Handover Management in 6G Satellite Integrated Terrestrial Networks

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Abstract

6G aims to deliver global seamless connectivity using sub-THz frequencies, expanding 5G capabilities under the IMT-2030 framework. It targets very high performance, including user data rates of 300–500 Mbit/s, ultra-dense connectivity (10^6–10^8 devices/km^2), support for extreme mobility (up to 1000 km/h), and ultra-low latency (0.1-1 ms). Achieving these goals in Non-Terrestrial Networks (NTN) requires highly efficient, near zero-latency handover mechanisms to ensure that handover is done in shortest possible time and with minimal interruption to the user data transmission.

Handover in telecommunication networks enables seamless continuity of a user equipment (UE) connection when transitioning between cells in connected mode. In terrestrial systems, handovers are primarily triggered by UE mobility, varying signal conditions, and load balancing. However, an additional and frequent cause arises from the rapid movement of Low Earth Orbit (LEO) satellite base stations (gNBs) in NTN. This results in unavoidable, high-frequency handovers. Handover with satellites are worsened by significant propagation delays of 1-7 ms compared to 0.3-33 μs in terrestrial network between UE and gNBs.

These delays challenge conventional measurement-based mobility procedures, as UE measurements sent to the source gNB may become outdated by the time they are processed and acted upon, leading to mistimed handovers. Furthermore, differences in signal propagation times between serving and target satellites can disrupt synchronization measurement windows (e.g., SSB/CSI-RS), preventing accurate neighbor cell detection.

To address these challenges, predictive approaches leveraging satellite ephemeris data or UE location information are essential. In this context, we investigate an ephemeris-based intra gNB-CU handover in a split gNB architecture. The split gNB architecture assumes central unit (CU) residing on the ground and distributed units (DU) deployed on satellites. We consider a UE switching between satellite gNB-DUs connected to the same gNB-CU on earth, thus this scenario is categorized as intra gNB-CU handover. The proposed approach minimizes execution delay and targets near zero-latency mobility by integrating principles of L1/L2-triggered conditional handover. L1/L2-triggered mobility is handover triggered by physical (L1) and link-layer (L2) conditions shared by the UE, rather than by higher-layer. This contributes to meeting stringent 6G requirements, including ultra-low latency, high mobility support, and seamless global coverage.