Annex - I

Performance Analysis and Resource Optimization in Aerial Access and Edge Computing Networks for 6G

Abstract:

In recent years, there has been a significant interest in ubiquitous coverage, high data rate connectivity, and mobile edge computing (MEC) as crucial services within the future sixth-generation (6G) wireless networks. These services are regarded as essential components, exemplifying the advancements anticipated in 6G technology. Nevertheless, the successful implementation of these services significantly relies on the availability of robust network coverage and telecommunication framework. Unfortunately, in far-flung and isolated regions, such framework is often lacking, posing significant challenges in achieving uninterrupted connectivity, comprehensive coverage, and efficient computation offloading. In this regard, the development of non-terrestrial networks (NTNs) and their integration with terrestrial networks is a potential research area in 6G networks. NTNs are favored for their cost-effective on-demand deployment and aim to provide ubiquitous coverage, uninterrupted connectivity, and efficient edge computing capabilities. In addition, the evolution of versatile aerial platforms with diverse capabilities has ushered an era of many unexplored possibilities and applications where these platforms can be utilized for providing access and edge computing services.

Inspired by the potential of integrated terrestrial and NTNs, in this thesis, we investigate the performance gains that can be achieved by aerial access and edge computing networks. Specifically, the research work, proposed systems models, and achieved contributions, based on the applications of aerial access and edge computing networks, are grouped into four research phases, as follows. In the first phase, we propose a downlink multi-tier space air-ground integrated network (SAGIN) comprising of millimeter wave (mmWave)-enabled aerial platforms, i.e., satellites and high-altitude platforms (HAPs), for complementing the terrestrial Terahertz (THz)-enabled small-cell base stations (SBSs). We evaluate the proposed SAGIN architecture against multiple performance evaluation parameters. In the second phase, we explore an uplink non-orthogonal multiple access (NOMA)-MEC-enabled aerial vehicular network operating at mmWave in which the ground vehicles are provided MEC services by a HAP. The mmWaves range is targeted to have high-rate data transmissions and NOMA implementation further enhances the bandwidth available for an individual vehicle. Here, the main objective is to minimize the transaction time of a NOMA cluster offloading its data to MEC servers located at the HAP. We devise a dual-layer optimization scheme for optimal resource allocation by using the Lagrange multipliers method and then attain convergence by implementing a sub-gradient approach. Targeting the 6G horizon, in the third phase, we investigate a NOMA-MEC enabled aerial-terrestrial network operating at mmWave where the terrestrial users are provided access and edge computing services by HAPs. We analyze the overall performance of the proposed model and aim to reduce the difference in transaction time among the users in a NOMA cluster by optimizing the transmission power and computational resources via successive convex approximation method. Finally, taking in the fourth phase, we explore a high-altitude edge computing-enabled SAGIN leveraging mmWave frequency range in which the Internet of Things (IoT) devices are provided access services by low-earth orbit satellites and HAPs while the HAPs offer MEC facility as well. NOMA is used as a multiple-access technique with different clustering mechanisms in uplink (UL) and downlink (DL) communication. We aim to establish high-rate data transmission in DL along with minimizing the transaction time of IoT devices offloading their data to the HAPs in UL communication. Our research findings not only validate the efficacy of integrating terrestrial and

NTNs but also offer practical insights for the design and optimization of aerial access and edge computing networks for 6G wireless communications, ensuring effective resource allocation, and meeting the diverse system requirements.

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