**3GPP TSG-RAN WG3 #122 R3-237927**

**13th – 17th Nov 2023 Chicago, USA**

**Agenda item: 26.2**

**Source: CATT, Qualcomm Incorporated, Nokia, Nokia Shanghai Bell, Ericsson, Huawei**

**Title: TP for 38.300 on Introduction of 5G Timing Resiliency and URLLC enhancements**

**Document for: Approval**

# 1 Introduction

This TP is to specify stage 2 to support the objectives in the WID on NR Timing Resiliency and URLLC enhancements.

Including the below items:

- Support the 5GS network timing synchronization status and reporting.

- Support adapting downstream and upstream scheduling based on RAN feedback for low latency communication.

- Support Interworking with TSN network deployed in the transport network

# 2 TP for 38.300

**----------------------------Change Begins-------------------------------------------------------------------------**

## 16.8 Support for Time Sensitive Communications

Time Sensitive Communications (TSC), as defined in TS 23.501 [3], is a communication service that supports deterministic communication and/or isochronous communication with high reliability and availability. Examples of such services are the ones in the area of Industrial Internet of Things, e.g. related to cyber-physical control applications as described in TS 22.104 [39].

To support strict synchronization accuracy requirements of TSC applications, the gNB may signal 5G system time reference information to the UE using unicast or broadcast RRC signalling with a granularity of 10 ns. Uncertainty parameter may be included in reference time information to indicate its accuracy. The UE may indicate to the gNB a preference to be provisioned with reference time information using UE Assistance Information procedure. Propagation delay compensation (PDC) mechanisms may be applied based on RTT or TA, and can be performed at the UE or gNB side. When performed at UE side, the PDC mechanisms are controlled via RRC signalling by the gNB.

The RTT-based PDC mechanism is achieved by using Rx-Tx time difference measurements of a single pair of configured TRS/PRS and SRS. The following figure describes the signalling procedures of UE-side RTT-based PDC:



Figure 16.8-1: Signalling Procedure of UE-side RTT-based PDC

1. The gNB provides measurement configurations to the UE;

2a/b. The gNB transmits TRS or PRS to the UE for measurements, and the UE transmits SRS to the gNB for measurement;

3a/b. Both the UE and the gNB perform Rx-Tx time difference measurements;

4. The gNB provides its Rx-Tx time difference measurement to the UE;

5. The UE performs PDC based on Rx-Tx time difference measurements from itself and the gNB.

The following figure describes the signalling procedures of gNB-side RTT-based PDC:



Figure 16.8-2: Signalling Procedure of gNB-side RTT-based PDC

1. The gNB provides measurement configurations to the UE;

2a/b. The gNB transmits TRS or PRS to the UE for measurements, and the UE transmits SRS to the gNB for measurement;

3a/b. Both the UE and the gNB perform Rx-Tx time difference measurements;

4. The UE reports its Rx-Tx time difference measurement to the gNB;

5. The gNB performs PDC based on Rx-Tx time difference measurements from itself and the UE.

The gNB may also receive TSC Assistance Information (TSCAI), see TS 23.501 [3], from the Core Network, e.g. during QoS flow establishment, or from another gNB during handover. TSCAI contains additional information about the traffic flow such as burst arrival time, burst periodicity, and survival time. TSCAI knowledge may be leveraged in the gNB's scheduler to more efficiently schedule periodic, deterministic traffic flows either via Configured Grants, Semi-Persistent Scheduling or with dynamic grants, and/or to improve the associated link reliability to meet the survival time requirement (see TS 22.104 [39]).

To support uplink periodic traffics of services with survival time requirement, configured grant resources can be used such that the mapping relation between the service and the configured grant is known to both gNB and UE, thus allowing the gNB to use configured grant retransmission scheduling (addressed by CS-RNTI) to trigger survival time state entry for the corresponding DRB. Upon survival time state entry, all RLC entities configured for the DRB are activated by the UE for duplication to prevent failure of subsequent messages and hence fulfilling the survival time requirement. If CA or DC duplication for the DRB is already activated, the DRB should enter survival time state when any retransmission grant for any of its active LCHs is received.

### 16.8.x1 Network timing synchronization monitoring

*Editor’s Note: the contents will be refined after checking the RAN2 CR.*

### 16.8.x1.0 General

While time synchronization service is offered by the 5GS, the network timing synchronization status of the gNB may change. The gNB detects timing synchronization degradation or improvement locally and informs the consumer of the information as follows:

- TSCTSF may receive information about timing synchronization status from the gNB via the AMF based on node-level reporting configuration.

- UE may receive clock quality information from the gNB based on UE-level clock quality control information.

### 16.8.x1.1 Network timing synchronization monitoring towards CN

The 5GC initiates RAN Timing Synchronisation Status (TSS) Reporting procedure to obtain the change of network timing synchronization status of gNBs.

Based on NG-RAN’s capabilities of reporting timing synchronisaation status, NG-RAN accepts or rejects the request from AMF. NG-RAN can be pre-configured with thresholds for attributes on timing synchronisaation status reporting via OAM. When the thresholds are met or exceeded, events will be triggered and NG-RAN reports Timing Synchronization Status to AMF. For detailed procedure on the Timing Synchronization Status reporting, refer to TS 38.401 Clause 8.x.1.

### 16.8.x1.2 Network timing synchronization monitoring towards UE

*Editor’s Note: RAN3 and RAN2 scope.*

### 16.8.x2 RAN feedback for adaptation of Burst Arrival Time and Periodicity

The NG-RAN may support the proative feedback and reactive feedback mechanisms as specified in TS 23. 501 [3]. The NG-RAN can provide the feedback in order to align the arrival of the traffic bursts with the next expected transmission opportunity over the air interface in each direction (i.e. DL or UL) for a QoS flow.

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## 16.y Support for TSN enabled Transport Network

*Editor’s Note: place holde, the details will be captured after the stg3 is lockdown.*

The NG-RAN may support the TSN enabled Transport Network during PDU Session Resource establishment or modification procedure as specified in TS 23. 501 [3].

**----------------------------Skipped unchange part-------------------------------------------------------------------------**

# 18 Small Data Transmission

## 18.0 General

Small Data Transmission (SDT) is a procedure allowing data and/or signalling transmission while remaining in RRC\_INACTIVE state (i.e. without transitioning to RRC\_CONNECTED state). SDT is enabled on a radio bearer basis and is initiated by the UE only if less than a configured amount of UL data awaits transmission across all radio bearers for which SDT is enabled, the DL RSRP is above a configured threshold, and a valid SDT resource is available as specified in clause 5.27.1 of TS 38.321 [6]. Maximum duration the SDT procedure can last is dictated by a SDT failure detection timer that is configured by the network (see clause 6.2.2 of TS 38.331 [12]).

SDT procedure is initiated with either a transmission over RACH (configured via system information) or over Type 1 CG resources (configured via dedicated signalling in *RRCRelease*). The SDT resources can be configured on initial BWP for both RACH and CG. RACH and CG resources for SDT can be configured on either or both of NUL and SUL carriers. The CG resources for SDT are valid only within the PCell of the UE when the *RRCRelease* with suspend indication is received. CG resources are associated with one or multiple SSB(s). For RACH, the network can configure 2-step and/or 4-step RA resources for SDT. When both 2-step and 4-step RA resources for SDT are configured, the UE selects the RA type according to clause 9.2.6. CFRA is not supported for SDT over RACH.

Once initiated, the SDT procedure is either:

- successfully completed after the UE is directed to RRC\_IDLE (via *RRCRelease*) or to continue in RRC\_INACTIVE (via *RRCRelease or RRCReject*) or to RRC\_CONNECTED (via *RRCResume or RRCSetup*); or

- unsuccessfully completed upon cell re-selection, expiry of the SDT failure detection timer, a MAC entity reaching a configured maximum PRACH preamble transmission threshold, an RLC entity reaching a configured maximum retransmission threshold, or expiry of SDT-specific timing alignment timer while SDT procedure is ongoing over CG and the UE has not received a response from the network after the initial PUSCH transmission.

Upon unsuccessful completion of the SDT procedure, the UE transitions to RRC\_IDLE.

For SDT, network should not send *RRCReject* in response to *RRCResumeRequest/RRCResumeRequest1* if DL data over any radio bearer configured for SDT is transmitted.

The initial PUSCH transmission during the SDT procedure includes at least the CCCH message. When using CG resources for initial SDT transmission, the UE can perform autonomous retransmission of the initial transmission if the UE does not receive confirmation from the network (dynamic UL grant or DL assignment) before a configured timer expires as specified in clause 5.4.1 of TS 38.321 [6]. After the initial PUSCH transmission, subsequent transmissions are handled differently depending on the type of resource used to initiate the SDT procedure:

- When using CG resources, the network can schedule subsequent UL transmissions using dynamic grants or they can take place on the following CG resource occasions. The DL transmissions are scheduled using dynamic assignments. The UE can initiate subsequent UL transmission only after reception of confirmation (dynamic UL grant or DL assignment) for the initial PUSCH transmission from the network. For subsequent UL transmission, the UE cannot initiate re-transmission over a CG resource.

- When using RACH resources, the network can schedule subsequent UL and DL transmissions using dynamic UL grants and DL assignments, respectively, after the completion of the RA procedure.

When SDT procedure is initiated, AS security is applied for all the radio bearers enabled for SDT as specified in clause 5.3.13.3 of TS 38.331 [12].

While the SDT procedure is ongoing, if data appears in a buffer of any radio bearer not enabled for SDT, the UE initiates a transmission of a non-SDT data arrival indication using *UEAssistanceInformation* message to the network and, if available, includes the resume cause.

SDT procedure over CG resources can only be initiated with valid UL timing alignment. The UL timing alignment is maintained by the UE based on a SDT-specific timing alignment timer configured by the network via dedicated signalling and, for initial CG-SDT transmission, also by DL RSRP of configured number of highest ranked SSBs which are above a configured RSRP threshold. Upon expiry of the SDT-specific timing alignment timer, the CG resources are released while maintaining the CG resource configuration.

Logical channel restrictions configured by the network while in RRC\_CONNECTED state and/or in *RRCRelease* message for radio bearers enabled for SDT, if any, are applied by the UE during SDT procedure.

The network may configure UE to apply ROHC continuity for SDT either when the UE initiates SDT in the PCell of the UE when the *RRCRelease* with suspend indication was received or when the UE initiates SDT in a cell of its RNA.

## 18.1 Support of SDT procedure over RACH

For SDT procedure over RACH, if the UE accesses a gNB other than the last serving gNB, the UL SDT data/signalling is buffered at the receiving gNB, and then the receiving gNB triggers the XnAP Retrieve UE Context procedure. The receiving gNB indicates SDT to the last serving gNB and the last serving gNB decides whether to relocate the UE context or not. Other SDT assistance information (e.g., single packet, multiple packets) may also be provided by the receiving gNB to help the decision of UE context relocation. If the UE is configured with the clock quality control information, the last serving gNB may perform full UE context relocation. If the last serving gNB decides not to relocate the full UE context, it transfers a partial UE context containing SDT RLC context information necessary for the receiving gNB to handle SDT via the Partial UE Context Transfer procedure.

Then, in case SDT is used for user data over DRBs, UL/DL tunnels are established for DRBs configured for SDT between the receiving gNB and the last serving gNB. The PDCP PDU of UL/DL data is transferred over the tunnels, until the last serving gNB terminates the SDT session and directs the UE to continue in RRC\_INACTIVE by sending the *RRCRelease* message.

Or in case SDT is used for signalling, SRB PDCP PDUs are transferred between the receiving gNB and the last serving gNB via the XnAP RRC Transfer procedure, until the last serving gNB terminates the SDT session and directs the UE to continue in RRC\_INACTIVE by sending the *RRCRelease* message.

During the SDT session, in case the receiving gNB detects that no more packets are to be transmitted, or radio link problem is detected, the receiving gNB may also request to terminate the SDT session to the last serving gNB via the UE Context Retrieve Confirmation procedure.

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