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ARCHITECTURAL DEFINITION OF ON-BOARD ANTENNA ARRAYS FOR DIVERSE BEAM-HOPPING ILLUMINATION SCHEMES IN 5G/6G NTN SCENARIOS

Abstract

Today's design of satellite communication payloads is based on the assumption that traffic demands can change irregularly with time over a given service area. With the advent of Non-Terrestrial Networks (NTN) in 5G/6G, advanced antenna systems are required on-board to maximize the capacity of the system and to adapt the communication resources to diverse traffic conditions.

Beam-hopping (BH) in multibeam satellite system is a technique used to sequentially illuminate a number of active beams over specific areas and intervals to serve a dynamic traffic demand. With BH, a lower number of active beams is used by flexibly accommodating the available power and bandwidth resources into the chosen set of beams. The use of BH brings advantages such as an increase in the spectral efficiency thanks to frequency reuse and the lower satellite cost as the payload power requirements are reduced.

In the literature, some authors have focused on the system-level evaluation of the performance of beam-hopping systems in terms of throughput increase or packet-lifetime [Zhang,2022]. Other researchers evaluate aims at optimizing the resource allocation in LEO [Wang,2019] or GEO systems [Lei 2020]. In [Zhao,2022] authors identify challenges of beam-hopping technology for LEO systems based on DVB-S2X framing, skipping the impact of 5G waveforms and frames. However, the impact of the proposed dynamic beam-hopping illumination patterns on the satellite platform and its feasibility in terms of antenna array design has not been evaluated.

The use of BH require different elements: first, antenna array, beamformer or beam selection network, flexible power assignment and a control mechanism to govern the beam illumination and produce the switching between illumination patterns. On the other hand, a beam-hopping controller is required to assign traffic streams to the corresponding active beams.

In this paper, we present a methodology to extract the requirements and specifications for the antenna on-board with beam-hopping in terms of electrical parameters, power consumption, technical feasibility and other KPIs. The proposed approach is based on a system-level simulation of a particular orbit and several traffic demand scenarios, that will allow the estimation of the optimum beam illumination sequence and finally the derivation of on-board antenna requirements. We compare different antenna array and beamformer architectures in order to define the best BH solution in terms of communication performance and feasibility. The results will support in the decision-making to set-up a beam-hopping strategy and will address the impact of the on-board antenna on the overall capacity.