

Agenda item: 4.2
Source: Sharp
Title: Support of Non GNSS capable devices in NTN systems (Rel-18)
Document for: Discussion and Decision

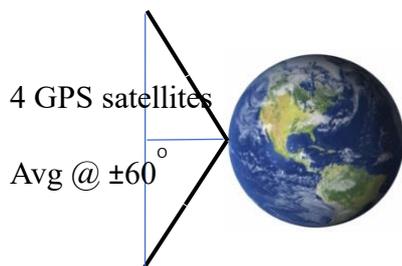
Background on GNSS vs non GNSS capable devices in NTN systems

GNSS capability is currently assumed to assist in time and frequency synchronization in the 5G network. Accurate time and frequency synchronization are necessary for 5G systems to operate dependably. Accurate synchronization is achieved in terrestrial systems without assuming GNSS capable devices. However, NTN systems operate with more extreme conditions. The propagation delays in terrestrial mobile systems are usually less than 1 ms. In contrast, the propagation delays in NTN are much longer, ranging from several milliseconds to hundreds of milliseconds. Doppler frequency shift in NTN LEO systems is typically 10 kHz per 1 GHz carrier frequency. For widely used Ka/Ku band satellite systems, this produces a Doppler frequency shift of over 100 kHz. The 5G network must accurately compensate the extreme delay and Doppler for reliable end-to-end communications using NTN systems.

To assist in correcting these effects, release 17 assumes NTN capable user equipment (UE) is equipped with a GNSS receiver, providing both a high accuracy clock and a positioning service. Also, the 5G network provides satellite ephemeris data to the UE. Using geometry along with knowledge of its location and velocity, and the satellite location and velocity, the UE can then calculate and compensate both time delay and Doppler effect as needed by the system.

GNSS Reliability and Power Issues

For the UE to determine its location in 3 dimensions using GNSS, it needs to receive a GNSS signal from 4 GNSS satellites at the same time. With GPS, 24 satellites are currently guaranteed to be active. As indicated in the following figure, when the UE is limited to GPS satellite reception within a solid angle of 60° of vertical, the UE will receive 4 GPS satellite signals on average.



This is a reliability issue particularly when the UE is in hilly/mountainous areas, or near man-made structures. This is not only an issue in remote areas. These are areas where terrestrial networks typically have problems and will want to request a switch over to NTN. But NTN will often have problems as well if reliant on GNSS.

GNSS power consumption in the UE is also a concern. UEs often power down GNSS until needed to conserve battery life. Powering up GNSS can take over a minute. So, NTN enabled UEs dependent on GNSS either leave GNSS circuitry powered on way more than desired, and sacrifice battery life, or they power down GNSS and cause a severe delay in NTN services when needed. Additionally, there are numerous IoT applications for NTN such as power grid or other infrastructure monitoring. These devices often rely on a battery that is rarely serviced. A low-power solution is particularly vital to facilitate these IoT applications.

Given the above, UEs dependent solely on GNSS for time and frequency synchronization will result in UEs that cannot establish a link due to GNSS outage, and likely a greatly reduced UE battery life.

Non-GNSS Based Time and Frequency Synchronization

Because of the discussion in the previous section, our position is that UEs relying solely on GNSS will not have a suitable NTN backup for poor coverage locations in terrestrial networks, as the conditions driving the poor coverage (shadowing) also drive GNSS outages. These devices will also have problems in remote hilly/mountainous regions for the same reasons. Additionally, switchover to NTN when UE GNSS capability is powered down may not be possible due to the delay in powering up UE GNSS capability. We see these applications for NTN being very important for user adoption. Without them, the enticement for NTN-enabled UEs appears to be coverage in flat terrains without terrestrial networks. We are concerned if this is broad enough. Providing a terrestrial network backup and providing good coverage in hilly/mountainous regions provides more reasons for user adoption of NTN-enabled UEs.

IoT is an additional key application for NTN. We acknowledge and appreciate the RAN1#105 progress on sporadic transmissions on NTN networks for GNSS enabled UEs. We expect this to give welcomed improvement in UE battery life. But there are limitations to this work. IoT applications are often very sensitive to battery power drain. GNSS circuitry needs to draw power long enough to establish location, which is undesirable. Additionally, we do not know what the sporadic transmission limitation will do for IoT innovation. There are also the GNSS outage concerns of the previous paragraph that is not adequately addressed by the sporadic transmissions progress in RAN1#105. These IoT applications would be better facilitated by a non-GNSS option that yields a significantly better battery life, and reduced outages.

For the above reasons, we propose a study on non-GNSS time and frequency synchronization methods in RAN 1 release 18.

Initial work may include:

- Establishing minimal synchronization reliability for deployment.
- Establishing minimal UE battery life for deployment.
- Adopting the following use cases:
 - o 5G connection established, then loss of GNSS.
 - o GNSS capable device attempting initial NTN access, with non-functioning GNSS. GNSS is non-functioning due to GNSS power-down on the UE, or due to GNSS outage.
 - o Stationary devices without GNSS capability.
 - o Economic mobile devices without GNSS capability (E.G., not a smart phone).
- Studying and enumerating various potential alternatives to GNSS. **Error! Reference source not found.** lists potential alternative positioning methods. Also, a re-designed RACH has been discussed in RAN1, as has the use of timestamps. These are ideas for GNSS alternatives to draw upon.
- With these use cases, benchmark potential synchronization methods in terms of reliability and UE battery life. Compare vs established minimums.

3GPP historically allows flexibility on implementations and avoids too much involvement in potential implementations. However, as a practical matter, the system must work. Here, that means examining potential implementations to ensure we have a system that will function to expectations.

We request this study be a part of release 18. Without this work, NTN-enabled UEs may not function acceptably, and thus deployment is further delayed.

Conclusion

We propose:

A Rel-18 study on non-GNSS based time and frequency synchronization for NTN-enabled UEs.

References

- [1] 3GPP TR 38.305 V16.3.0, "User Equipment (UE) Positioning in NG-RAN," December 2020.