**3GPP SA WG2 Meeting #146E S2-215569**

**Elbonia, August 16 -- 30, 2021** (revision of S2-21xxxx)

**Source: Nokia, Nokia Shanghai Bell, Verizon, AT&T, Siemens, Sennheiser, Huawei, HiSilicon, Matrixx, ZTE, China Unicom**

**Title: New SID: Study on 5G Timing Resiliency, TSC & URLLC enhancements**

**Document for: Approval**

**Agenda Item: 9.1.4**

3GPP™ Work Item Description

Information on Work Items can be found at <http://www.3gpp.org/Work-Items>
See also the [3GPP Working Procedures](http://www.3gpp.org/specifications-groups/working-procedures), article 39 and the TSG Working Methods in [3GPP TR 21.900](http://www.3gpp.org/ftp/Specs/html-info/21900.htm)

# Title: Study on 5G Timing Resiliency and TSC&URLLC enhancements

## Acronym: FS\_5GTTUe

## Unique identifier: ?

Potential target Release: Rel-18

## 1 Impacts

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Affects:** | UICC apps | ME | AN | CN | Others (specify) |
| **Yes** |  | X | X | X |  |
| **No** |  |  |  |  |  |
| **Don't know** | X |  |  |  | X |

## 2 Classification of the Work Item and linked work items

### 2.1 Primary classification

This work item is a

|  |  |
| --- | --- |
|  | Feature |
|  | Building Block |
|  | *Work Task* |
| X | Study Item |

### 2.2 Parent Work Item

|  |
| --- |
| Parent Work / Study Items  |
| Acronym | Working Group | Unique ID | Title (as in 3GPP Work Plan) |
|  |  |  |  |

### 2.3 Other related Work Items and dependencies

|  |
| --- |
| Other related Work Items (if any) |
| Unique ID | Title | Nature of relationship |
| 910039 | 5G Timing Resiliency System | Stage 1 work item |
| 800007 | Service requirements for cyber-physical control applications in vertical domains (cyberCAV)  | Stage 1 work item |
|  |  |  |
|  | (Stage 1 work item for the above study to be added) |  |

## 3 Justification

Rel-16 introduces Integration with IEEE TSN Centralized configuration model, Ability to support gPtP Time synchronization, distribution of external clock via 5GS, also introduces Traffic assistance information for deterministic traffic from IEEE TSN networks.

Rel-17 introduces generic Enablers to support Time Sensitive communication for any application, Ability to support AF activated time sync, PtP, uplink and UE-UE time sync, BMCA and also for the AF to request QoS parameters, TSC assistance.

So far, integration with IEEE TSN distributed model is not supported as this was deprioritized during Rel-17. Introducing support for integration with IEEE TSN distributed model enables dynamic stream addition/removal, also dynamic resource management in RAN, resource (capacity, latency) that needs to be reserved should be explicitly requested. 5GS (Bridge) would have to support the specific IEEE signaling and control protocols (receive, process, send messages as a bridge), and map them into 5GS QoS and forwarding procedures. IEEE protocol work is still partially work in progress for the advanced capabilities (mainly RAP protocol). In R18 timeframe, the following IEEE protocols are mature for consideration:

* Topology and forwarding management: Spanning Tree Protocols
* VLAN and group membership management: MVRP, MMRP
* Stream registration (QoS reservation): ,

Generic TSC and exposure enhancements to 5GS for IP and ETH applications are needed for the following reasons:

* Current UPF selection is largely based on DNN, S-NSSAI but it is not possible to select a desired UPF based on expected transport delay or topological distance for a UPF considering desired packet delay budget for the session.
* Current Exposure framework enables AF to request QoS parameters, provide traffic characteristics but not reliability criteria which is important for many time sensitive IP and ETH applications

Currently, Dual UE/Dual PDU Sessions based solutions are used to solve the issue of low air interface reliability. The industrial device must support the redundancy deduplication protocol. 5GS only support Reliability protocols with multiple user plane paths that could be differentiated by MAC address, e.g. IEEE 802.1CB (then the UPF can forward them into different PDU Sessions, otherwise the UPF cannot recognize the packets). Some industry devices does not support any redundancy deduplication protocol, while some others may only use ring topology for protection e,g, MRP (Media Redundancy Protocol, defined in IEC 62439-2) and HSR (High-availability Seamless Redundancy, defined in IEC 62439-3) are also supported by industry Ethernet in order to ensure the reliability. In such case, the packets in the ring cannot be differentiated by MAC address thus cannot be transferred via two QoS Flows/PDU Sessions. FRER (Frame Replication and Elimination for Reliability) increases E2E reliability by replicating (and modifying) every packet of the stream. Rel-16 specifies many redundancy mechanisms that can be supported within 5G System. 5GS as FRER transparent bridge can be supported by current 3GPP specs but 5GS as FRER aware bridge cannot be supported by current 3GPP specification and that requires the ability for 5GS to detect packets, create and/or eliminate duplicates.Current 3GPP specification doesn‘t offer the ability for any AF to request 5GS to support certain reliability needs that will be essential for many applications.

Dual Connectivity (DC) will increase deployment costs. Besides, DC will cause spectrum resource problems in inter-frequency deployment and interference problems in intra-frequency deployment. Furthermore, the UE could be in a sheltered environment and cannot contact both RANs, especially during UE mobility.

Besides, the importance of the packets in industry scenario is different from each other due to survival time. If the survival time only permit 2 continuous packets lost and one packet is not transferred correctly in time, the reliability of the next packet needs to be enhanced, otherwise the service continuity cannot be guaranteed), the 5GS needs to recognize the packets that are crucially important and enhance the transmission reliability for the packets to guarantee the service continuity, especially in UE to UE scenario.

In the meantime, SA1 is also specifying new requirements for 5G System to remain resilient if there is GNSS failure and for 5G System to act as a backup and offer wireless and indoor-capable time synchronization service for other applications (e.g. financial, power grid systems).

RAN needs to support a large number of UEs in the real world (e.g. in a harbor). However, usually high reliability and low latency will come at expense of capacity. Only limited quantity of UEs could be supported.

* The importance of the information within the packets is different from each other. For example, Ethernet has a minimum frame size of 64 Bytes, comprising an 18-Byte header and a payload of 46 Bytes. The application-layer packet payload of industrial applications is usually small, e.g. 20 Bytes. (Please see TS 22.104 ). The 5GS should be able to transmit more efficiently small payload including those smaller that the Ethernet frame payload in order to safeguarding the resources which can be perceived as an improvement of the overall capacity, e.g. reducing the transmission of unnecessary bits.

As the requirement from SA1 (see TS 22.104), the E2E delay requirement could be lower than 2ms.

* For the low latency transfer, it may introduce some waiting time and it is an unnecessary waste for latency based on current assumption. It is assumed that RAN will use SPS (Semi-persistent scheduling) in this case. The uplink packets at UE side may arrive at any time due to no synchronization between industrial device e.g. a PLC) and 5G system. If the packet arrives at a downlink slot, then it has to wait for the first uplink slot to be transferred and vice versa. When the PDB value is really low , for example 2 ms, it is challenging for RAN to fulfill the requirement if the packet missed the first slot, since the typical value is 250 us per slot. For example, if the transmission latency for transferring a packet in DL on N3 is 1 ms. Then RAN has only 1 ms, which means that RAN have only 1 or 2 slot available for fulfilling the 1 ms delay. If RAN is not able to transmit as soon as possible (e.g. due to micro-congestion), the packet will be delivered with a latency greater than the required PDB of 2 ms.
* When the CN PDB value is also stringent, it may not be able to be fulfilled the target PDB for example due to be micro-congestion in N3 interface.
* The situation could be worse during UE mobility (i.e. Handover) as the forwarding tunnel will introduce more delay or jitter, but from other hand if the forwarding tunnel is not used, the DL path will be interrupted during HO execution until the establishment of GTP-U tunnel towards the target RAN node finished.

Currently, the QoS monitoring only support collecting the average delay of packet transfer in air interface, but the SA1 requirements in TS 22.261[5] and TS 22.104 [1] defines the KPI and the related monitoring E2E, i.e. from the ingress and egress point of the 5G system, which effect the application. The application needs to be aware of the worst situation in the network and react based on that. Besides, there are some requirements from ACIA to expose more KPIS e.g. packet loss radio, to enable troubleshooting.

IETF standards for DETNET is complete, IETF standard for DETNET: RFC 8557 (DetNet Problem Statement), RFC 8578 (DetNet Use Cases), RFC 8655 (DetNet Architecture). 3GPP spec impacts due to 5GS integration with IETF DETNET, if any, on top of generic TSC enhancements introduced for any AF and IP applications needs to be studied.

## 4 Objective

Following are the objectives for this study:

1. Support for 5G Timing Resiliency requirements defined by SA1. Monitoring, detection and reporting of Time Source failure.
	* Study holdover capabilities within 5GS (i.e., network entities involved in time distribution or timestamping like UPF/NW-TT, gNB, UE/DS-TT)
	* Study exposure of 5GS support for timing resiliency and negotiation with 3rd parties and the ability for 3rd party to request to request resilient timing with specific KPIs (e.g., accuracy, coverage area, time interval).
2. Essential spec impacts due to 5GS integration with IEEE TSN distributed model for ETH applications:
	* 5GS is compliant for integration of IEEE TSN protocols needed for distributed configuration; externally observable behavior in terms of traffic forwarding, policing and scheduling as required by select protocols as follows:
		+ LRP IEEE 802.1CS as the baseline for RAP.
	* 5GS Enhancements that allow 5GS Bridge to support Ethernet based control/signalling protocols, including MMRP, MVRP, MSRP and Spanning Tree protocols
		+ VLAN and group membership management: MVRP, MMRP
		+ Stream registration (QoS reservation): MSRP IEEE 802.1Q clause 35.1
3. Exposure enhancements to 5GS for AF to request reliable criteria and maximum E2E delay reporting:
	* Ability for AF to request a certain reliability criteria in addition to QoS
	* Study whether and how to enhance, expose E2E QoS Monitoring and related KPI (e.g. maximum E2E delay of the packets);
4. Enhancements for reliability:
	* Support high reliability without relying on Dual connectivity enhancements or enhancements needed for duplication redundancy protocol at application layer (e.g. FRER, two UE(s) with a single network configuration).
	* Study how to improve the support of reliability considering survival time;
5. Support for low latency(e.g. a 2-ms PDB) and low jitter.
	* Study how to improve the support of E2E determinism and low latency communication (e.g. optimal UPF selection, efficient N3 transmission), considering also RAN micro-congestion (e.g. micro-congestion could arise due to conflicting allocations of CG/SPS scheduler).
	* Study architectural impacts to minimize disruption (ensuring E2E latency, improved reliability) and low jitter during handover (e.g. considering support of DAPS HO);
6. Study how to improve the efficiency of network resources usage to improve the capacity of TSC/URLLC services, e.g. reducing the transmission of unnecessary bits.

## 5 Expected Output and Time scale

|  |
| --- |
| **New specifications**  |
| Type  | TS/TR number | Title | For info at TSG#  | For approval at TSG# | Rapporteur |
| Internal TR | 23.abc | *Study on timing resiliency and TSC enhancements* | *SA#96**June**2022(TBD)* | *SA#97**Sep**2022(TBD)* | Devaki Chandramouli, Devaki.chandramouli@nokia.com  |

|  |
| --- |
| **Impacted existing TS/TR** |
| TS/TR No. | Description of change  | Target completion plenary# | Remarks |
|  |  |  |  |

## 6 Work item Rapporteur(s)

Devaki Chandramouli, Devaki.chandramouli@nokia.com

## 7 Work item leadership

SA2

## 8 Aspects that involve other WGs

Potential RAN impact to be covered by RAN WGs.

Potential security impact to be covered by SA3.

Potential charging and OAM impact to be covered by SA5.

## 9 Supporting Individual Members

|  |
| --- |
| Supporting IM name |
| Nokia |
| Nokia Shanghai Bell |
| Verizon |
| AT&T |
| Siemens |
| Sennheiser |
| Huawei |
| HiSilicon |
| Matrixx |
| ZTE |
| China Unicom |
|  |