**3GPP TSG-WG SA2 Meeting #139E e-meeting S2-2003581**

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**Source: NTT DOCOMO, Qualcomm Incorporated, Nokia, Nokia Shanghai Bell, Sennheiser, Samsung**

**Title: KI #3B, Sol #7: Update for support of PTP over IP**

**Document for: Approval**

**Agenda Item: 8.10**

**Work Item / Release: FS\_IIoT / Rel-17**

*Abstract of the contribution: The document proposes to update Solution #7 for support of PTP over IP*

# Proposal

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## 6.7 Solution #7: Exposure of Time Synchronization

### 6.7.1 Introduction

For Key Issue #3B: Exposure of time synchronization, a solution is needed that allows "any AF that has knowledge of deterministic application requirements" to "be able to request TSC services from the 5GS and as authorized, be notified of pertinent network events." This solution provides a mechanism to do that whereby the AF may learn 5GS capabilities to support time synchronization, request time synchronization with specified requirements, and supply information that can be used to optimize and configure time synchronization procedure for connected devices.

The solution is applicable for IP and Ethernet types of PDU Sessions.

The solution is applicable for the following synchronization methods:

1) assuming use of a gPTP client (IEEE 802.1AS [6] Time Aware System) or PTP client (IEEE 1588-2008 [X]), e.g. including leveraging the DS-TT and NW-TT capabilities defined in Rel-16 with IEE802.1AS protocol support,

2) assuming use of a gPTP client (IEEE 802.1AS [6] Time Aware System) or PTP client (IEEE 1588-2008 [X]) in UPF/NW-TT, where the time source is provided by the 5GS, and UPF/NW-TT is configured to create the (g)PtP message for conveying the timing information (time sync methods as defined in Rel-16).  
3) assuming use of the 5GS time source by 5GS; where the 5G-AN provides a 5GS reference time to the UE via 3GPP radio layer and UE may provide it to the applications or devices behind the UE by implementation specific means out of scope of 3GPP.

4) assuming use of the 5GS time source by 5GS; where the 5G-AN provides a 5GS reference time to the UE via 3GPP radio layer and DS-TT provides PTP messages for conveying the timing information to devices behind the UE.

This solution can be used together with e.g. Solution #1 for the time source to locate in a TSN node behind the DS-TT/UE.

To enable the above capabilities, this solution proposes to enhance External Exposure of Network Capability (see TS 23.501 [2], clause 5.20), specifically for Provisioning and Monitoring capabilities.

To cover a wide range of possible time synchronization requirements for TSC applications, the AF requests is supplemented with requirements for synchronization. When a requirement for a specific synchronization parameter is provided in the AF request, the PCF may dynamically replace default values with values that meet the specific requirement provided by the AF.

### 6.7.2 Functional Description

The following capabilities are proposed:

- The AF requests Time Synchronization service via External Parameter Provisioning, supplying the NEF with requirements for one or more of a time synchronization method, supported (g)PTP versions, Timing Domain, (TSN GM or 5GS GM), Master Port of the Domain (NW-TT port and/or DS-TT port), Sync-Generation Port (NW-TT port and/or DS-TT port), required synchronization accuracy (both in terms of required (g)PTP rate for each DN port, synchronization accuracy in microseconds per device link, and number of connected (g)PTP slaves in case 5GS provides the Timing Domain). The AF also provides Target UE(s) Identification or Spatial Validity Condition (i.e. to target a geographical area), AF Identification. Note GPSI may be applied to identify the individual UE in a manner like that used for AF influence on Traffic Routing (see TS 23.501 [2], clause 5.6.7). Then:

- Time synchronization method 1 (the time source is located in the DN or Device Side):  
  
Timing Domain is provided from the DN or Device Side and gPTP or PTP method is applied.The PCF may, according to PCC rule authorization, choose a 5QI based on the QoS Reference and dynamically set the PDB and/or MDBV according to requirements for (g)PTP protocol (e.g. required number of synchronization clients and (g)PtP messaging rate). The 5GS acts as a PTP Boundary Clock. For Ethernet type PDU sessions, both PTP over UDP/IP and gPTP over Ethernet are applicable. For IP type PDU sessions, PTP over UDP/IP is applicable. In this case, neither of the NW-TT port or DS-TT port is Sync-Generation Port, but NW-TT port and/or DS-TT port can be Master Port(s). (Master: N and/or D, Sync-Gen: Neither of N or D)

NOTE 1: It is assumed that 5G internal system clock is made available to all user plane nodes in the 5G system (e.g. to UEs via SIB/RRC messages).

- Time synchronization method 2 (the time source is provided by the UPF/NW-TT in 5GS via gPTP or PTP):

Timing Domain is to be provided from the 5GS (or the AF and the 5GS shares the same Timing Domain). The PCF may, according to PCC rule authorization, choose a 5QI based on the QoS Reference and dynamically set the PDB and/or MDBV according to requirements for (g)PTP protocol. Further, the PCF may, according to PCC rule authorization, choose a (g)PTP message generation rate for the UPF/NW-TT adaptively. If the AF does not provide a required (g)PTP message rate, the 5GS may determine a (g)PTP message rate based on 5GS constraints. The 5GS acts as a (g)PTP grandmaster. For Ethernet type PDU sessions, both PTP over UDP/IP and gPTP over Ethernet are applicable. For IP type PDU sessions, PTP over UDP/IP is applicable. The PTP grandmaster resides in NW-TT. In this case, the NW-TT Port is Master Port, and it delivers Sync messages to nodes outside 5GS. NW-TT is assumed to be Sync-Generation Port, so it generates Sync messages and may deliver Sync messages to other Master port(s) inside 5GS. DS-TT port may or may not be Master port. (Master: N, Sync-Gen: N)

Editor's note: Need to consider the case that NW-TT port is Master Port but not Sync-Generation Port with DS-TT port being Sync-Generation Port is FFS.

- Time synchronization method 3 (the time source is provided by the 5GS and 5G-AN provides a 5GS reference time to the UE via 3GPP radio layer; UE provides time information to attached devices using implementation specific means):

Timing Domain is not applicable. A PCC rule for time synchronization is not required. The method is applicable for both IP type and Ethernet type PDU sessions. In this case, the DS-TT port is the Sync-Generation Port and Master Port for the Domain. The DS-TT will not deliver Sync messages inside 5GS, but delivers Sync messages to nodes outside 5GS. (Master: D, Sync-Gen: D)- Time synchronization method 4 (the time source is provided by the DS-TT in 5GS via gPTP or PTP):

Timing Domain is to be provided from the 5GS (or the AF and the 5GS shares the same Timing Domain). The 5GS acts as a (g)PTP grandmaster. For Ethernet type PDU sessions, both PTP over UDP/IP and gPTP over Ethernet are applicable. For IP type PDU sessions, PTP over UDP/IP is applicable. The PTP grandmaster resides in DS-TT. Solution #X: “PTP GM support by DS-TT” describes the details for the PTP grandmaster in DS-TT. In this case, the DS-TT port is Master Port for the Domain, and the DS-TT delivers Sync messages to nodes outside 5GS. DS-TT port may or may not be Sync-Generation Port. If DS-TT port is not Sync-Generation Port, then the NW-TT port is Sync-Generation Port, which generates Sync messages and delivers them to the DS-TT port inside 5GS. (Master: D, Sync-Gen: D or N)

Editor's note: Need to provide additional information (e.g. required accuracy) received from the AF to the UE/DS-TT using PMIC for any of the above methods is FFS.

- If the AF does not provide a required synchronization accuracy over the air interface, the 5GS may determine a synchronization accuracy based on 5GS constraints.

NOTE 2: this is intended for a wide range of applications, ex. motion control use-cases, VIAPA, smart grid applications where requirements for synchronization accuracy and deployment scenario may be very diverse.

- The 5GS exposes the following to aid the AF in formulating a request for Time Synchronization that will be acceptable to the 5GS:

- 5GS Support for Time Synchronization to 5GS. (5G GM/TSN GM)

- supported time synchronization methods. (Method 1, 2, 3, 4)

- supported (g)PTP versions:

- IEEE 802.1AS [6] (i.e. gPTP), and/or

- PTP over UDP/IPv4 as per IEEE 1588-2008 [X] Annex D, and/or

- PTP over UDP over IPv6 as per IEEE 1588-2008 [X] Annex E.

- Master Port Supported (Master: NW-TT and/or DS-TT)

- Sync-Generation supported (Sync-Generation: NW-TT and/or DS-TT)

- Minimum Time Synchronization accuracy supported.

- Minimum gPTP or PTP message generation supported, and maximum number of clients that can be supported at the minimum gPTP or PTP message rate.

Editor's note: Whether AF outside the trust domain should know which entity in the system generate the messages is FFS.

To support notification, the additional events may be added to the list of monitoring capabilities specified for the NEF in TS 23.502 [3] (see clause 4.15.3.1).

### 6.7.3 Procedures

The following procedure is used to expose 5GS information to aid the AF in formulating a request for Time Synchronization



Figure 6.7.3-1: Time Synchronization capability exposure towards AF



Figure 6.7.3-2: Time Synchronization Request

### 6.7.4 Impacts on existing services and interfaces

To be completed.

**AF**

- Provides the parameters to the NEF to configure the Time Synchronization service.

**NEF**

- Exposes the 5GS capabilities to support Time Synchronization service. Authorizes the Time Synchronization service request from the AF. Controls the (g)PTP functionality in DS-TT and NW-TT:

- start/stop PTP/UDP/IP timestamp insertion and residence time calculation in DS-TT and/or NW-TT,

- instruction to start/stop sending PTP time sync messages from NW-TT (incl. PTP version, domain number(s), sending rate, etc) or from DS-TT.

**UE**

- Distributes the 5G reference time to DS-TT and optionally to applications or devices behind the UE (by mechanism out of scope of 3GPP), for IP and Ethernet types of PDU Sessions.

**DS-TT**

- Indicates a support for PTP/UDP/IP residence time calculation in Port Management Information container to the network.

- When activated by NEF, calculates and adds the measured residence time between the NW-TT and DS-TT into the Correction Field (CF) of the PTP time synchronization messages conveyed over UDP/IP, applies to IP and Ethernet types of PDU Sessions.

- When activated by NEF, (if the time source is located behind the DS-TT as in Solution #1): Inserts a timestamp to the PTP time synchronization messages conveyed over UDP/IP, applies to IP and Ethernet types of PDU Sessions.

- When activated by NEF, supports Sync-Generation.

**UPF/NW-TT**

- When activated by NEF, (if the time source is located in the DN): Inserts a timestamp to the PTP time synchronization messages conveyed over UDP/IP, applies to IP and Ethernet types of PDU Sessions.

- When activated by NEF, (if the time source is located in the NW-TT): generates PTP time sync messages (with the indicated PTP version, domain number(s), sending rate, etc), applies to IP and Ethernet types of PDU Sessions.

- Replicates the PTP time synchronization messages conveyed over UDP/IP in DL direction to the PDU Sessions, applies to IP and Ethernet types of PDU Sessions.

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