Statement of Previous Research

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My interests lie in theoretical computer science; my positive experiences in algorithms courses led to the decision to pursue research in this area. As such, during my undergraduate studies I found myself studying scheduling algorithms under the supervision of Professor Samir Khuller.

Broadcast Scheduling

Broadcast scheduling is becoming increasingly relevant as the demand for information exceeds what traditional scheduling can supply; in the broadcasting model, information can be disseminated to several users via one broadcast, as opposed to individual and redundant information transfers. Commercial systems such as the Intel Intercast System and the Hughes DirecPC are already implementing broadcasting models. Common methods of data distribution, such as radio and satellite, are also based on variations of these models. Information providers who resort to broadcasting face the problem of creating optimal schedules.

There are many ways to measure the quality of a broadcast schedule. One measure is described as follows: say that the response time for a specific request is the delay experienced by the client. Then for a given set of requests, the maximum response time is the longest interval that any client has to wait for their request to be satisfied. If we consider only the schedules that satisfy all requests, the optimal schedule is one which minimizes the maximum response time. This is called *min-max* broadcast scheduling. This measure is of particular interest to the client, who wants to know the maximum time that he has to wait as an individual. Even if another measure says a particular schedule is good, the client will be unhappy if he has to wait a long time. Other measures such as the average or cumulative response time have been studied. The problem of minimizing the average response time is known to be NP-hard.

I illustrate the problem with the following example. Assume that the objective function is to minimize the maximum response time. Suppose items A and B are requested at time 0, item A again at time 1, and items C and D at time 2. One schedule might broadcast $[A, B, A, D, C]$. A better schedule, however, might broadcast item B first so that it can satisfy the two demands for item A via one broadcast. One optimal schedule broadcasts $[B, A, C, D]$.

In a joint work with Thomas Erlebach, Renars Gailis and Samir Khuller, I studied the broadcast model from several perspectives. In the case where the objective is to minimize the average response time, we provided a simpler proof that the problem was NP-hard. In addition, we showed that when the objective is to minimize the maximum response time, the broadcast problem is NP-hard. Both of these proofs take an arbitrary instance of the Vertex Cover problem and create a scheduling instance, where all "satisfactory" schedules adhere to a particular structure. This technique was also used in the following variation of windows scheduling. In the windows scheduling problem, each request is associated with a deadline and the goal is to create a schedule that maximizes the number of requests serviced. We consider the problem where the scheduler must service all requests, but is now allowed

to delay deadlines by a factor of α. The goal is then to minimize α. We can show that if there is a $(2-\epsilon)$-approximation, then $P = NP$.

I also considered the online setting with the objective of minimizing the maximum response time. It had been previously claimed that no online algorithm could perform better than twice the optimal solution. (An online algorithm has no knowledge of future requests.) The example given was flawed, but I found a different example that proved this assertion. It was also claimed that the $FIFO$ (First-In-First-Out) algorithm was 2-competitive. (An online algorithm is 2-competitive means that it performs no worse twice the performance of the optimal offline solution for all inputs.) My research focused especially on this result and in the process of finding the proof, I explored various approaches, including the study of what we defined the "density" of an interval, a metric that upper-bounded the maximum response time. The approach that finally yielded the proof involves bounding at all times the difference of the queues (i.e. set of pages with outstanding requests) of the optimal solution and of $FIFO$.

The best upper bound for the windows scheduling problem is $\frac{3}{4}$ [2]. That algorithm uses an LP-rounding technique, in which the problem is relaxed to a linear program, solved optimally, and then rounded to an integral solution. We construct a problem instance where LP-rounding cannot yield an approximation factor better than $\frac{17}{18}$.

These results are to be published and presented at the 2008 ACM-SIAM Symposium on Discrete Algorithms [1]. My research was supported by an NSF REU grant and a research award appropriated by the University of Maryland to select undergraduates.

Other Research

I also spent some time investigating the generic application process as a matching problem between applicants and schools. This work was motivated by two cursory observations that schools often reveal the number of applications received per year as an indication of the strength of their programs, and also that applicants are generally applying to more places than in the past.

Currently, I am focusing on the study of algorithmic game theory, particularly mechanism design, under the supervision of Professor Anna Karlin at the University of Washington. One particularly interesting direction of research involves looking at problems at the intersection of scheduling theory and mechanism design. Please see my proposal of research for details.

References

[1] J. Chang, T. Erlebach, R. Gailis and S. Khuller. Broadcast Scheduling: Algorithms and Complexity. To appear in *Proceedings of 19th Annual ACM-SIAM Symposium on Discrete Algorithms*, 2008.

[2] R. Gandhi, S. Khuller, S. Parthasarathy and A. Srinivasan. Dependent Rounding in Bipartite Graphs. *Proceedings of IEEE Symposium on Foundations of Computer Science*, 2002.