDCCH Physical Downlink Control Channel

PDSCH Physical Downlink Shared Channel

PEI Paging Early Indication

PER Packet Error Rate

PH Paging Hyperframe

PLMN Public Land Mobile Network

PNI-NPN Public Network Integrated NPN

PO Paging Occasion

PQI PC5 5QI

PRACH Physical Random Access Channel

PRB Physical Resource Block

PRG Precoding Resource block Group

PRS Positioning Reference Signal

PS-RNTI Power Saving RNTI

PSDB PDU Set Delay Budget

PSER PDU Set Error Rate

PSI PDU Set Importance

PSIHI PDU Set Integrated Handling Information

PSS Primary Synchronisation Signal

PTM Point to Multipoint

PTP Point to Point

PTW Paging Time Window

PUCCH Physical Uplink Control Channel

PUSCH Physical Uplink Shared Channel

PWS Public Warning System

QAM Quadrature Amplitude Modulation

QFI QoS Flow ID

QMC QoE Measurement Collection

QoE Quality of Experience

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

RLM Radio Link Monitoring

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

RVQoE RAN visible QoE

SCS SubCarrier Spacing

SD Slice Differentiator

SDAP Service Data Adaptation Protocol

SDT Small Data Transmission

SD-RSRP Sidelink Discovery RSRP

SFI-RNTI Slot Format Indication RNTI

SHR Successful Handover Report

SIB System Information Block

SI-RNTI System Information RNTI

SLA Service Level Agreement

SL-PRS Sidelink Positioning Reference Signal

SL-RSRP Sidelink RSRP

SMC Security Mode Command

SMF Session Management Function

SMTC SS/PBCH block Measurement Timing Configuration

S-NSSAI Single Network Slice Selection Assistance Information

SNPN Stand-alone Non-Public Network

SNPN ID Stand-alone Non-Public Network Identity

SPR Successful PSCell Addition/Change Report

SPS Semi-Persistent Scheduling

SR Scheduling Request

SRAP Sidelink Relay Adaptation Protocol

SRS Sounding Reference Signal

SRVCC Single Radio Voice Call Continuity

SS Synchronization Signal

SSB SS/PBCH block

SSS Secondary Synchronisation Signal

SSSG Search Space Set Group

SST Slice/Service Type

SU-MIMO Single User MIMO

SUL Supplementary Uplink

TA Timing Advance

TB Transport Block

TCE Trace Collection Entity

TNL Transport Network Layer

TPC Transmit Power Control

TRP Transmit/Receive Point

TRS Tracking Reference Signal

TSS Timing Synchronization Status

TTNB Time To Next Burst

U2N UE-to-Network

U2U UE-to-UE

UAV Uncrewed Aerial Vehicle

UCI Uplink Control Information

UDC Uplink Data Compression

UDM Unified Data Management

UE-Slice-MBR UE Slice Maximum Bit Rate

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

VR Virtual Reality

V2X Vehicle-to-Everything

Xn-C Xn-Control plane

Xn-U Xn-User plane

XnAP Xn Application Protocol

XR eXtended Reality

*Next Modified Subclause*

## 16.15 eXtended Reality Services

### 16.15.1 General

This clause describes the functionalities for the support of eXtended Reality (XR) services that require high data rate and low latency communications. An overview of XR services is available in TR 38.835 [57], while the service requirements are documented in TS 22.261 [19]. Please note however that some of those functionalities need not be limited to the provision of XR services.

### 16.15.2 Awareness

XR-Awareness relies on QoS flows, PDU Sets, Data Bursts and traffic assistance information (see TS 23.501 [3]).

The following **PDU Set QoS Parameters** may be provided by the SMF to the gNB as part of the QoS profile of the QoS flow, and to enable PDU Set based QoS handling at least one of them shall be provided:

- PDU Set Delay Budget (PSDB): as defined in TS 23.501 [3], upper bound for the duration between the reception time of the first PDU (at the UPF for DL, at the UE for UL) and the time when all PDUs of a PDU Set have been successfully received (at the UE in DL, at the UPF in UL). When available, supersedes the PDB of the QoS flow.

- PDU Set Error Rate (PSER): as defined in TS 23.501 [3], upper bound for a rate of non-congestion related PDU Set losses between RAN and the UE. When available, it supersedes the PER of the QoS flow.

NOTE 1: In this release, a PDU set is considered as successfully delivered only when all PDUs of a PDU Set are delivered successfully.

- PDU Set Integrated Handling Information (PSIHI): indicates whether all PDUs of the PDU Set are needed for the usage of PDU Set by application layer, as defined in TS 23.501 [3].

NOTE 2: For a given QoS flow, the PDU Set QoS parameters are common for all PDU Sets but can be different for UL and DL.

During the Xn-handover preparation procedure, the source gNB sends the stored PDU Set QoS Parameters as part of the QoS profile to the target NG-RAN node. For NG handover, the AMF provides the PDU Set QoS parameters to the target gNB by means of the NGAP HANDOVER REQUEST message.

The UPF can identify PDUs that belong to PDU Sets, and may indicate to the gNB the following **PDU Set Information** in the GTP-U header:

- PDU Set Sequence Number;

- Indication of End PDU of the PDU Set;

- PDU Sequence Number within a PDU Set;

- PDU Set Size in bytes;

- PDU Set Importance (PSI), which identifies the relative importance of a PDU Set compared to other PDU Sets within the same QoS Flow.

NOTE: PDU Set Information can be provided without PDU Set QoS Parameters.

5GC may provide XR traffic assistance information to gNB through NG AP TSC Assistance Information (TSCAI) as specified in clause 5.37.8 of TS 23.501[3] (for both GBR and non-GBR QoS flows):

- UL and/or DL Periodicity;

- N6 Jitter Information (i.e. between UPF and Data Network) associated with the DL Periodicity.

This assistance information can be used by the gNB to configure DRX to enable better UE power saving.

In addition, 5GC may provide the following information through NG-U as specified in clauses 5.37.5.2 and 5.37.9 of TS 23.501[3]:

- Indication of End of Data Burst in the GTP-U header of the last PDU in downlink. This information can be used by the gNB to push the UE back to sleep when possible.

- Indication of Data Burst Size in the GTP-U header of the first PDUs of the data burst in downlink. This information can be used by the gNB to assist radio resource management.

- Indication of Time To Next Burst in the GTP-U header in downlink. This information represents the interval between the transmission of the last PDU in the current data burst and the first PDU of the next data burst, and can be used by the gNB to assist scheduling in downlink.

Finally, 5GC may provide the Multi-modal Service ID (MMSID) to NG-RAN when establishing and/or updating the corresponding QoS Flows.

In the uplink, the UE needs to be able to identify PDU Sets and Data Bursts dynamically, including PSI. How this is done is left up to UE implementation but when possible for a QoS flow, this is indicated to the gNB via UE Assistance Information.

### 16.15.3 Power Saving

Most XR video frame rates (15, 30, 45, 60, 72, 90 and 120 fps) correspond to periodicities that are not an integer (66.66, 33.33, 22.22, 16.66, 13.88, 11.11 and 8.33 ms respectively). The gNB may configure a DRX cycle expressed in rational numbers so that the DRX cycle matches those periodicities, e.g. for the traffic with a frame rate of 60 fps, the network may configure the UE with a DRX cycle of 50/3 ms.

Configured grants may be configured without the need for the UE to wake up to monitor possible grants for UL retransmissions of configured grants, thus increasing the number of power saving opportunities for the UE.

### 16.15.4 Capacity

#### 16.15.4.1 Physical Layer Enhancements

The following enhancements for configured grant-based PUSCH transmission are introduced:

- Support of multiple CG PUSCH transmission occasions within a single period of a CG configuration;

- Indication of unused CG PUSCH occasion(s) of a CG configuration with Uplink Control Information multiplexed in CG PUSCH transmission of the CG configuration.

#### 16.15.4.2 Layer 2 Enhancements

##### 16.15.4.2.1 Assistance Information

In order to enhance the scheduling of uplink resources for XR, the following improvements are introduced:

- One additional buffer size table to reduce the quantisation errors in BSR and DSR (defined below) reporting (e.g. for high bit rates):

- Whether, for an LCG, the new table can be used in addition to the regular one is configured by the gNB;

- When the new table is configured for an LCG, it is used whenever the amount of the buffered data of that LCG to be reported is within the range of the new table, otherwise the regular table is used.

- Delay Status Report (DSR) of buffered data via a dedicated MAC CE:

- Triggered for an LCH when the remaining time before discard of any buffered PDCP SDU goes below a configured threshold (threshold configured per LCG by the gNB);

- When triggered for an LCH:

- Reports for each reporting threshold configured, the buffer size and the shortest remaining time before discard of buffered PDCP SDUs associated to this reporting threshold.

- Reporting of uplink assistance information (jitter range, burst arrival time, UL data burst periodicity) per QoS flow by the UE via UE Assistance Information. In case target gNB receives the burst arrival time from source gNB during the handover preparation procedure, the target gNB may use it by considering the SFN offset of the source gNB.

##### 16.15.4.2.2 Discard

When the PSIHI indicates that all PDUs of the PDU Set are needed for a QoS flow, as soon as one PDU of a PDU set is known to be lost, the remaining PDUs of that PDU Set can be considered as no longer needed by the application and may be subject to discard operation at the transmitter to free up radio resources.

NOTE 1: It cannot always be assumed that the remaining PDUs are not useful and can safely be discarded. Also, in case of Forward Error Correction (FEC), active discarding of PDUs when assuming that a large enough number of packets have already been transmitted for FEC to recover without the remaining PDUs is not recommended as it might trigger an increase of FEC packets.

In uplink, the UE may be configured with PDU Set based discard operation for a specific DRB. When configured, the UE discards all packets in a PDU set when one PDU belonging to this PDU set is discarded due to discard timer expiry.

The gNB may perform downlink PDU Set discarding based on implementation by taking at least PSDB, PSI, PSIHI parameters into account.

In case of congestion, for downlink, the gNB may perform PDCP SDU discarding based on PSI. For uplink, dedicated downlink signalling is used to request the UE to apply a shorter discard timer to PDCP SDUs belonging to *low importance* PDU Sets in PDCP.

NOTE 2: How PDU Sets are identified as *low importance* is left up to UE implementation. When a PSI is available, it can be used according to the guidelines specified in TS 26.522 [58].

The transmitting PDCP entity can inform the receiving one of gaps in the sequence of transmitted PDCP SN, resulting from PDCP SDU discard, via a PDCP control PDU.

##### 16.15.4.2.X Logical Channel Priority Adjustment

In order to cope with possible congestion, an LCH may be configured with an additional priority to be used when any of its buffered PDCP SDU has a remaining time before discard going below a configured threshold.

##### 16.15.4.2.Y RLC Retransmissions

For operation of RLC Acknowledged Mode (AM), the following improvements are introduced:

- To avoid unnecessary RLC retransmissions:

- On the transmitter side, when the RLC entity receives a discard indication for an SDU from PDCP, it immediately stops any further transmission or retransmission of that SDU and its corresponding segment if any;

- On the receiver side, a complete PDU can only be missing for a given time before it is abandonned and the transmitter notified.

Editor’s Note: details of the notification are FFS.

- To ensure timely RLC retransmissions, when the remaining time before discard of an RLC SDU:

- Falls below a first threshold, a retransmission is triggered; and/or

- Falls below a second threshold, polling is triggered.

##### 16.15.4.2.Z Rate Control

In downlink, the gNB can suggest an uplink bit rate to the UE to enable faster adaptation of the source rate to uplink congestion..

Editor’s Note: exact naming of the procedure can be fixed later on.

### 16.15.5 Non-Homogeneous support of PDU set based handling in NG-RAN

During a handover from a gNB supporting PDU Set based handling to another gNB, the source gNB signals the PDU Set Information over Xn-U if the target node has signalled the support of PDU Set based handling in the Xn Handover Request Acknowledge message.

During a handover, transition from RRC\_INACTIVE to RRC\_CONNECTED or RRC re-establishment from a gNB not supporting PDU Set based handling to a gNB supporting PDU Set based handling, the target/new serving gNB may indicate the support of PDU Set based handling to the SMF during the Path Switch Request procedure or Handover Resource Allocation procedure (in case of NG handover), the SMF will act as specified in TS 23.501[3]. If the indication is absent, the SMF infers that PDU Set based handling is not supported by the target/new serving gNB node, then the SMF will act as specified in TS 23.501[3].

During a handover, transition from RRC\_INACTIVE to RRC\_CONNECTED or RRC re-establishment from a gNB node not supporting PDU Set based handling to a gNB node supporting PDU Set based handling, the target/new serving gNB node may receive unmarked PDU(s) (i.e. PDU(s) without PDU Set Information Container) forwarded from the source/last serving gNB, node and marked PDU(s) (i.e. PDU(s) with PDU Set Information Container) from UPF, how the target/new serving gNB node handles the marked and unmarked PDUs for the same QoS flow is up to implementation.

### 16.15.Y Measurement Gaps

To enable transmission and reception during some of the measurements gaps required for RRM measurements, the following enhancements are introduced:

- Explicit DCI based indication to cancel a particular measurement gap.

Editor’s Note: will be revisted once RAN1 & RAN4 progress further.

*End of Changes*