**3GPP TSG-SA2 Meeting #156E *S2-230xxxx***

**Electronic, April 17-21, 2023**

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| *CR-Form-v12.1* |
| **CHANGE REQUEST** |
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|  | **23.501** | **CR** | **xxxx** | **rev** | **-** | **Current version:** | **18.1.0** |  |
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| *For* [***HE******LP***](http://www.3gpp.org/3G_Specs/CRs.htm#_blank)*on using this form: comprehensive instructions can be found at* [*http://www.3gpp.org/Change-Requests*](http://www.3gpp.org/Change-Requests)*.* |
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| ***Proposed change affects:*** | UICC apps |  | ME |  | Radio Access Network |  | Core Network | **X** |

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| ***Title:***  | RAN timing synchronization status report |
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| ***Source to WG:*** | NTT DOCOMO |
| ***Source to TSG:*** | SA2 |
|  |  |
| ***Work item code:*** | TRS\_URLLC |  | ***Date:*** | 2023-04-07 |
|  |  |  |  |  |
| ***Category:*** | **F** |  | ***Release:*** | Rel-18 |
|  | *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](http://www.3gpp.org/ftp/Specs/html-info/21900.htm). | *Use one of the following releases:Rel-8 (Release 8)Rel-9 (Release 9)Rel-10 (Release 10)Rel-11 (Release 11)…Rel-15 (Release 15)Rel-16 (Release 16)Rel-17 (Release 17)Rel-18 (Release 18)* |
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| ***Reason for change:*** | RAN3 has responded (in S2-23xxxx/R3-230811) to the question: *“SA2 would like to kindly request RAN2 and RAN3 to provide feedback whether both scopes (group of cells per gNB, group of cells across gNBs) can be beneficial and supported.”*RAN3 answer:*- Depending on gNB topology, clock quality information can be the same for some or all cells of a gNB. Also, topologies can exist where clock quality information is different between “groups of cells within a single gNB” (e.g. cells served by different gNB-DUs).**- RAN3 understands that it shall be possible for NG-RAN to ensure that UEs are kept in RRC\_IDLE or RRC\_INACTIVE state when moving between cells of a gNB with the same clock quality. From RAN3 point of view, this can be supported with just the “Event ID”.**- RAN3 does not see a need to support “group of cells across gNBs” in Release 18, considering its limited applicability and the likely specification effort (e.g. coordination of the reference report ID over the Xn interface).*Based on the LS response, the report scope of *“group of cells across gNBs”* is not to be supported, and the report scope of *“groups of cells within a single gNB”* is to be supported. In the latter case, the RAN can provide a distinct Event ID for each group of cells that share the same clock status, therefore a scope of the Reference report ID can be removed, and Reference report ID can be replaced with the Event ID in the specifications.When the RAN clock status is reported to the TSCTSF, the TSCTSF still needs to know the "scope" of the status, i.e. either a single gNB or a list of Cell IDs within a single gNB. TSCTSF then sets the Area of Presence to correspond to this scope, and subscribes for the UE presence in AoI from the AMF.  |
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| ***Summary of change:*** | Clarify that the scope of the timing synchronization status received by the TSCTSF may be either a single gNB ID or a list of Cell IDs within a gNB. Remove the corresponding Editor's Note. |
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| ***Consequences if not approved:*** |  |
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| ***Clauses affected:*** | 5.27.1.12 |
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|  | **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 ...  |
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| ***Other comments:*** |  |
|  |  |
| ***This CR's revision history:*** |  |

\*\*\* BEGIN CHANGES \*\*\*

#### 5.27.1.12 Support for network timing synchronization status monitoring

While the time synchronization service is offered by the 5GS, based on 5G access stratum-based time distribution or (g)PTP-based time distribution, the network timing synchronization status of the nodes involved in the operation (e.g. NG-RAN nodes and/or UPF/NW-TTs) may change. NG-RAN and UPF/NW-TT can detect timing synchronization degradation or improvement locally. The support for network timing synchronization status monitoring enables the 5GS to modify time synchronization service for a UE or a group of UEs depending on the current synchronization status and notify service updates. There may be three consumers of this information:

- TSCTSF may receive node-level information about timing synchronization status from NG-RAN and/or UPF/NW-TT directly from OAM or alternatively, if supported by a node, using control plane signalling at node level. Node level signalling uses UMIC for UPF/NW-TT case and an AMF service to report N2 node level information for NG-RAN case.

- AF may subscribe to time synchronization status notifications for a UE or group of UEs for which the AF requests or has requested time synchronization service (for 5G access stratum time distribution or (g)PTP services).

- For 5G access stratum time synchronization service, the UE may receive clock quality information from the NG-RAN based on UE subscription data stored in the UDM (see clause 5.27.1.11) or AF request for clock quality reporting to the UE.

Editor's note: Support for RRC\_INACTIVE and RRC\_IDLE states depends on RAN2 feedback.

When activating time synchronization for a UE, TSCTSF requests the AMF (via PCF using AM policy) to instruct the UE to transition to RRC CONNECTED to the network in the case when the UE later detects that the RAN timing synchronization status has changed while the UE is in RRC\_INACTIVE or RRC\_IDLE state.

RAN nodes may be pre-configured with the thresholds for each timing synchronization status attribute, if supported, that is described in Table 5.27.1.12-1. When the network timing synchronization status exceeds the threshold (i.e. status degradation), or the network timing synchronization status meets the thresholds again (i.e. status improvement), the RAN node notifies the TSCTSF (either using N2 node level signalling via AMF, or via OAM) with the RAN Node ID, the scope of the timing synchronization status (either a single gNB ID or a list of Cell IDs within a gNB) and the corresponding network timing synchronization status attributes as described in this clause. The NG-RAN indicates the status change to the UEs via SIB9:

- When the network timing synchronization status exceeds the threshold, the NG-RAN includes in SIB9 a reference report ID. When the network timing synchronization status meets the thresholds again (i.e. status improvement), the NG-RAN stops broadcasting the reference report ID in SIB9. Either event serves as a notification for the UEs reading the SIB9 that there is new clock quality information available.

- The UE in RRC\_INACTIVE or RRC\_IDLE state compares the reference report ID in SIB9 (or lack of reference report ID) with locally stored reference report ID to determine if it had retrieved the last available clock quality information already. The reference report ID consists of the scope of the report ID and an Event ID (an integer). Scope should support providing clock quality for all the cells within a single NG-RAN node.

- If the UE is instructed by AMF (via Registration or the UE Configuration Update procedure) to reconnect to the network in the case when the UE determines that report ID has changed, the UE in RRC\_INACTIVE or RRC\_IDLE state reconnects to the network. After the UE has reconnected to the network, the NG-RAN uses unicast RRC signalling to provision the clock quality information to the UEs.

The network timing synchronization status information from NG-RAN or UPF/NW-TT to the TSCTSF can contain the following information as described in the Table 5.27.1.12-1.

Table 5.27.1.12-1: Information elements contained in NG-RAN or UPF timing synchronization status information

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| Information Name | Description | Category |
| Synchronization state | Indicates the state of the node synchronization, represented by the values "Locked", "Holdover", or "Freerun". | Optional |
| Synchronization performance | Traceable to UTCTraceable to GNSSFrequency stability | Optional |
| Clock quality | clock accuracy | Optional |
| Parent time source | Describes the primary source the node is currently using, represented by the values "SyncE", "PTP", "GNSS", "atomic clock", "terrestrial radio", "serial time code", "NTP", "hand set", "other". | Optional |
| Editor's note: Information elements contained in NG-RAN depends on RAN capabilities to determine them and pending RAN WGs feedback.NOTE 1: Clock is in the "Locked", "Holdover", or "Freerun" mode, as defined in ITU‑T G.810 [164]. |

The TSCTSF determines the UEs impacted by NG-RAN timing synchronization status change (i.e. degradation, failure or improvement) or UPF timing synchronization status change (only for the case when UPF/NW-TT is involved in providing time information to DS-TT).

- For NG-RAN case, when the TSCTSF receives the status degradation report, the TSCTSF discovers the AMFs serving the impacted RAN Nodes, and subscribes to receive notifications for UE presence in Area of Interest information. The Area of Interest is set to match with the scope of the timing synchronization status as reported to the TSCTSF, i.e. either a single gNB ID or a list of Cell IDs within a gNB, as described in clause 5.3.4.4. The subscription is targeted to any UE in the AMF. When the AMF notifies the TSCTSF for the UE presence in Area of Interest, the TSCTSF correlates information about impacted RAN nodes and the UE location information received from AMF. If the RAN node notifies the TSCTSF for the status improvement (i.e. the pre-configured thresholds are met in the RAN), the TSCTSF modifies the subscription to remove the corresponding Area of Interest from the subscription.

- For UPF case, the TSCTSF determines the UEs for which an impacted UPF/NW-TT is configured to send (g)PTP messages.

If NG-RAN or UPF timing synchronization status change, the TSCTSF may perform the following:

- For AFs that subscribe for 5G access stratum time synchronization service or (g)PTP time synchronization service status update (i.e. change in acceptance criteria support status), the TSCTSF may provide notification towards the AF when there is a change in support status for a UE or group of UEs.

- Deactivating/reactivating/updating time synchronization services:

- (g)PTP time synchronization service case: For UEs that are part of a PTP instance and which are impacted by NG-RAN or UPF time synchronization status degradation or improvement:

- If TSCTSF determines that the clock quality acceptance criteria provided by AF can still be met, then TSCTSF may update the clockQuality information sent in Announce messages (see clause 7.6.2 of IEEE 1588 [8]) for the PTP instance using existing procedures and existing PMIC/UMIC information. The handling of Announce messages follows existing procedures as described in clause 5.27.1.6.

- If TSCTSF determines that the clock quality acceptance criteria provided by AF cannot be met, then TSCTSF informs the AF about the acceptance criteria result.

- If TSCTSF determines that the clock quality acceptance criteria provided by AF can be met again then TSCTSF informs the AF about the acceptance criteria result.

For 5G access stratum time synchronization service, clock quality reporting control information manages the NG-RAN timing synchronization status notifications to the UE. When AMF provides the 5G access stratum time distribution indication and the Uu time synchronization error budget to NG-RAN, AMF also includes the clock quality reporting control information provided by the TSCTSF or received from UDM. Clock quality reporting control information may be present in the AF request or Access and Mobility Subscription data at the UDM, and contains the following fields:

- Clock quality detail level. It indicates whether and which clock quality information to provide to the UE and can take one of the following values: clock quality metrics or acceptable/not acceptable indication.

- If the clock quality detail level equals "clock quality metrics", the NG-RAN provides clock quality metrics to the UE that reflect its current timing synchronization status. Clock quality metrics refers to the following information: clock accuracy, traceability to UTC and to GNSS, frequency stability, parent time source, synchronization state.

- If the clock quality detail level equals "acceptable/not acceptable indication", clock quality acceptance criteria for the UE. The NG-RAN provides an acceptable indication to the UE if the NG-RAN's timing synchronization status matches the acceptance criteria received from AMF; otherwise, NG-RAN indicates "not acceptable" to the UE. Acceptance criteria can be defined based on one or more of the following attributes: parent time source, traceability to UTC and to GNSS, synchronization state, clock accuracy, frequency stability.

Editor's note: Attributes that can be used for clock quality acceptance criteria depends on RAN capabilities to determine them and pending RAN WGs feedback

When determining the clock quality metrics for a UE and when determining whether clock quality is acceptable or not acceptable for a UE, NG-RAN considers whether propagation delay compensation is performed while UE capabilities and internal inaccuracies are assumed to be budgeted by the client network operator when agreeing the required clock accuracy with the 5G network operator. To provision clock quality information to the UEs, the NG-RAN uses unicast RRC signalling:

- For UEs in RRC Connected state, the NG-RAN uses unicast RRC signalling.

- The UE that is not in RRC\_CONNECTED state may establish or resume the RRC connection to receive the clock quality information from the NG-RAN.

\*\*\* END OF CHANGES \*\*\*