ACTIVITIES AND OPERATIONS OF THE ADVANCED COMPUTING RESEARCH FACILITY

CRF

July 1986 – October 1986

ARGONNE NATIONAL LABORATORY, Argonne, Illinois

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Activities and Operations of the Advanced Computing Research Facility

July - October 1986

Gail W. Pieper
Mathematics and Computer Science Division

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Activities and Operations of the Advanced Computing Research Facility

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prepared by

Gail W. Pieper

1. Summary

This report discusses research activities and operations of the Advanced Computing Research Facility (ACRF) at Argonne National Laboratory from July 1986 through October 1986. The facility is currently supported by the Department of Energy, and is operated by the Mathematics and Computer Science Division at Argonne. Over the past four-month period, we installed a new commercial multiprocessor, the Intel iPSC-VX/d4 hypercube. In addition, four other commercial multiprocessors continue to be available for research—an Encore Multimax, a Sequent Balance 21000, an Alliant FX/8, and an Intel iPSC/d5—as well as a locally designed multiprocessor, the Lemur. These machines are being actively used by scientists at Argonne and throughout the nation in a wide variety of projects concerning computer systems with parallel and vector architectures.

We have continued to sponsor a variety of classes, workshops, and seminars to train researchers on computing techniques for the advanced computer systems at the Advanced Computing Research Facility. For example, we have taught courses on writing programs for parallel computer systems and hosted the first annual Alliant users group meeting. We are also organizing a Sequent users group meeting and a two-day workshop on performance evaluation of parallel computers and programs.
7. Installations and Configuration Changes

In late 1985 and early 1986, the Advanced Computing Research Facility acquired four new multiprocessors: an Encore Multimax, with 20 processors sharing 20 megabytes of memory; a Sequent 8000, with 12 processors and 16 megabytes of shared memory; an Alliant FX/8, with 8 vector processors sharing 32 megabytes of memory; and an Intel iPSC-VX/d5 five-dimensional hypercube with 32 nodes, each having .5 megabyte of memory.

During the summer of 1986, the Sequent 8000 was upgraded gradually, while we served as a test site for the Sequent 21000. This larger system, with 24 processors sharing 16 megabytes of memory, officially replaced the Balance 8000 in September.

A fifth multiprocessor, the Intel iPSC/d4, was added to the ACRF in October 1986. This computer system features a four-dimensional hypercube architecture with 16 nodes, each having 1.5 megabytes of memory. A special feature of this system is its vector capability, making the machine suitable for research in high-performance numerical computations. The Argonne iPSC-VX/d4 was the first vector system installed at a customer site. Like the other machines in the ACRF, the iPSC runs a version of UNIX®, with Fortran and C compilers, and is connected via local network to ARPANET/MILNET, BITNET, MFENET, and TYMNET.

3. User Facility Activities

The Mathematics and Computer Science Division encourages the use of ACRF's specialized resources. Current projects and proposed work indicate that the ACRF is beginning to meet its objective of serving as a national user facility for advanced computing research.

3.1. Projects

During the past few months, a number of researchers have initiated projects on the ACRF. The following list gives the names, affiliations, and research descriptions of our most recent ACRF participants.

Terry Disz - Illinois Benedictine College
Graphics techniques for analysis of parallel algorithms

Sven Hammarling - Numerical Algorithms Group Ltd.
Level 2 BLAS

Floyd Hanson - University of Illinois at Chicago
Implementation of parallel algorithms

Elizabeth Jessup - Yale University
Symmetric tridiagonal algorithms on the hypercube

Stephen Nash - Johns Hopkins University
Methods, algorithms, and software for scientific computation

P. Thistlewaite - Australia National University
A parallel logic programming implementation for a theorem prover in relevance logic
Robert White - North Carolina State University
Analysis of multisplitting methods applied to iterative techniques

Vandevelde - California Institute of Technology
Basic linear algebra on the hypercube

Christopher Thompson - A.E.R.E. Harwell, England
Automatic parallelization of serial Fortran programs using Toolpack
Solving incompressible fluid flow using parallel solution algorithms on the Alliant

Results from two of these projects have already been presented at conferences:

E. Jessup, "A Comparison of Cuppens' Method and Multisection on the Hypercube,"
Second Conference on Hypercube Multiprocessors, Knoxville, Tennesses, Sept. 29 - Oct. 1, 1986

R. White, "Multisplitting and Parallel Iterative Methods," First World Conference on

3.2. Proposals

As classes and workshops familiarize researchers with the new machines in the ACRF, potential users propose new applications and techniques to implement on our advanced computers. The first step in obtaining access to the high-performance computers of the ACRF is to submit an informal proposal to the reviewers in the MCS Division. Interested researchers should contact the ACRF scientific director for more information on the submission of proposals. Listed below are the titles of the proposals most recently accepted by the MCS Division, along with the authors and their affiliations.

Joseph Fisher - Multiflow Computer, Inc.
Interaction between Long Instruction Work Machines and Multiprocessors

Thomas Crockett - NASA Langley Research Center
Parallel Algorithms for Structural Engineering Applications

Vijay Naik - NASA Langley Research Center
Parameters That Influence Communication Costs and Overall System Performance

Martha Ann Griesel - Jet Propulsion Laboratory
Applications of Parallelism to Current Algorithms for Intelligence Analysis

Jorge Nocedal - Northwestern University
Nonsymmetric Eigenvalue Problems Arising in Power Systems

Richard Maestro - Boeing Computer Services
Algorithms for Multivariate Spline Problems
3.3. User Education

Classes on parallel computing were held August 11-13 and October 1-3, 1986 (see Appendix A). The attendees, totaling over twenty per class, represented universities, industry, and various research laboratories located from New York to California, Texas to Iowa. The intent of the classes was to familiarize the attendees with the ACRF environment, to offer ample hands-on experience on the parallel computer systems, and to apply parallel programming to each attendee's area of research. During the classes, the attendees were taught how to write and run several programs, with Fortran and C being the primary programming languages. Session topics that were addressed included monitors and their implementation with macros, and the environment of multiprocessors such as the Sequent and Alliant. Additional classes will be scheduled for late fall and winter.

On September 18-19, MCS sponsored the first Alliant Computer Systems Users' Group Meeting (see Appendix B). Approximately one hundred people attended this meeting, traveling from as far as Germany and England, and representing a wide variety of computer corporations, industry, universities, and research centers.

Other events planned by MCS include a two-day workshop on performance evaluation of parallel computers and programs, and a summer institute on parallel programming for graduate and post-doctoral researchers.
3.4. Visitors

The MCS Division invites scientists from industry, universities, and other research laboratories to participate in the various ACRF research projects. Graduate and undergraduate students, postdoctoral candidates, and faculty stay for periods of time ranging from two weeks to several months. During the reporting period from July to October, approximately 30 researchers participated in ACRF-related projects. Currently, we have several visitors here working on projects involving computer graphics, high-performance algorithms, and software tools for advanced-architecture computers.

3.5. Seminars

For the past several years MCS and Computing Services have jointly sponsored a series of seminars on high-performance computing. Below are listed the names of our most recent speakers, their affiliations, and the title of their talk.

Zahari Zlatev
_A Survey of the Advances in the Exploitation of the Sparsity in the Solution of Large Problems_
Riso National Laboratory, Denmark
August 7, 1986

Dennis Parkinson
_Parallel Processing Experience Using the DAP_
Queen Mary College, London
August 21, 1986

Paul van Dooren
_On Kogbetlianiz's SVD Algorithm in the Presence of Clusters_
Research Laboratory Brussels, Belgium
August 22, 1986

Eric Vandevelde
_Solving Matrix Problems on Hypercubes_
California Institute of Technology
September 17, 1986

Hans P. Zima
_The Design of a Parallelization System for SUPRENUM_
University of Bonn
September 26, 1986

J. B. Rosen and A. T. Phillips
_Multitasking and Algorithms for Constrained Optimization_
University of Minnesota
October 2, 1986

Lee Higbie
_The CHoPP Parallel Processor_
Sullivan Computer Corporation
October 13, 1986
4. Advanced Scientific Computing Research in the ACRF

The advanced computing research program, focusing on parallel architecture, aims to create portable algorithms, software, and programming techniques for both numeric and reasoning tasks. The following sections highlight the advanced scientific computing research in the ACRF, which is divided into four areas: (1) algorithms and software, (2) parallel programming methodologies, (3) programming languages, and (4) advanced computer architectures.

4.1. Algorithms and Software

A major goal of our research is to create algorithms and software that achieve high performance and portability on advanced computer architectures.

In collaboration with J. Scroggs (University of Illinois, Urbana) and R. Chin and G. Hedstrom (Lawrence Livermore National Laboratory), we have developed a parallel convection-diffusion solver for singularly perturbed problems based on domain decomposition. The program was written using SCHEDULE (see the discussion below on Parallel Programming Methodologies) and has been run successfully on the Alliant FX/8 and CRAY-2 computers.

SCHEDULE is also being used to schedule preconditioned computations associated with finite difference approximations. This work is being conducted in collaboration with J. Diaz and a graduate student from the University of Oklahoma.

In a more theoretical study, we conducted a high-dimensional search of proper parameters for number theoretic quadrature rules. For this search, the Alliant FX/8 system proved invaluable. We were able to obtain speedups of approximately 10 over the VAX. Moreover, the Alliant automatically optimizes programs written in standard Fortran 77, so that no special programming techniques are needed to take advantage of the Alliant's parallel processing abilities. We intend to continue this work, extending our search to higher dimensions and perhaps sorting out the equivalence patterns for bicycle rules.

Another project exploiting the features of the Alliant involved parallelizing two difference approximation routines in MINPACK. Since almost all user function calls are in such routines, the results were impressive: we achieved a 7:1 reduction in time over the sequential routines (with a 3:2 reduction over the whole program).

4.2. Parallel Programming Methodologies

Closely associated with our work on algorithms and software is research on parallel programming methodologies. In 1985, we developed a package (called SCHEDULE) of a Fortran-callable subroutine that aids in programming explicitly parallel algorithms in Fortran. This package has been modified several times during the last year to improve the user interface. One significant advantage of SCHEDULE is that no machine-dependent statements or extensions are required in the user's code. A graphics display has also been interfaced with
the package; it shows a large-grain data dependency graph with dynamically allocated nodes executing on a parallel machine. SCHEDULE now runs on the Alliant FX/8 and CRAY-2 computers.

We have also designed three tools for transforming Fortran DO loops to improve performance on vector architecture. These tools were written in the Toolpack tool-writing environment [Cowell and Thompson, 1986]. We are now extending this work by the creation of tool fragments for analyzing programs for dependencies that inhibit parallelization. Our aim is to create interactive tools to aid in writing programs for parallel architectures.

We have begun investigating the role that abstract programming/program transformation methodology can play in preparing programs to run on distributed memory parallel computers such as the Intel hypercube. The approach currently being studied starts with an existing program for solving a numerical problem. The programmer augments this program with statements that indicate how its storage is to be partitioned among the hypercube processors. Program transformations have been written to take the augmented program and insert the communication statements necessary to permit execution on the hypercube. This approach has the advantage of helping to ensure that communication is carried out correctly in the transformed program, so that it does not deadlock. For programs that solve problems well-suited to the hypercube architecture, substantial speedups can be obtained. A paper discussing this work was presented at the ORNL hypercube meeting, September 29 - October 1.

We have begun a major extension to our monitors/macros package for programming parallel computers. The extensions provide macros for the SEND and RECEIVE operations that allow communication and synchronization among processes that do not share memory. We are developing a macro package that would allow the same program to run, for example, on a shared-memory machine like a Sequent, on a hypercube, and on a network of Suns. We are also preparing for the distribution of our monitor package through NETLIB.

We have begun to work on improved debugging techniques for parallel processors. We have already implemented a trace facility in the monitors/macros package that provides useful information on the execution path of the program and has proved to be helpful in debugging concurrent programs. We have also formulated preliminary plans for developing a graphics tool to display the computational dependency of the parallelism within a program. Such a tool would allow the user to graphically define the computational dependencies among processes and to make an easy translation to Fortran from the dependency graph. Given the proper interface, the tool might also allow the algorithm designer to isolate an executing parallel process and to "view" the details of its execution through a graphical display.

4.3. Programming Languages

Our implementation of a parallel version of the Warren Abstract Machine has been extremely well received by researchers involved with logic programming systems. The advantage of our system is that it permits testing a variety of different parallel logic programming languages. We have initiated a cooperative venture with the Swedish Institute of Computer Science, the University of Manchester, England; and Imperial College, London. Our WAM system will be used as the parallel emulator of a Warren Abstract Machine to get data vital to the design of the next generation of parallel logic inference engines.

We have also begun preliminary work analyzing the effectiveness of Ada®, which is available on the Sequent Balance 21000. Serving as consultants to the Ada Europe Numerics Working Group, we participated in the drafting of a proposed standard for mathematical packages in Ada. Our particular concerns involve provisions for elementary mathematical functions.
4.4. Advanced Computer Architectures

We have been studying various advanced computers to evaluate their software environments and to gain an understanding of their performance potential.

One study analyzed the results of running various programs on the Sequent Balance system. The programs included MACHAR and the ELEFUNT suite of transportable Fortran test programs, the Fortran version of the arithmetic test program PARANOIA, and prototype programs from the INTFUNT test suite for intrinsic functions. The results are reported in Cody [1986].

We also continue to update our survey of commercial and experimental high-performance computer systems. The latest version [Dongarra and Duff, 1986], prepared in October, has been widely distributed throughout the United States and Europe.

5. Publications

Listed below are publications relating to advanced computing research carried out by Mathematics and Computer Science Division staff. This list updates the much more extensive list given in the previous progress report [Mihaly and Pieper, 1986].


References

W. J. Cody, 1986. *ELEFUNT Test Results under NS32000 Fortran V2.5.3 on the Sequent Balance*, MCS-TM-80 (September).


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<tr>
<th>Attendees of Parallel Processing Class - August 11-13, 1986</th>
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<tr>
<td>Virgilio Almeida</td>
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<td>Vanderbilt University</td>
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<td>Nashville, TN</td>
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<td>Peg Bennon</td>
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<td>CS/ANL</td>
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<td>Naba Barkakati</td>
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<td>Naval Research Laboratory</td>
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<td>Washington, D.C.</td>
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<td>Richard Barr</td>
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<td>S.M.U.</td>
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<td>Dallas, Texas</td>
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<td>Prasad R. Chintamaneni</td>
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<td>Jet Propulsion Lab.</td>
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<td>Rodrigo Fontecilla</td>
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<td>University of Maryland</td>
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<td>Greg Ammar</td>
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<td>Mark Arnold</td>
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<td>Edward Borosky</td>
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<td>A. Purkayastha</td>
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<td>P. Sadayappan</td>
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<td>Richard Schaff</td>
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APPENDIX B

First Annual Alliant Users’ Group Meeting - September 18-19, 1986
Attendee List

David Berkley
AT&T Bell Labs
Room 6E324
600 Mountain Ave.
Murray Hill, NJ 07974

Craig Bethke
Assistant Professor
University of Illinois
Department of Geology
1301 W. Green St.
Urbana, IL 61801

Christopher Bosch
Staff Scientist
Science Applications Int’l
1213 Jefferson Davis Highway
Suite 1500
Arlington, VA 22202

Allen Bourgeat
Argonne National Lab
9700 South Cass Ave.
Argonne, IL 60439

John Bowne
Apollo Computer
330 Billerica Rd.
Chelmsford, MA 01824

Robert Bruen
Systems Manager
MIT, 35-205
Dept. of Aeronautics
77 Mass Ave.
Cambridge, MA 02139

Steve Chen
AT&T Bell Labs
Room 1G-427
Crawfords Corner Rd.
Holmdel, NJ 07733

Joe Clark
Manager, Computer Operations
AT&T Bell Labs
Room 1A-101
600 Mountain Ave.
Murray Hill, NJ 07974

Jim Cody
Argonne National Lab
9700 South Cass Ave.
Argonne, IL 60439

Terry Coley
Research Assistant
Caltech
127-72
Pasadena, CA 91125

Eugene Day
Systems Coordinator
University of Maryland
Room 3133, English Classroom Bldg.
College Park, MD 10742

John D’Arcy
Member of technical Staff
AT&T Bell Labs
Room 2C-225
1247 S. Cedar Crest Blvd.
Allentown, PA 18103

Jack Dongarra
Computer Scientist
Argonne National Lab
MCS, Bldg. 221
9700 South Cass Ave.
Argonne, IL 60439

Sam Ebenstein
Ford Motor Company
Scientific Research Dept.
Dearborn, MI
Catherine Forth  
Manager, Computer Appl & Consl  
General Electric Co. - Corp R&D  
P.O. Box 8  
Schenectady, NY 12301

Dr. Peter Fruhwein  
Apollo Computer GMBH  
Hahnstr 70  
D-6000 Frankfurt, Germany

Myron Ginsberg  
Staff Research Scientist  
GM Research Lab  
Computer Science Dept.  
GM Technical Center  
Warren, MI 48090

Gene Guglielmo  
Computer Scientist  
Naval Weapons Center  
Scientific Computing Branch  
Code 1412  
Chine Lake, CA 93555

Prof. Robert Haber  
University of Illinois  
2129d Newmark Lab  
208 N. Romine St.  
Urbana, IL 61801

Ken Hillstrom  
Argonne National Lab  
9700 South Cass Ave.  
Argonne, IL 60493

Myron Ginsberg  
GM Research Lab  

Eric Hilman  
Apollo Computer  
330 Billerica Road  
Chelmsford, MA 01824

David Houck  
AT&T Bell Labs  
Crawfords Corner Rd.  
Holmdel, NJ 07733

Esthymious Housos  
Member of Technical Staff  
AT&T Bell Labs  
Room 1F-434  
Crawfords Corner Rd.  
Holmdel, NJ 07733

Jack Hudson  
Sandia National Labs  
P.O. Box 5800  
Division 2113  
Albuquerque, NM 87185

Tom Jacobs  
Technical Staff  
AT&T Bell Labs  
Naperville-Wheaton Rd.  
Naperville, IL 60566

John Kalman  
Argonne National Lab  
9700 South Cass Ave.  
Argonne, IL 60439

Charles Kennedy  
Electronics Engineer  
Ballistics Research Lab  
Attn: SLCBR-VL-V  
Aberdeen Proving Ground, MD 21005

Larry Hicks  
Project Engineer  
Hughes Aircraft Co.  
P.O. Box 92426  
Mail Stop A17/8  
Los Angeles, CA 90009

Ken Hillstrom  
Argonne National Lab  
9700 South Cass Ave.  
Argonne, IL 60493

Esthymious Housos  
Member of Technical Staff  
AT&T Bell Labs  
Room 1F-434  
Crawfords Corner Rd.  
Holmdel, NJ 07733

Jack Hudson  
Sandia National Labs  
P.O. Box 5800  
Division 2113  
Albuquerque, NM 87185

Tom Jacobs  
Technical Staff  
AT&T Bell Labs  
Naperville-Wheaton Rd.  
Naperville, IL 60566

John Kalman  
Argonne National Lab  
9700 South Cass Ave.  
Argonne, IL 60439

Charles Kennedy  
Electronics Engineer  
Ballistics Research Lab  
Attn: SLCBR-VL-V  
Aberdeen Proving Ground, MD 21005

Norman Kluksdahl  
Research Associate  
Arizona State University  
Ctr for Solid State Electronics  
University Ave., Room 135  
Tempe, AZ 85287
David Krowitz  
System Manager  
MIT  
77 Mass Ave., 54-527  
Cambridge, MA 02139

Dr. David Kuck  
University of Illinois  
Center for Supercomputing R&D  
Room 305 Talbot Lab  
104 S. Wright St.  
Urbana, IL 61801

Jeffrey Kvam  
Technical Staff  
Numerical Algorithms Group  
1101 31st St., Suite 100  
Downers Grove, IL 60515

Dr. Scott Lamson  
Applied Mathematician  
General Electric Corporate R&D  
P.O. Box 8, DWC-115  
Schenectady, NY 12301

Mark Lawrence  
Technical Staff  
Logicon/Amoco Research Center  
P.O. Box 3385  
Tulsa, OK 74102

Paul Leach  
Apollo Computer  
330 Billerica Rd.  
Chelmsford, MA 01824

Jun-Jim Liu  
Technical Staff  
AT&T Bell Labs  
Room 1G-433  
Crawfords Corner Rd.  
Holmdel, NJ 07733

Warren Luce  
VP Operations & Customer Service  
AT&T - TECH  
1515 Route 10, 2nd Floor  
Parsipany, NJ 07054

Bill Martin  
Associate Professor  
University of Michigan  
Dept. of Nuclear Engineering  
Ann Arbor, MI 48109

Prof. Robert McMeeking  
University of California  
Materials Program  
Dept. of Mechanical Engineering  
Santa Barbara, CA 93106

Dr. Peter Meenan  
Manager, System Appl Services  
General Electric R&D Center  
P.O. Box 8  
Schenectady, NY 12301

Paul Messina  
Director, MCS Division  
Argonne National Laboratory  
9700 South Cass Ave.  
Argonne, IL 60439

Keith Miller  
Head of Operations & Planning  
TASC  
One Jacob Way  
Reading, MA 01867

Michael Minkoff  
Argonne National Lab  
9700 South Cass Ave.  
Argonne, IL 60439

Stephen Morris  
Senior Research Officer  
Herzberg Inst. of Astrophysics  
National Research Council of Canada  
5071 W. Saanich Rd.  
Victoria, BC V8X 4M6

Rick Morrison  
Technical Staff  
AT&T Bell Labs  
Room IH6C336  
Naperville-Wheaton Rd.  
Naperville, IL 60566
Professor Earl Murman
MIT
Aeronautics & Astronautics Dept.
77 Mass Ave., 33-217
Cambridge, MA 02139

Myron Nack
Hughes Support Systems Group
Bldg. A1, Mail Stop 3C/923
P.O. Box 9399
Long Beach, CA 90810

Philip Nicoletti
Senior Computer Analyst
EG&G-WASC
Collins Ferry Road
Morgantown, WV 26505

Michael Norman
University of Illinois
Nat’l Ctr for Supercomputing
605 E. Springfield Ave.
Champaign, IL 61820

Michael O’Rourke
California State University
6000 J Street
Sacramento, CA 95819

Jim Patterson
Asst. Professor - Computer Science
Eastern Kentucky University
and
Argonne National Lab - MCS
9700 S. Cass Ave.
Argonne, IL 60439

David Phelan
Research Assistant
University of Illinois
208 N. Romine St.
Urbana, IL 61801

Dr. James Pool
Executive Vice-President
Numerical Algorithms Group
1101 31st St., Suite 100
Downers Grove, IL 60515

John Quintana
Project Manager
AT&T Bell - Tech
1515 Route 10, 2nd Floor
Parsipany, NJ 07054

Allan Rosenberg
Physicist
Johns Hopkins University
Applied Physics Lab
Johns Hopkins Rd.
Laurel, MD 20707

Ponnuswamy Sadayappan
AT&T Bell Labs
Room 3A529
600 Mountain Ave.
Murray Hill, NJ 07974

W. Leo Scanlon
System Analyst
TASC
One Jacob Way
Reading, MA 01867

Philip Schueller
Senior Scientist
Hughes Aircraft Company
P.O. Box 92426
Building A-17, MS/8
Los Angeles, CA 90009

Phillip Shaffer
Computer Scientist
General Electric Co.
One River Rd., 37-2019
Schenectady, NY 12345

Gordon Short
Sun Microsystems
2550 Garcia Ave.
Mountain View, CA 94043

Lev Slutsman
AT&T Bell Labs
Crawfords Corner Rd.
Holmdel, NJ 07733

Brian Smith
Computer Scientist
Argonne National Lab
9700 S. Cass Avenue
Argonne, IL 60439
Danny Sorensen
Computer Scientist
Argonne National Lab
MCS Division
9700 S. Cass Avenue
Argonne, IL 60439

Dr. Tom Stephenson
Manager, Image Processing & AI Lab
TASC
One Jacob Way
Reading, MA 01867

Rick Stevens
Argonne National Lab
MCS Division
9700 S. Cass Ave.
Argonne, IL 60439

Sidney Stuart
Group Leader
The Mitre Corp.
Burlington Rd.
Bedford, MA 01730

Thomas Taylor
Director of Sales/Marketing
Pacific Sierra Research
312 Main St., Suite 203
Placerville, CA 95667

Jay Tompkins
Research Scientist
Amoco Production Co.
P.O. Box 3385
Tulsa, OK 74102

Alex Treadway
Technical Staff
Sandia National Labs
P.O. Box 5800
Albuquerque, NM 87185

Dr. Geoffrey Vallis
University of California
Scripps Inst. of Oceanography
M/S A-021
LaJolla, CA 92039

Bob Vanderbei
AT&T Bell Labs
Crawfords Corner Rd.
Holmdel, NJ 07733

Vish Visvanathan
AT&T Bell Labs
Room 3A529
600 Mountain Ave.
Murray Hill, NJ 07974

David Weaver
Section Leader
EG&G-WASC
Collins Ferry Road
Morgantown, WV 26505

Joe Weening
Stanford University
Dept. of Computer Science
Stanford, CA 94305

Dan Wessol
Senior Scientist
EG&G Idaho Inc.
1955 Fremont
P.O. Box 1625
Idaho Falls, Idaho 83415

Glen West
Programmer/Analyst
Computer Sciences Corp.
Defense Systems Division
200 Sparkman Drive
Huntsville, AL 35805

Bob White
Staff Scientist
North Carolina State University
and
Argonne National Laboratory
MCS Division
9700 South Cass Avenue
Argonne, IL 60439

Greg Wolfe
Technical Staff
TASC
One Jacob Way
Reading, MA 01867
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