**SA WG2 Meeting #S2-140E S2-200xxxx**

**19 August - 2 September, 2020, Electronic (revision of S2-20xxxxx)**

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| *CR-Form-v12.0* |
| **CHANGE REQUEST** |
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|  | **23.501** | **CR** |  | **rev** | **-** | **Current version:** | **16.5.1** |  |
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| *For* ***HE******LP*** *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 |  | Radio Access Network |  | Core Network | **X** |

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|  |
| ***Title:***  | Addressing wording comments from IEEE LS response on TSN support  |
|  |  |
| ***Source to WG:*** | Ericsson |
| ***Source to TSG:*** | SA2 |
|  |  |
| ***Work item code:*** | Vertical\_LAN |  | ***Date:*** | 2020-07-27 |
|  |  |  |  |  |
| ***Category:*** | **F** |  | ***Release:*** | Rel-16 |
|  | *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. | *Use one of the following releases:Rel-8 (Release 8)Rel-9 (Release 9)Rel-10 (Release 10)Rel-11 (Release 11)Rel-12 (Release 12)Rel-13 (Release 13)Rel-14 (Release 14)Rel-15 (Release 15)Rel-16 (Release 16)* |
|  |  |
| ***Reason for change:*** | The LS response from IEEE 802.1 task group includes a number of editorial or wording comments, which are addressed in this CR in order to have a clear specification and prevent inconsistencies and misalignment with IEEE.Note that “TSN working domain” corresponds to the “gPTP domain” as defined in clause 3 of TS 23.501. Therefore the suggestion from IEEE LS to replace TSN working domain to gPTP domain was not followed. |
|  |  |
| ***Summary of change:*** | Wording changes as proposed or pointed out in the IEEE LS response. |
|  |  |
| ***Consequences if not approved:*** | Comments from IEEE remain unaddressed, leading to unclear specification, misalignment with IEEE specifications or inconsistencies.  |
|  |  |
| ***Clauses affected:*** | 2, 4.4.8.1, 4.4.8.2, 5.8.2.5.3, 5.27.0, 5.27.1.1, 5.27.1.2.2, 5.27.1.3, 5.27.1a, 5.27.5, 5.28.1, 5.28.4, 5.33.2.1, F |
|  |  |
|  | **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:*** |  |

**\* \* \* \* Start of Change \* \* \* \***

# 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 22.261: "Service requirements for next generation new services and markets; Stage 1".

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

[4] 3GPP TS 23.203: "Policies and Charging control architecture; Stage 2".

[5] 3GPP TS 23.040: "Technical realization of the Short Message Service (SMS); Stage 2".

[6] 3GPP TS 24.011: "Point-to-Point (PP) Short Message Service (SMS) support on mobile radio interface: Stage 3".

[7] IETF RFC 7157: "IPv6 Multihoming without Network Address Translation".

[8] IETF RFC 4191: "Default Router Preferences and More-Specific Routes".

[9] IETF RFC 2131: "Dynamic Host Configuration Protocol".

[10] IETF RFC 4862: "IPv6 Stateless Address Autoconfiguration".

[11] ITU‑T Recommendation I.130: "Method for the characterization of telecommunication services supported by an ISDN and network capabilities of an ISDN".

[12] ITU‑T Recommendation Q.65: "The unified functional methodology for the characterization of services and network capabilities".

[13] 3GPP TS 24.301: "Non-Access-Stratum (NAS) protocol for Evolved Packet System (EPS): Stage 3".

[14] IETF RFC 3736: "Stateless DHCP Service for IPv6".

[15] 3GPP TS 23.228: "IP Multimedia Subsystem (IMS); Stage 2".

[16] 3GPP TS 22.173: "IMS Multimedia Telephony Service and supplementary services; Stage 1".

[17] 3GPP TS 23.122: "Non-Access-Stratum (NAS) functions related to Mobile Station in idle mode".

[18] 3GPP TS 23.167: "3rd Generation Partnership Project; Technical Specification Group Services and Systems Aspects; IP Multimedia Subsystem (IMS) emergency sessions".

[19] 3GPP TS 23.003: "Numbering, Addressing and Identification".

[20] IETF RFC 7542: "The Network Access Identifier".

[21] 3GPP TS 23.002: "Network Architecture".

[22] 3GPP TS 23.335: "User Data Convergence (UDC); Technical realization and information flows; Stage 2".

[23] 3GPP TS 23.221: "Architectural requirements".

[24] 3GPP TS 22.153: "Multimedia priority service".

[25] 3GPP TS 22.011: "Service Accessibility".

[26] 3GPP TS 23.401: "General Packet Radio Service (GPRS) enhancements for Evolved Universal Terrestrial Radio Access Network (E-UTRAN) access".

[27] 3GPP TS 38.300: "NR; NR and NG-RAN Overall Description".

[28] 3GPP TS 38.331: "NR; Radio Resource Control (RRC); Protocol Specification".

[29] 3GPP TS 33.501: "Security architecture and procedures for 5G system".

[30] 3GPP TS 36.300: "Evolved Universal Terrestrial Radio Access (E-UTRA) and Evolved Universal Terrestrial Radio Access Network (E-UTRAN); Overall description; Stage 2".

[31] 3GPP TS 37.340: "Evolved Universal Terrestrial Radio Access (E-UTRA) and NR; Multi-connectivity; Stage 2".

[32] 3GPP TS 23.214: "Architecture enhancements for control and user plane separation of EPC nodes; Stage 2".

[33] 3GPP TS 22.101: "3rd Generation Partnership Project; Technical Specification Group Services and Systems Aspects; Service aspects; Service principles".

[34] 3GPP TS 38.413: "NG-RAN; NG Application Protocol (NGAP)".

[35] 3GPP TS 33.126: "Lawful Interception Requirements".

[36] 3GPP TS 23.682: "Architecture enhancements to facilitate communications with packet data networks and applications".

[37] 3GPP TS 22.280: "Mission Critical Services Common Requirements (MCCoRe); Stage 1".

[38] 3GPP TS 23.379: "Functional architecture and information flows to support Mission Critical Push To Talk (MCPTT); Stage 2".

[39] 3GPP TS 23.281: "Functional architecture and information flows to support Mission Critical Video (MCVideo); Stage 2".

[40] 3GPP TS 23.282: "Functional architecture and information flows to support Mission Critical Data (MCData); Stage 2".

[41] 3GPP TS 32.240: "Charging management; Charging architecture and principles".

[42] 3GPP TS 38.401: "NG-RAN Architecture description".

[43] 3GPP TS 23.402: "Architecture enhancements for non-3GPP accesses".

[44] IETF RFC 4960: "Stream Control Transmission Protocol".

[45] 3GPP TS 23.503: "Policy and Charging Control Framework for the 5G System".

[46] 3GPP TS 23.041: "Public Warning System".

[47] 3GPP TS 24.501: "Non-Access-Stratum (NAS) protocol for 5G System (5GS); Stage 3".

[48] 3GPP TS 24.502: "Access to the 5G System (5GS) via non-3GPP access networks; Stage 3".

[49] 3GPP TS 29.500: "5G System; Technical Realization of Service Based Architecture; Stage 3".

[50] 3GPP TS 38.304: "NR; User Equipment (UE) procedures in idle mode".

[51] 3GPP TS 36.331: "Evolved Universal Terrestrial Radio Access (E-UTRA); Radio Resource Control (RRC); Protocol specification".

[52] 3GPP TS 36.304: "Evolved Universal Terrestrial Radio Access (E-UTRA); User Equipment (UE) procedures in idle mode".

[53] Void.

[54] IETF RFC 4861: "Neighbor Discovery for IP version 6 (IPv6)".

[55] 3GPP TS 23.271: "Functional stage 2 description of Location Services (LCS)".

[56] 3GPP TS 23.060: "General Packet Radio Service (GPRS); Service description; Stage 2".

[57] IETF RFC 4555: "IKEv2 Mobility and Multihoming Protocol (MOBIKE)".

[58] 3GPP TS 29.510: "5G System: Network function repository services; Stage 3".

[59] 3GPP TS 29.502: "5G System: Session Management Services: Stage 3".

[60] IETF RFC 7296: "Internet Key Exchange Protocol Version 2 (IKEv2) ".

[61] 3GPP TS 23.380: "IMS Restoration Procedures".

[62] 3GPP TS 24.229: "IP multimedia call control protocol based on Session Initiation Protocol (SIP) and Session Description Protocol (SDP); Stage 3".

[63] 3GPP TS 23.292: "IP Multimedia Subsystem (IMS) centralized services; Stage 2".

[64] 3GPP TS 23.222: "Functional architecture and information flows to support Common API Framework for 3GPP Northbound APIs".

[65] 3GPP TS 29.244: "Interface between the Control Plane and the User Plane Nodes; Stage 3".

[66] 3GPP TS 32.421: "Telecommunication management; Subscriber and equipment trace; Trace concepts and requirements".

[67] 3GPP TS 32.290: "5G system; Services, operations and procedures of charging using Service Based Interface (SBI)".

[68] 3GPP TS 32.255: "5G Data connectivity domain charging; Stage 2".

[69] 3GPP TS 38.306: "NR; User Equipment -UE) radio access capabilities".

[70] 3GPP TS 36.306: "Evolved Universal Terrestrial Radio Access -E-UTRA); User Equipment -UE) radio access capabilities".

[71] 3GPP TS 29.518: "5G System; Access and Mobility Management Services; Stage 3".

[72] 3GPP TS 23.285: "Architecture enhancements for V2X services".

[73] IETF RFC 2865: "Remote Authentication Dial In User Service (RADIUS)".

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[75] 3GPP TS 29.281: "General Packet Radio System (GPRS) Tunnelling Protocol User Plane (GTPv1-U)".

[76] 3GPP TS 26.238: "Uplink streaming".

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[78] International Telecommunication Union (ITU), Standardization Bureau (TSB): "Operational Bulletin No. 1156"; http://handle.itu.int/11.1002/pub/810cad63-en (retrieved October 5, 2018).

[79] 3GPP TS 28.533: "Management and orchestration; Architecture framework".

[80] 3GPP TS 24.250: "Protocol for Reliable Data Service; Stage 3".

[81] IETF RFC 8684: "TCP Extensions for Multipath Operation with Multiple Addresses".

 [82] draft-ietf-tcpm-converters-14: "0-RTT TCP Convert Protocol".

Editor's note: The above document cannot be formally referenced until it is published as an RFC.

[83] IEEE 802.1CB-2017: "IEEE Standard for Local and metropolitan area networks-Frame Replication and Elimination for Reliability".

[84] 3GPP TS 23.316: "Wireless and wireline convergence access support for the 5G System (5GS)".

[85] WiFi Alliance Technical Committee, Hotspot 2.0 Technical Task Group: "Hotspot 2.0 (Release 2) Technical Specification".

[86] 3GPP TS 23.288: "Architecture enhancements for 5G System (5GS) to support network data analytics services".

[87] 3GPP TS 23.273: "5G System (5GS) Location Services (LCS); Stage 2".

[88] 3GPP TS 23.216: "Single Radio Voice Call Continuity (SRVCC); Stage 2".

[89] CableLabs DOCSIS MULPI: "Data-Over-Cable Service Interface Specifications DOCSIS 3.1, MAC and Upper Layer Protocols Interface Specification".

[90] BBF TR-124 issue 5: "Functional Requirements for Broadband Residential Gateway Devices".

[91] BBF TR-101 issue 2: "Migration to Ethernet-Based Broadband Aggregation".

[92] BBF TR-178 issue 1: "Multi-service Broadband Network Architecture and Nodal Requirements".

[93] BBF WT-456: "AGF Functional Requirements".

[94] BBF WT-457: "FMIF Functional Requirements".

Editor's note: The references to BBF WT-456 and WT-457 will be revised when finalized by BBF.

[95] IEEE Std 802.1Qcc-2018: "IEEE Standard for Local and metropolitan area networks - Bridges and Bridged Networks – Amendment 31: Stream Reservation Protocol (SRP) Enhancements and Performance Improvements".

[96] Void.

[97] IEEE Std 802.1AB-2016: "IEEE Standard for Local and metropolitan area networks -- Station and Media Access Control Connectivity Discovery".

[98] IEEE Std 802.1Q-2018: "IEEE Standard for Local and metropolitan area networks--Bridges and Bridged Networks".

[99] 3GPP TS 38.423: "NG-RAN; Xn Application Protocol (XnAP)".

[100] 3GPP TS 36.413: "Evolved Universal Terrestrial Radio Access Network (E-UTRAN); S1 Application Protocol (S1AP)".

[101] 3GPP TS 29.274: "Evolved General Packet Radio Service (GPRS) Tunnelling Protocol for Control plane (GTPv2-C); Stage 3".

[102] 3GPP TS 23.632: "User Data Interworking, Coexistence and Migration; stage 2".

[103] 3GPP TS 29.563: "5G System (5GS); HSS services for interworking with UDM; Stage 3".

[104] IEEE Std 802.1AS-2020: "IEEE Standard for Local and metropolitan area networks--Timing and Synchronization for Time-Sensitive Applications".

[105] 3GPP TS 22.104: "Service requirements for cyber-physical control applications in vertical domains".

[106] IEEE Std 802.11-2012: "IEEE Standard for Information technology - Telecommunications and information exchange between systems - Local and metropolitan area networks - Specific requirements - Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications".

[107] IEEE 1588-2019: "IEEE Standard for a Precision Clock Synchronization Protocol for Networked Measurement and Control".

[108] 3GPP TS 28.552: "Management and orchestration; 5G performance measurements".

[109] 3GPP TS 24.193: "Access Traffic Steering, Switching and Splitting; Stage 3".

[110] 3GPP TS 24.526: "User Equipment (UE) policies for 5G System (5GS); Stage 3".

[111] 3GPP TS 22.186: "Enhancement of 3GPP support for V2X scenarios; Stage 1".

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[113] IEEE: "Guidelines for Use of Extended Unique Identifier (EUI), Organizationally Unique Identifier (OUI), and Company ID (CID)", https://standards.ieee.org/content/dam/ieee-standards/standards/web/documents/tutorials/eui.pdf.

[114] 3GPP TS 32.256: "Charging Management; 5G connection and mobility domain charging; Stage 2".

[115] 3GPP TS 33.210: "Network Domain Security (NDS); IP network layer security".

[116] 3GPP TS 38.415: "PDU Session User Plane Protocol".

[117] 3GPP TS 24.535: "Device-side Time-Sensitive Networking (TSN) Translator (DS-TT) to network-side TSN Translator (NW-TT) protocol aspects; Stage 3".

[118] 3GPP TS 32.274: "Charging Management; Short Message Service (SMS) charging".

[119] 3GPP TS 23.008: "Organization of subscriber data".

[120] 3GPP TS 38.314: "NR; Layer 2 measurements".

[121] 3GPP TS 23.287: "Architecture enhancements for 5G System (5GS) to support Vehicle-to-Everything (V2X) services".

[122] 3GPP TS 29.503: "5G System; Unified Data Management Services; Stage 3".

**\* \* \* \* Next Change \* \* \* \***

### 4.4.8 Time Sensitive Communication

#### 4.4.8.1 General

The 5G System is extended to support time-sensitive communication as defined in IEEE 802.1 Time-Sensitive Networking (TSN) standards .

This Release of the specification supports integration of 5G System with TSN networks that are based on IEEE 802.1 TSN networks that apply the fully centralized configuration model (IEEE Std 802.1Qcc [95]). IEEE 802.1 TSN is a set of standards to define mechanisms for the time-sensitive (i.e. deterministic) transmission of data over Ethernet networks.

**\* \* \* \* Next Change \* \* \* \***

#### 4.4.8.2 Architecture to support Time Sensitive Communication

The 5G System is integrated with the external network as a TSN bridge. This "logical" TSN bridge (see Figure 4.4.8.2-1) includes TSN Translator functionality for interoperation between TSN System and 5G System both for user plane and control plane. 5GS TSN translator functionality on user plane consists of Device-side TSN translator (DS-TT) and Network-side TSN translator (NW-TT). The TSN AF is the component of the AF that provides the control plane functionality for the integration of the 5GS to a TSN network, e.g., the interactions with the CNC. 5G System specific procedures in 5GC and RAN, wireless communication links, etc. remain hidden from the TSN network. To achieve such transparency to the TSN network and the 5GS to appear as any other TSN Bridge, the 5GS provides TSN ingress and egress ports via DS-TT and NW-TT. DS-TT and NW-TT optionally support:

- hold and forward functionality for the purpose of de-jittering;

- per-stream filtering and policing as defined in IEEE 802.1Q [98] clause 8.6.5.1.

DS-TT optionally supports link layer connectivity discovery and reporting as defined in IEEE 802.1AB [97] for discovery of Ethernet devices attached to DS-TT. NW-TT supports link layer connectivity discovery and reporting as defined in IEEE 802.1AB [97] for discovery of Ethernet devices attached to NW-TT. If a DS-TT does not support link layer connectivity discovery and reporting, then NW-TT performs link layer connectivity discovery and reporting as defined in IEEE 802.1AB [97] for discovery of Ethernet devices attached to DS-TT on behalf of DS-TT.

NOTE 1: If NW-TT performs link layer connectivity discovery and reporting on behalf of DS-TT, it is assumed that LLDP frames are transmitted between NW-TT and UE on the default QoS Flow. Alternatively, SMF can establish a dedicated QoS Flow matching on the Ethertype defined for LLDP (IEEE 802.1AB [97]).

There are three TSN configuration models defined in IEEE P802.1Qcc [95]. Amongst the three models:

- fully centralized model is supported in this release of the specification;

- fully distributed model is not supported in this release of the specification;

- centralized network/distributed user model model is not supported in this Release of the specification.

NOTE 2: This release supports interworking with TSN using IEEE 802.1Q [98] clause 8.6.8.4 scheduled traffic and IEEE 802.1Q [98] clause 8.6.5.1 per-stream filtering and policy.



Figure 4.4.8.2-1: System architecture view with 5GS appearing as TSN bridge

NOTE 3: Whether DS-TT and UE are combined or are separate is up to implementation.

**\* \* \* \* Next Change \* \* \* \***

##### 5.8.2.5.3 Support of Ethernet PDU Session type

When configuring an UPF acting as PSA for an Ethernet PDU Session Type, the SMF may instruct the UPF to route the traffic based on detected MAC addresses as follows.

- The UPF learns the MAC address(es) connected via N6 based on the source MAC addresses of the DL traffic received on a N6 Network Instance.

- The UPF learns the MAC address(es) of UE(s) and devices conncted behind, if any, based on the source MAC address contained within the UL traffic received on a PDU Session (N3/N9 interface).

- The UPF forwards DL unicast traffic (with a known destination address) on a PDU Session determined based on the source MAC address(es) used by the UE for the UL traffic.

- The UPF forwards UL unicast traffic (with a known destination address) on a port (PDU Session or N6 interface) determined based on the source MAC address(es) learned beforehand.

- In the case of multicast and broadcast traffic (if the destination MAC address is a broadcast or multicast address):- for DL traffic received by UPF on a N6 Network Instance the UPF should forward the traffic to every DL PDU Session (corresponding to any N4 Session) associated with this Network Instance

- for uplink traffic received by UPF over a PDU session on a N3/N9 interface, the UPF should forward the traffic to the N6 interface and downlink to every PDU session (except toward the one of the incoming traffic) associated with the same N6 Network Instance

- for uplink and downlink unicast traffic received by UPF, if the destination MAC has not been learnt, the UPF should forward the traffic to every PDU session associated with the same N6 Network Instance and towards the N6 interface. In any case the traffic is not replicated on the PDU Session or the N6 interface of the incoming traffic.

NOTE 1: The UPF can consider a PDU Session or a N6 interface to be active or inactive in order to avoid forwarding loops. User data traffic is not sent on inactive PDU sessions or inactive N6 interface. This release of the specification does not further specify how the UPF determines whether a PDU Session or N6 interface is considered active or inactive.

NOTE 2: This release of the specification supports only a single N6 interface in a UPF associated with the N6 Network Instance.

- if the traffic is received with a VLAN ID, the above criteria apply only towards the N6 interface or PDU session matching the same VLAN ID, unless the UPF is instructed to remove the VLAN ID in the incoming traffic.

- if the destination MAC address of traffic refers to the same N6 interface or PDU session on which the traffic has been received, the frame shall be dropped.

In order to handle scenarios where a device behind a UE is moved from one UE to another UE, a MAC address is considered as no longer associated with a UPF interface when the MAC address has not been detected as Source MAC address in UL traffic for a pre-defined period of time or it has been detected under a different interface (PDU Session or N6).

For ARP/IPv6 Neighbour Solicitation traffic, a SMF's request to respond to ARP/IPv6 Neighbour Solicitation based on local cache information or to redirect such traffic from the UPF to the SMF overrules the traffic forwarding rules described above.

NOTE 3: Local policies in UPF associated with the Network Instance can prevent local traffic switching in the UPF between PDU Sessions either for unicast traffic only or for any traffic. In the case where UPF policies prevent local traffic switching for any traffic (thus for broadcast/multicast traffic) some mechanism such as responding to ARP/ND based on local cache information or local multicast group handling is needed to ensure that upper layer protocol can run on the Ethernet PDU sessions.

The SMF may ask to get notified with the source MAC addresses used by the UE.

In order to request the UPF to act as defined above, the SMF may, for each PDU Session corresponding to a Network Instance, set an Ethernet PDU Session Information in a DL PDR that identifies all (DL) Ethernet packets matching the PDU session. Alternatively, for unicast traffic the SMF may provide UPF with dedicated forwarding rules related with MAC addresses notified by the UPF.

**\* \* \* \* Next Change \* \* \* \***

### 5.27.0 General

This clause describes 5G System features that support TSC and allow the 5G System to be integrated transparently as a bridge in an IEEE 802.1 TSN network.

During the PDU Session establishment, the UE shall request to establish a PDU Session as an always-on PDU Session, and the PDU Sessions used for TSC are established as Always-on PDU session as described in clause 5.6.13. In this release of the specification:

- Home Routed PDU Sessions are not supported for TSC services;

- TSC PDU Sessions are supported only with PDU Session type Ethernet and SSC mode 1;

- Service continuity for TSC PDU Sessions is not supported when the UE moves from 5GS to EPS.

**\* \* \* \* Next Change \* \* \* \***

#### 5.27.1.1 General

For supporting TSN time synchronization, the 5GS is integrated with the external network as a TSN bridge as described in clauses 4.4.8 and 5.28.1. It shall be modelled as an IEEE 802.1AS [104] compliant entity according to TS 22.104 [105]. For TSN time synchronization, the entire E2E 5G system can be considered as an IEEE 802.1AS [104] "time-aware system". Only the TSN Translators (TTs) at the edges of the 5G system need to support the IEEE 802.1AS [104] operations. UE, gNB, UPF, NW-TT and DS- TTs are synchronized with the 5G GM (i.e. the 5G internal system clock) which shall serve to keep these network elements synchronized. The TTs located at the edge of 5G system fulfil all functions related to IEEE 802.1AS [104], e.g. gPTP support, timestamping, Best Master Clock Algorithm (BMCA), rateRatio. Figure 5.27.1-1 illustrates the 5G and TSN grandmaster (TSN GM) clock distribution model via 5GS.



Figure 5.27.1-1: 5G system is modelled as IEEE 802.1AS compliant time aware system for supporting TSN time synchronization

Figure 5.27.1-1 depicts the two synchronizations systems considered: the 5GS synchronization and the TSN domain synchronization, as well as the Master (M) and Slave (S) ports considered when the TSN GM is located at TSN working domain.

- 5GS synchronization: Used for NG RAN synchronization. 5G RAN synchronization is specified in TS 38.331 [28].

- TSN domain synchronization: Provides synchronization service to TSN network. This process follows IEEE 802.1AS [104].

The two synchronization processes can be considered independent from each other and the gNB only needs to be synchronized to the 5G GM clock.

To enable TSN domain synchronization, the 5GS calculates and adds the measured residence time between the TTs into the Correction Field (CF) of the synchronization packets of the TSN working domain.

**\* \* \* \* Next Change \* \* \* \***

#####  5.27.1.2.2 Distribution of TSN grandmaster clock and time-stamping

The mechanisms for distribution of TSN GM clock and time-stamping described in this clause are according to IEEE 802.1AS [104].

Upon reception of a downlink gPTP message the NW-TT makes an ingress timestamping (TSi) for each gPTP event (Sync) message and uses the cumulative rateRatio received inside the gPTP message payload (carried within Sync message for one-step operation or Follow\_up message for two-step operation) to calculate the link delay from the upstream TSN node (gPTP entity) expressed in TSN GM time as specified in IEEE 802.1AS [104]. NW-TT then calculates the new cumulative rateRatio (i.e. the cumulative rateRatio of the 5GS) as specified in IEEE 802.1AS [104] and modifies the gPTP message payload (carried within Sync message for one-step operation or Follow\_up message for two-step operation) as follows:

- Adds the link delay from the upstream TSN node in TSN GM time to the correction field.

- Replaces the cumulative rateRatio received from the upstream TSN node with the new cumulative rateRatio.

- Adds TSi in the Suffix field of the gPTP packet as described in Annex H.

UPF then forwards the gPTP message from TSN network to the UEs via all PDU sessions terminating in this UPF that the UEs have established to the TSN network. All gPTP messages are transmitted on a QoS Flow that complies with the residence time upper bound requirement specified in IEEE 802.1AS [104].

NOTE: The sum of the UE-DS-TT residence time and the PDB of the QoS Flow needs to be lower than the residence time upper bound requirement for a time-aware system specified in IEEE 802.1AS [104].

A UE receives the gPTP messages and forwards them to the DS-TT. The DS-TT then creates egress timestamping (TSe) for the gPTP event (Sync) messages for external TSN working domains. The difference between TSi and TSe is considered as the calculated residence time spent within the 5G system for this gPTP message expressed in 5GS time. The DS-TT then uses the rateRatio contained inside the gPTP message payload (carried within Sync message for one-step operation or Follow\_up message for two-step operation) to convert the residence time spent within the 5GS in TSN GM time and modifies the payload of the gPTP message that it sends towards the downstream TSN node as follows:

- Adds the calculated residence time expressed in TSN GM time to the correction field.

- Removes TSi from the Suffix field.

**\* \* \* \* Next Change \* \* \* \***

#### 5.27.1.3 Support for multiple TSN working domains

Each TSN working domain sends its own gPTP messages. The related Ethernet frames carry the gPTP multicast Ethernet destination MAC address and the gPTP message carries a specific PTP "domainNumber" that indicates the time domain they are referring to. The NW-TT makes ingress timestamping (TSi) for the gPTP event messages of all domains and forwards the gPTP messages of all domains to the UEs as specified in clause 5.27.1.2.2.

A UE receives gPTP messages and forwards them all to the DS-TT. The DS-TT receives the original TSN GM clock timing information and the corresponding TSi via gPTP messages for one or more TSN working domains. The DS-TT then makes egress timestamping (TSe) for the gPTP event messages for every external TSN working domain. Ingress and egress time stamping are based on the 5G system clock at NW-TT and DS-TT.

NOTE 1: An end-station can select TSN timing information of interest based on the "domainNumber" in the gPTP message.

The process described in clause 5.27.1.2.2 is thus repeated for each TSN working domain between a DS-TT and the NW-TT it is connected to.

NOTE 2: If all TSN working domains can be made synchronous and the synchronization can be provided by the 5G clock, the NW-TT output ports towards the connected TSN networks propagate the 5G clock via gPTP messages (i.e. the 5G system acts as an IEEE 802.1AS [104] compliant time-aware system, and in this case is the grandmaster for all the TSN working domains).

NOTE 3: This Release of specification supports multiple TSN working domains, and the TSN AF does not participate in the gPTP time synchronization process. If the 5GS supports transmission gates or the stream gates (scheduled traffic or per-stream filtering and policing, respectively in IEEE 802.1Q [98]), then they operate based on a single given TSN working domain.

**\* \* \* \* Next Change \* \* \* \***

### 5.27.1a Periodic deterministic QoS

This feature allows the 5GS to support periodic deterministic communication where the traffic characteristics are known a-priori, and a schedule for transmission from the UE to a downstream node, or from the UPF to an upstream node is provided via external protocols outside the scope of 3GPP (e.g. IEEE 802.1 TSN).

The features include the following:

- Providing TSC Assistance Information (TSCAI) that describe TSC flow traffic patterns at the gNB ingress and UE egress interfaces for traffic in downlink and uplink direction, respectively;

- Support for hold & forward buffering mechanism (see clause 5.27.4) in DS-TT and NW-TT to de-jitter flows that have traversed the 5G System.

**\* \* \* \* Next Change \* \* \* \***

### 5.27.3 Support for TSC QoS Flows

TSC QoS Flows use a Delay Critical GBR resource type and TSC Assistance Information. TSC QoS Flows may use standardized 5QIs, pre-configured 5QIs or dynamically assigned 5QI values (which requires signalling of QoS characteristics as part of the QoS profile) as specified in clause 5.7.2. For each instance of Periodicity, within each Period (defined by periodicity value), TSC QoS Flows are required to transmit only one burst of maximum size MDBV within the 5G-AN PDB. Known QoS Flow traffic characteristics provided in the TSCAI may be used to optimize scheduling in the 5GS.

The following is applicable for the QoS profile defined for TSC QoS Flows:

1. The TSC Burst Size may be used to set the MDBV as follows:

 The maximum TSC Burst Size is considered as the largest amount of data within a time period that is equal to the value of 5G-AN PDB of the 5QI that was set for this traffic class. The maximum value of TSC Burst Size should be mapped to a 5QI with MDBV that is equal or higher. This 5QI also shall have a PDB value that satisfies the bridge delay capabilities (see clause 5.27.5 for more details) reported for the corresponding traffic class. For TSC QoS Flows, the Maximum Burst Size of the aggregated TSC streams to be allocated to this QoS Flow can be similarly mapped to a 5QI with MDBV value that is equal or higher, and the PDB of this 5QI shall also satisfy the bridge delay capabilities reported.

2. The PDB is explicitly divided into 5G-AN PDB and CN PDB as described in clause 5.7.3.4. Separate delay budgets are necessary for calculation of expected packet transmit times on 5G System interfaces. For the TSC QoS Flow, the5G-AN PDB is set to value of 5QI PDB minus the CN PDB as described in clause 5.7.3.4. The CN PDB may be static value or dynamic value and is up to the implementation of 5GS bridge.

3. The Maximum Flow Bitrate calculated by the TSN AF as per Annex I.1 may be used to set GFBR.

4. ARP is set to a pre-configured value.

**\* \* \* \* Next Change \* \* \* \***

### 5.27.5 5G System Bridge delay

In order for the 5G System to participate as a TSN bridge according to transmission gate schedules specified, the 5GS Bridge is required to provide Bridge Delays as defined in IEEE 802.1Qcc [95] for each port pair and traffic class of the 5GS bridge to an IEEE 802.1 TSN system. In order to determine 5GS Bridge Delays, the following components are needed:

1. UE-DS-TT Residence Time: the time taken within the UE and DS-TT to forward a packet between the UE and DS-TT port. UE-DS-TT Residence Time is provided at the time of PDU Session Establishment by the UE to the network.

NOTE 1: UE-DS-TT Residence Time is the same for uplink and downlink traffic and applies to all traffic classes.

2. Per traffic class minimum and maximum delays between the UE and the UPF/NW-TT that terminates the N6 interface (including UPF and NW-TT residence times), independent of frame length that a given 5GS deployment supports. The per-traffic class delays between the UE and the UPF/NW-TT are pre-configured in the TSN AF (see clause 5.28.4).

The TSN AF calculates the 5GS independentDelayMin and independentDelayMax values for each port pair and for each traffic class using the above components.

The dependentDelayMin and dependentDelayMax for 5GS Bridge specify the time range for a single octet of an Ethernet frame to transfer from ingress to egress and include the time to receive and store each octet of the frame, which depends on the link speed of the ingress Port as per IEEE 802.1Qcc [95].

NOTE 2: Further details how TSN AF determines dependentDelayMin and dependentDelayMax are up to implementation.

Since Residence times may vary among UEs and per traffic class delay between the UE and the UPF/NW-TT may vary among UPFs, the 5GS Bridge Delay is determined after the PDU Session Establishment for the corresponding UPF and the UE by the TSN AF. The TSN AF deduces the related port pair(s) from the port number of the DS-TT Ethernet port and port number of the serving NW-TT Ethernet port(s) when the TSN AF receives the 5GS Bridge information for a newly established PDU Session and caculates the bridge delays per port pair.

**\* \* \* \* Next Change \* \* \* \***

### 5.28.1 5GS TSN bridge management

5GS functions acts as one or more TSN Bridges of the TSN network. The 5GS Bridge is composed of the ports on a single UPF (i.e. PSA) side, the user plane tunnel between the UE and UPF, and the ports on the DS-TT side. For each 5GS Bridge of a TSN network, the port on NW-TT support the connectivity to the TSN network, the ports on DS-TT side are associated to the PDU Session providing connectivity to the TSN network.

The granularity of the 5GS TSN bridge is per UPF. The bridge ID of the 5GS TSN bridge is bound to the UPF ID of the UPF as identified in TS 23.502 [3]. The TSN AF stores the binding relationship between a port on UE/DS-TT side and a PDU Session during reporting of 5GS TSN bridge information. The TSN AF also stores the information about ports on the UPF/NW-TT side. The UPF/NW-TT forwards traffic to the appropriate egress port based on the traffic forwarding information. From the TSN AF point of view, a 5GS TSN bridge has a single NW-TT entity within UPF and the NW-TT may have multiple ports that are used for traffic forwarding.

NOTE 1: How to realize single NW-TT entity within UPF is up to implementation.

There is only one PDU Session per DS-TT port for a given UPF. All PDU Sessions which connect to the same TSN network via a specific UPF are grouped into a single 5GS bridge. The capabilities of each port on UE/DS-TT side and UPF/NW-TT side are integrated as part of the configuration of the 5GS Bridge and are notified to TSN AF and delivered to CNC for TSN bridge registration and modification.

NOTE 2: It is assumed that all PDU sessions which connect to the same TSN network via a specific UPF are handled by the same TSN AF.



Figure 5.28.1-1: Per UPF based 5GS bridge

NOTE 3: If a UE establishes multiple PDU Sessions terminating in different UPFs, then the UE is represented by multiple 5GS TSN bridges.

In order to support TSN scheduled traffic (clause 8.6.8.4 in IEEE Std 802.1Q-2018) over 5GS Bridge, the 5GS supports the following functions:

- Configure the bridge information in 5GS.

- Report the bridge information of 5GS Bridge to TSN network after PDU session establishment.

- Receiving the configuration from TSN network as defined in clause 5.28.2.

- Map the configuration information obtained from TSN network into 5GS QoS information (e.g. 5QI, TSC Assistance Information) of a QoS Flow in corresponding PDU Session for efficient time-aware scheduling, as defined at clause 5.28.2.

The bridge information of 5GS Bridge is used by the TSN network to make appropriate management configuration for the 5GS Bridge. The bridge information of 5GS Bridge includes at least the following:

- Information for 5GS Bridge:

- Bridge ID

 Bridge ID is to distinguish between bridge instances within 5GS. The Bridge ID can be derived from the unique bridge MAC address as described in IEEE 802.1Q [98], or set by implementation specific means ensuring that unique values are used within 5GS;

- Bridge Name (Bridge Name as defined in IEEE 802.1Q [98]);

- Number of Ports;

- list of port numbers.

- Capabilities of 5GS Bridge as defined in 802.1Qcc [95]:

- 5GS Bridge delay per port pair per traffic class, including 5GS Bridge delay (dependent and independent of frame size, and their maximum and minimum values: independentDelayMax, independentDelayMin, dependentDelayMax, dependentDelayMin), ingress port number, egress port number and traffic class.

- Propagation delay per port (txPropagationDelay), including transmission propagation delay, egress port number.

- VLAN Configuration Information.

NOTE 4: This Release of the specification does not support the modification of VLAN Configuration Information at the TSN AF.

- Topology of 5GS Bridge as defined in IEEE 802.1AB [97]:

- Chassis ID subtype and Chassis ID of the 5GS Bridge.

- Traffic classes and their priorities per port as defined in IEEE 802.1Q [98].

- Stream Parameters as defined in clause 12.31.1 in IEEE 802.1Q [98], in order to support PSFP:

- MaxStreamFilterInstances: The maximum number of Stream Filter instances supported by the bridge;

- MaxStreamGateInstances: The maximum number of Stream Gate instances supported by the bridge;

- MaxFlowMeterInstances: The maximum number of Flow Meter instances supported by the bridge;

- SupportedListMax: The maximum value supported by this Bridge component of the AdminControlListLength and OperControlListLength parameters. It is available for use by schedule computation software to determine the Bridge component’s control list capacity prior to computation.

The following parameters: independentDelayMax and independentDelayMin, how to calculate them is left to implementation and not defined in this specification.

Bridge ID of the 5GS Bridge, port number(s) of the Ethernet port(s) in NW-TT could be preconfigured on the UPF. The UPF is selected for a PDU Session serving TSC as described in clause 6.3.3.3.

Port number of Ethernet port on the DS-TT for the PDU Session is assigned by the UPF during PDU session establishment. The port number of the DS-TT Ethernet port for a PDU Session shall be reported to the SMF from the UPF and further stored at the SMF. SMF provides the port number and MAC address of the Ethernet port in DS-TT of the related PDU session and port number(s) and MAC address(es) of the Ethernet port(s) in NW-TT to the TSN AF via PCF. If a PDU session for which SMF has reported port numbers to TSN AF is released, then SMF informs TSN AF accordingly.

The TSN AF is responsible to receive the bridge information of 5GS Bridge from 5GS, as well as register or update this information to the TSN network.

**\* \* \* \* Next Change \* \* \* \***

### 5.28.4 QoS mapping tables

The mapping tables between the traffic class and 5GS QoS Profile is provisioned and further used to find suitable 5GS QoS profile to transfer TSN traffic over the PDU Session. QoS mapping procedures are performed in two phases: (1) QoS capability report phase as described in clause 5.28.1, and (2) QoS configuration phase as in clause 5.28.2

(1) The TSN AF shall be pre-configured (e.g. via OAM) with a mapping table. The mapping table contains TSN traffic classes, pre-configured bridge delays (i.e. the preconfigured delay between UE and UPF/NW-TT) and priority levels. Once the PDU session has been setup and after retrieving the information related to UE-DS-TT residence time, the TSN AF deduces the port pair(s) consisting of one NW-TT port and one DS-TT port and determines the bridge delay per port pair per traffic class based on the pre-configured bridge delay and the UE-DS-TT residence time. The TSN AF updates bridge delays per port pair and traffic class and reports the bridge delays and other relevant TSN information such as the Traffic Class Table (clause 12.6.3 in IEEE Std 802.1Q) for every port, according to the IEEE 802.1Q [98] and IEEE 802.1Qcc [95] to the CNC.

(2) CNC distributes the TSN QoS requirements and transmission gate scheduling parameters to 5GS Bridge via TSN AF.

The PCF mapping table provides a mapping from TSN QoS information (see TS 23.503 [45], clauses 6.2.1.2 and 6.1.3.23) to 5GS QoS profile. Based on trigger from TSN AF, the PCF may trigger PDU session modification procedure to establish a new 5G QoS Flow or use the pre-configured 5QI for 5G QoS Flow for the requested traffic class according to the selected QoS policies and the TSN AF traffic requirements.

Figure 5.28.4-1 illustrates the functional distribution of the mapping tables.



Figure 5.28.4-1: QoS Mapping Function distribution between PCF and TSN AF

The minimum set of TSN QoS-related parameters that are relevant for mapping the TSN QoS requirements are used by the TSN AF: traffic classes and their priorities per port, TSC Burst Size of TSN streams, 5GS bridge delays per port pair and traffic class (independentDelayMax, independentDelayMin, dependentDelayMax, dependentDelayMin), propagation delay per port (txPropagationDelay) and UE-DS-TT residence time.

Once the CNC retrieves the necessary information, it proceeds to calculate scheduling and paths. The configuration information is then set in the bridge as described in clauses 5.28.2 and 5.28.3. The most relevant information received is the PSFP information and the schedule of transmission gates for every traffic class and port of the bridge. At this point, it is possible to retrieve the TSN QoS requirements by identifying the traffic class of the port. The traffic class to TSN QoS and delay requirement mapping can be performed using the QoS mapping table in the TSN AF as specified in TS 23.503 [45]. Subsequently in the PCF, the 5G QoS Flow can be configured by selecting a 5QI as specified in TS 23.503 [45]. This feedback approach uses the reported information to the CNC and the feedback of the configuration information coming from the CNC to perform the mapping and configuration in the 5GS.

If the Maximum Burst Size of the aggregated TSC streams in the traffic class is provided by CNC via TSN AF to PCF, PCF can derive the required MDBV taking the Maximum Burst Size as input. If the default MDBV associated with a standardized 5QI or a pre-configured 5QI in the QoS mapping table cannot satisfy the aggregated TSC Burst Size, the PCF provides the derived MDBV in the PCC rule and then the SMF performs QoS Flow binding as specified in clause 6.1.3.2.4 of TS 23.503 [45].

Maximum Flow Bit Rate is calculated over PSFPAdminCycleTime as described in Annex I and provided by the TSN AF to the PCF, while GBR is calculated over an Averaging Window for the 5QI by the PCF. The Maximum Flow Bit Rate is adjusted according to Averaging Window associated with a pre-configured 5QI in the QoS mapping table or another selected 5QI (as specified in TS 23.503 [45]) to obtain GBR of the 5GS QoS profile. GBR is then used by SMF to calculate the GFBR per QoS flow. QoS mapping table in the PCF between TSN parameters and 5GS parameters should match the delay, aggregated TSC burst size and priority, while preserving the priorities in the 5GS. An operator enabling TSN services via 5GS can choose up to eight traffic classes to be mapped to 5GS QoS profiles.

Once the 5QIs to be used for TSN streams are identified by the PCF as specified in TS 23.503 [45], then it is possible to enumerate as many bridge port traffic classes as the number of selected 5QIs.

**\* \* \* \* Next Change \* \* \* \***

#### 5.33.2.1 Dual Connectivity based end to end Redundant User Plane Paths

In order to support highly reliable URLLC services, a UE may set up two redundant PDU Sessions over the 5G network, such that the 5GS sets up the user plane paths of the two redundant PDU Sessions to be disjoint. The user's subscription indicates if user is allowed to have redundant PDU Sessions and this indication is provided to SMF from UDM.

NOTE 1: It is out of scope of 3GPP how to make use of the duplicate paths for redundant traffic delivery end-to-end. It is possible to rely on upper layer protocols, such as the IEEE 802.1 TSN (Time Sensitive Networking) FRER (Frame Replication and Elimination for Reliability) [83], to manage the replication and elimination of redundant packets/frames over the duplicate paths which can span both the 3GPP segments and possibly fixed network segments as well.

NOTE 2: The following redundant network deployment aspects are within the responsibility of the operator and are not subject to 3GPP standardization:

- RAN supports dual connectivity, and there is sufficient RAN coverage for dual connectivity in the target area.

- UEs support dual connectivity.

- The core network UPF deployment is aligned with RAN deployment and supports redundant user plane paths.

- The underlying transport topology is aligned with the RAN and UPF deployment and supports redundant user plane paths.

- The physical network topology and geographical distribution of functions also supports the redundant user plane paths to the extent deemed necessary by the operator.

- The operation of the redundant user plane paths is made sufficiently independent, to the extent deemed necessary by the operator, e.g. independent power supplies.

Figure 5.33.2.1-1 illustrates an example user plane resource configuration of dual PDU sessions when redundancy is applied. One PDU Session spans from the UE via Master NG-RAN to UPF1 acting as the PDU Session Anchor, and the other PDU Session spans from the UE via Secondary NG-RAN to UPF2 acting as the PDU Session Anchor. As described in TS 37.340 [31], NG-RAN may realize redundant user plane resources for the two PDU sessions with two NG-RAN nodes (i.e. Master NG-RAN and Secondary NG-RAN as shown in Figure 5.33.2.1-1) or a single NG-RAN node. In both cases, there is a single N1 interface towards AMF.

Based on these two PDU Sessions, two independent user plane paths are set up. UPF1 and UPF2 connect to the same Data Network (DN), even though the traffic via UPF1 and UPF2 may be routed via different user plane nodes within the DN.

In order to establish two redundant PDU sessions and associate the duplicated traffic coming from the same application to these PDU sessions, URSP or UE local configuration is used as specified in TS 23.503 [45].

NOTE 3: Using URSP, duplicated traffic from the application, associated to the redundant PDU Sessions, is differentiated by two distinct traffic descriptors, each in a distinct URSP rule. These traffic descriptors need to have different DNNs, IP descriptors or non-IP descriptors (e.g. MAC address, VLAN ID), so that the two redundant PDU sessions are matched to the Route Selection Descriptors of distinct URSP rules.

The redundant user plane set up applies to both IP and Ethernet PDU Sessions.



Figure 5.33.2.1-1: Example scenario for end to end redundant User Plane paths using Dual Connectivity

Support of redundant PDU Sessions include:

- UE initiates two redundant PDU Session and provides different combination of DNN and S-NSSAI for each PDU Session.

- The SMF determines whether the PDU Session is to be handled redundantly. The determination is based on the policies provided by PCF for the PDU Session, combination of the S-NSSAI, DNN, user subscription and local policy configuration. The SMF uses these inputs to determine the RSN which differentiates the PDU Sessions that are handled redundantly and indicates redundant user plane requirements for the PDU Sessions in NG-RAN.

- Operator configuration of UPF selection ensures the appropriate UPF selection for disjoint paths.

- At establishment of the PDU Sessions or at transitions to CM-CONNECTED state, the RSN parameter indicates to NG-RAN that redundant user plane resources shall be provided for the given PDU sessions by means of dual connectivity. The value of the RSN parameter indicates redundant user plane requirements for the PDU Sessions. This request for redundant handling is made by indicating the RSN to the NG-RAN node on a per PDU Session granularity. PDU Sessions associated with different RSN values shall be realized by different, redundant UP resources. Based on the RSN and RAN configuration, the NG-RAN sets up dual connectivity as defined in TS 37.340 [31] so that the sessions have end to end redundant paths. When there are multiple PDU Sessions with the RSN parameter set and with different values of RSN, this indicates to NG-RAN that CN is requesting dual connectivity to be set up and the user plane shall be handled as indicated by the RSN parameter and the associated RAN configuration. If the RSN value is provided to the NG-RAN, NG-RAN shall consider the RSN value when it associates the PDU Sessions with NG-RAN UP.

NOTE 4: The decision to set up dual connectivity remains in NG-RAN as defined today. NG-RAN takes into account the additional request for the dual connectivity setup provided by the CN.

- Using NG-RAN local configuration, NG-RAN determines whether the request to establish RAN resources for a PDU Session is fulfilled or not considering user plane requirements indicated by the RSN parameter by means of dual connectivity. If the request to establish RAN resources for PDU Session can be fulfilled by the RAN, the PDU Session is established even if the user plane requirements indicated by RSN cannot be satisfied. If the NG-RAN determines the request to establish RAN resources cannot be fulfilled then it shall reject the request which eventually triggers the SMF to reject the PDU Session establishment towards the UE. The decision for each PDU Session is taken independently (i.e. rejection of a PDU Session request shall not release the previously established PDU Session). The RAN shall determine whether to notify the SMF if the RAN resources indicated by the RSN parameter can no longer be maintained and SMF can use that to determine if the PDU Session should be released.

- In the case of Ethernet PDU Sessions, the SMF has the possibility to change the UPF (acting as the PSA) and select a new UPF based on the identity of the Secondary NG-RAN for the second PDU Session if the Secondary NG-RAN is modified (or added/released), using the Ethernet PDU Session Anchor Relocation procedure described in clause 4.3.5.8 of TS 23.502 [3].

- The SMF's charging record may reflect the RSN information.

- The RSN indication is transferred from Source NG-RAN to Target NG-RAN in the case of handover.

**\* \* \* \* Next Change \* \* \* \***

Annex F (informative):
Redundant user plane paths based on multiple UEs per device

This clause describes an approach to realize multiple user plane paths in the system based on a device having multiple UEs and specific network deployments.

The approach assumes a RAN deployment where redundant coverage by multiple gNBs (in the case of NR) is generally available. Upper layer protocols, such as the IEEE 802.1 TSN (Time Sensitive Networking), can make use of the multiple user plane paths.

The UEs belonging to the same terminal device request the establishment of PDU Sessions that use independent RAN and CN network resources using the mechanisms outlined below.

This deployment option has a number of preconditions:

- The redundancy framework uses separate gNBs to achieve user plane redundancy over the 3GPP system. It is however up to operator deployment and configuration whether separate gNBs are available and used. If separate gNBs are not available for a device, the redundancy framework may still be applied to provide user plane redundancy in the rest of the network as well as between the device and the gNB using multiple UEs.

- Terminal devices integrate multiple UEs which can connect to different gNBs independently.

- RAN coverage is redundant in the target area: it is possible to connect to multiple gNBs from the same location. To ensure that the two UEs connect to different gNBs, the gNBs need to operate such that the selection of gNBs can be distinct from each other (e.g. gNB frequency allocation allows the UE to connect to multiple gNBs).

- The core network UPF deployment is aligned with RAN deployment and supports redundant user plane paths.

- The underlying transport topology is aligned with the RAN and UPF deployment and supports redundant user plane paths.

- The physical network topology and geographical distribution of functions also supports the redundant user plane paths to the extent deemed necessary by the operator.

- The operation of the redundant user plane paths is made sufficiently independent, to the extent deemed necessary by the operator, e.g., independent power supplies.

Figure F-1 illustrates the architecture view. UE1 and UE2 are connected to gNB1 and gNB2, respectively and UE1 sets up a PDU Session via gNB1 to UPF1, while UE2 sets up a PDU Session via gNB2 to UPF2. UPF1 and UPF2 connect to the same Data Network (DN), but the traffic via UPF1 and UPF2 might be routed via different user plane nodes within the DN. UPF1 and UPF2 are controlled by SMF1 and SMF2, respectively.



Figure F-1: Architecture with redundancy based on multiple UEs in the device

The approach comprises the following main components shown as example using NR in figure F-2.

- **gNB selection:** The selection of different gNBs for the UEs in the same device is realized by the concept of UE Reliability Groups for the UEs and also for the cells of gNBs. By grouping the UEs in the device and cells of gNBs in the network into more than one reliability group and preferably selecting cells in the same reliability group as the UE, it is ensured that UEs in the same device can be assigned different gNBs for redundancy as illustrated in Figure F-2, where UE1 and the cells of gNB1 belong to reliability group A, and UE2 and the cells of gNB2 belong to reliability group B.



Figure F-2: Reliability group-based redundancy concept in RAN

For determining the reliability grouping of a UE, one of the following methods or a combination of them can be used:

- It could be configured explicitly to the UE and sent in a Registration Request message to the network using an existing parameter (such as an S-NSSAI in the Requested NSSAI where the SST is URLLC; the Reliability Group can be decided by the SD part).

- It could also be derived from existing system parameters (e.g., SUPI, PEI, S-NSSAI, RFSP) based on operator configuration.

The Reliability Group of each UE is represented via existing parameters and sent from the AMF to the RAN when the RAN context is established, so each gNB has knowledge about the reliability group of the connected UEs.

NOTE: An example realisation can be as follows: the UE's Allowed NSSAI can be used as input to select the RFSP index value for the UE. The RAN node uses the RFSP for RRM purposes and can based on local configuration determine the UE's Reliability Group based on the S-NSSAI in Allowed NSSAI and/or S-NSSAI for the PDU Session(s).

The reliability group of the RAN (cells of gNBs) entities are pre-configured by the O&M system in RAN. It is possible for gNBs to learn the reliability group neighbouring cells as the Xn connectivity is set up, or the reliability group of neighbouring cells are also configured into the gNBs.

In the case of connected mode mobility, the serving gNB prioritizes candidate target cells that belong to different reliability group than the UE. It follows that normally the UE is handed over only to cells in the same reliability group. If cells in the same reliability group are not available (UE is out of the coverage of cells of its own reliability group or link quality is below a given threshold) the UE may be handed over to a cell in another reliability group as well.

If the UE connects to a cell whose reliability group is different from the UE's reliability group, the gNB initiates a handover to a cell in the appropriate reliability group whenever such a suitable cell is available.

In the case of an Idle UE, it is possible to use the existing cell (re-)selection priority mechanism, with a priori UE config using dedicated signalling (in the RRCConnectionRelease message during transition from connected to idle mode) to configure the UE to reselect the cells of the appropriate reliability group for camping in deployments where the cell reliability groups use different sets of frequencies.

- **UPF selection.** UPF selection mechanisms as described in clause 6.3.3 can be used to select different UPFs for the UEs within the device. The selection may be based either on UE configuration or network configuration of different DNNs leading to the same DN, or different slices for the two UEs. It is possible to use the UE's Reliability Group, described above for gNB selection, as an input to the UPF selection. The proper operator configuration of the UPF selection can ensure that the path of the PDU Sessions of UE1 and UE2 are independent.

- **Control plane.** The approach can optionally apply different control plane entities for the individual UEs within the device. This may be achieved by using:

- different DNNs for the individual UEs within the device to select different SMFs,

- or applying different slices for the individual UEs within the device either based on UE configuration or network subscription, to select different AMFs and/or SMFs.

**\* \* \* \* End of Changes \* \* \* \***