The Game of Drones: Joint Optimization of UAV Deployment and Caching in Wireless Networks

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ABSTRACT

Unmanned Aerial Vehicles (UAVs), or commonly known as drones, have attracted the interest of research and industry [1]. Their agility, autonomy and fast deployment can be leveraged in wireless communications providing connectivity to terrestrial users as flying base stations. Their major capability is that they can quickly change their position and thus adjust to traffic variation and user mobility. Additionally, well-known vendors such as Google, Facebook, Amazon and Nokia use drones to extend coverage in cases where stable wireless infrastructure is not feasible or increases the cost. Despite all these benefits, drones have limited endurance, owing to their practical size, weight and power (SWAP) constraints. For this reason, energy efficiency and resource management in UAV-assisted networks have been examined from various perspectives (resource allocation, optimal placement, trajectory planning, etc.) [2].

In this work, we consider the use case where UAVs act as mobile/flying base stations, in order to complement and/or enhance the performance of a ground cellular network. More specifically, we consider UAVs with local storage capacity that can serve user requests for the cached contents. This is a scenario commonly considered for cases of crowded hotspots, peak hours, areas with limited connectivity, natural disasters, etc.

The problem of optimal caching has been considered before for UAVs. However, previous works focus only on caching allocation decisions, neglecting two important aspects of UAVs: flexibility in changing their position and battery constraints. The former can be exploited to enhance caching efficiency, and the latter --if neglected-- could lead to overestimation of the performance. To this end, in this work, we are the first to consider the problem of jointly deciding the UAV placement and which contents to cache in each of them.

We model the problem of optimizing the cache hit ratio, and show that it is of NP-hard complexity. We design a lightweight greedy-based algorithm for placement/caching that guarantees an (1/2)-approximation. The proposed algorithm exploits user-centric information such as content request distribution and user location for decision process. As a second step, we incorporate the battery constraint in our model and design a modified version of the greedy algorithm, that takes into account the number of users associated with a UAV and the number of requests that the UAV is expected to serve, to allocate contents in the cache. Our initial simulation results show that jointly optimizing UAV placement and caching, increases network performance in terms of cache hit ratio, compared to approaches that focus either exclusively on caching or both perspectives but independently. Additionally, taking into account the battery constraints, leads to a more efficient resource allocation strategy and coverage across the network area, mitigating communication failures. As future step, we aim to test our model in real world scenarios and also study the routing process in the UAV networks.

REFERENCES

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