**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 technical comments from IEEE LS response on TSN support  |
|  |  |
| ***Source to WG:*** | Ericsson |
| ***Source to TSG:*** | SA2 |
|  |  |
| ***Work item code:*** | Vertical\_LAN |  | ***Date:*** | 2020-07-13 |
|  |  |  |  |  |
| ***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:*** | 1. In connection with the NOTE in 5.28.3.1 the LS states that Static Filtering Entries seem to be only supported in one direction, i.e., uplink, but expresses that the support for static forwarding is not clarified.
2. The LS sees a mismatch that single N6 interface is supported for Ethernet while multiple NW-TT ports are supported for TSN.
3. In connection with 5.8.2.5.3 the LS states that it is unclear whether IVL or SVL is supported.
4. The term Serving NW-TT port is not specified.
5. The LS indicates that the need for DS-TT MAC address is not clear.
6. The LS indicates that the hold and forward buffering mechanism is not clear.
7. “the traffic class of the port” is not proper terminology
 |
|  |  |
| ***Summary of change:*** | 1. Clarify that this release of the specification does not support static filtering entries in the downlink direction.
2. Clarify that in this release the use of multiple NW-TT ports is implementation specific.
3. Clarify that the spec supports IVL, since the existing text points to that direction.
4. Remove the concept of Serving NW-TT port, since this is neither defined nor explained anywhere. A DS-TT port may send/receive traffic to/from any NW-TT port, so there should not be a concept of “serving” NW-TT port. The actual NW-TT port is determined by the forwarding table.
5. Clarify that this release of the specification requires a DS-TT MAC address to be assigned; that MAC address is not used for user data traffic, only for identification of the PDU Session.
6. Clarify that the this release provides the hold and forward buffering mechanism to achieve externally observable behavior identical to scheduled traffic with up to eight queues (8.6.8.4 in IEEE Std 802.1Q-2018) and with protected windows (Annex Q.2 in IEEE Std 802.1Q-2018).
7. Change “the traffic class of the port” to “the traffic class of the TSN stream” in 5.28.4.
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|  |  |
| ***Consequences if not approved:*** | Comments from IEEE remain unaddressed, leading to unclear specification, misalignment with IEEE specifications or inconsistencies.  |
|  |  |
| ***Clauses affected:*** | 5.8.2.5.3, 5.8.2.11.9, 5.8.2.11.10, 5.27.4, 5.27.2, 5.27.5, 5.28.1, 5.28.2, 5.28.3.1 |
|  |  |
|  | **Y** | **N** |  |  |
| ***Other specs*** | **X** |  |  Other core specifications  | TS/TR 23.502 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 \* \* \* \***

##### 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.

NOTE 3: This release of the specification supports Independent VLAN Learning (IVL) and does not support Shared VLAN Learning (SVL), as described in IEEE 802.1Q [98]

- 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 should 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 4: 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 \* \* \* \***

#### 5.8.2.11 Parameters for N4 session management

##### 5.8.2.11.1 General

These parameters are used by SMF to control the functionality of the UPF as well as to inform SMF about events occurring at the UPF.

The N4 session management procedures defined in clause 4.4.1 of TS 23.502 [3] will use the relevant parameters in the same way for all N4 reference points: the N4 Session Establishment procedure as well as the N4 Session Modification procedure provide the control parameters to the UPF, the N4 Session Release procedure removes all control parameters related to an N4 session, and the N4 Session Level Reporting procedure informs the SMF about events related to the PDU Session that are detected by the UPF.

The parameters over N4 reference point provided from SMF to UPF comprises an N4 Session ID and may also contain:

- Packet Detection Rules (PDR) that contain information to classify traffic (PDU(s)) arriving at the UPF;

- Forwarding Action Rules (FAR) that contain information on whether forwarding, dropping or buffering is to be applied to a traffic identified by PDR(s);

- Multi-Access Rules (MAR) that contain information on how to handle traffic steering, switching and splitting for a MA PDU Session;

- Usage Reporting Rules (URR) contains information that defines how traffic identified by PDR(s) shall be accounted as well as how a certain measurement shall be reported;

- QoS Enforcement Rules (QER), that contain information related to QoS enforcement of traffic identified by PDR(s);

- Session Reporting Rules (SRR) that contain information to request the UP function to detect and report events for a PDU session that are not related to specific PDRs of the PDU session or that are not related to traffic usage measurement.

- Trace Requirements;

- Port Management Information Container in 5GS;

- Bridge Information.

The N4 Session ID is assigned by the SMF and uniquely identifies an N4 session.

If the UPF indicated support of Trace, the SMF may activate a trace session during a N4 Session Establishment or a N4 Session Modification procedure. In that case it provides Trace Requirements to the UPF. The SMF may deactivate an on-going trace session using a N4 Session Modification procedure. There shall be at most one trace session activated per N4 Session at a time.

For the MA PDU Session, the SMF may add an additional access tunnel information during an N4 Session Modification procedure by updating MAR with addition of an FAR ID which refers to an FAR containing the additional access tunnel information for the MA PDU session for traffic steering in the UPF. For the MA PDU Session, the SMF may request Access Availability report per N4 Session, during N4 Session Establishment procedure or N4 Session Modification procedure.

A N4 Session may be used to control both UPF and NW-TT behaviour in the UPF. A N4 session support and enable exchange of TSN bridge configuration between the SMF and the UPF:

- Information that the SMF needs for bridge management (clause 5.8.2.11.9);

- Information that 5GS transparently relays between the AF the NW-TT: transparent Port Management Information Container.

When a N4 Session related with bridge management is established, the UPF allocates a dedicated port number for the DS-TT side of the PDU Session. The UPF then provides to the SMF following configuration parameters for the N4 Session:

- DS-TT port number.

After the N4 session has been established, the SMF and UPF may at any time exchange transparent bridge Port Management Information Container over a N4 session.

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

##### 5.8.2.11.9 Bridge Management Information

The following table describes the Bridge Management Information (BMI) that includes the information required to configure a 5GS logical bridge for TSC PDU Sessions.

Table 5.8.2.11.9-1: Bridge Management Information

|  |  |  |
| --- | --- | --- |
| Attribute | Description | Comment |
| NW-TT Port Number | Port Number allocated by the NW-TT  |  |
| DS-TT Port Number | Port Number allocated by the NW-TT for the DS-TT for a given TSC PDU Session |  |

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

##### 5.8.2.11.10 Port Management Information Container

The following table describes the Port Management Information Container (PMIC) that includes information exchanged transparently via 5GS between TSN AF and NW-TT.

Table 5.8.2.11.10-1: Port Management Information Container

|  |  |  |
| --- | --- | --- |
| Attribute | Description | Comment |
| Port Management Information as in Table 5.28.3.1-1 | Information exchanged transparently between NW-TT and TSN AF via 5GS |  |

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

### 5.27.2 TSC Assistance Information (TSCAI)

TSC assistance information describes TSC traffic characteristics for use in the 5G System. The knowledge of TSN traffic pattern is useful for the gNB to allow it to more efficiently schedule periodic, deterministic traffic flows either via Configured Grants, Semi-Persistent Scheduling or with dynamic grants. TSC assistance information, as defined in Table 5.27.2-1, is provided from SMF to 5G-AN, e.g. upon QoS Flow establishment. The TSCAI parameters are set according to corresponding parameters obtained from the TSN AF. The TSN AF identifies the PDU session as described in clause 5.28.2. This release of the specification TSCAI is provided assuming constant bit rate periodic TSC traffic where periodic means that the traffic is repeating continuously, with a constant time (the period) between each occurrence, and there is a single burst of back-to-back packets in each period.

The TSN AF is responsible for obtaining PSFP (IEEE 802.1Q [98]) parameters and use them to calculate traffic pattern parameters (such as burst arrival time with reference to the ingress port, periodicity, and flow direction) and responsible of forwarding these parameters in TSC Assistance Container to the SMF (via PCF). TSN AF may enable aggregation of TSN streams if the TSN streams belong to the same traffic class, terminate in the same egress port and have the same periodicity and compatible Burst arrival time. One set of parameters and one container are being calculated by the AF for multiple TSN streams to enable aggregation of TSN streams to the same QoS Flow.

Annex I describe how the traffic pattern information is determined.

NOTE 1: Further details of aggregation of TSN streams (including determination of burst arrival times that are compatible so that TSN streams can be aggregated) are left for implementation.

In this case, TSN AF creates one TSC Assistance Container for the aggregated TSN streams. The SMF will bind PCC rules with a TSC Assistance Container as described in clause 6.1.3.2.4 of TS 23.503 [45]. The SMF derives TSCAI on a per QoS Flow basis and send it to 5G-AN. The Burst Arrival Time and Periodicity component of the TSCAI that the SMF signals to the 5G-AN are specified with respect to the 5G clock. The SMF is responsible for mapping the Burst Arrival Time and Periodicity from a TSN clock to the 5G clock based on the time offset and cumulative rateRatio between TSN time and 5GS time as measured and reported by the UPF.

The TSCAI parameter determination in SMF is done as follows:

- For traffic in downlink direction, the SMF corrects the Burst Arrival Time in the TSN Assistance Container based on the latest received time offset measurement from the UPF and sets the TSCAI Burst Arrival Time as the sum of the corrected value and CN PDB as described in clause 5.7.3.4.

- For traffic in uplink direction, the SMF corrects the Burst Arrival Time in the TSN Assistance Container based on the latest received time offset measurement from the UPF and sets the TSCAI Burst Arrival Time as the sum of the corrected value and UE-DS-TT Residence Time.

- The SMF corrects the Periodicity in the TSN Assistance Container by the previously received cumulative rateRatio from the UPF and sets the TSCAI Periodicity as the corrected value.

- The SMF sets the TSCAI Flow Direction as the Flow Direction in the TSN Assistance Container.

NOTE 2: In order for the TSN AF to get Burst Arrival Time, Periodicity on a per TSN stream basis, support for IEEE 802.1Q [98] (as stated in clause 4.4.8.2) Per-Stream Filtering and Policing (PSFP) with stream gate operation is a prerequisite.

In the case of drift between TSN time and 5G time, the UPF updates the offset to SMF using the N4 Report Procedure as defined in TS 23.502 [3] clause 4.4.3.4. In the case of change of cumulative rateRatio between TSN time and 5G time, the UPF updates the cumulative rateRatio to SMF using the N4 Report Procedure as defined in TS 23.502 [3] clause 4.4.3.4. The SMF may then trigger a PDU Session Modification as defined in TS 23.502 [3] clause 4.3.3 in order to update the TSCAI parameter to the NG-RAN without requiring AN or N1 specific signalling exchange with the UE.

NOTE 3: In order to prevent frequent updates from the UPF, the UPF sends the offset or the cumulative rateRatio only when the difference between the current measurement and the previously reported measurement is larger than a threshold as described in TS 23.502 [3] clause 4.4.3.4.

Table 5.27.2-1: TSC Assistance Information

|  |  |
| --- | --- |
| Assistance Information | Description |
| Flow Direction | The direction of the TSC flow (uplink or downlink). |
| Periodicity | It refers to the time period between start of two bursts. |
| Burst Arrival time | The arrival time of the data burst at either the ingress of the RAN (downlink flow direction) or egress interface of the UE (uplink flow direction). |

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

### 5.27.4 Hold and Forward Buffering mechanism

DS-TT and NW-TT support a hold and forward mechanism to schedule traffic as defined in IEEE 802.1Q [98] if 5GS is to participate transparently as a bridge in a TSN network. That is, the hold and forward buffering mechanism in this release of the specification provides externally observable behavior identical to scheduled traffic with up to eight queues (8.6.8.4 in IEEE Std 802.1Q-2018) and with protected windows (Annex Q.2 in IEEE Std 802.1Q-2018). Frames are only transmitted from a given buffer according to the open time interval of the corresponding transmission gate; otherwise, frames are hold back (which corresponds to a closed transmission gate). The protected windows scheme implies that only a single transmission gate is open at any single time. Thus, the Hold and Forward buffering mechanism allows PDB based 5GS QoS to be used for TSC traffic.

To achieve externally observable behavior according to the protected windows scheme, 5GS provides AdminControlList, AdminBaseTime, AdminCycleTime, and TickGranularity as defined in IEEE 802.1Q [98] on a per Ethernet port basis to DS-TT and NW-TT for the hold and forward buffering mechanism as described in clause 5.28.3.

NOTE: The details of how the Hold and Forward buffer ing mechanism is provided by the TSN Translator is up to implementation.

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

### 5.28.2 5GS Bridge configuration

In order to schedule TSN traffic over 5GS Bridge, the configuration information of 5GS Bridge is mapped to 5GS QoS within the corresponding PDU Session. The QoS parameters mapping for TSN is described in TS 23.503 [45] clause 6.1.3.23.

The configuration information of 5GS Bridge as defined in IEEE 802.1Q [98], includes the following:

- Bridge ID of 5GS Bridge.

- Configuration information of scheduled traffic on ports of DS-TT and NW-TT:

- Egress ports of 5GS Bridge, e.g., ports on DS-TT and NW-TT;

- Traffic classes and their priorities.

NOTE 1: In this Release of the specification, scheduled traffic (8.6.8.4 in IEEE Std 802.1Q-2018 [98]) is only supported with protected windows, (see Annex Q.2 in IEEE Std 802.1Q [98]), therefore, it is enough to support AdminControlList, AdminBaseTime, AdminCycleTime, and TickGranularity for the configuration of the 5GS.

The configuration information of 5GS Bridge as defined in IEEE 802.1Q [98], includes the following:

- Chassis ID of 5GS Bridge;

- Traffic forwarding information as defined in IEEE 802.1Q [98] clause 8.8.1:

- Destination MAC address and VLAN ID of TSN stream;

- Port number in the Port MAP as defined in IEEE 802.1Q [98] clause 8.8.1.

- Configuration information per stream according to IEEE 802.1Q [98] clause 8.6.5.1:

- Ingress port number of 5GS Bridge, i.e., ports on DS-TT/NW-TT;

- Stream priority.

NOTE 2: In order to support IEEE 802.1Q [98] clause 8.6.5.1, it is required to support the Stream Identification function as specified by IEEE 802.1CB-2017 [83].

The SMF report the MAC address of the DS-TT port of the related PDU Session to TSN AF via PCF as the MAC address of the PDU Session. The association between the MAC address used by the PDU Session, 5GS Bridge ID and port number on DS-TT is maintained at TSN AF and further used to assist to bind the TSN traffic with the UE's PDU session.

With the Traffic forwarding information as defined in IEEE 802.1Q [98] clause 8.8.1 and PSFP information as defined in IEEE 802.1Q [98] clause 8.6.5.1, the TSN AF identifies the ingress port and egress port for a stream and derives the DS-TT MAC address of corresponding PDU session carrying this stream.

The TSN AF requests the PCF to reserve resources for an AF session with support for Time Sensitive Networking (TSN) as defined in clause 6.1.3.23 in TS 23.503 [45].

The TSN AF uses the stream filter instances in PSFP information as defined in IEEE 802.1Q [98] clause 8.6.5.1, and additionally traffic class information as defined in IEEE 802.1Q [98] clause 8.6.8.4, to derive the service data flow for TSN streams. The TSN AF uses the Priority values in the stream filter instances in PSFP information (if available) as defined in IEEE 802.1Q [98] clause 8.6.5.1, and may additionally use scheduled traffic information as defined in IEEE 802.1Q [98] clause 8.6.8.4, to derive the TSN QoS information for a given TSN stream or flow of aggregated TSN streams. The TSN AF determines the TSC Assistance Container as described in clause 5.27.2. The TSN AF associates the TSN QoS information and TSC Assistance Container with the corresponding service data flow description and provides to the PCF and the SMF as defined in TS 23.503 [45] clause 6.1.3.23.

NOTE 3: When the TSN stream priority information from PSFP is not available (priority value in stream filters is set to wild card) Scheduled traffic information IEEE 802.1Q [98] clause 8.6.8.4 can be used in combination with PSFP IEEE 802.1Q [98] clause 8.6.5.1 to obtain a priority value.

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

### 5.27.5 5G System Bridge delay

In order for the 5G System to participate as a TSN bridge according to 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 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 receives the 5GS Bridge information for a newly established PDU Session and caculates the bridge delays per port pair as requested by the CNC.

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

## 5.28 Support of integration with TSN

### 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.

NOTE 2: Given that this release of the specification supports only a single N6 interface in a UPF associated with the N6 Network Instance, the use of multiple NW-TT ports is implementation specific.

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 3: 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 4: 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 traffic scheduling 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 5: 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 information:

- Maximum number of filters, which defines the maximum number of streams that the bridge can handle;

- Maximum number of gates, which can be equal or less than the maximum number of filters;

- Maximum number of meters (optional) if meassurements are required;

- Maximum length of the PSFPAdminControlList parameter that can be handled.

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.

This release of the specification requires that each DS-TT port is assigned with a globally unique MAC address.

NOTE 6: The MAC address of the DS-TT port must not be used in user data traffic; it is used for identification of the PDU Session and the associated bridge port within the 3GPP system.

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 \* \* \* \***

### 5.28.3 Port and bridge management information exchange in 5GS

#### 5.28.3.1 General

Port and bridge management information is exchanged between CNC and TSN AF. The port management information, is related to Ethernet ports located in DS-TT or NW-TT.

5GS shall support transfer of standardized and deployment-specific port management information transparently between TSN AF and DS-TT or NW-TT, respectively inside a Port Management Information Container. NW-TT may support one or more ports. In this case, each port uses separate Port Management Information Container. 5GS shall also support transfer of standardized and deployment-specific bridge management information transparently between TSN AF and NW-TT, respectively inside a Bridge Management Information Container. Table 5.28.3.1-1 and Table 5.28.3.1-2 list standardized port management information and bridge management information, respectively.

Table 5.28.3.1-1: Standardized port management information

|  |  |  |  |
| --- | --- | --- | --- |
| Port management information | Applicability (see Note 6) | Supported operations by TSN AF(see Note 1) | Reference |
| DS-TT | NW-TT |
| **General** |  |  |  |  |
| Port management capabilities (see Note 2) | X | X | R |  |
| **Bridge delay related information** |  |  |  |  |
| txPropagationDelay | X | X | R | IEEE 802.1Qcc [95] clause 12.32.2.1 |
| **Traffic class related information** |  |  |  |  |
| Traffic class table | X | X | RW | IEEE 802.1Q [98] clause 12.6.3 and clause 8.6.6. |
| **Gate control information** |  |  |  |  |
| GateEnabled | X | X | RW | IEEE 802.1Q [98] Table 12-29 |
| AdminBaseTime | X | X | RW | IEEE 802.1Q [98] Table 12-29 |
| AdminControlList | X | X | RW | IEEE 802.1Q [98] Table 12-29 |
| AdminCycleTime (see Note 3) | X | X | RW | IEEE 802.1Q [98] Table 12-29 |
| AdminControlListLength (see Note 3) | X | X | RW | IEEE 802.1Q [98] Table 12-28 |
| Tick granularity | X | X | R | IEEE 802.1Q [98] Table 12-29 |
|  |  |  |  |  |
|  |  |  |  |  |
| **General Neighbor discovery configuration****(NOTE 4)** |  |  |  |  |
| adminStatus | D | X | RW | IEEE 802.1AB [97] clause 9.2.5.1 |
| lldpV2LocChassisIdSubtype | D | X | RW | IEEE 802.1AB [97] Table 11-2 |
| lldpV2LocChassisId | D | X | RW | IEEE 802.1AB [97] Table 11-2 |
| lldpV2MessageTxInterval | D | X | RW | IEEE 802.1AB [97] Table 11-2 |
| lldpV2MessageTxHoldMultiplier | D | X | RW | IEEE 802.1AB [97] Table 11-2 |
| **NW-TT port neighbor discovery configuration** |  |  |  |  |
| lldpV2LocPortIdSubtype |  | X | RW | IEEE 802.1AB [97] Table 11-2 |
| lldpV2LocPortId |  | X | RW | IEEE 802.1AB [97] Table 11-2 |
| **DS-TT port neighbor discovery configuration** |  |  |  |  |
| lldpV2LocPortIdSubtype | D |  | RW | IEEE 802.1AB [97] Table 11-2 |
| lldpV2LocPortId | D |  | RW | IEEE 802.1AB [97] Table 11-2 |
| **Neighbor discovery information for each discovered neighbor of NW-TT** |  |  |  |  |
| lldpV2RemChassisIdSubtype |  | X | R | IEEE 802.1AB [97] Table 11-2 |
| lldpV2RemChassisId |  | X | R | IEEE 802.1AB [97] Table 11-2 |
| lldpV2RemPortIdSubtype |  | X | R | IEEE 802.1AB [97] Table 11-2 |
| lldpV2RemPortId |  | X | R | IEEE 802.1AB [97] Table 11-2 |
| TTL |  | X | R | IEEE 802.1AB [97] clause 8.5.4 |
| **Neighbor discovery information for each discovered neighbor of DS-TT****(NOTE 5)** |  |  |  |  |
| lldpV2RemChassisIdSubtype | D |  | R | IEEE 802.1AB [97] Table 11-2 |
| lldpV2RemChassisId | D |  | R | IEEE 802.1AB [97] Table 11-2 |
| lldpV2RemPortIdSubtype | D |  | R | IEEE 802.1AB [97] Table 11-2 |
| lldpV2RemPortId | D |  | R | IEEE 802.1AB [97] Table 11-2 |
| TTL | D |  | R | IEEE 802.1AB [97] clause 8.5.4.1 |
| **Per-Stream Filtering and Policing information**(NOTE 10) |  |  |  |  |
| Stream Filter Instance Table(NOTE 8) |  |  |  | IEEE 802.1Q [98] Table 12-32 |
| StreamHandleSpec | X | X | RW | IEEE 802.1Q [98] Table 12-32 |
| PrioritySpec | X | X | RW | IEEE 802.1Q [98] Table 12-32 |
| StreamGateInstanceID | X | X | RW | IEEE 802.1Q [98] Table 12-32 |
| Stream Gate Instance Table(NOTE 9) |  |  |  | IEEE 802.1Q [98] Table 12-33 |
| StreamGateInstance | X | X | R | IEEE 802.1Q [98] Table 12-33 |
| PSFPAdminBaseTime | X | X | RW | IEEE 802.1Q [98] Table 12-33 |
| PSFPAdminControlList | X | X | RW | IEEE 802.1Q [98] Table 12-33 |
| PSFPAdminCycleTime | X | X | RW | IEEE 802.1Q [98] Table 12-33 |
| PSFPTickGranularity | X | X | R | IEEE 802.1Q [98] Table 12-33 |
| NOTE 1: R = Read only access; RW = Read/Write access.NOTE 2: Indicates which standardized and deployment-specific port management information is supported by DS-TT or NW-TT.NOTE 3: AdminCycleTime and AdminControlListLength are optional for gate control information.NOTE 4: If DS-TT supports neighbor discovery, then TSN AF sends the general neighbor discovery configuration for DS-TT Ethernet ports to DS-TT. If DS-TT does not support neighbor discovery, then TSN AF sends the general neighbor discovery configuration for DS-TT Ethernet ports to NW-TT using the Bridge Management Information Container (refer to Table 5.28.3.1-2) and NW-TT performs neighbor discovery on behalf on DS-TT.NOTE 5: If DS-TT supports neighbor discovery, then TSN AF retrieves neighbor discovery information for DS-TT Ethernet ports from DS-TT. If DS-TT does not support neighbor discovery, then TSN AF retrieves neighbor discovery information for DS-TT Ethernet ports from NW-TT, using the Bridge Management Information Container (refer to Table 5.28.3.1-2), the NW-TT performing neighbor discovery on behalf on DS-TT.NOTE 6: X = applicable; D = applicable when validation and generation of LLDP frames is processed at the DS-TT.NOTE 7: Void.NOTE 8: There is a Stream Filter Instance Table per Stream.NOTE 9: There is a Stream Gate Instance Table per Gate.NOTE 10: The use of PSFP information is mandatory at the TSN AF and is optional at both DS-TT and NW-TT. TSN AF uses the PSFP information at TSN bridge configuration time to identify the DS-TT MAC address of the PDU Session as described in clause 5.28.2 and for determination of the traffic pattern information as described in Annex I. The PSFP information can be used at the DS-TT (if supported) and at the NW-TT (if supported) for the purpose of per-stream filtering and policing as defined in IEEE 802.1Q [98] clause 8.6.5.1. |

Table 5.28.3.1-2: Standardized bridge management information

|  |  |  |
| --- | --- | --- |
| Bridge management information | Supported operations by TSN AF(see NOTE 1) | Reference |
|
| **Information for 5GS Bridge** |  |  |
| Bridge Address | R |  |
| Bridge Name | R |  |
| Bridge ID | R |  |
| **Topology of 5GS Bridge** |  |  |
| Chassis ID subtype and Chassis ID of the 5GS Bridge | R | IEEE 802.1AB [97] |
| **Traffic forwarding information**  |  |  |
| Static Filtering Entry (NOTE 3) | RW | IEEE 802.1Q [98] clause 8.8.1 |
| **General Neighbor discovery configuration****(NOTE 2)** |  |  |
| adminStatus | RW | IEEE 802.1AB [97] clause 9.2.5.1 |
| lldpV2LocChassisIdSubtype | RW | IEEE 802.1AB [97] Table 11-2 |
| lldpV2LocChassisId | RW | IEEE 802.1AB [97] Table 11-2 |
| lldpV2MessageTxInterval | RW | IEEE 802.1AB [97] Table 11-2 |
| lldpV2MessageTxHoldMultiplier | RW | IEEE 802.1AB [97] Table 11-2 |
| **DS-TT port neighbor discovery configuration for DS-TT ports (NOTE 4)** |  |  |
| **>DS-TT port neighbor discovery configuration for each DS-TT port** |  |  |
| >> DS-TT port number | RW |  |
| >> lldpV2LocPortIdSubtype | RW | IEEE 802.1AB [97] Table 11-2 |
| >> lldpV2LocPortId | RW | IEEE 802.1AB [97] Table 11-2 |
| **Discovered neighbor information for DS-TT ports****(NOTE 4)** |  |  |
| **>Discovered neighbor information for each DS-TT port****(NOTE 4)** |  |  |
| >> DS-TT port number | R |  |
| >> lldpV2RemChassisIdSubtype | R | IEEE 802.1AB [97] Table 11-2 |
| >> lldpV2RemChassisId | R | IEEE 802.1AB [97] Table 11-2 |
| >> lldpV2RemPortIdSubtype | R | IEEE 802.1AB [97] Table 11-2 |
| >> lldpV2RemPortId | R | IEEE 802.1AB [97] Table 11-2 |
| >> TTL | R | IEEE 802.1AB [97] clause 8.5.4.1 |
| **Stream Parameters** |  |  |
| Maximum number of filters, which defines the maximum number of streams that the bridge can handle | R | IEEE 802.1Q [98] |
| Maximum number of gates, which can be equal or less than the maximum number of filters | R | IEEE 802.1Q [98] |
| Maximum number of meters (optional) if measurements are required | R | IEEE 802.1Q [98] |
| Maximum length of the PSFPAdminControlList parameter that can be handled |  | IEEE 802.1Q [98] |
| NOTE 1: R = Read only access; RW = Read/Write access.NOTE 2: General neighbor discovery information is included only when NW-TT performs neighbor discovery on behalf of DS-TT.NOTE 3: If the Static Filtering Entry information is present, NW-TT uses Static Filtering Entry information to determine the NW-TT egress port for forwarding UL TSC traffic. If the Static Filtering Entry information is not present, then the forwarding information as in clause 5.8.2.5.3 applies. This release of the specification does not support Static Filtering Entries in the downlink direction.NOTE 4: DS-TT discovery configuration and DS-TT discovery information are used only when DS-TT does not support LLDP and NW-TT performs neighbor discovery on behalf of DS-TT. These IEs are deliverered via the procedures for the PDU session for the DS-TT port, while the other IEs of the table are deliverered via the procedures for any of the PDU sessions of the 5GS TSN bridge. |

Exchange of port and bridge management information between TSN AF and NW-TT or DS-TT allows TSN AF to:

1) retrieve port management information for a DS-TT or NW-TT Ethernet port or bridge management information for a 5GS TSN bridge;

2) send port management information for a DS-TT or NW-TT Ethernet port or bridge management information for a 5GS TSN bridge;

3) subscribe to and receive notifications if specific port management information for a DS-TT or NW-TT Ethernet port changes or bridge management information changes.

Exchange of port management information between TSN AF and NW-TT or DS-TT is initiated by DS-TT or NW-TT to:

- notify TSN AF if port management information has changed that TSN AF has subscribed for.

Exchange of bridge management information between TSN AF and NW-TT is initiated by NW-TT to:

- notify TSN AF if bridge management information has changed that TSN AF has subscribed for.

Exchange of port management information is initiated by DS-TT to:

- provide port management capabilities, i.e. provide information indicating which standardized and deployment-specific port management information is supported by DS-TT.

TSN AF indicates inside the Port Management Information Container or Bridge Management Information Container whether it wants to retrieve or send port or bridge management information or intends to (un-)subscribe for notifications.

**\* \* \* \* 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 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 TSN 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 has received 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 scheduling 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 TSN stream. 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.

**\* \* \* \* End of Change \* \* \* \***