IAF SPACE COMMUNICATIONS AND NAVIGATION SYMPOSIUM (B2)
Advances in Space-based Communication Systems and Services, Part 2 (3)

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ENABLING MULTI-TENANT CELLULAR IOT SERVICES OVER LEO CONSTELLATIONS IN FUTURE 6G NETWORKS

Abstract

Satellite-based, non-terrestrial networks (NTN) are crucial in providing global connectivity coverage, supporting important use cases in future 3rd Generation Partnership Project (3GPP) 6th generation networks (6G). Existing systems stand out due to their high complexity and specialized user equipment (UE) that comes with high operational costs. The rise of CubeSat and SmallSat spacecraft technology drastically cuts the cost of deployment, especially in Low Earth Orbits (LEO). Possible access architectures for NTN include repeater-like architectures with transparent payloads, where the gNB/eNB is located on the ground segment, or regenerative payloads, with a full gNB/eNB located on the satellite. A key NTN service is expected to be based on the extension of the NB-IoT (NarrowBand Internet of Things) protocol deployed over low-density LEO constellations using regenerative payloads, that are able to operate without having an active feeder-link connection with a ground station. Enabling this service requires solving two key architectural challenges, namely the operation of the NB-IoT protocol in store and forward mode and supporting multi-tenancy, with multiples service providers using the same LEO constellation to extend their service footprint. The main contribution of this paper is twofold. First, we propose a revised 3GPP architecture for NB-IoT services with a regenerative NTN architecture supporting discontinuous service and feeder-link connectivity, whilst supporting multi-tenancy by adding store and forward functionality. Second, we propose a practical NB-IoT constellation and provide a capacity analysis. That constellation enabling for NB-IoT coverage across the globe may be possible with as little as one satellite, assuming its orbit covers the whole globe. Furthermore, we analyze delays in authentication and user data transport along with the maximum number of supported UE per satellite due to capacity constraints in the feeder-link under typical data patterns and statistical channel models. We find that variations in revisit and visibility times for both UEs and ground stations significantly impact the maximum number of supported users. This is exacerbated by the lack of inter-satellite links, which is likely the case in small constellations, due to limited visibility. Our research concludes with a feasibility analysis of global NB-IoT services through LEO constellations featuring both service and feeder-link discontinuity. A small constellation can provide intermittent global coverage supporting thousands of UEs, permitting low-cost NB-IoT connectivity in otherwise undeserved areas. Finally, the paper points

out that new architectures for discontinuous backhauling, as one of the key NTN challenges, must be solved by future 6G networks.