Ph.D. Dissertation Proposal Defense

Candidate: Hazim Shakhatreh
Date: Wednesday, May 17, 2017
Time: 10:00 AM
Venue: ECE 202
Title: Wireless Coverage Using Unmanned Aerial Vehicles

Abstract

Unmanned aerial vehicles (UAVs) can be used to provide wireless coverage during emergency cases where each UAV serves as an aerial wireless base station when the cellular network goes down. They can also be used to supplement the ground base station in order to provide better coverage and higher data rates for the users. During such a situation, the UAVs need to return periodically to a charging station for recharging, due to their limited battery capacity. In the first work, we study the problem of minimizing the number of UAVs required for a continuous coverage of a given area, given the recharging requirement. Due to its intractability, we study partitioning the coverage graph into cycles that start at the charging station. We first characterize the minimum number of UAVs to cover such a cycle based on the charging time, the traveling time, and the number of subareas to be covered by the cycle. Based on this analysis, we then develop an efficient algorithm to solve the problem.

Prior studies on UAV-based wireless coverage typically consider an Air-to-Ground path loss model, which assumes that the users are outdoor and located on a 2D plane. In the second work, we propose using UAVs to provide wireless coverage for indoor users inside a high-rise building. First, we present realistic Outdoor-Indoor path loss models and describe the tradeoff introduced by these models. Then we study the problem of efficient placement of a single UAV, where the objective is to minimize the total transmit power required to cover the entire high-rise building. Due to the limited transmit power of a UAV, we formulate the problem of minimizing the number of UAVs required to provide wireless coverage to high rise building and prove that this problem is NP-complete. Due to the intractability of the problem, we use clustering to minimize the number of UAVs required to cover indoor users.

In the third work, we aim to maximize the indoor wireless coverage using UAVs equipped with directional antennas. We study the case that the UAVs are using one channel, thus in order to maximize the total indoor wireless coverage, we avoid any overlapping in their coverage volumes. We present two methods to place the UAVs; providing wireless coverage from one building side and from two building sides. In the first method, we utilize circle packing theory to determine the 3-D locations of the UAVs in a way that the total coverage area is maximized. In

the second method, we place the UAVs in front of two building sides and efficiently arrange the UAVs in alternating upside-down arrangements. We show that the upside-down arrangements problem can be transformed from 3D to 2D and based on that we present an efficient algorithm to solve the problem.

Committee Members:

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Relevant Publications:

1. H. Shakhatreh, A. Khreishah, J. Chakareski, H. B. Salameh, and I. Khalil, "On the continuous coverage problem for a swarm of uavs," in Sarnoff Symposium, 2016 IEEE 37th. IEEE, 2016, pp. 130–135.

2. H. Shakhatreh, A. Khreishah, and B. Ji, "Providing Wireless Coverage to High-rise Buildings Using UAVs" Accepted to appear in IEEE ICC 2017, Paris, France.

3. H. Shakhatreh, A. Khreishah, A. Alsarhan, I. Khalil, A. Sawalmeh, and N.Othman, " Efficient 3D Placement of a UAV Using Particle Swarm Optimization" Accepted to appear in ICICS 2017, Irbid, Jordan.

4. H. Shakhatreh, A. Khreishah, and I. Khalil, "The Indoor Mobile Coverage Problem Using UAVs," submitted to IEEE Transactions on Wireless Communications.

5. H. Shakhatreh and A. Khreishah, "Maximizing Indoor Wireless Coverage using UAVs Equipped with Directional Antennas," submitted to IEEE Transactions on Wireless Communications.