Abstract

Unmanned Aerial Vehicles (UAVs) are being massively adopted for a wide range of tasks from agriculture to riot-control and monitoring. The massive rise in the use of UAVs is attributed to the high resolution of spatiotemporal data it can offer, the availability of on-demand services, and the provisioning of the additional features of portability and reconfigurability. This Thesis aims to enhance the information handling capacity and controllability of the commercially available, off-the-shelf UAVs, by connecting them over wireless networks. Enabling the use of UAVs over networks facilitates the implementations of substantial and processing-intensive tasks, which, in regular UAVs, are either absent or not feasible. These integrations vastly improve the capabilities of UAVs and the scope of their applications without incurring significant changes in their flight metrics or additional economic factors. The goal of achieving robust offloading in UAV networks can be categorized to address one of these three questions – 1) *When to offload*, 2) *How to offload*, and 3) *Where to offload?*

The first three objectives of this Thesis fall under the purview of the first question. The first objective evaluates the enhancement of UAV controllability and resilience through the incorporation of a network-based control and stabilization approach, which operates in addition to the UAVs' existing stabilization mechanisms. The second objective reduces the network load caused by the repeated transmission of massive amounts of UAV sensory data by voluntarily reducing the data transmitted over the network, and predicting the missing values based on a Long-Short Term Memory (LSTM) prediction model at a remote server. This approach enhances the network scalability by allowing the simultaneous control of multiple UAVs, using the amount of network resources consumed by a single UAV. The third objective focuses on a decentralized, yet collaborative task accomplishment scheme for offload ing information within the airborne network only. This objective analyses the efficacy and speed of task completion through the use of multiple UAVs communicating opportunistically with one another.

The fourth and fifth objectives of this Thesis attempt to address the second question. Towards this, these two objectives aim to choose the optimal information offload path in UAV networks in a decentralized manner. The fourth objective proposes a reduced offload path discovery scheme, which is accentuated with an energy-aware path selection mechanism. Here, the source UAV has the information of all the UAVs constituting the optimal path to the destination UAV. Similarly, the fifth objective also proposes an optimal offload path selection mechanism in UAV networks. However, in contrast to the previous objective, the source UAV does not have any information of the other UAVs except its immediate neighbors. Each UAV hosts a pre-trained Multi-Armed Bandit (MAB) model, which selects the UAV that will subsequently offload towards the destination, based on reward maximization at each of the UAVs.

Finally, the sixth objective proposes an optimized offload target selection scheme in UAV networks to address the third question. This objective proposes a Nash bargaining-based weighted intra-edge processing offload scheme to distribute the processing load appropriately within the UAV network.

The performance of the proposed schemes highlight the effectiveness of offloading in UAV networks by enhancing network scalability for supporting an additional 56% UAVs over the same network, and increasing the collective network processing speed by 100%, compared to a UAV network that follows a star topology. Additional advantages of this work include a significant reduction in network traffic through opportunistic information exchanges, increased network lifetimes, reduced task accomplishment times, higher collective savings of UAV energy, and increased UAV survival rate.

Keywords – UAV Networks, Drones, Quadrotors, Scalability, Energy-aware, Network lifetime, Nash bargaining, Multi-Armed Bandit, Opportunistic communication, Decentralized networks, Offloading, Routing.