RESEARCH STATEMENT

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I am a researcher in Computer Science primarily trained in designing and analyzing algorithms for problems in distributed computing, wireless networks, approximation algorithms, graph theory, combinatorial optimization, and computational geometry. Much of my primary research work has been on various geometric and combinatorial optimization problems in wireless networks. At the same time, I have been involved with applied research in the fields of computer science, biomedical, biomechanical, and mechanical engineering. Thus, my overall research work can be classified into two distinct categories: theoretical, and applied. At the core of my interests lies the scientific aspect of the activities that I have undertaken. In the following, I describe only my recent theoretical research activities.

Theoretical Work

My primary research activity has been in the field of algorithms. This work has largely been motivated by problems encountered in wireless networks such as network coordination and organization, embedding the network in low-dimensional euclidean space, and exploiting the existence rather than knowledge of geometry to obtain robust and efficient algorithms for some classical network problems. Investigation of these problems was the subject of my Ph.D. dissertation and I have expanded on this research in various ways while working as a postdoctoral fellow in the Department of Computing Science at the University of Alberta.

Typically, in wireless networks, battery is a valuable resource, hence, network coordination takes on an added importance for the purposes of avoiding needless activity, while maintaining coverage of the network nodes. For this purpose, *dominating set* has been proposed to act as a way of selecting a small subset of coordinators that enter a high-energy state while the rest of the nodes enter a low-energy state, conserving their battery. In my most recent on-going project I study the *dominating set* problem on *disk graph* model of a wireless network. This graph model is a common theoretical model where network nodes are represented by disk centers and the radio communication range is modeled as the disk radii; in the graph, there is an edge between two vertices if the corresponding disks intersect. The dominating set problem is a classical graph theoretical optimization problem that has been well studied on general graphs and on various special graph classes. Typically, optimization problems on disk graphs have admitted very good approximations, but obtaining an approximation guarantee better than the one for general graphs ($O(\log n)$) for the dominating set problem had been elusive. In my work with Gibson, we obtain a $(1+\varepsilon)$ approximation, which represents a significant improvement. We also studied the weighted case and obtain a $O(\log\log\log\log n)$ approximation. We hope to further improve on this in the near future.

Clustering is one of the most useful and well studied problems in computer science, and there are various kinds of clusterings that have been proposed for various purposes in engineering, epidemiology, data-mining, machine learning, etc. In wireless networks, typically mutual proximity among network nodes serves as a clustering criteria, whereas minimizing the number of clusters is a typical objective. In my work with Salavatipour which will appear in Scandinavian Symposium and Workshops on Algorithm Theory (SWAT 2010), we model a homogeneous network as a *unit disk graph* and study the *minimum clique partition* problem on network nodes, that is, partition the network nodes into fewest cliques possible. The problem has been used as a black-box in a number of applications. The problem is NP-hard and various constant-factor approximations are known. We showed how to obtain a $(1+\varepsilon)$-approximation for the problem by exploiting the specific geometric structure of the underlying graph. We show how this approximation can be obtained without the use of geometry, which is an important weakening of the input model.

The computational geometry community that has been involved in research on wireless networks has crucially exploited the well studied geometric structure of the host space in which the network resides. However, other research has suggested that it is unreasonable to assume availability of (reasonably) accurate global coordinates. Furthermore, it is unreasonable to expect to compute these coordinates from network topology even in simples cases. This has lead researchers to try to find ways to leverage the existence rather than explicitly requiring geometry corresponding to the network in the design of efficient algorithms for classical problems. The obvious benefit is that this allows for a significant weakening of input assumptions, and the algorithms tend to be resilient to errors in the input. In my recent work which appeared in the proceedings of International Symposium on Algorithms and Computation (ISAAC 2009), I proposed a new framework which can be applied to several NP-hard problems on graphs that model wireless networks, to obtain $(1+\varepsilon)$-approximations.