3GPP TSG RAN Rel-19 workshop
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RWS-230412

High Accuracy Timing Services in Rel-19

Huawei, HiSilicon

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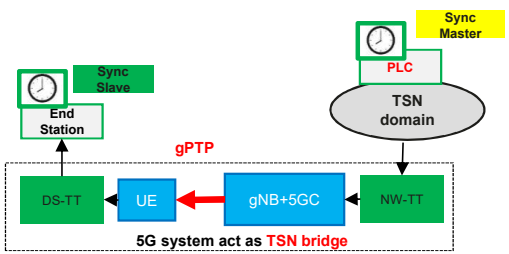
Motivation of High Accuracy Timing Service (HATS)

R16: IIOT sync | **R17+R18: IIOT sync + more use cases** | **R19: High accuracy timing SERVICE**

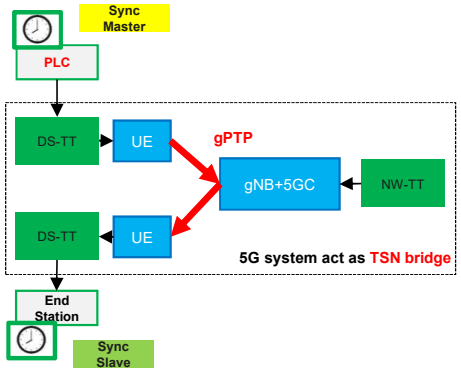
- **Scenario**: 5G IIOT sync (DL time sync)
- **Target**: E2E synchronicity 1us (Uu budget ~ 900ns)
- **Technologies**:
  a. 5GS to support TSC as TSN bridge
  b. Accurate reference time delivery via SIB/unicast RRC



Downlink time synchronization (GM@PLC)

Only small part of industrial automation market

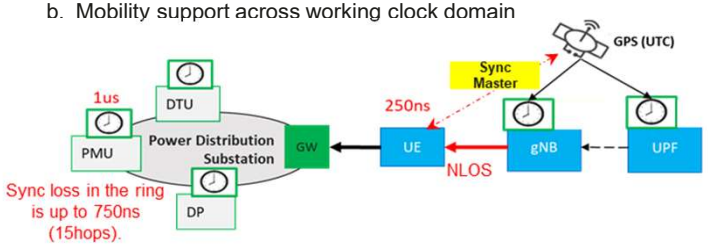
- **Scenario**: 5G IIOT sync (UL time sync), Smart Grid, Finance/Banking, GPS/GNSS fails/degrades
- **Target**: E2E synchronicity 1us (Uu budget ~ 275ns)
- **Technologies**:
  a. Propagation delay compensation
  b. Synchronization status awareness



Uplink time synchronization (GM@UE)

Enable accessing market beyond R16 TSN

- **Scenario**: 5G IIOT sync/Smart Grid future applications and practical deployment requirement
- **Target**: E2E synchronicity 250ns-1us by considering
  - UE-side time distribution accuracy (Smart Grid/IIOT with15 hops/750ns)
  - Outdoor/NLOS deployment (Smart Grid within 20km^2 area)
  - Mobility requirement (Mobile Robot moving across multiple working clock domains)
- **Technologies**:
  a. Timing accuracy enforcement
  b. Mobility support across working clock domain



Smart Grid Power Distribution Substation (IEC 61850, SA1 TS 22.104)

Make HATS as a commercial service

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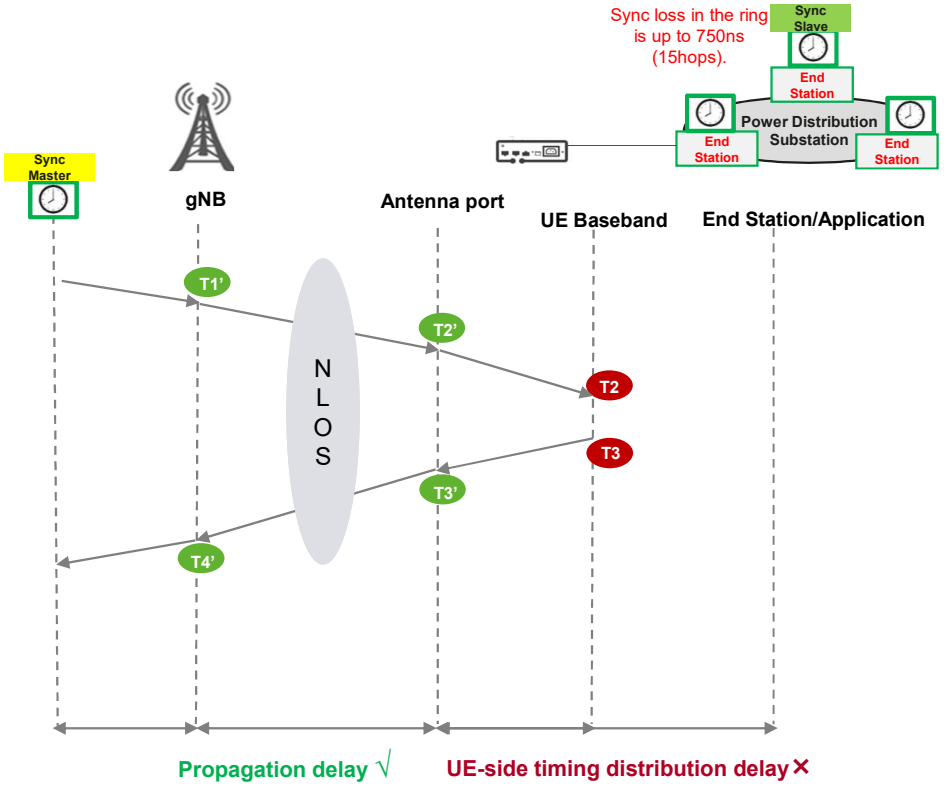
Timing Accuracy Enforcement

Enhanced E2E delay measurement and compensation

- **Motivation**
  - Currently, propagation delay can be measured and compensated by PDC via [T1', T2', T3' and T4'].
  - The UE-side timing distribution delay between UE receiving Antenna port and End Station/Application boundary is overlooked, which is one noticeable component of E2E synchronicity.
  - The current RTT-based measurement and PDC has not taken this component into account and thus the stringent accuracy cannot be guaranteed, e.g. E2E 250ns.

- **Proposal**
  - The UE indicates the related UE-side timing distribution accuracy to gNB for E2E timing accuracy enforcement.
  - E2E delay measurement and compensation is enhanced by taking the UE indication into account.
    - *NOTE1: The UE-side timing distribution (in)accuracy can be up to 15hops/750ns as specified in TS 22.104.*



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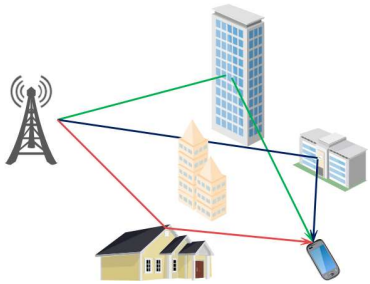
Timing Accuracy Enforcement

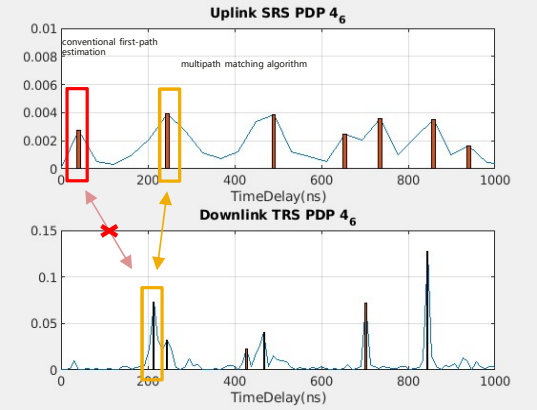
Propagation delay error mitigation in NLOS

- **Motivation**
  - Currently, the first arrival path (FAP) for both UL and DL are used for RTT calculation ,which are assumed to be aligned in LOS.
  - For Smart Grid, it is prone to cause misalignment of FAP between DL and UL for RTT calculation in NLOS, which causes errors and is not desirable for practical deployment scenarios.



Power distribution substation in urban is normally deployed in NLOS with rich multipath and severe blockage

- **Proposal**
  - The UE RX-TX time difference is extended by considering multi-path to align the DL and UL paths for RTT-based PDC calculation.



Evaluation results:
In case that unaligned UL and DL paths are used for PDC calculation, additional misalignment error will be introduced to the calculated propagation delay, e.g. may be up to 80ns in this scenario.

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Mobility Support Across Working Clock Domains

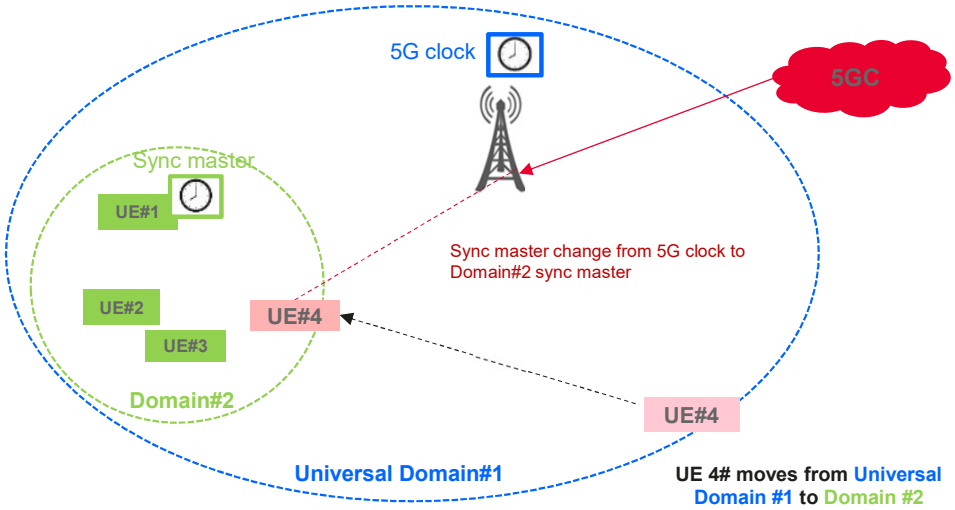
Timing service optimization in support of mobility

Motivation

- Mobility enhances flexibility in the manufacturing process as specified in TS 22.104, which is important to 5GS integration with TSN.
- However, the sync master change due to UE's mobility could cause considerable interruption time and accuracy loss for the timing service performance in 5GS.

Proposal

- Awareness of working clock domain change by gNB to optimize the timing service performance due to UE's mobility.
  - *NOTE2: SA2 coordination is needed.*



Multiple working clock domains

When robot (UE#4) moves to a production line to participate in a task, it needs to sync with domain#2. Accordingly, the gNB needs to adjust the Uu timing mechanism for UE#4 based on the synchronicity of domain#2.

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Summary of Proposals for HATS

Potential scope of WI of HATS in Rel-19

- **Timing accuracy enforcement**
  - To further enhance E2E delay measurement and compensation for timing accuracy enforcement [**RAN2**, RAN1, RAN4]
    - The UE indicates the related UE-side timing distribution accuracy to gNB for E2E timing accuracy enforcement.
    - E2E delay measurement and compensation is enhanced by taking the UE indication into account.
      - *NOTE1: The UE-side timing distribution (in)accuracy can be up to 15hops/750ns as specified in TS 22.104.*
  - To mitigate the prorogation delay errors in NLOS for timing accuracy enforcement [**RAN2**, RAN1]
    - The UE RX-TX time difference is extended to consider multi-path to align the DL and UL paths for RTT-based PDC calculation.
- **Mobility support across working clock domains**
  - Awareness of working clock domain change by gNB to optimize the timing service performance due to UE's mobility [**RAN3**, RAN2]
    - *NOTE2: SA2 coordination is needed.*

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