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

**19 August - 2 September, 2020, Elbonia (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:*** | Solving Synchronization issues, addressing IEEE LS response | | | | | | | | | |
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| ***Source to WG:*** | Ericsson | | | | | | | | | |
| ***Source to TSG:*** | SA2 | | | | | | | | | |
|  |  | | | | | | | | | |
| ***Work item code:*** | Vertical\_LAN | | | | |  | ***Date:*** | | | 2020-08-06 |
|  |  | | | |  | |  | | |  |
| ***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 can be 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)* | |
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| ***Reason for change:*** | | The purpose of this CR is to address technical issues pointed out by IEEE’s LS response.  -BMCA is not supported in Rel. 16, instead a static method based on external port configuration (dependent on Qualcomm CR).  -Operations, state machines, variables and data structures in the 5GS shall comply with IEEE 802.1AS. So, operations described in clause 5.27.1.2.2 are just described in a highlevel manner, not a duplication of IEEE 802.1AS operations. Then we propose to illustrate how the state machines, variables, and data structures are used for clarity.  -DS-TT does not remove TSi from the suffix field, instead it removes the suffix that contains the TSi.  -TSN time and 5GS time are not defined and not present in other clauses. To solve this these terms have been replaced by TSN GM clock and 5GS clock. | | | | | | | | |
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| ***Summary of change:*** | | -  -Add note to state that operations, state machines, variables and data structures in 5GS comply with IEEE 802.1AS. Illustrate how these are used.  -State that the description in 5.27.1.2.2 is highlevel.  -DS-TT removes the suffix containing the TSi before sending the gPTP message towards the downstream TSN node.  -Add that TSi information is carried by the upstreamTxTime. Adding it also in Annex H. | | | | | | | | |
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| ***Consequences if not approved:*** | | Comments from IEEE remain unaddressed, leading to unclear specification, misalignment with IEEE specifications or inconsistencies. | | | | | | | | |
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| ***Clauses affected:*** | | 5.27.1.1, 5.27.1.2.2, 5.27.2, H.2 | | | | | | | | |
|  | |  | | | | | | | | |
|  | | **Y** | **N** |  | | | |  | | |
| ***Other specs*** | | **x** |  | Other core specifications | | | | QC CR BMCA | | |
| ***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 \* \* \* \***

#### 5.27.1.1 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 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. (g)PTP support, timestamping, Best Master Clock Algorithm (BMCA), rateRatio, and external port configuration (clause 10.3.1.1, method b, IEEE 802.1AS [104], i.e. local static configuration). Figure 5.27.1-1 illustrates the 5G and TSN 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 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 clock and time-stamping

The mechanisms for distribution of TSN clock and time-stamping described in this clause on a high level, 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.

NOTE: According to IEEE 802.1AS [104], the TSi information is carried by the upstreamTxTime.

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 Suffix field that contains TSi.

**\* \* \* \* 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.

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 GM clock and 5G clock 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 \* \* \* \***

# H.2 Signalling of ingress time for time synchronization

The ingress time (upstreamTxTime) is provided from the NW-TT/UPF to the DS-TT/UE as part of a gPTP Sync or Follow\_up message using the Suffix field defined in clause 13.4 of IEEE 1588-2008 [107]. The structure of the Suffix field follows the recommendation of clause 14.3 of IEEE 1588-2008 [107], with an organizationId specific to 3GPP, an organizationSubType referring to an ingress timestamp, and data field that carries the ingress timestamp encoded as specified in clause 5.3.3 of IEEE 1588-2008 [107]. TS 24.535 [117] specifies the fields in the gPTP Sync message.

The operations, state machines, global variables, and data structures internal to the 5G system, need to comply with IEEE 802.1AS [104].

As an example, the cumulativeScaledRateOffset in the Sync message is replaced at the ingress with the value corresponding to the computed rateRatio by the PortSyncSyncReceive state machine.

The PortSyncSyncSend and MDSyncSend state machines are invoked at the egress. The members of the MDSyncSend structure created by the PortSyncSyncSend state machine in 10.2.12.2.1 of IEEE 802.1AS [104] are taken from the respective fields of the transported Sync or Follow\_Up message, including the Follow\_Up informaton TLV (with upstreamTxTime taken from the suffix that was appended at the ingress).

These members are not taken from global variables that correspond to PortSyncSync structure members, as there is no PortSyncSync structure in this case. It can be noted that the SiteSync state machine is not invoked.

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