FS_IIoT KI#3B: Time synchronization service exposure open ENs

Nokia

TS 23.501 CR2629 (S2-2102032) ENs (1/2)

- Editor's note 1: It is assumed that the NG-RAN already provides 5G timing reference time over Uu towards the UE. Additional impact to activate this "Access Stratum-based 5G clock sync" when it is requested by the AF is FFS.

- As of Rel-16:
  - The UE can be absolutely synchronized to 5G clock using referenceTimeInfo (referenced to an SFN) used together with the estimation of the DL SFN boundary at the UE
  - referenceTimeInfo IE can be included in SIB9 (optional SIB) or DLInformationTrasfer
  - There are different ways **(choice is implementation specific)** the gNB may forward referenceTimeInfo IE to the UE(s):
    - periodically broadcasted on DL-SCH (periodicity from 80ms to 5.12s)
    - broadcast on-demand on DL-SCH
    - unicast on DL-SCH
    - unicast on-demand on DL-SCH

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- For Rel-17 when time synchronization becomes a service:
  - 5GS needs to ensure time synchronization is configured to satisfy AF's request
  - **"Access Stratum-based 5G clock sync" indication towards the gNB ensures that it understands that referenceTimeInfo IE is required at the UE side as part of a service that may be impacted:**
    - Sync accuracy requirement can influence referenceTimeInfo scheduling to a UE (unicast) or the cell (broadcast) and its periodicity.
      - For example, if the NG-RAN node does not have active SIB9, AF request for time sync can trigger the NG-RAN to reconfigure SIB9 or RRC signaling towards the cell or a dedicated UE
  - RAN3 background: RAN3 is studying the impact of mobility events for time synchronization (e.g., propagation delay compensation configuration). It may be beneficial for the target NG-RAN node to know that the referenceTimeInfo configuration for the UE at the source gNB as early as possible during NG and Xn handover

- **Proposal #1: "Access Stratum-based 5G clock sync" to be forwarded via NGAP as part of time sync assistance information.**

- FFS as part of UE context or PDU Session procedures via NGAP signaling

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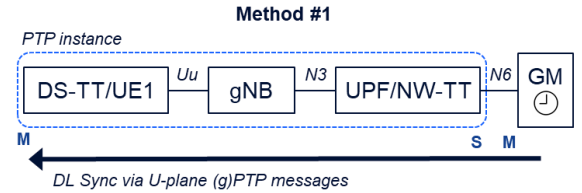
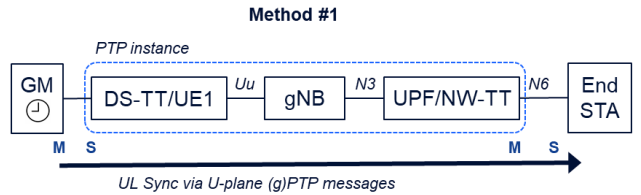
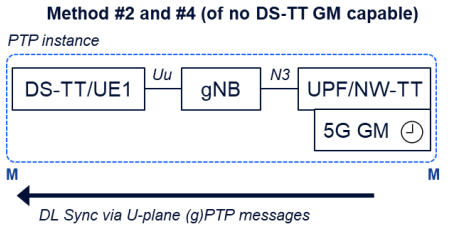
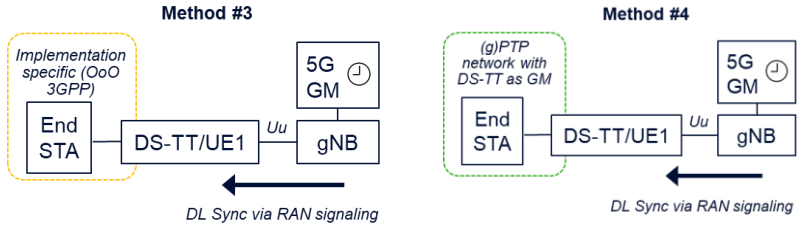
- Editor's note 2: The clock accuracy attribute for time synchronization configuration, NEF exposure of 5G time domain accuracy, AF input regarding requested accuracy and use of time sync accuracy within 5G System is FFS.
- Two synchronization methods supported in 5GS:
  - 5G internal clock distribution: using AS based 5G-clock sync (via SIB9/RRC) (Method #3, #4)
  - Vertical clock distribution: using (g)PTP messages via u-plane (Method #1, #2)
- Factors that impact Time Sync accuracy for (g)PtP:
  - NW-TT and DS-TT time stamping based on 5G Clock in the (g)PtP messages
  - gNB provided referenceTimeInfo distribution (via SIB9/RRC), periodicity, gNB and UE support for propagation compensation delay.
  - DS-TT determination of offset using referenceTimeInfo and (g)PtP messages to align with the end station.
  - # of PTP instances (each PTP instance and hop adds a certain error budget)
- Factors that impact Time Sync accuracy for AS based 5G-clock sync:
  - gNB provided referenceTimeInfo distribution (via SIB9/RRC), periodicity, gNB and UE support for propagation compensation delay.
- **Observation: Fulfilling time sync accuracy for vertical distribution and AS based 5G-clock sync are dependent on NG-RAN provided referenceTimeInfo, PDC**



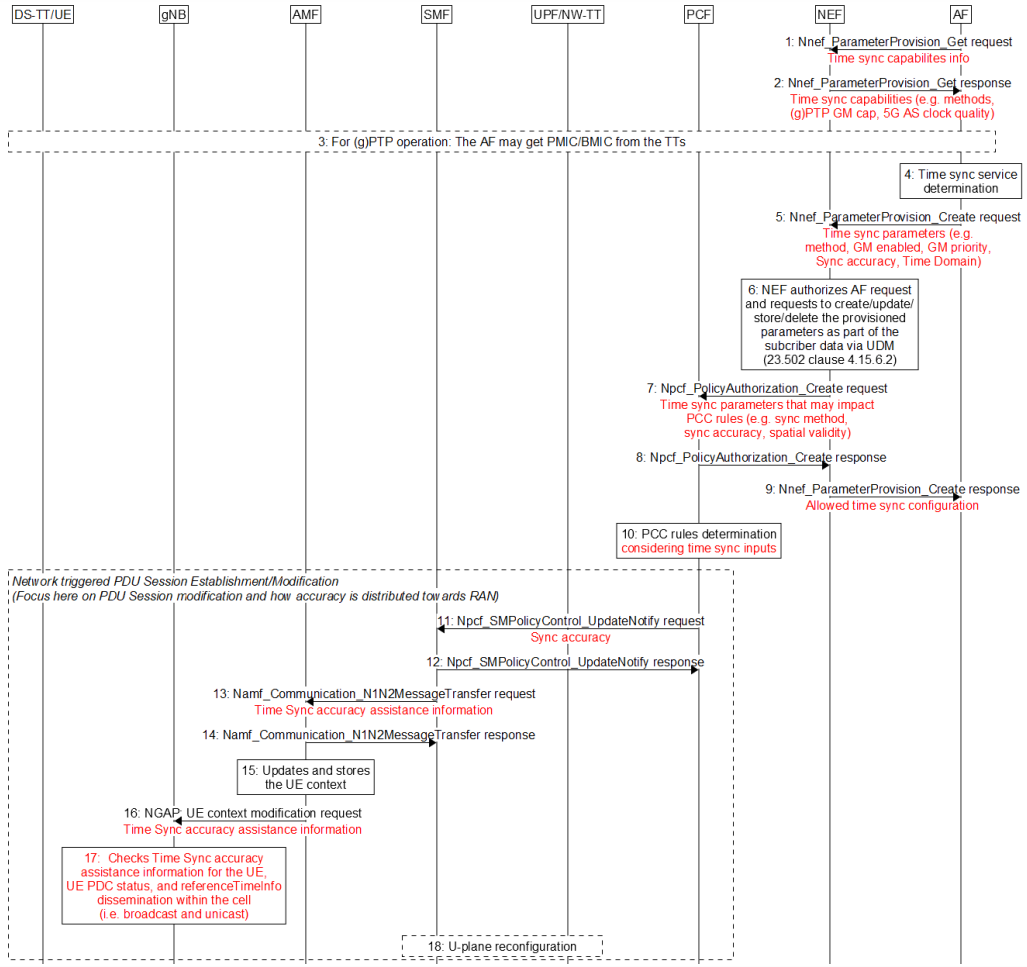






TS 23.501 CR2629 (S2-2102032) ENs (2/2)

- Editor's note 2: The clock accuracy attribute for time synchronization configuration, NEF exposure of 5G time domain accuracy, AF input regarding requested accuracy and use of time sync accuracy within 5G System is FFS.
- How to use accuracy within 5GS?
  - The NEF exposes the Access Stratum-based 5G clock sync clock quality
  - AF provides a synchronization requirement
    - The AF can request to use 5G AS clock for the UE(s) and within its request it may indicate the same accuracy capability the NEF exposed or a more relaxed value (e.g. 1s)
    - If not provided the 5GS can determine and offer time sync accuracy based on its own constraints.
  - **Proposal #2: 5GC forwards the sync accuracy provided by AF as Time Sync assistance information towards the serving NG-RAN node**
    - FFS as part of UE context or PDU Session procedures via NGAP signaling
- The accuracy can be used at the gNB to assist: referenceTimeInfo distribution (via SIB9/RRC), propagation delay compensation decision, handover configuration at the target gNB (i.e. to determine when referenceTimingInfo context transfer is needed).



Backup: Background information

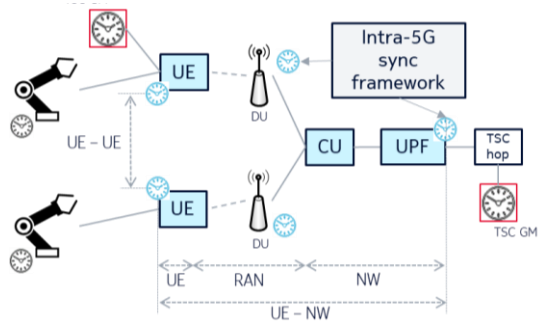
EN2: Background PDC (1/2)

- RAN2 gathered the scenarios and evaluations for synchronization error budget (3 parts: Uu interface, Device, Network) for PDC discussion
- R2-2009755 (RAN2#112E) Summary of E-mail discussion on Propagation Delay Compensation in RAN2
  - Focusing on **network related part of the 5GS E2E budget.** According to the RAN3 LS in R3-187252 (RAN3#102E): The maximum absolute time error (TE) between TSN GM clock and gNB is summarized in the following table

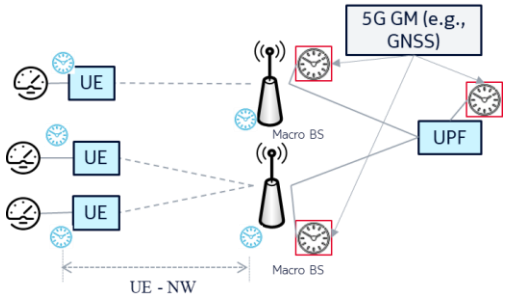
Synchronization source	*Synchronization accuracy*
Local on-site GNSS receiver (GPS is TSN GM clock)	|TE| = 100 ns absolute, 200ns relative between nodes.
Local on-site TSN GM clock	TE is negligible.
Remote TSN GM clock entity using cascaded PTP capable transport network connections	|TE| ~N*40ns, where N is number of PTP hops.

  - In R2-2009755 the following considerations are mentioned:
    - For the control-to-control use case: The connection between UPF (NW-TT) and gNB is assumed to span over maximum four (g)PTP capable hops relative to the 5G GM
    - For the smart grid use case: The NW accuracy does not depend on the path between the 5GS components, but on the synchronization error between two 5G GM clock instances (e.g. GNSS receivers) → the maximum error between the GNSS receivers is 200ns
- RAN1 is doing its PDC studies based on the Uu part of the accuracy budget (see next slide values) as informed by RAN2 in their LS to RAN1

RAN scenarios



Scenario 1 Control-to-Control GM behind CN and Scenario 2 Control-to-Control GM behind UE

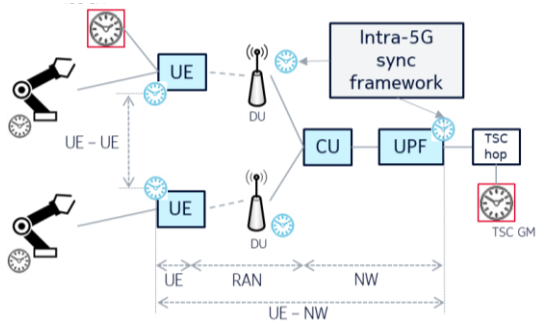


Scenario 3 smart grid

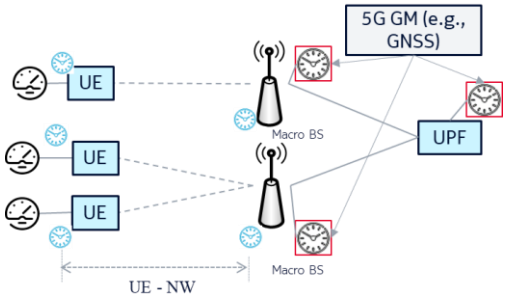
EN2: Background PDC (2/2)

- R2-2010704 (RAN2#112E) Report for Rel-16 (NR-U, Power Savings and 2-step RACH) and IIoT and Small Data lists the agreements:
  - The Uu interface budget for Scenario 1, 2 and 3 are respectively calculated as following:
    - Scenario 1: Uu budget = 900ns – Device – Network scenario1
    - Scenario 2: Uu budget = (900ns – 2xDevice – 2xNetwork scenario2)/2 (assumption is based on gPTP)
    - Scenario 3: Uu budget = 1000ns – Device – Networkscenario3 (baseline assumption that this is based on GNSS)
  - The Device part time synchronization accuracy budget is assumed to be in the range ±50 to ±100ns, this applies to all three scenarios
  - The error caused by the limited granularity of referenceTimeInfo-r16 IE (±5ns) is to be included in the network part budget, and RAN1 should be informed not to include this error in Uu interface.
  - The Network part time synchronization accuracy budget for Scenario 1, 2, and 3 are assumed to be the following:
    - Scenario 1: ±120 to ±200ns (NetworkScenario1) (*assuming 3-5 hops worst case scenario*
    - Scenario 2: ±240 to ±400ns (2xNetworkScenario2) *(assuming 6-10hops worst case scenario)*
    - Scenario 3: ±100ns (NetworkScenario3)
  - The per Uu interface time synchronization accuracy for Scenario 1, 2 and 3 are as following:
    - Scenario 1: ±595ns to ±725ns
    - Scenario 2: ±145ns to ±275ns
    - Scenario 3: ±795ns to ±845ns

RAN scenarios



Scenario 1 Control-to-Control GM behind CN and Scenario 2 Control-to-Control GM behind UE



Scenario 3 smart grid

TS 23.502 CR2539 (S2-2102033) ENs

- Editor's note 1: 5G AS Clock quality and Access Stratum-based 5G clock sync is FFS.
- See slide 5
- Editor's note 2: How a clock accuracy parameter as well as other parameters for time synchronization can be supported is FFS.
- See slide 5

Background: Accuracy PTP

- From IEEE Std 1588-2019:
  - The clockAccuracy is one of the attributes that characterizes a PTP Instance for the purpose of the best master clock algorithm.
  - The clockAccuracy indicates the expected accuracy of a PTP Instance when it is the Grandmaster PTP Instance, or in the event it becomes the Grandmaster PTP Instance.

Table 5—clockAccuracy enumeration

Value (hex)	**Specification**
00 to 16	Reserved
17	The time is accurate to within 1 ps
18	The time is accurate to within 2.5 ps
19	The time is accurate to within 10 ps
1A	The time is accurate to within 25 ps
1B	The time is accurate to within 100 ps
1C	The time is accurate to within 250 ps
1D	The time is accurate to within 1 ns
1E	The time is accurate to within 2.5 ns
1F	The time is accurate to within 10 ns
20	The time is accurate to within 25 ns
21	The time is accurate to within 100 ns
22	The time is accurate to within 250 ns
23	The time is accurate to within 1 µs
24	The time is accurate to within 2.5 µs
25	The time is accurate to within 10 µs
26	The time is accurate to within 25 µs
27	The time is accurate to within 100 µs
28	The time is accurate to within 250 µs
29	The time is accurate to within 1 ms
2A	The time is accurate to within 2.5 ms
2B	The time is accurate to within 10 ms
2C	The time is accurate to within 25 ms
2D	The time is accurate to within 100 ms
2E	The time is accurate to within 250 ms
2F	The time is accurate to within 1 s
30	The time is accurate to within 10 s
31	The time is accurate to >10 s
32 to 7F	Reserved
80 to FD	Designated for assignment by alternate PTP Profiles
FE	Unknown
FF	Reserved