**3GPP TSG-RAN WG2 Meeting #117 Electronic *R2-2203588***

21 February – 03 March 2022 R2-2203069

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| *CR-Form-v12.2* | | | | | | | | |
| CHANGE REQUEST | | | | | | | | |
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|  |  | **CR** |  | **rev** | **1** | **Current version:** |  |  |
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| *For* [***HELP***](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:*** | RAN enhancements in the support of slicing | | | | | | | | | |
|  |  | | | | | | | | | |
| ***Source to WG:*** | Nokia, Nokia Shanghai Bell | | | | | | | | | |
| ***Source to TSG:*** | RAN2 | | | | | | | | | |
|  |  | | | | | | | | | |
| ***Work item code:*** |  | | | | |  | ***Date:*** | | |  |
|  |  | | | |  | |  | | |  |
| ***Category:*** |  |  | | | | | ***Release:*** | | |  |
|  | *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-16 (Release 16) Rel-17 (Release 17) Rel-18 (Release 18) Rel-19 (Release 19)* | |
|  |  | | | | | | | | | |
| ***Reason for change:*** | | Introduction of enhancements in slicing support in RAN, see RP-212534  Introduce support for UE-Slice-Maximum Bit Rate. | | | | | | | | |
|  | |  | | | | | | | | |
| ***Summary of change:*** | | 1) Introduction of slice specific cell reselection in 9.2.1.2, and 16.3.X  2) Introduction of the support of Slice-Maximum Bit Rate in 16.3.1  3) Introduction of slice specific RACH resources in 16.3.1, and 16.3.3  4) Multicarrier resource sharing has been added.  5) Resource repartitioning configuration-based solution has been added.  6) Support for UE-Slice-Maximum Bit Rate has been added. | | | | | | | | |
|  | |  | | | | | | | | |
| ***Consequences if not approved:*** | | Rel-17 slicing enhancments in RAN are not supported and resource shortage of an S-NSSAI is not efficiently handled | | | | | | | | |
|  | |  | | | | | | | | |
| ***Clauses affected:*** | | 2, 3.1, 9.2.1.2, 10.5, 12.1, 16.3.1, 16.3.3, 16.3.3.X (New clause), 16.3.X (New Clause to be added between 16.3.3 and 16.3.4) | | | | | | | | |
|  | |  | | | | | | | | |
|  | | **Y** | **N** |  | | | |  | | |
| ***Other specs*** | | **X** |  | Other core specifications | | | | TS 38.304 CR 0235  TS 38.306 CR in R2-2204029  TS 38.321 CR 1190  TS 38.331 CR 2921  TS 38.331 CR in R2-2204028  TS 38.413 CR 682 | | |
| ***affected:*** | | **X** |  | Test specifications | | | | TS 38.463 CR 679 | | |
| ***(show related CRs)*** | | **X** |  | O&M Specifications | | | | TS 38.473 CR 856  TS 38.423 CR 745  TS 37.340 CR xxx | | |
|  | |  | | | | | | | | |
| ***Other comments:*** | |  | | | | | | | | |
|  | |  | | | | | | | | |
| ***This CR's revision history:*** | | Changes from CR 0436 (R2-2204176 / R3-222954) are merged into this CR | | | | | | | | |

*First Modified Subclause*

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non‑specific.

- For a specific reference, subsequent revisions do not apply.

- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.

[1] 3GPP TR 21.905: "Vocabulary for 3GPP Specifications".

[2] 3GPP TS 36.300: "Evolved Universal Terrestrial Radio Access (E-UTRA) and Evolved Universal Terrestrial Radio Access Network (E-UTRAN); Overall description; Stage 2".

[3] 3GPP TS 23.501: "System Architecture for the 5G System; Stage 2".

[4] 3GPP TS 38.401: "NG-RAN; Architecture description".

[5] 3GPP TS 33.501: "Security Architecture and Procedures for 5G System".

[6] 3GPP TS 38.321: "NR; Medium Access Control (MAC) protocol specification".

[7] 3GPP TS 38.322: "NR; Radio Link Control (RLC) protocol specification".

[8] 3GPP TS 38.323: "NR; Packet Data Convergence Protocol (PDCP) specification".

[9] 3GPP TS 37.324: " E-UTRA and NR; Service Data Protocol (SDAP) specification".

[10] 3GPP TS 38.304: "NR; User Equipment (UE) procedures in Idle mode and RRC Inactive state".

[11] 3GPP TS 38.306: "NR; User Equipment (UE) radio access capabilities".

[12] 3GPP TS 38.331: "NR; Radio Resource Control (RRC); Protocol specification".

[13] 3GPP TS 38.133: "NR; Requirements for support of radio resource management".

[14] 3GPP TS 22.168: "Earthquake and Tsunami Warning System (ETWS) requirements; Stage 1".

[15] 3GPP TS 22.268: "Public Warning System (PWS) Requirements".

[16] 3GPP TS 38.410: "NG-RAN; NG general aspects and principles".

[17] 3GPP TS 38.420: "NG-RAN; Xn general aspects and principles".

[18] 3GPP TS 38.101-1: "NR; User Equipment (UE) radio transmission and reception; Part 1: Range 1 Standalone".

[19] 3GPP TS 22.261: "Service requirements for next generation new services and markets".

[20] 3GPP TS 38.202: "NR; Physical layer services provided by the physical layer"

[21] 3GPP TS 37.340: "NR; Multi-connectivity; Overall description; Stage-2".

[22] 3GPP TS 23.502: "Procedures for the 5G System; Stage 2".

[23] IETF RFC 4960 (2007-09): "Stream Control Transmission Protocol".

[24] 3GPP TS 26.114: "Technical Specification Group Services and System Aspects; IP Multimedia Subsystem (IMS); Multimedia Telephony; Media handling and interaction".

[25] Void.

[26] 3GPP TS 38.413: "NG-RAN; NG Application Protocol (NGAP)".

[27] IETF RFC 3168 (09/2001): "The Addition of Explicit Congestion Notification (ECN) to IP".

[28] 3GPP TS 24.501: "NR; Non-Access-Stratum (NAS) protocol for 5G System (5GS)".

[29] 3GPP TS 36.331: "Evolved Universal Terrestrial Radio Access (E-UTRA); Radio Resource Control (RRC); Protocol specification".

[30] 3GPP TS 38.415: "NG-RAN; PDU Session User Plane Protocol".

[31] 3GPP TS 38.340: "NR; Backhaul Adaptation Protocol (BAP) specification".

[32] 3GPP TS 38.470: "NG-RAN; F1 application protocol (F1AP) ".

[33] 3GPP TS 38.425: "NG-RAN; NR user plane protocol".

[34] 3GPP TS 23.216: "Single Radio Voice Call Continuity (SRVCC); Stage 2".

[35] 3GPP TS 38.101-2: "User Equipment (UE) radio transmission and reception; Part 2: Range 2 Standalone".

[36] 3GPP TS 38.101-3: "User Equipment (UE) radio transmission and reception; Part 3: Range 1 and Range 2 Interworking operation with other radios".

[37] 3GPP TS 37.213: "Physical layer procedures for shared spectrum channel access".

[38] 3GPP TS 38.213: "NR; Physical layer procedures for control".

[39] 3GPP TS 22.104 "Service requirements for cyber-physical control applications in vertical domains".

[40] 3GPP TS 23.287: "Architecture enhancements for 5G System (5GS) to support Vehicle-to-Everything (V2X) services".

[41] 3GPP TS 23.285: "Technical Specification Group Services and System Aspects; Architecture enhancements for V2X services".

[42] 3GPP TS 38.305: "NG Radio Access Network (NG-RAN); Stage 2 functional specification of User Equipment (UE) positioning in NG-RAN".

[43] 3GPP TS 37.355: "LTE Positioning Protocol (LPP)".

[44] 3GPP TS 29.002: "Mobile Application Part (MAP) specification".

[xx] 3GPP TS 28.541: "5G Network Resource Model (NRM)".

*Next 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

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

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

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

UCI Uplink Control Information

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

V2X Vehicle-to-Everything

Xn-C Xn-Control plane

Xn-U Xn-User plane

XnAP Xn Application Protocol

*Next Modified Subclause*

#### 9.2.1.2 Cell Reselection

A UE in RRC\_IDLE performs cell reselection. The principles of the procedure are the following:

- Cell reselection is always based on CD-SSBs located on the synchronization raster (see clause 5.2.4).

- The UE makes measurements of attributes of the serving and neighbour cells to enable the reselection process:

- For the search and measurement of inter-frequency neighbouring cells, only the carrier frequencies need to be indicated.

- Cell reselection identifies the cell that the UE should camp on. It is based on cell reselection criteria which involves measurements of the serving and neighbour cells:

- Intra-frequency reselection is based on ranking of cells;

- Inter-frequency reselection is based on absolute priorities where a UE tries to camp on the highest priority frequency available;

- An NCL can be provided by the serving cell to handle specific cases for intra- and inter-frequency neighbouring cells;

- Black lists can be provided to prevent the UE from reselecting to specific intra- and inter-frequency neighbouring cells;

- White lists can be provided to request the UE to reselect to only specific intra- and inter-frequency neighbouring cells;

- Cell reselection can be speed dependent;

- Service specific prioritisation.

- Slice specific cell reselection information can be provided to facilitate the UE to reselect a cell that supports specific slices.

In multi-beam operations, the cell quality is derived amongst the beams corresponding to the same cell (see clause 9.2.4).

*Next Modified Subclause*

10.5 Rate Control

10.5.1 Downlink

In downlink, for GBR flows, the gNB guarantees the GFBR and ensures that the MFBR is not exceeded while for non-GBR flows, it ensures that the UE-AMBR is not exceeded (see clause 12). When configured for a GBR flow, the gNB also ensures that the MDBV is not exceeded. When received and supported, the gNB in addition ensures that the UE-Slice-MBR is not exceeded as specified in TS 23.501 [3].

10.5.2 Uplink

The UE has an uplink rate control function which manages the sharing of uplink resources between logical channels. RRC controls the uplink rate control function by giving each logical channel a priority, a prioritised bit rate (PBR), and a buffer size duration (BSD). The values signalled need not be related to the ones signalled via NG to the gNB. In addition, mapping restrictions can be configured (see clause 16.1.2).

The uplink rate control function ensures that the UE serves the logical channel(s) in the following sequence:

1. All relevant logical channels in decreasing priority order up to their PBR;

2. All relevant logical channels in decreasing priority order for the remaining resources assigned by the grant.

NOTE 1: In case the PBRs are all set to zero, the first step is skipped and the logical channels are served in strict priority order: the UE maximises the transmission of higher priority data.

NOTE 2: The mapping restrictions tell the UE which logical channels are relevant for the grant received. If no mapping restrictions are configured, all logical channels are considered.

NOTE 3: Through radio protocol configuration and scheduling, the gNB can guarantee the GFBR(s) and ensure that any of the MFBR(s), the UE-AMBR and, when supported and feasible, the UE-Slice-MBR is not exceeded in uplink (see clause 12).

NOTE 4: The mapping restrictions allows the gNB to fulfil the MDBV requirements through scheduling at least for the case where logical channels are mapped to separate serving cells.

If more than one logical channel have the same priority, the UE shall serve them equally.

*Next Modified Subclause*

12 QoS

12.1 Overview

The **5G QoS model** is based on QoS Flows (see TS 23.501 [3]) and supports both QoS Flows that require guaranteed flow bit rate (GBR QoS Flows) and QoS Flows that do not require guaranteed flow bit rate (non-GBR QoS Flows). At NAS level (see TS 23.501 [3]), the QoS flow is thus the finest granularity of QoS differentiation in a PDU session. A QoS flow is identified within a PDU session by a QoS Flow ID (QFI) carried in an encapsulation header over NG-U.

The **QoS architecture** in NG-RAN, both for NR connected to 5GC and for E-UTRA connected to 5GC, is depicted in the Figure 12-1 and described in the following:

- For each UE, 5GC establishes one or more PDU Sessions;

- Except for NB-IoT and IAB-MT in SA mode, for each UE, the NG-RAN establishes at least one Data Radio Bearers (DRB) together with the PDU Session and additional DRB(s) for QoS flow(s) of that PDU session can be subsequently configured (it is up to NG-RAN when to do so);

- If NB-IoT UE supports NG-U data transfer, the NG-RAN may establish Data Radio Bearers (DRB) together with the PDU Session and one PDU session maps to only one DRB;

- The NG-RAN maps packets belonging to different PDU sessions to different DRBs;

- NAS level packet filters in the UE and in the 5GC associate UL and DL packets with QoS Flows;

- AS-level mapping rules in the UE and in the NG-RAN associate UL and DL QoS Flows with DRBs.



**Figure 12-1: QoS architecture**

NG-RAN and 5GC ensure quality of service (e.g. reliability and target delay) by mapping packets to appropriate QoS Flows and DRBs. Hence there is a 2-step mapping of IP-flows to QoS flows (NAS) and from QoS flows to DRBs (Access Stratum).

At **NAS level**, a QoS flow is characterised by a QoS profile provided by 5GC to NG-RAN and QoS rule(s) provided by 5GC to the UE. The QoS profile is used by NG-RAN to determine the treatment on the radio interface while the QoS rules dictates the mapping between uplink User Plane traffic and QoS flows to the UE. A QoS flow may either be GBR or Non-GBR depending on its profile. The QoS profile of a QoS flow contains QoS parameters, for instance (see TS 23.501 [3]):

- For each QoS flow:

- A 5G QoS Identifier (5QI);

- An Allocation and Retention Priority (ARP).

- In case of a GBR QoS flow only:

- Guaranteed Flow Bit Rate (GFBR) for both uplink and downlink;

- Maximum Flow Bit Rate (MFBR) for both uplink and downlink;

- Maximum Packet Loss Rate for both uplink and downlink;

- Delay Critical Resource Type;

- Notification Control.

NOTE: The Maximum Packet Loss Rate (UL, DL) is only provided for a GBR QoS flow belonging to voice media.

- In case of Non-GBR QoS only:

- Reflective QoS Attribute (RQA): the RQA, when included, indicates that some (not necessarily all) traffic carried on this QoS flow is subject to reflective quality of service (RQoS) at NAS;

- Additional QoS Flow Information.

The QoS parameter Notification Control indicates whether notifications are requested from the RAN when the GFBR can no longer (or again) be fulfilled for a QoS Flow. If, for a given GBR QoS Flow, notification control is enabled and the RAN determines that the GFBR cannot be guaranteed, RAN shall send a notification towards SMF and keep the QoS Flow (i.e. while the NG-RAN is not delivering the requested GFBR for this QoS Flow), unless specific conditions at the NG-RAN require the release of the NG-RAN resources for this GBR QoS Flow, e.g. due to Radio link failure or RAN internal congestion. When applicable, NG-RAN sends a new notification, informing SMF that the GFBR can be guaranteed again.

If Alternative QoS parameters Sets are received with the Notification Control parameter, the NG-RAN may also include in the notification a reference corresponding to the QoS Parameter Set which it can currently fulfil as specified in TS 23.501 [3]. The target NG-RAN node may include in the notification control indication the reference to the QoS Parameter Set which it can currently fulfil over Xn to the source NG-RAN node during handover.

In addition, an Aggregate Maximum Bit Rate is associated to each PDU session (Session-AMBR), to each UE (UE-AMBR) and to each slice per UE (UE-Slice-MBR). The Session-AMBR limits the aggregate bit rate that can be expected to be provided across all Non-GBR QoS Flows for a specific PDU Session and is ensured by the UPF. The UE-AMBR limits the aggregate bit rate that can be expected to be provided across all Non-GBR QoS Flows of a UE and is ensured by the RAN (see clause 10.5.1). The UE-Slice-MBR limits the aggregate bit rate that can be expected to be provided across all GBR and Non-GBR QoS Flows corresponding to PDU Sessions of the UE for the same slice (S-NSSAI) as specified in TS 23.501 [3] and is ensured by the RAN (see clause 10.5.1).

The 5QI is associated to QoS characteristics giving guidelines for setting node specific parameters for each QoS Flow. Standardized or pre-configured 5G QoS characteristics are derived from the 5QI value and are not explicitly signalled. Signalled QoS characteristics are included as part of the QoS profile. The QoS characteristics consist for instance of (see TS 23.501 [3]):

- Priority level;

- Packet Delay Budget (including Core Network Packet Delay Budget);

- Packet Error Rate;

- Averaging window;

- Maximum Data Burst Volume.

At **Access Stratum** level, the data radio bearer (DRB) defines the packet treatment on the radio interface (Uu). A DRB serves packets with the same packet forwarding treatment. The QoS flow to DRB mapping by NG-RAN is based on QFI and the associated QoS profiles (i.e. QoS parameters and QoS characteristics). Separate DRBs may be established for QoS flows requiring different packet forwarding treatment, or several QoS Flows belonging to the same PDU session can be multiplexed in the same DRB.

In the uplink, the mapping of QoS Flows to DRBs is controlled by mapping rules which are signalled in two different ways:

- Reflective mapping: for each DRB, the UE monitors the QFI(s) of the downlink packets and applies the same mapping in the uplink; that is, for a DRB, the UE maps the uplink packets belonging to the QoS flows(s) corresponding to the QFI(s) and PDU Session observed in the downlink packets for that DRB. To enable this reflective mapping, the NG-RAN marks downlink packets over Uu with QFI.

- Explicit Configuration: QoS flow to DRB mapping rules can be explicitly signalled by RRC.

The UE always applies the latest update of the mapping rules regardless of whether it is performed via reflecting mapping or explicit configuration.

When a QoS flow to DRB mapping rule is updated, the UE sends an end marker on the old bearer.

In the downlink, the QFI is signalled by NG-RAN over Uu for the purpose of RQoS and if neither NG-RAN, nor the NAS (as indicated by the RQA) intend to use reflective mapping for the QoS flow(s) carried in a DRB, no QFI is signalled for that DRB over Uu. In the uplink, NG-RAN can configure the UE to signal QFI over Uu.

For each PDU session, a default DRB may be configured: if an incoming UL packet matches neither an RRC configured nor a reflective mapping rule, the UE then maps that packet to the default DRB of the PDU session. For non-GBR QoS flows, the 5GC may send to the NG-RAN the Additional QoS Flow Information parameter associated with certain QoS flows to indicate that traffic is likely to appear more often on them compared to other non-GBR QoS flows established on the same PDU session.

Within each PDU session, it is up to NG-RAN how to map multiple QoS flows to a DRB. The NG-RAN may map a GBR flow and a non-GBR flow, or more than one GBR flow to the same DRB, but mechanisms to optimise these cases are not within the scope of standardization.

*Next Modified Subclause*

## 16.3 Network Slicing

### 16.3.1 General Principles and Requirements

In this clause, the general principles and requirements related to the realization of network slicing in the NG-RAN for NR connected to 5GC and for E-UTRA connected to 5GC are given.

A network slice always consists of a RAN part and a CN part. The support of network slicing relies on the principle that traffic for different slices is handled by different PDU sessions. Network can realise the different network slices by scheduling and also by providing different L1/L2 configurations.

Each network slice is uniquely identified by a S-NSSAI, as defined in TS 23.501 [3]. NSSAI (Network Slice Selection Assistance Information) includes one or a list of S-NSSAIs (Single NSSAI) where a S-NSSAI is a combination of:

- mandatory SST (Slice/Service Type) field, which identifies the slice type and consists of 8 bits (with range is 0-255);

- optional SD (Slice Differentiator) field, which differentiates among Slices with same SST field and consist of 24 bits.

The list includes at most 8 S-NSSAI(s).

The UE provides NSSAI (Network Slice Selection Assistance Information) for network slice selection in *RRCSetupComplete*, if it has been provided by NAS (see clause 9.2.1.3). While the network can support large number of slices (hundreds), the UE need not support more than 8 slices simultaneously. A BL UE or a NB-IoT UE supports a maximum of 8 slices simultaneously.

Network Slicing is a concept to allow differentiated treatment depending on each customer requirements. With slicing, it is possible for Mobile Network Operators (MNO) to consider customers as belonging to different tenant types with each having different service requirements that govern in terms of what slice types each tenant is eligible to use based on Service Level Agreement (SLA) and subscriptions.

The following key principles apply for support of Network Slicing in NG-RAN:

**RAN awareness of slices**

- NG-RAN supports a differentiated handling of traffic for different network slices which have been pre-configured. How NG-RAN supports the slice enabling in terms of NG-RAN functions (i.e. the set of network functions that comprise each slice) is implementation dependent.

**Selection of RAN part of the network slice**

- NG-RAN supports the selection of the RAN part of the network slice, by NSSAI provided by the UE or the 5GC which unambiguously identifies one or more of the pre-configured network slices in the PLMN.

**Resource management between slices**

- NG-RAN supports policy enforcement between slices as per service level agreements. It should be possible for a single NG-RAN node to support multiple slices. The NG-RAN should be free to apply the best RRM policy for the SLA in place to each supported slice.

**Support of QoS**

- NG-RAN supports QoS differentiation within a slice, and per Slice-Maximum Bit Rate may be enforced per UE, if feasible. How NG-RAN enables UE-Slice-MBR enforcement and rate limitation (see TS 23.501 [3]) is up to network implementation.

**RAN selection of CN entity**

- For initial attach, the UE may provide NSSAI to support the selection of an AMF. If available, NG-RAN uses this information for routing the initial NAS to an AMF. If the NG-RAN is unable to select an AMF using this information or the UE does not provide any such information the NG-RAN sends the NAS signalling to one of the default AMFs.

- For subsequent accesses, the UE provides a Temp ID, which is assigned to the UE by the 5GC, to enable the NG-RAN to route the NAS message to the appropriate AMF as long as the Temp ID is valid (NG-RAN is aware of and can reach the AMF which is associated with the Temp ID). Otherwise, the methods for initial attach applies.

**Resource isolation between slices**

- The NG-RAN supports resource isolation between slices. NG-RAN resource isolation may be achieved by means of RRM policies and protection mechanisms that should avoid that shortage of shared resources in one slice breaks the service level agreement for another slice. It should be possible to fully dedicate NG-RAN resources to a certain slice. Some RACH resources can be associated to specific slice(s). Other aspects how NG-RAN supports resource isolation is implementation dependent.

**Access control**

- By means of the unified access control (see clause 7.4), operator-defined access categories can be used to enable differentiated handling for different slices. NG-RAN may broadcast barring control information (i.e. a list of barring parameters associated with operator-defined access categories) to minimize the impact of congested slices.

**Slice Availability**

- Some slices may be available only in part of the network. The NG-RAN supported S-NSSAI(s) is configured by OAM. Awareness in the NG-RAN of the slices supported in the cells of its neighbours may be beneficial for inter-frequency mobility in connected mode. It is assumed that the slice availability does not change within the UE's registration area.

- The NG-RAN and the 5GC are responsible to handle a service request for a slice that may or may not be available in a given area. Admission or rejection of access to a slice may depend by factors such as support for the slice, availability of resources, support of the requested service by NG-RAN.

**Support for UE associating with multiple network slices simultaneously**

- In case a UE is associated with multiple slices simultaneously, only one signalling connection is maintained and for intra-frequency cell reselection, the UE always tries to camp on the best cell. For inter-frequency cell reselection, dedicated priorities can be used to control the frequency on which the UE camps.

**Granularity of slice awareness**

- Slice awareness in NG-RAN is introduced at PDU session level, by indicating the S-NSSAI corresponding to the PDU Session, in all signalling containing PDU session resource information.

**Validation of the UE rights to access a network slice**

- It is the responsibility of the 5GC to validate that the UE has the rights to access a network slice. Prior to receiving the Initial Context Setup Request message, the NG-RAN may be allowed to apply some provisional/local policies, based on awareness of which slice the UE is requesting access to. During the initial context setup, the NG-RAN is informed of the slice for which resources are being requested.

*Next Modified Subclause*

### 16.3.3 Resource Isolation and Management

#### 16.3.3.1 General

Resource isolation enables specialized customization and avoids one slice affecting another slice.

Hardware/software resource isolation is up to implementation. Each slice may be assigned with either shared, prioritized or dedicated radio resource up to RRM implementation and SLA as in TS 28.541 [xx].

To enable differentiated handling of traffic for network slices with different SLA:

- NG-RAN is configured with a set of different configurations for different network slices by OAM;

- To select the appropriate configuration for the traffic for each network slice, NG-RAN receives relevant information indicating which of the configurations applies for this specific network slice.

Slice specific RACH configuration for RA isolation and prioritization can be included in SIB1 messages. The slice specific RACH configurations are associated to specific slice groups, and if not provided for a slice or slice group that UE considers for selecting the RACH configuration, then the UE does not consider the slice(s) for selecting the slice specific RACH configuration, i.e., the UE uses the common RACH configuration. In the UE, NAS provides the slice group to be considered during RA to AS.

Editor's Note: Details of slice grouping and how it is provided to the UE are FFS, depends on SA2.

*New Subclause*

#### 16.3.3.X Handling of Slice Resources

The NG-RAN node may use Multi-Carrier Resource Sharing or Resource Repartitioning to allocate resources to a slice during the procedures described in 16.3.4 to support the slice service continuity in case of slice resources shortage.

In Multi-Carrier Resource Sharing the RAN node can setup the dual connectivity or carrier aggregation with different frequency and overlapping coverage where the same slice is available.

The Resource Repartitioning allows a slice to use resources from the shared pool or/and prioritized pool when its own dedicated or prioritized resources are not available and the use of unused resources in the prioritized pool is as specified in TS 28.541 [xx].

Slice RRM policies/restrictions associated with Resource Repartitioning are configured from O&M.

Measurements of RRM policy utilization according to resource types defined in TS 28.541 [xx] are reported from RAN nodes to O&M and may lead O&M to update the configuration of the Slice RRM policies/restrictions.

*New Subclause (to be added between 16.3.3 and 16.3.4)*

### 16.3.X Slice aware cell reselection

Slice specific cell reselection information can be included in SIB messages and in *RRCRelease* message. The slice specific cell reselection information provides information about the frequencies where slice group(s) are supported. It may include reselection priorities per slice group per frequency and corresponding list(s) of cells where the slice group(s) are supported or not supported. In the UE, NAS provides the slice(s) or slice group(s) and their priorities to be considered during cell reselection.

When a UE supports slice aware cell reselection, and when slice specific cell reselection information is provided to the UE, then the UE uses the slice specific cell reselection information. Valid cell reselection information provided in *RRCRelease* always has a priority over cell reselection information provided in SIB messages. When no slice specific reselection information is provided for any slice or slice group that UE AS received from NAS to be considered during cell reselection, then the UE uses the general cell reselection information, i.e., without considering the slice priorities.

Editor's Note: Details of slice grouping and how it is provided to the UE are FFS, depends on SA2.

*End of Changes*