A massively parallel algorithm for nonlinear multicommodity flow problems has been designed and tested. A new promising algorithm for quadratic stochastic programs with network structures has also been developed.
1 Major Accomplishments

We have made significant progress on the design and implementation of parallel algorithms for large scale problems with network structures. Our research emphasizes both paradigms of parallel computing: (1) Coarse-grain decompositions on small scale parallel architectures (e.g., CRAY Y-MP), and (2) Fine-grain decompositions on massively parallel architectures (e.g., Connection Machine CM-2). Two achievements stand out from our progress to date:

1.1 Solving Multicommodity Network Problems

We have designed a massively parallel algorithm for nonlinear multicommodity network flow problems, Zenios [21]. The algorithm has been implemented on a Connection Machine CM-2 with up to 64K processing elements. The implementation for dense transportation problems runs at 3 GFLOPS. A sparse implementation — for arbitrary network topologies — runs at approximately 400 MFLOPS. We have experimented with quadratic programs with $10^7$ columns and $10^8$ rows. Solution times range from a few minutes to 1 hour. A study comparing our methods with existing technology — including interior point algorithms — is under way. At this point we feel that no other method can solve quadratic programs of this size.

We have also designed a decomposition method for linear/nonlinear multicommodity flow problems, Zenios, Pinar and Dembo [22]. Our approach
here is based on a smoothed linear/quadratic penalty (LQP) method combined with a simplicial decomposition. The specific algorithmic choices we have made appear very successful in solving the large Patient Distribution System (PDS) problems generated by the Air Force. (A comparative table is attached). The algorithm is also well-suited for vector computing and coarse grain parallelism, as reported in Pinar and Zenios [1990].

1.2 Solving Stochastic Network Problems

Dealing with uncertainty using optimisation is a problem that dates back to the early days of linear programming. Unfortunately, stochastic programming models can grow in size very rapidly. We have designed an algorithm for quadratic stochastic programs with network structures. The algorithm induces a fine-grain decomposition of the problem. It has been implemented on the Connection Machine CM-2 and used to solve some financial modeling problems. This work is at a very early stage but results are very encouraging.

2 The Impact on Applications

1. We have solved the patient distribution system (PDS) models successfully. We appear to have the most efficient method among those reported in the literature.

2. Professor Rick Rosenthal from the Naval Postgraduate School has contacted us with a problem for scheduling marines for training programs. It appears that a model formulation fits into a network framework and can be solved by our algorithms. Discussions on this problem are under way.

3. A problem from Navy personnel scheduling was brought to us by Dr. J. Krass -San Diego Laboratory. Current models have been proven unsolvable by existing network algorithms and the problem is currently being solved using heuristics. We are currently working with Dr. Krass to generate the problem data in the format required by our solvers.
3 Industry Participation

Some of our research on financial modeling applications using supercomputers has attracted interest from both the finance industry and computer industry. Digital Equipment Corporation made an equipment award of $1.7M to establish the HERMES Laboratory for Financial Modeling and Simulation. Union Bank of Switzerland is sponsoring a project in the Laboratory on parallel computing models for mortgage-backed financing. Fujitsu Research (Japan) has expressed interest in sponsoring another project.

4 Graduate Student Supervision

Five graduate students, one MBA student and a full time research associate are involved with different aspects of this research. Mr. M. Pinar defended successfully his Dissertation proposal on "Coarse-Grain Decomposition of Network Structured Problems". Mr. S. Nielsen will be defending his dissertation proposal on "Massively Parallel Algorithms for Network Structured Problems". Mr. E. Chajakis completed a Master's thesis on "Synchronous and Asynchronous Parallel Implementations of Relaxation Methods for Network Problems" and he is now developing a PhD dissertation topic. All students have co-authored at least one paper that has been accepted for publication. The remaining graduate students are at earlier stages. The research associate and the MBA student are involved with the activities of the HERMES Laboratory.

5 Publications

The working papers and publications that acknowledge the AFOSR support are given in this section.


2. S.A. Zenios and J.D. Hutchinson, "Financial Simulations on a Massively Parallel Connection Machine", Decision Sciences Department,


