Potential Projects

Here is a list of suggested projects. Some of the projects offer research opportunities that could lead to publication in a leading conference. Generally speaking, there is scope for three kinds of project activities: surveying a topic, pursuing research problems, and experimentally evaluating algorithms for certain problems covered in class. You can work either alone or with one other student on any project. For each of the projects, a presentation (30 minutes to an hour) will be required. For surveys and research problems, a paper of up to 10 pages also needs to be submitted by June 5. For the experimental projects, a short demonstration of the experimental runs should be given.

The list of projects is tentative. In the next couple of weeks, more projects may be added. Also, suggestions for projects are most welcome.

- **Multicommodity flow**: In the multicommodity flow problem, which is a generalization of the network flow problem, we are given a flow network and a set of commodities, that need to shipped from their sources to their destinations. The goal is to ship as much of the commodities as possible, while keeping the shipping costs lows. This problem has a number of applications in routing, transportation, operations research, and other areas of computer science. This project concerns the experimental evaluation of exact and approximate algorithms for the multicommodity flow problem including the local balancing algorithm of Awerbuch and Leighton (which we will cover in class), algorithms based on the first- and second-order methods of Muthukrishnan, Suel, and others, and other algorithms due to Stein et al. Relevant articles will be provided.

- **Convergence of BGP**: The Border Gateway Protocol (BGP) is an Internet protocol that permits policy routing; that is, BGP allows routers to use general preference policies for route selection (instead of or in addition to shortest-path or minimum-delay considerations). Using BGP, routers keep exchanging reachability information until all routers converge to a stable set of routes. Recently, it has been shown that BGP allows policies that may require a long convergence time, or in some cases, even cause the system to diverge. The best way to ensure convergence of BGP while allowing general routing policies is still open. While this appears to be a very hard problem to solve, in this project we will review the recent literature in this area and explore potential approaches. If this project leads to new results, then there is scope for a strong conference publication.

- **Communication structures for ad hoc wireless networks**: Ad hoc wireless networks differ from fixed-connection wired networks and cellular networks there is no fixed infrastructure and the communication capabilities of the network are limited by the battery power of the network nodes. In such a network, it is useful to identify certain subgraphs that would form the underlying structure for certain communication tasks. This project concerns determining communication structures that optimize certain performance measures. One concrete performance measure is *interference number*, which measures the amount of interference among the network nodes. Finding a spanning tree with minimum interference number is open. We will proceed by first determining whether the problem is NP-complete (which I strongly suspect), and if so, seeking approximation algorithms. There are other interesting network optimization problems also in this area. If this project is carried out to its depth, there is potential for a conference publication.

- **Power laws for the Internet**: Power laws are expressions of the form $y \approx x^a$, where x and y are measures of interest and a is a constant. Recent research has shown the presence of surprisingly simple power-law relationships both for Internet traffic and for Internet topology. These findings, if understood well, will help in improving the design of Internet protocols, and developing better analytical models. In this project, we survey the work done in this area and extract some key points that we can take home for future reference.

- **Caching in peer-to-peer systems**: A peer-to-peer system is a collection of collaborating nodes that overlay a "logical" network on the top of the Internet. The last few years have seen the development of a number of commercial (Gnutella, Napster, Freenet) and academic (Oceanstore, Pastry, Chord) peer-to-peer networks. While the central problem of locating data in a peer-to-peer system has been well-studied, an analytical study of caching in such a system (especially, an unstructured peer-to-peer system) has not received much attention, to the best of my knowledge. In this project, we will review the current literature in the area, develop models and perform a preliminary analysis. If this project is carried out to its depth, there is potential for a conference publication.

- **Grid computing**: A computational grid is to processing what a peer-to-peer network is to file sharing. Grid computing enables selecting and sharing a collection of geographically distributed computational resources (such as supercomputers, clusters, storage systems, and instruments). In this project, we will survey resource discovery algorithms and protocols used in grid computing.