3GPP SA WG1 Meeting #98e
Electronic meeting, 09-19 May 2022

S1-221068

Study on Non-Universal Time: Local sharing and delivering of common time and frequency

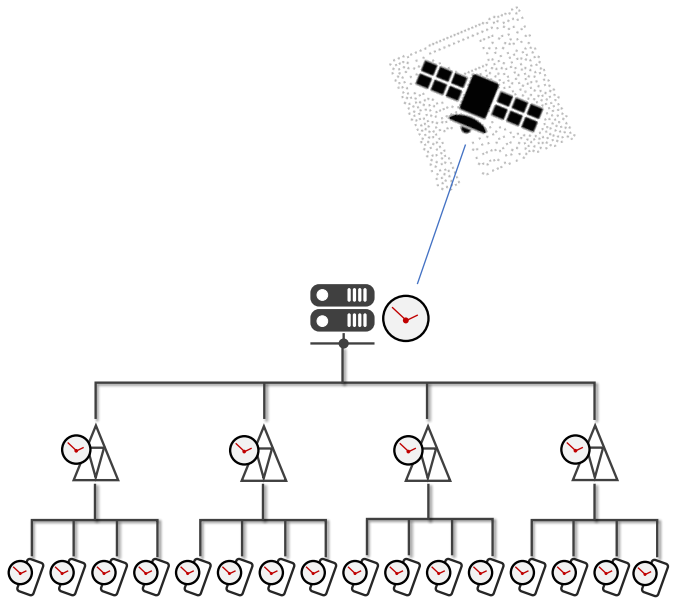
Proposal for SA1 Rel-19 SID

National Institute of
Information and Communications Technology

Considering reference timescale - Current status -

While UTC or GNSS Time is reference timescale that never stop and can be shared around the world, it is often inaccessible and inconvenient for the following reasons

- Requires antenna and open sky
- Weak signal strength received by the UE, thus requiring more power for amplification, etc. during reception
- Requires long signal integration time to achieve nano second accuracy required by some 5G systems



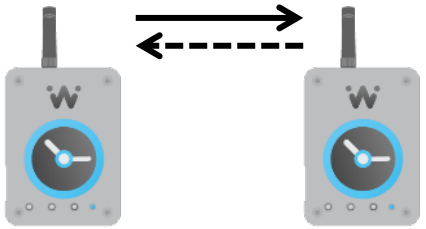
This difficulty is becoming more critical to achieve the low latency and high reliability that will become increasingly important in the future.

Technological background - Technical trend -

On the other hand, it is possible to synchronize each other's system clocks at the nanosecond level by compensating signal propagation time through two-way communication, or by installing a highly accurate and stable clock (e.g., atomic clock).

a. Phase synchronization of network

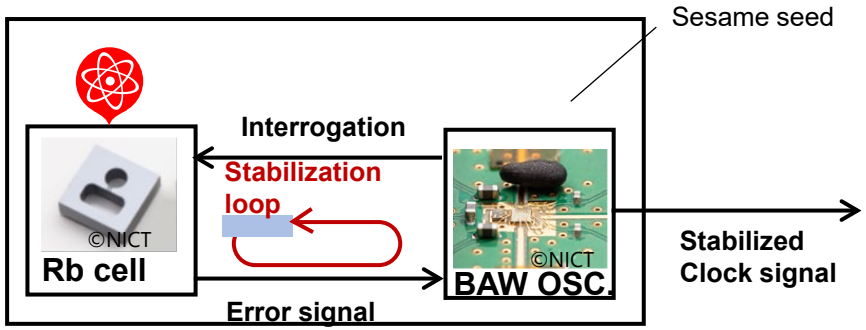
New technique for precision synchronization in pico-second level has been developed.



Synchronization of clock difference and via wireless communication.
Using carrier phase for precision and reduced bandwidth

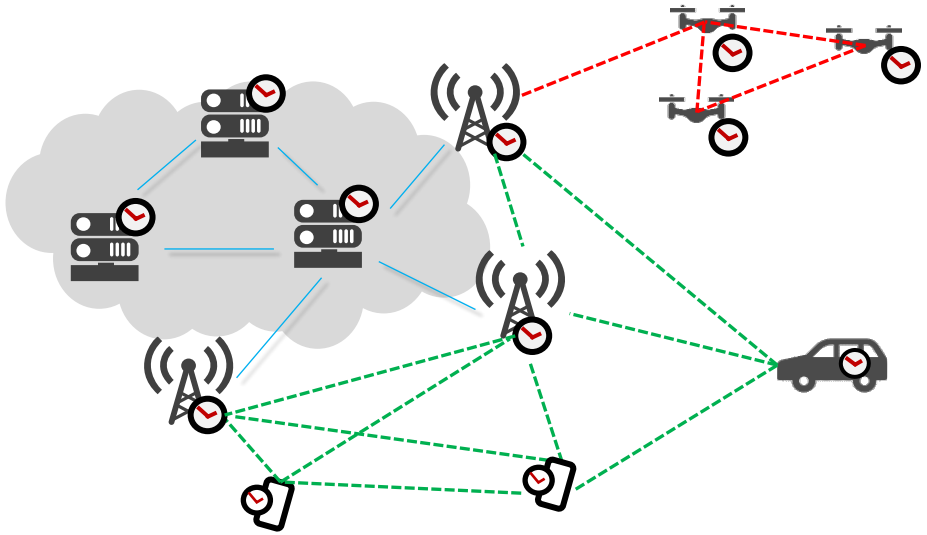
b. Clocks in terrestrial network

Stable oscillators such as Chip-scale atomic clocks are becoming popular.



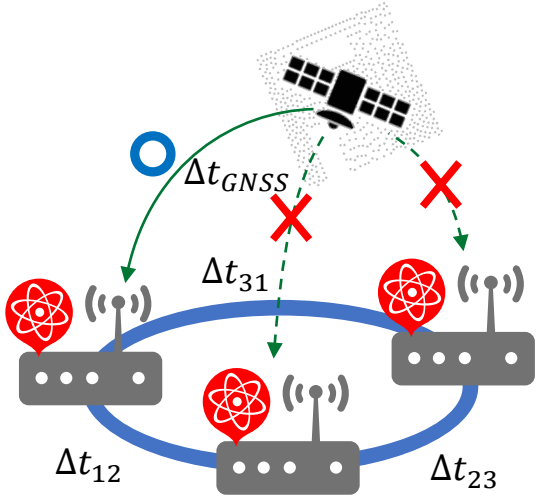
c. Cluster clocks

Decentralized synchronization (Cluster clock)



- ✓ Flexible
- ✓ Robust
- ✓ Reliable
- ✓ Convenient
- ✓ Inclusive
- ✓ Good stability

Distributed clock system where chip-scale atomic clocks are distributed over RAN.



Network model of cluster clock

1. Data collection (Δt_{12}, Δt_{23}, Δt_{31},Δt_{GNSS})
2. Time estimation using Kalman filter
3. Supply the estimated data to nodes

Synchronization procedure

Progresss in local clock management may free the clock system from the universal time such as UTC. Why not local timescale for URLLC?

Non-universal time (NUT)
(or could be “Local Network Time (LNT))

Thus, it is possible to define a local timescale and the system is locally synchronized to it particularly if the UTC or GPS Time is not available.

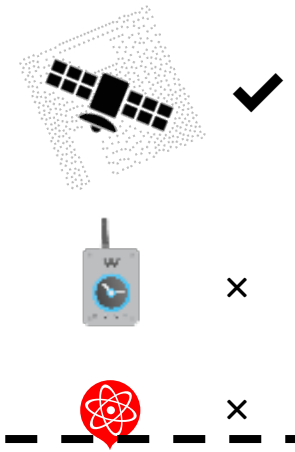
Such local timescale, Non-universal time (NUT), is a clue to realize M2M and V2X communications with high reliability and low latency, where synchronization over short distances is important.

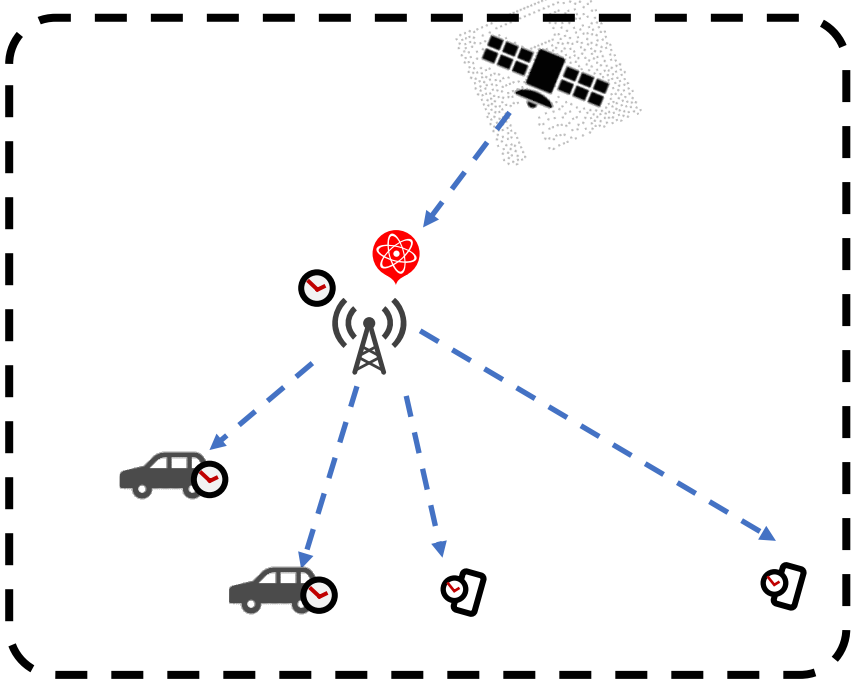
Also, by having a local shared time, if some terminals have good access to GNSS and easy access to UTC, all terminals will be able to access UTC in 2-hops via the NUT.

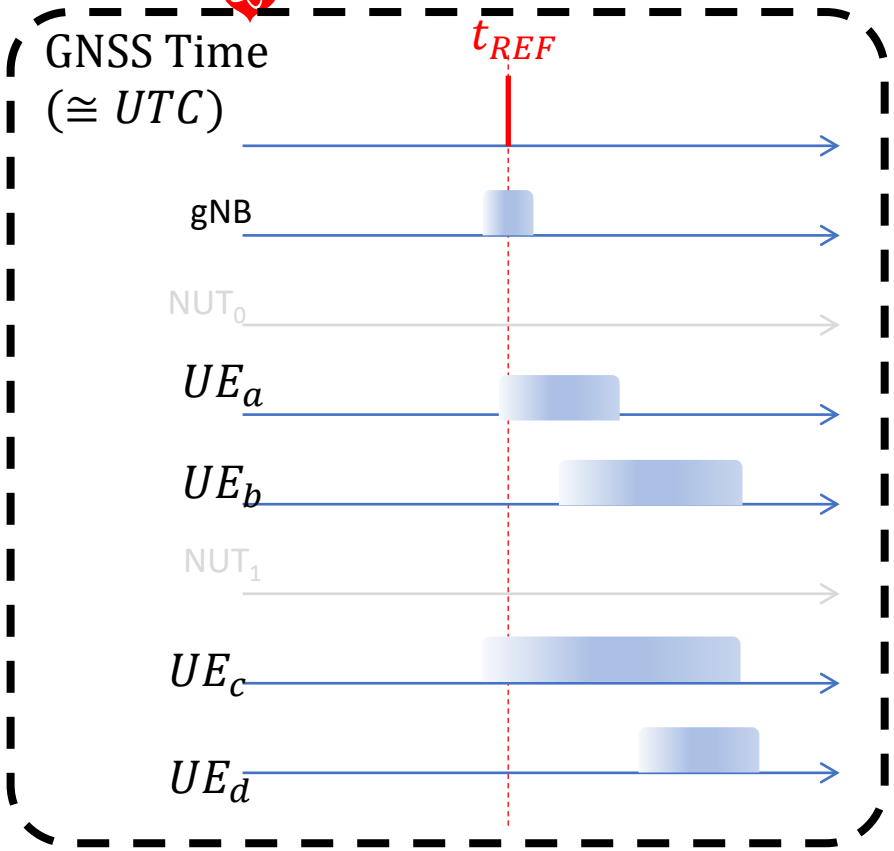
Objective of the Study Item

- Study use cases and possible new services made feasible by defining and sharing a local timescale.
- Study technical requirement for the local timescale such as
  - ✓ Rank the quality of local timescales and determine the criteria of characteristics such as stability or time error from UTC.
- Study the methods
  - ✓ For determining the local time system according to accuracy requirements and use cases
  - ✓ For distributing local time information and UTC over wireless networks
  - ✓ Of subscription management for time information

Present:







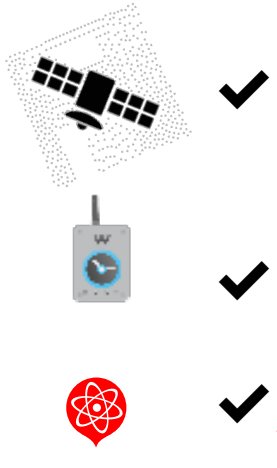
$t_{REF} = UTC \sim t_{gNB}$

Delay of the timing depending on the distance between UE and gNB.

Depends on the GNSS availability in gNB, which requires accessibility to the roof and open sky.

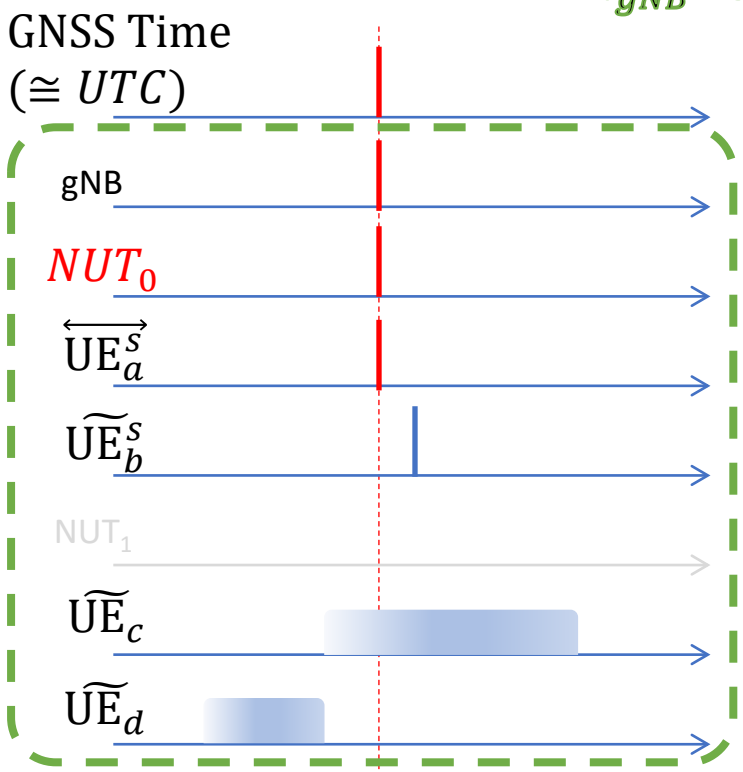
Conventional quartz clocks require frequent synchronizations to gNB.

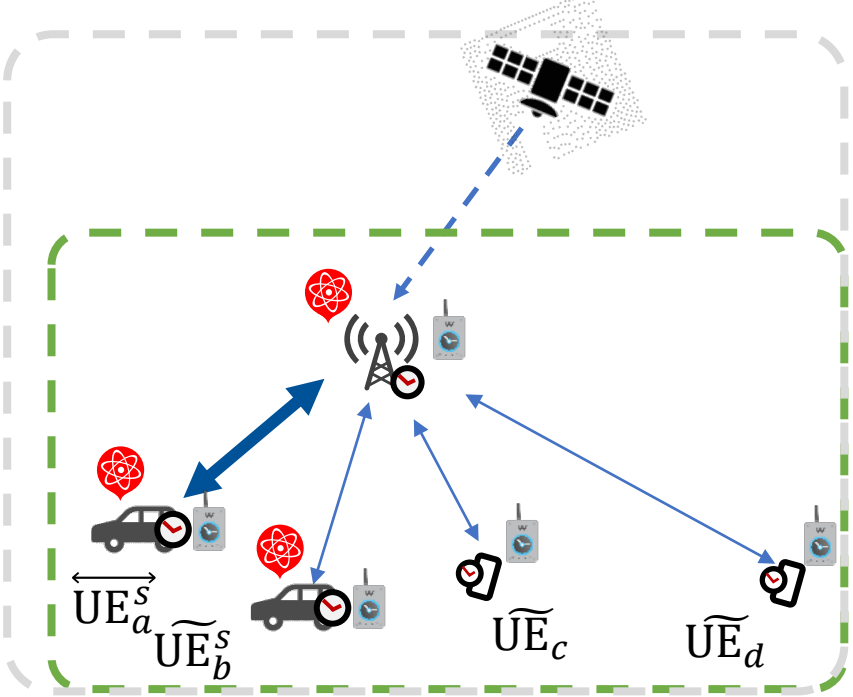
Case 1: GNSS available



t_{REF}

$t_{REF} = NUT_0$
$= t_{gNB} \sim UTC$





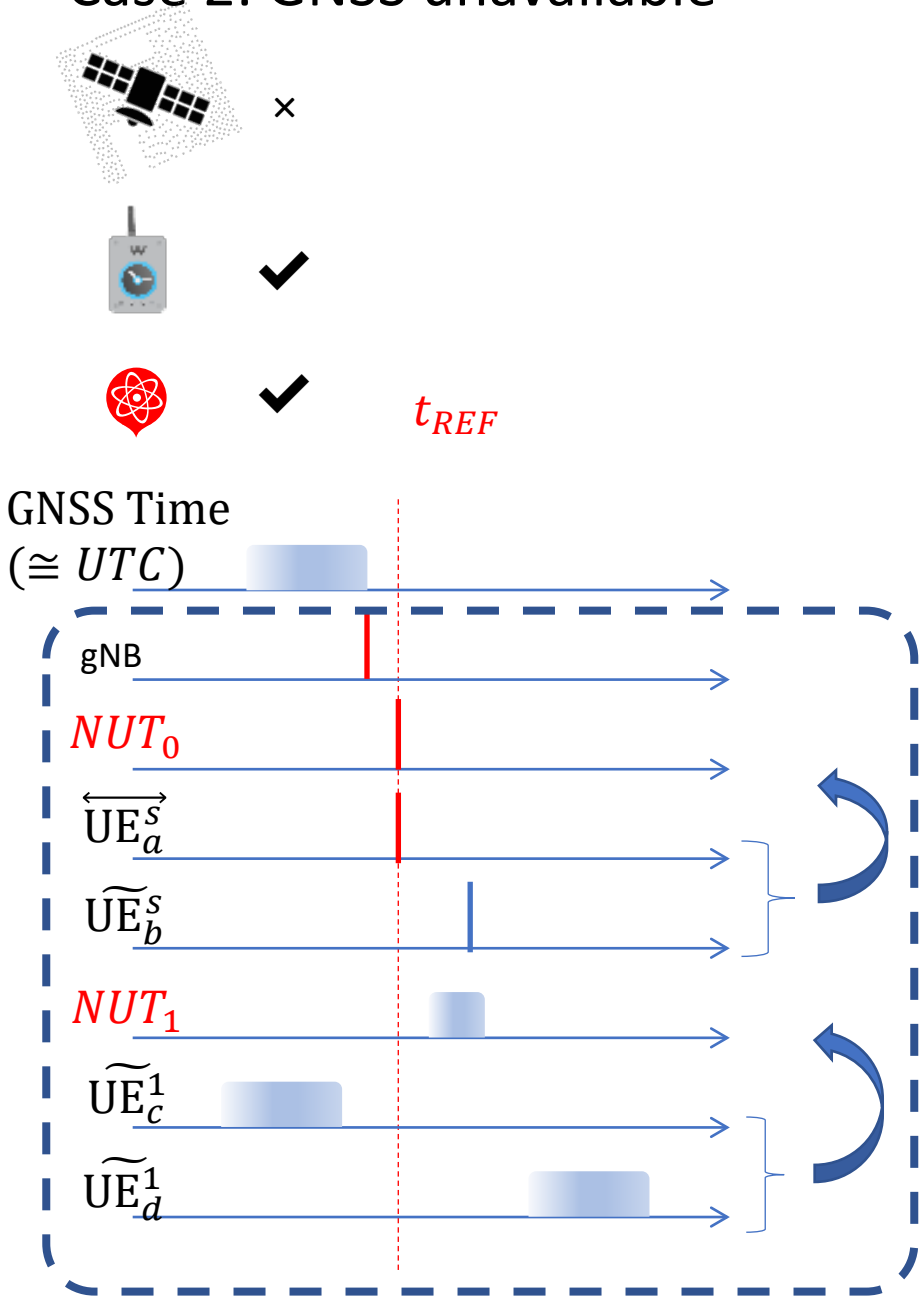
$\longleftrightarrow$ Tight synchronization using frequent two-way synchronization

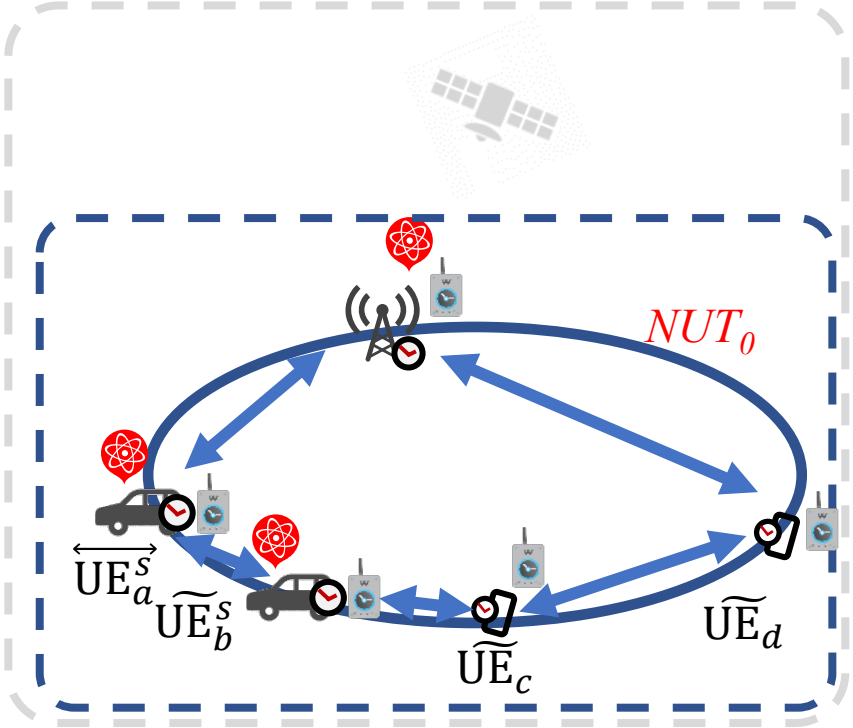
ex) $\overleftrightarrow{UE}_a^s$ with stable osc.

$\sim$ Loose and infrequent synchronization after the initial two-way synchronization

ex) $\widetilde{UE}_c$

Case 2: GNSS unavailable





$t_{REF} = NUT_0$
$\neq t_{gNB} \neq UTC$

Stable local timescale NUT_0 is generated by the most stable (single) oscillator or a virtual timescale made of a local ensemble (cluster clock).

Once NUT_0 is defined and shared by all, UEs are not directly affected by either the GNSS availability, or the status of single master clock for the case using an ensemble timescale.

The local timescale may have grades and non-URLLC users use conventional local timescale (ex NUT_1), leading to on-demand provision of time.