Research Statement

Azarakhsh Malekian *

My research until now has focused on combinatorial optimization and approximation algorithms. Currently, I am interested in the role of combinatorial optimization and approximation algorithms within the context of computational economics (combinatorial auctions, and game theory). Here, I provide a short summary of the research that I have done during the past two years and also describe problems of current interest.

1 Data Migration Problem

Data migration problems arise while trying to reorganize data layouts to deal with dynamically changing demand. It is desirable to complete the data migration process as quickly as possible because the system is running inefficiently until the migration is complete. We assume that we have m different data items and a set D of N disks. Data item i currently resides in set $S_i \subset D$. In the target layout, a copy of this item is needed on all disks in set $T_i \subseteq D$. In this work, we consider two standard communication models. In the half duplex model, in each round a disk may act as either a sender or a receiver of a single data item. In other words, the communication in a single round is a matching. In the full duplex model, each disk may act as a sender *and* a receiver for an item in each round. Our goal is to convert one given layout to a target layout using the smallest number of rounds. This problem is NP-hard, and hence we consider polynomial time approximation algorithms. This problem was first studied by Khuller, Kim, and Wan [3]. An approximation algorithm with factor 9.5 was presented for the half duplex model. We improve this approximation factor to 6.5. In addition, we present a factor 4 approximation algorithm for the full duplex model [2].

2 Gas Station Problem

The Gas station problem is defined as follows: We have a vehicle with a given tank capacity and it is assumed that at each gas station, gas may be purchased at a certain price. The goal is to find the cheapest route to go from one city to another one, or to achieve the cheapest tour when visiting a set of locations. We

*Department of Computer Science. University of Maryland, College Park, MD 20742, USA. Email: `malekian@cs.umd.edu`

present a dynamic programming solution to find the cheapest way to go from one city to another. Moreover, we solved this problem for the case when only a bounded number of refill stops is allowed. The solution contains the information about the stations that the vehicle should stop at as well as the gas amount that should be purchased at each station. Since the cheapest tour problem visiting a set of locations is NP-hard, we provided an approximation algorithm for it [4].

3 Stochastic Facility Location

One of the most well-known problems in computer science and operation research is the facility location problem. The facility location problem is defined as follows: We want to build a set of facilities to serve a set of costumers with the minimum total cost. The possible locations to build the facilities are given and building a facility at location i costs f_i. Each costumer j should be assigned to a facility i and cost c_{ij}(proportional to their distance). The goal is to choose the locations to build facilities in a way to minimize the total cost. Although, in most real situations, we have uncertain information about the set of costumers. In the stochastic facility location, we assume that there are two phases: In the first phase, we have only probabilistic information about the set of costumers but purchasing facilities is cheap and then in the second phase the true demand set is revealed but the facility costs are increased. The goal is to open a primary set of facilities in the first phase and then after knowing the true demand set, open some new facilities in the second phase to minimize the expected total cost. Different models were used to represent the probabilistic information of the first phase. We used the scenario based model. Each scenario is a list of all the costumers and their associated probability of presence. In this model, polynomial number of possible scenarios are given as input. We present a 2.32 approximation algorithm for the stochastic facility location in the scenario based model. The solution is based on the primal-dual method and the greedy augmentation[5].

4 Current Research

Wireless devices are usually powered by batteries and therefore their energy utilization needs to be monitored and optimized. Different objective functions can be considered for this problem. One formulation that was proposed by Abrams, Goel, and Plotkin [1] is as follows. Create a graph whose vertices correspond to sensors, and each region being monitored corresponds to a hyper-edge formed by the sensors that can monitor the region. They require that the sensors be partitioned into K groups, with each group being active in a time-slot. The coverage of each group is the number of hyper-edges covered by the group. The goal is to maximize the total coverage. They show that a random partitioning yields a simple distributed protocol, with a reasonable performance. Our approach for this problem is based on Max k-cut and semidefinite programming.

If the number of sensors covering each region (we call it d) is at most 3, the problem can be reduced to Max k-cut, and the approximation algorithm for Max k-cut can be used to improve the existing factor.

For higher values of d, we consider a semidefinite programming formulation. We are currently pursuing other variants of the problem. For example, the case when we have a minimum coverage requirement for each time slot. We are also considering allowing the sensors to be both flexible and fixed in location and the case where sensors may be activate in more than one time slot.

I have recently become interested in game theory after attending talks given in SODA and STOC conferences. I took an advanced microeconomics course in order to get better acquainted with this field, and I am highly interested in pursuing my research in further exploring this field.

References

[1] Z. Abrams, A. Goel and S. Plotkin. Set K-Cover algorithms for energy efficient monitoring in wireless sensor networks. *Information Processing in Sensor Networks*, pp. , (2004).

[2] S. Khuller, Y.A. Kim and A. Malekian. Improved Algorithms for Data Migration. *APPROX 2006* pp. 164–175.

[3] S. Khuller, Y.A. Kim and Y.C. Wan. Algorithms for Data Migration with Cloning, *Siam J. on Comput.*, Vol. 33, No. 2, pp. 448–461,Feb. 2004.

[4] S. Khuller, A. Malekian, J. Mestre. To Fill or Not to Fill: The Gas Station Problem. *Submitted to ICALP 2007*

[5] M. Mahdian and A. Malekian. Improved Algorithms for Stochastic and Priority Facility Location Problems. *To be submitted*