Mathematics and Computer Science Division Activities
April 1, 1983 – March 31, 1984
MATHEMATICS AND COMPUTER SCIENCE DIVISION ACTIVITIES

April 1, 1963 - March 31, 1984

Mathematics and Computer Science Division
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ABSTRACT

This report reviews the research activities in the Mathematics and Computer Science Division at Argonne National Laboratory for the period April 1, 1983, through March 31, 1984. The body of the report discusses various projects carried out in four major areas of research: applied analysis, computational mathematics, software engineering, and advanced scientific computing. The research computing facility is also briefly described. Information on section staff, visitors, workshops, and seminars is found in the appendices.
MATHEMATICS AND COMPUTER SCIENCE DIVISION ACTIVITIES

April 1, 1983 - March 31, 1984

With several workshops in the planning stage, a series of special seminars on high performance computing under way, a major initiative in advanced scientific computing just begun, one book recently published and another completed, and a new experimental computer installed, the Mathematics and Computer Science (MCS) Division has experienced another active year.

The focus of these activities is on techniques in mathematics and computer science that promise to be useful in solving scientific and engineering problems. Our approach involves the formulation of new analytical and numerical methods, the design of computational algorithms, their implementation in computer programs, and their application in practical problems. This year we have also devoted considerable effort to devising concepts that will provide a better understanding of parallel architectures.

Our activities continue to reflect a mix of theory and application. For example, our research on the TAMPR transformation system enabled us to write transformations that largely automate the conversion of programs from Fortran to Pascal for an National Semiconductor 16032 microcomputer. Quadrature research, too, comprises both the development of numerical integration techniques and their dissemination through the Quadrature Users' Guide.

The division is loosely organized into three areas — applied analysis, computational mathematics, and software engineering; in addition, a new program has been initiated in advanced scientific computing. Among these areas there is considerable collaboration. For instance, research on adapting linear algebra algorithms for vector processors led to new techniques for moving software across widely different architectures. These techniques will also be used in our study of the parallelism inherent in automated reasoning and in the design of algorithms for exploiting such parallelism.

Collaborative projects with other Argonne divisions provide stimulating opportunities to apply our research results and extend them as needed to tackle real-world problems. Recent activities of this type include development of numerical algorithms for modeling three-dimensional fluid flows, investigations on the use of automated reasoning in the development of fault-tolerant control systems for a research reactor, development of an automated diagnostician to speed up the identification of failed components in a large relay interlock system, and optimization of the design of certain fusion reactor components.

Another important component of our research is interaction with universities and other research institutions. Representative efforts include analysis of Sturm-Liouville operators, with A. Zettl and Man Kam Kwong of Northern Illinois University; evaluation of optimization software, with M. Lenard of Boston University; work on software for interactive data fitting, with R. Crane of the RCA Laboratorie; David Sarnoff Research Center; and work on the theory of quadrature rules of optimum trigonometric degree,
This report highlights some of the activities in the Mathematics and Computer Science Division from April 1, 1983 - March 31, 1984. During this period significant progress was made in several areas:

1. A new program was initiated in advanced computing research, with a focus on parallel processing. An Advanced Computing Research Facility was established, based initially on a Denelcor HEP, to support our expanded activities.

2. A new programming methodology for parallel computers was developed based on the use of monitors implemented by means of macro libraries. The macros offer a convenient mechanism for writing programs that require the synchronization of multiple processes.

3. Collaborative research with scientists from the Soviet Union culminated with the design of the TOPELITZ package. This package is a collection of Fortran subroutines for the numerical solution of systems of linear equations with coefficient matrices of Toeplitz or circulant form.

4. A new procedure was developed for characterizing singular Sturm-Liouville differential expressions. The procedure avoids the practical difficulties of the classical theory of Weyl.

5. A new method was developed for calculating higher frequency Fourier transforms. The technique, based on the MIPS method and the tail asymptotic expansion, is more reliable and far more efficient than the traditional Trapezoidal Rule.

6. Work was completed on a software package for estimating the Jacobian matrix of a nonlinear mapping with the least possible number of function evaluations. The routines are easy to use, completely portable, and highly efficient for sparse problems.

7. A book entitled Automated Reasoning: Introduction and Applications was completed and published by Prentice-Hall. The book, which is intended for both the novice and the person familiar with automated reasoning, includes chapters on puzzles, circuit design, and formal logic.

8. A new technique was developed for obtaining vector performance from pipelined MIMD computers. The technique involves use of buffering blocks of data to registers in conjunction with pipelined floating point operations.

These and other activities below reflect the efforts of a scientific staff of 20. A complete list of division members, their publications, and their professional activities is provided in the appendices. Also included is a list of people who visited Argonne to conduct seminars, participate in workshops, or collaborate on special projects.
I. APPLIED ANALYSIS

Applied analysis research at Argonne involves the application of analytical and numerical techniques to problems in the natural and engineering sciences. Current interest focuses on spectral analysis of Sturm-Liouville operators, functional inequalities, bifurcation and stability analysis of nonlinear phenomena, and modeling and analysis of fluid flow and materials science problems.

A. Qualitative Analysis

Hans G. Kaper, Gary K. Leaf, Bernard J. Matkowsky*, Man Kam Kwong†, and Anton Zettl†

Qualitative Analysis refers to the analysis of classes of equations that share certain formal characteristics. The objective is to obtain information about the existence of solutions, their uniqueness, and their properties. This information, in turn, provides guidelines for the quantitative solution of a given problem on a computer. In the applied analysis program, emphasis is placed on Sturm-Liouville operators, bifurcation phenomena, and functional inequalities.

1. Sturm-Liouville Operators

Hans G. Kaper, Man Kam Kwong†, and Anton Zettl†

A Sturm-Liouville eigenvalue problem is defined by a differential equation
\[-(py')'+qy=\lambda r y\]
on an interval \((a,b)\), and a set of boundary conditions at the endpoints of the interval. Here \(p\), \(q\), and \(r\) are functions defined on \((a,b)\), and \(\lambda\) is a parameter. A standard assumption is that the weight function \(r\) is strictly positive (or strictly negative) on \((a,b)\).

Motivated by earlier work in linear transport theory, we investigated nonnegative and indefinite weight functions and singular differential equations with positive definite weight functions. Three projects were completed. The first focused on the partial range completeness properties of the eigenfunctions. The second project dealt with the oscillation properties of eigenfunctions of regular Sturm-Liouville problems. The third involved a regularizing transformation for singular differential equations with positive definite weight functions.

We also completed an analysis in which we used a regularizing transformation to characterize self-adjoint realizations of singular Sturm-Liouville differential expressions on a compact interval. In particular, we showed that the Friedrichs extension can be characterized by any of a set of equivalent "boundary conditions" at the singular endpoint(s). Our procedure avoids the practical difficulties of Weyl's classification theory and puts into perspective the role played by the so-called "natural" boundary conditions (existence of a finite limit as one approaches a singular endpoint).

* Northwestern University
† Northern Illinois University
2. Bifurcation Phenomena

Hans G. Kaper, Gary K. Leaf, and B. J. Matkowsky*

We continued work on the modeling of burner-stabilized gaseous fuel combustion in three-dimensional space. Research focused on the derivation of a model from the fluid dynamics equations that describe conservation of mass and momentum and from the transport equations that describe heat conduction and the diffusion of chemical species. In the final model, the fluid flow is coupled to the transport mechanisms by convection; coupling in the reverse direction occurs by means of the thermal expansion mechanism of the gaseous fuel. We obtained a set of approximate equations describing the evolution of the flame front and the jump conditions for the fluid variables across the flame front. The method of matched asymptotic expansions is used to derive the model from the basic equations. We are now investigating the stability of various solutions of our model.

3. Functional Inequalities

Hans G. Kaper, M. Minkoff, and A. Zettl†

We are analyzing methods for estimating the L2-norms of derivatives of order \(k (k=1, \ldots, n-1)\) of functions defined on the positive half of the real line in terms of the L2-norms of the function and its \(n\)th derivative. Interest focuses on an algorithm proposed by Ljubic in 1960 and two algorithms proposed by Kupcov in 1975.

B. Quantitative Analysis

Hans G. Kaper, Gary K. Leaf, and Anton Zettl†

Quantitative Analysis refers to the development and analysis of methods for finding approximate solutions to scientific and engineering problems.

1. Fluid Flow Problems

Gary K. Leaf

We worked with W. T. Sha of Argonne's Components Technology (CT) Division on a project to improve the numerical procedures used in the COMMIX system of fluid flow simulation programs. As a first step, we extended a two-dimensional scheme (introduced by Raithby) to a three-dimensional scheme. We are currently analyzing the results to determine the effectiveness of the new scheme in reducing numerical discrepancies arising from cross flow dissipation.

In collaboration with S. P. Vanka of the CT Division, we are investigating numerical schemes for solving finite difference approximations to pressure-linked fluid flow equations as a fully coupled system. The procedure is based on solving the set of nonlinear simultaneous equations by a combination of Newton's method and efficient sparse matrix techniques. The method does not require any under-relaxation or other convergence-enhancing techniques.

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* Northwestern University
† Northern Illinois University
2. Sturm-Liouville Eigenvalue Problems

Hans G. Kaper and Anton Zettl†

While theoretical results obtained on Sturm-Liouville eigenvalue problems have had some impact on computational algorithms, in general interaction has been limited. For example, existing codes may be good at finding eigenvalues, but they generally fail in the computation of other, non-discrete parts of the spectrum. In the summer of 1983, we supervised one student in work on numerical aspects of Sturm-Liouville problems with indefinite weights. A computer code SLEIGN was extended to cover left-definite problems. Detailed investigations were made of a Sturm-Liouville problem with indefinite weight arising in the stability analysis of an accelerating liquid sphere and a Sturm-Liouville problem with complex coefficients.

C. Constructive Analysis

Gary Leaf

Constructive Analysis refers to the development of mathematical models for describing and analyzing physical phenomena. The work is carried on in collaboration with scientists in other Argonne divisions and outside the Laboratory. Two efforts are currently under way.

In collaboration with G. Klinzing at the University of Pittsburgh and F. Aguirre at Bethlehem Steel Homer Research Laboratory, we are studying liquid-liquid interaction. We developed a model that describes the simultaneous mass and heat transfer of partially miscible liquid-liquid systems. The model features nonlinear relationships between the heat of solution and the concentrations of each phase and is designed to obtain accurate temperature and concentration profiles. The objective is to understand the role of the interfacial temperature on the mass transfer rates between partially miscible liquid-liquid systems.

In collaboration with N. Q. Lam of the Materials Science and Technology Division, we developed a mathematical model that describes radiation-induced segregation in a thin film. Two effects are predicted by the model and have been observed experimentally by others. First, the surface precipitate film grows rapidly to a quasi-steady level and then dissolves slowly as radial segregation becomes competitive. Second, since the radial segregation gives rise to silicon enrichment outside the beam, a precipitation of the nickel silicide phase will be induced in unirradiated regions.

† Northern Illinois University
II. COMPUTATIONAL MATHEMATICS

Computational mathematics research at Argonne involves the design and analysis of numerical algorithms, the development of special techniques to measure algorithm reliability and efficiency, and the preparation of software based on broadly applicable computational methods. Efforts focus on development of new algorithms for Bessel functions, investigation of optimization algorithms, design and dissemination of quadrature techniques, study of methods for solving partial differential equations, and development of improved techniques for solving problems in numerical linear algebra. We have also begun a new effort on programming methodology for multiprocessors.

A. Optimization

Burton S. Garbow, Kenneth E. Hillstrom, Michael Minkoff, Jorge J. Moré, and Danny C. Sorensen

Optimization continues to play a major role in research activities at Argonne. One part of our studies is concerned with the development of new algorithms for general optimization problems. These algorithms can then be implemented in our MINPACK collection of high-quality optimization software. Another part of our studies focuses on specially structured optimization problems that arise in specific energy applications such as methods for solving partial differential equations. We also carry out a small research program in the evaluation of mathematical software.

1. MINPACK

Jorge J. Moré, Danny C. Sorensen, Kenneth E. Hillstrom, and Burton S. Garbow

Optimization research currently focuses on large-scale optimization and linearly constrained optimization. The approaches being considered are trust region methods, restricted subspace methods, and Newton methods. In addition, we are investigating possible applications of parallelism in optimization.

We began an investigation of trust region methods for large-scale problems that allow storage of the Jacobian or Hessian matrix. The standard step calculation of trust region methods requires a minimization over n-dimensional subspace and order n work. With our new methods, however, the step calculation can be replaced by a minimization over a specially chosen k-dimensional subspace with the property that the minimization requires order n work and storage but with k a fraction of n. Theoretical results show that global convergence takes place for a wide choice of subspaces.

We also proposed the use of restricted subspace methods for cases where the Hessian matrix cannot be stored. These methods have the advantage of immediately extending conjugate-gradient type methods to a globally convergent class of methods and represent a continuous bridge between these methods and Newton's method. Computational experimentation with these methods has revealed that when the Hessian matrix is ill-conditioned, the dimension of the search subspace must increase in order to realize a reasonable rate of convergence. Research is under way to analyze and overcome this difficulty.
We continued to test and refine our implementations of Newton and quasi-Newton methods, with an emphasis on active set strategy. For bounds-constrained problems, the active set strategy is satisfactory, but more work is needed for general linear constraints.

In conjunction with Division efforts in parallel processing, we started investigating possible applications of parallelism within optimization. At present, we are considering algorithms for global optimization, large-scale optimization, and linear programming.

We have also begun development of MINPACK-2, a collection of optimization subprograms for solving systems of nonlinear equations, nonlinear least squares problems, and unconstrained minimization and linearly constrained minimization problems. As part of this effort, we collaborated with D. Thuente of Purdue University in developing a line search that guarantees a sufficient decrease of the function and is consistent with the performance requirements of our optimization codes. Tests show that it performs better than other line searches. We also improved our package for estimating the sparse Jacobian matrix of a nonlinear mapping. The package now handles both row-oriented and column-oriented definitions of the sparsity pattern. The overhead and storage requirements were also reduced, and the codes are now in Fortran 77.

2. Optimization with Structure

Michael Minkoff

General mathematical programming methods are often inadequate for solving large-scale optimization problems that arise in energy systems analyses. We are therefore studying new approaches that explore the special structure of these problems. Our work during the past year involved two collaborative projects.

The first project, carried out with L. Hively (Oak Ridge National Laboratory), involved the use of state-of-the-art optimization techniques in systems analysis for a Tokamak design. We modified the VMCON software to directly treat upper and lower bounds on the variables. This modification not only reduces the storage requirement but also ensures that the algorithm remains within these constraints during optimization, thereby making VMCON more useful for problems in which simulation subproblems (such as ODEs or PDEs) occur.

The second project, carried out with R. Land and M. Blander of the Chemical Technology Division, focused on problems for non-ideal chemical solutions that cannot be formulated as dual geometric programs. Our original approach, based on solving a sequence of geometric programs with the use of a merit function line search, did not achieve sufficient robustness. As an alternative, we are analyzing the log convexity of such problems in an effort to devise a general duality approach.

B. Approximations and Software Basics

William J. Cody, Jr., and Michael Minkoff

Work on approximations and software basics involves the production of transportable, high-quality software for special functions, especially Bessel functions.
We refined a transportable program for ALGAMA, the logarithm of the gamma function, and informally distributed it to requestors. We also continued work on proper parameterization of RJBESL, a transportable program for J Bessel functions of real argument and order.

In collaboration with R. Crane (RCA Laboratories David Sarnoff Research Center), we continued development of an interactive package for one-dimensional data fitting. We prepared an enhanced program for IBM equipment which includes a data-smoothing capability and graphics (using DISSPLA). We also added a B-spline representation that permits pointwise conditions on the approximating function and allows its derivatives to be incorporated either as equations in an overdetermined system or as equality or inequality constraints. We also have begun modifying the package to improve its portability and to move it to our VAX/UNIX system. Our goal is to produce an easily transported package for fitting with linear constraints.

C. Quadrature
James N. Lyness

The present thrust of our quadrature research comprises both the design of quadrature techniques and algorithms and the dissemination of quadrature software.

In the area of design, much of our work focused on techniques for the numerical evaluation of Fourier transforms. The standard approach consists of truncating the infinite tails and then calculating the Fourier coefficients by using the Trapezoidal Rule. When the tail is a Gaussian tail, this is an efficient approach. For tails that decay less rapidly, however, this approach becomes unduly expensive, requiring a lengthy interval to be sampled sufficiently densely for accuracy. We have developed an economic and reliable method for the higher frequency transforms based on the MIPS method and the tail asymptotic expansion. In addition, a pilot study of the use of extrapolation was carried out. The results were encouraging; we found that some problems can be handled efficiently in this way.

Work on series acceleration methods continued with B. Gabutti of the University of Turin, Italy. We determined a large class of extensions of the Euler-Knopp method. These are mainly analytical and apply principally to expansions in terms of special functions.

We continue to collaborate also with L. Gatteschi of the University of Turin, Italy, on the theory of quadrature rules of optimum trigonometric degree.

In the area of software dissemination, we distributed a preliminary version of the Quadrature Users' Guide. This is a problem-oriented manual that deals with integration over a triangle and emphasizes how to choose and use a method. We plan to update the guide periodically to incorporate new advances in the area.
D. Linear Algebra


Our major efforts in linear algebra research during the past year have involved exploring new methods for improving the accuracy of eigenvalues, preparing a machine-independent version of EISPACK, designing parallel algorithms for advanced computers, and completing the TOEPLITZ package.

1. Eigenvalue Accuracy
   Jack J. Dongarra and J. H. Wilkinson**

We implemented algorithms for improving the accuracy of a simple eigenvalue/eigenvector pair and applied the same technique for the singular value problem. These algorithms use the orthogonal triangularization factors from the QR algorithm to minimize the work needed to improve the accuracy; extended precision is used only at critical points.

2. EISPACK
   Jack J. Dongarra, Burton S. Garbow, and Cleve Moler*

We developed a machine-independent version of EISPACK and released it to various sites for testing. The new version, which includes enhancements for several routines to improve efficiency, is being distributed by IMSL and the National Energy Software Center.

3. Parallel Algorithms
   Jack J. Dongarra and Ahmed Sameh†

Work in parallel algorithms involves the design of algorithms for solving narrow banded systems and the Helmholtz difference equations that are suitable for multiprocessing systems. The organization of the algorithms highlights the large grain parallelism inherent in such problems.

4. TOEPLITZ Package
   Burton S. Garbow, James M. Boyle, Wayne R. Cowell, and Kenneth W. Dritz

The TOEPLITZ package is a collection of Fortran subroutines for the numerical solution of systems of linear equations with coefficient matrices of Toeplitz or circulant form. The package, completed this year, is the product of a Soviet-American collaborative effort.

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E. Numerical Solution of Partial Differential Equations

Gary K. Leaf and Michael Minkoff

This activity deals with the analysis of methods and software design for solving systems of nonlinear partial differential equations, including parabolic, mixed parabolic-elliptic, and some hyperbolic systems. We use the method of lines to reduce a system of PDEs to a system of ordinary differential equations. Reduction is achieved by means of a Galerkin procedure; the resulting system of ODEs is solved with a modified version of the GEARIB package developed by Hindmarsh at Lawrence Livermore Laboratory. The initial software implementation developed to test our techniques resulted in the design of the DISPL1 package; a more general version called DISPL2 has also been produced.

During this period we developed for DISPL2 a user-controlled dump/restart facility. This facility causes the package to be exited when a user-specified criterion is satisfied, for example, when the concentration at a specific location reaches a particular value. Moreover, the facility allows the package to be re-entered (after the user modifies the problem specification) and the computation to be resumed. We have frequently encountered the need for this capability and expect it will make DISPL2 more useful in solving simulation problems.

We continued to interact with DISPL users, specifically with 1) G. Klinzing of Pittsburgh and F. Aguirre of Bethlehem Steel Homer Research Laboratory on a model for simultaneous mass and heat transfer of partially miscible liquid-liquid systems, 2) Z. Nagy and R. Land of the Chemical Technology Division on the modeling of the current density vs. overpotential relation for electrode kinetics studies, 3) N. Q. Lam of the Materials Science and Technology (MST) Division on a model describing radiation-induced segregation in a thin film, and 4) S. Das and R. Poeppel of MST on the modeling of the melting and vaporization of oxide fuel pins.
III. SOFTWARE ENGINEERING

Software Engineering research in the MCS Division includes activities that range from theoretical work on automated reasoning, abstract programming, and program transformations to application of software engineering techniques in the production of program packages like Toolpack. Much of this work is concerned with devising better ways of designing and producing highly reliable, easily usable computer software. In addition, Argonne is participating in work on standards for Fortran and PL/I.

A new program in Advanced Scientific Computing has also been initiated. The goal is to gain an understanding of the level of parallelism possible in numerical and non-numerical tasks, to devise effective means for expressing the parallelism, and to exploit the potential strengths of particular architectures.

A. Automated Reasoning

Lawrence T. Wos, Brian T. Smith, Ewing L. Lusk, John R. Gabriel, and Ross A. Overbeek

Automated reasoning has emerged as an exciting new research area. We are concentrating on three areas: theory, software, and applications.

Over the past year several experiments with linked UR-resolution were carried out. Preliminary results indicate that the use of linked inference rules allow much larger reasoning steps than standard inference rules and give the user greater control. The experiments have led to several new theoretical results, including variations of linked UR-resolution and linked hyperresolution. We also enhanced the set of support strategy to permit the power exhibited in the first level of a search to extend recursively throughout the investigation.

To support this theoretical work, we continued to enhance our automated reasoning software. A new program, called ITP, was implemented and extended to include more user-oriented features. In addition, we completed the design of the Logic Machine Control Language (LMCL, a language for specifying automated reasoning programs) and started work on an LMCL processor. We also designed an LMA-based automated reasoning system that would take advantage of large-granularity parallelism in automated reasoning algorithms. Such parallelism comes from overlapping the inference, demodulation, subsumption, and database functions of an automated reasoning process.

We continued to evaluate and improve our theoretical tools by encouraging their use in practical applications. Motivated by our efforts in the design of reactor control systems, for example, we added a Prolog subcomponent to the LMA abstract architecture. The mechanism was tested and found to increase efficiency substantially. Similarly, work on circuit design resulted in improvements to the LMA package; in particular, a new general-purpose algorithm was added for applying large numbers of demodulators and a special-purpose weighting mechanism was implemented to support simplification of large Boolean expressions.

We also wrote and published a book entitled Automated Reasoning: Introduction and
Applications (Prentice-Hall, 1984), which introduces the basic concepts of automated reasoning, discusses various applications, and presents problems for both the novice and the expert.

B. Program Development Aids and Automated Transformation
James M. Boyle, Wayne R. Cowell, Kenneth W. Dritz, Burton S. Garbow, and Brian T. Smith

Our work on software tools and techniques has three main concerns: analyzing programming environments oriented to the development and maintenance of Fortran programs, developing an abstract programming methodology to make programming easier and faster, and automatically creating reliable variants of software routines. The broad range of activities included under this area makes it possible for MCS scientists both to develop new software production tools and to test them in a working environment.

1. Software Tools and Programming Environments
Wayne R. Cowell, James M. Boyle, Kenneth W. Dritz, and Burton S. Garbow

The Toolpack project involves the development of Fortran-oriented software tools incorporated in a prototype common programming environment.

Considerable progress was made in the development of a library of routines called TIECODE. These routines, most of which are written in Fortran 77, provide an interface between a tool and the host computer system. Thus, TIECODE enables the tools and IST (the system in which the tools are integrated) to appear host-independent. We have begun implementing TIECODE on the MCS VA and the IBM/CMS system, and plan to install it on several other major computer systems during the year. TIECODE and Toolpack/IST, together with user documentation, will be distributed in the third quarter of 1984 through the Numerical Algorithms Group Inc.

2. Abstract Programming
James M. Boyle and Kenneth W. Dritz

Abstract programming involves the use of both problem-related abstractions and abstractions of the programming process itself. By encapsulating certain details — separating tasks that are commonly mixed or isolating their interactions with other parts of the program — abstractions make it easier to write clear, correct programs.

In a non-numeric application of abstract programming, we studied the feasibility of transforming TAMPR Format Control Language (FCL) programs to Fortran. The transformation involves treating one program as an abstract specification for another. We designed representations for the FCL language constructs and wrote (or adapted) transformations to carry out roughly the first half of the conversion of FCL to Fortran.

We also studied the use of abstract programming in a numerical context, with the goal of writing a quaternion generalized eigensolver subroutine. The hand-written version of this program derives its efficiency by exploiting the fact that certain ostensibly quaternion elements of the matrix can be rotated so that they are real. We devised an
assertion notation, based on statements in first-order predicate calculus, to communicate that certain variables are real at certain points in the program. Transformations were written to utilize these assertions to cause the optimizations. Use of these transformations resulted in a program as fast as the hand-written one.

3. Automated Program Transformation

James M. Boyle and Kenneth W. Dritz

We are investigating methods for specifying, implementing, and proving the correctness of program transformations. Particular attention is given to collections of transformations that are applicable to large classes of programs and that substantially modify them.

Our focus during the past year has been on making the TAMPR system transportable. We completed a set of TAMPR transformations capable of evolving applicative Lisp programs into Fortran ones. The Fortran version of the transformer was then transported to the Ridge-32 scientific workstation computer. The one difficulty encountered in transporting the program—the order of storing characters in a word—was quickly corrected. The execution time of the transformation interpreter on the Ridge-32 was almost exactly the same as on the VAX, excellent performance for a workstation.

We also implemented two transportable recognizers for TAMPR, one for programs and one for transformations. The two were then used to build recognizers for several additional grammars: Fortran 77, Pascal, and a version of the LMCL language.

Motivated by a request from the High Energy Physics Division, we helped convert programs from Fortran to Pascal, to enable them to run on the NS 16000 microcomputer chip. The task involved writing transformations and modifying FCL programs to carry out major portions of this conversion automatically. Significantly, only twenty per cent of the needed transformations had to be newly written for this application; for the rest, we were able to use transformations originally designed for other purposes. This ability to reuse transformations in different applications is one of the major advantages of a transformation-based programming methodology.

C. Language and Arithmetic Systems Activities

William J. Cody, Kenneth W. Dritz, Paul C. Messina, and Brian T. Smith

Language and arithmetic systems research studies address the problem of ensuring that programming languages and arithmetic systems meet the diversified and changing needs of their users. Argonne is participating in four projects: revisions of ANS Fortran, revisions of ANS PL/I, tracking of scientific programming languages for use in the Department of Energy, and development of IEEE standards for floating-point arithmetic. Our special concern in these projects is the suitability of the language and computer arithmetic for numerical computations.

1. Fortran Standards Committee

Brian T. Smith

Since the 1977 revision of ANS Fortran, the X3J3 Fortran Standards Committee of the American National Standards Institute (ANSI) has been considering revisions of the
standard. During the past year a derived data type mechanism and a proposal on user-defined generic subprograms for arithmetic data types were incorporated into Standing Document S7. Language facilities to support the IEEE base-independent floating-point standard were further discussed with the IEEE committee P894 and the Fortran committee; the Fortran committee has accepted the principle that detailed specifications of the semantics of the floating point environment by language standards are appropriate.

2. PL/I Standards Committee
   Kenneth W. Pritz

   To represent the interests of those using large scientific computers, Argonne and SHARE Inc. are jointly sponsoring a membership on the ANSI technical committee X3J1 (PL/I), which is revising the American National Standard for PL/I. During this past year we continued our development of proposed extensions for numerical analysis. We secured committee approval for our outline proposal for “named computational constants.” In addition, we wrote successful outline proposals defining built-in functions required for environmental enquiries. Added to our previously accepted proposals, these features will provide the framework within ANS PL/I for a parameterized model of floating-point arithmetic. They will permit the construction of portable PL/I mathematical software, and they will support the derivation of implementation-independent (parameterized) accuracy theorems for that software.

3. Language Working Group
   Paul C. Messina and Brian T. Smith

   The Language Working Group (LWG) was formed by the DOE-established Advanced Computing Committee (ACC) to recommend a common programming language for the national laboratories. With the dissolution of the ACC, the DOE Scientific Computing Information Exchange Council agreed to oversee LWG activities. The main thrust of the LWG activities currently involves the detailed analysis of language features proposed for the next Fortran standard (popularly known as Fortran 8X). We presented to the Fortran Standards Committee written comments on major portions of the proposed language; many of our recommendations were followed. We also prepared an article for publication in the newsletters of member computer centers.

4. IEEE Standards
   William J. Cody

   During the past several years, the IEEE Computer Society began drafting a radix-independent standard for floating-point arithmetic. The first draft has now been completed and forwarded to higher-level standards committees within IEEE for approval. We prepared an expository paper, including the full text of the draft, for publication.
IV. ADVANCED SCIENTIFIC COMPUTING

A new program in Advanced Scientific Computing has been initiated that emphasizes the interaction between algorithms, the software environment, and advanced computer architectures, for both numerical and reasoning tasks. This program comprises two related activities: 1) the establishment of an Advanced Computing Research Facility (ACRF) supporting our research activities and operating as a user facility; and 2) the development of a broad research program building on existing expertise in software engineering, computational mathematics, and applied analysis. The goal is to gain an understanding of the level of parallelism possible in numerical and non-numerical tasks, to devise effective means for expressing the parallelism, and to exploit the potential strengths of particular architectures.

A. Advanced Computing Research Facility

Jack J. Dongarra, Ewing L. Lusk, Paul C. Messina, Ross Overbeek, and Danny Sorensen

As the first step in establishing the ACRF, single-PEM HEP through a joint research and development agreement with Denelcor Corporation. The HEP is the only commercially available MIMD (Multiple Instruction stream Multiple Data stream) computer. The HEP is being connected to our VAX and thus to MILNET and to the Argonne local network and will be used for a wide range of computational and reasoning applications.

We also began experiments on the eight-processor Gigacomputer currently in Argonne's High Energy Physics Division. This machine has successfully run demonstration programs verifying full parallelism and synchronization via interlocked memory-to-memory transfers. This system will soon be moved to our facility and attached to our VAX.

B. Advanced Computing Research

Jack J. Dongarra, Ewing L. Lusk, Ross Overbeek, Danny C. Sorensen, and Paul Benioff

We began an expanded program of research focusing on the development of algorithms, software, and new techniques for multiprocessor systems. Although this work has been under way for only a few months, significant results have already been achieved.

Building on previous work on standard linear algebra software, we adapted algorithms for various problems to run on several state-of-the-art machines. Two approaches aimed at achieving software transportability were considered. First, we investigated methods for expressing a collection of algorithms in terms of a few high-level modules. The key is to choose a set of modules at a level of granularity that will permit efficient implementations on a wide spectrum of architectures. Individual modules can then be treated separately and retargeted for efficiency on quite different architectures. Software maintenance would be enhanced because more of the basic mathematical structure would be retained within the formulation of the algorithm. The fine computational detail required for efficiency would be isolated within the high-level modules. Software users would also benefit through the ability to move existing codes
to new environments and experience a reasonable level of efficiency with minimal effort. This has the effect of concealing the peculiarities of a particular machine from a potential user, permitting him to concentrate his efforts on his application instead of the computing environment. Second, in areas where this approach is not effective, we began exploring algorithms targeted to a specific architecture type rather than a specific machine.

We also began investigating the extent to which automated reasoning and logic programming tasks can be made parallel. Preliminary analyses indicate that potential speedups of at least a factor of 10 are attainable in automated reasoning programs on machines that support a moderate number of loosely coupled processors. In addition, another factor of 4 to 7 might be obtainable through the use of tightly coupled processors. We also designed an LMA-based automated reasoning system that would take advantage of large-granularity parallelism available in automated reasoning algorithms.

Motivated by the difficulty of programming parallel computers with the low-level synchronization mechanisms currently available, we began developing a methodology that conceptualizes the complex tasks of multiprocessing. We designed a macro package that encapsulates several synchronization patterns, and we used the package successfully to encode algorithms from artificial intelligence, numerical analysis, and data processing. Not only were programs debugged more quickly, but this also provided a portable yet highly efficient method for programming parallel computers with disparate architectures.

We also began investigating quantum-mechanical Hamiltonian models of computers. Two types are being considered. The first is Hamiltonian models of Turing machines which dissipate no energy and for which the Hamiltonian is time-independent and simple and contains finite range interactions only. The second type involves Hamiltonian models of cellular automata for which the Hamiltonian is time-independent, simple, and spatially local (the interaction occurs between cells and their immediate neighbors only). As lattices of computers that communicate with their neighbors, cellular automata are a standard class of parallel processors. The goal is to determine the necessary and sufficient conditions to impose on a Hamiltonian so that an actual physical model can be constructed.

Our experimental work on parallel linear algebra algorithms revealed that the Fortran environment on the Denelcor HEP was concealing the view of register memory as local processing memory. By implementing vector techniques in software, we were able to make efficient use of this register memory. An increase of two orders of magnitude in megaflop rate was obtained over a comparable sequential Fortran program.
V. RESEARCH COMPUTING FACILITY

The Research Computing Facility (RCF) is intended to study the effectiveness of using smaller computers to support our research activities and, through access to computer networks, facilitate collaboration with colleagues at other institutions throughout the country. Its ultimate objective is to provide innovative yet effective facilities that enable us to conduct the experimentation that is vital to much of our mathematics and computer science research. Operation of the RCF based on a VAX 11/780 minicomputer was first established in late 1981. The VAX is running the UNIX operating system developed by Western Electric Corporation and enhanced by the University of California, Berkeley. The system is connected to Argonne's central computing facility through the ANL Intra-Laboratory Network and to the ARPA network.

The RCF has proved useful to most of our research activities. It has provided a responsive interactive environment with excellent tools for most program development activities and for the production of technical publications. Indeed, because of its heavy use, we have added two disk drives and expect to connect a second CPU later this year. In keeping with our emphasis on innovative systems, we also plan to add a Ridge-32 workstation and evaluate its suitability for our research needs.
Appendix A

PERMANENT STAFF

J. M. Boyle, Ph.D., Northwestern University, 1970

W. J. Cody, Jr., M.A., University of Oklahoma, 1956; D.Sc. (Hon.), Elmhurst College, 1977

W. R. Cowell, Ph.D., University of Wisconsin, 1954

J. J. Dongarra, Ph.D., University of New Mexico, 1980

K. W. Dritz, M.S., Massachusetts Institute of Technology, 1967

J. R. Gabriel, M.S., University of Otago, New Zealand, 1953

R. S. Garbow, M.S., The University of Chicago, 1952

K. E. Hillstrom, M.S., Northwestern University, 1957

H. G. Kaper, Ph.D., Rijksuniversiteit, Groningen, 1965

G. K. Leaf, Ph.D., University of Illinois, 1961

E. L. Lusk, Ph.D., University of Maryland, 1970

J. N. Lynness, D. Phil., Oxford University, 1957

P. C. Messina, Ph.D., University of Cincinnati, 1972

M. Minkoff, Ph.D., University of Wisconsin, 1973

J. J. Moré, Ph.D., University of Maryland, 1970

R. A. Overbeek, Ph.D., Pennsylvania State University, 1971

G. W. Pieper, Ph.D., University of Illinois, 1969

B. T. Smith, Ph.D., University of Toronto, 1969

D. C. Sorensen, Ph.D., University of California, San Diego, 1977

L. T. Wos, Ph.D., University of Illinois, 1957
Appendix B

TEMPORARY STAFF AND CONSULTANTS

Temporary Appointments
Paul Benioff, Ph.D., University of California - Berkeley
Carl Oliver, Resident Associate (detailed to Washington, D.C.)

Faculty Research Leave Appointments
Man Kam Kwong, Ph.D., The University of Chicago
(on leave from Northern Illinois University)
Ahmed Sameh, Ph.D., University of Illinois
(on leave from the University of Illinois)

Visiting Scientists
Frederick Atkinson
University of Toronto

Consultants
James H. Wilkinson, FRS
Stanford University
Gary Roediger
Corporate Computer Services
Appendix C

PROFESSIONAL ACTIVITIES

Division members participated in the following professional activities during the period April 1, 1983 - March 31, 1984.

W. J. Cody
Associate Editor, Transactions on Mathematical Software
Member, International Federation for Information Processing Working Group 2.5 for Mathematical Software
Member, IEEE Subcommittee for Floating-Point Arithmetic
Chairman, IEEE Standards Subcommittee for Radix and Format Independent Floating Point Standard
Consultant, C. Abaci

W. R. Cowell
Council Chairman, Toolpack Project

K. W. Dritz
Member, X3J1 PL/I Standards Committee
Member, SHARE PL/I Project

J. R. Gabriel
Member, American Society of Mechanical Engineers
Process Control Computer Committee

B. S. Garbow
Consultant, C. Abaci

H. G. Kaper
Associate Editor, Integral Equations and Operator Theory
Associate Editor, Transport Theory and Statistical Physics
SIAM Visiting Lecturer
Adjunct Professor, Northern Illinois University

J. N. Lyness
Associate Editor, Mathematics of Computation
Adjunct Professor, Northern Illinois University

P. C. Messina
Member, Conference Planning Committee, Computer Modeling and Applications, CSUI-ANL Conference, September 22-23, 1983
Chairman, DOE Advanced Computing Committee Language Working Group
Member, Energy Research Supercomputer Facility Advisory Board
Member, Task Group for Supercomputer Acquisition Strategy
M. Minkoff  
Area Editor, SIGMAP Newsletter

J. J. Moré  
Associate Editor, SIAM Journal on Numerical Analysis  
Associate Editor, SIAM Journal on Scientific and Statistical Computing  
Associate Editor, Numerische Mathematik

G. W. Pieper  
Lecturer, Illinois Benedictine College

B. T. Smith  
Chairman, SIGNUM Fortran Committee  
Member, DOE Advanced Computing Committee Language Working Group  
Member, International Federation for Information Processing Working Group 2.5 for Mathematical Software  
Member, X3J3 Fortran Standards Committee

D. C. Sorensen  
Associate Editor, SIAM Journal of Scientific and Statistical Computing

L. T. Wos  
Editor-in-Chief, Journal of Automated Reasoning  
Distinguished Visitor, IEEE Computer Society 1983-84  
President, Association for Automated Reasoning
Appendix D

PRESENTATIONS

The following list reflects articles published, reports distributed, and talks presented from April 1, 1983, to March 31, 1984. We continue to send out a periodic mailing of abstracts of our publications, through which we hope to keep scientists better informed of the work of the Mathematics and Computer Science Division and to encourage interactions with other research institutions.

Publications

J. Boyle and M. N. Muralidharan, "Program Reusability Through Program Transformation," Proceedings of the ITT Workshop on Reusability in Programming, Newport, Rhode Island, September 7-9, 1983


Reports

(October 1983)


B. S. Garbow, "The TOEPLITZ Package Implementation Guide," ANL-83-17 (October 1983)


E. L. Lusk and R. A. Overbeek, "Implementation of Monitors with Macros: A programming Aid for the HEP and Other Parallel Processors," ANL-83-97 (December 1983)


Technical Memoranda


J. N. Lyness, "QUG2--Integration over a Triangle," MCS-TM 13 (August 1983)


Oral Presentations


J. M. Boyle, "The TAMPR Program Transformation System," IFIP WG2.1 Meeting, Catalina Island, California, January 12, 1984

J. M. Boyle, "Transforming Applicative Lisp to Fortran Using TAMPR," NATO Advanced Scientific Institute on Program Transformation, Technical University of Munich, September 15, 1983

W. J. Cody, "Floating-Point Issues," SIAM Meeting, Norfolk, Virginia, November 9, 1983


W. R. Cowell, "The Toolpack/IST Software Development Environment," Regional Computer Centre of Copenhagen University, Copenhagen, Denmark, April 25, 1983


W. R. Cowell, "The Toolpack/IST Software Development Environment," University of Osnabrueck, Osnabrueck, West Germany, April 29, 1983


J. J. Dongarra, "Experiments with Small Granularity Parallel Tasks on the CRAY X-MP-2 and Denelcor HEP," Gleneden Beach, Oregon, March 1984


K. W. Dritz, "History of Multitasking in PL/I (IBM and Otherwise)," Argonne Workshop on Programming the Next Generation of Supercomputers, Albuquerque, February 27, 1984


J. R. Gabriel, "Notes on Teaching Computing," Microprocessors in the College/University Environment: Aspects of Technology and Applications, University of Atlanta, Georgia, April 3-7, 1983


E. Lusk, "Automated Reasoning in Man-Machine Control Systems," Ninth Annual Advanced Control Conference, Purdue University, September 19, 1983


P. C. Messina, "Automated Reasoning—An Overview," DOE AMS Program Managers Meeting, Germantown, Maryland, April 21, 1983


M. Minkoff, "Constrained Optimization and Differential Equations," Exxon Research, October 14, 1983

J. J. Moré, "Trust Region Methods," Umea University, Sweden, April 1983

J. J. Moré, "Estimation of Sparse Hessian Matrices and Graph Coloring Problems," Umea University, Sweden, April 1983

J. J. Moré, "Estimation of Sparse Hessian Matrices and Graph Coloring Problems," Linköping University, Sweden, April 1983

J. J. Moré, "Estimation of Sparse Hessian Matrices and Graph Coloring Problems," Kungl. Teknika Hogskolan, Sweden, April 1983


J. J. Moré, two-week course on Algorithms and Software for Nonlinear Optimization, University of Calabria, Italy, October 1983


L. Wos, "An Introduction to Automated Reasoning," Western Michigan, March 22, 1983


L. Wos Host, Tutorial Workshop in Automated Reasoning, Argonne National Laboratory, June 14-15, 1983
Appendix E

VISITORS PROGRAM

The Visitors Program encourages interactions with the applied mathematical sciences research community. Following is a list of students and visiting scientists who came to Argonne for work in mathematics and computer science during the period April 1, 1983, through March 31, 1984.

Faculty and Staff Appointments

Howard Blair
Ubaldo Garcia-Palomares
Guilio Giunta
Amnon Gonen
Johann Hejtmanek
Lawrence Henschen
Waldo Kabat
Bernard Matkowsky
David Thuente
Robert Veroff
Anthony Wojcik
Anton Zeißl

Iowa State University
University Simon Bolivar, Venezuela
Italian National Science Foundation, Italy
Herzlia, Israel
Universitaet Wien
Northwestern University
Illinois Institute of Technology
Northwestern University
Purdue University
University of New Mexico
Illinois Institute of Technology
Northern Illinois University

Resident Student Associates

Kevin W. Hopkins
David Jabon
William McCune, Jr.
Otto Quintero

Greenville College
University of Chicago
Northwestern University
University of New Mexico

Student Aides

Zachary Franco
Harvard University
### Student Research Participants

<table>
<thead>
<tr>
<th>Name</th>
<th>Institution</th>
</tr>
</thead>
<tbody>
<tr>
<td>John Bechtold</td>
<td>Northwestern University</td>
</tr>
<tr>
<td>Anthony Capozzoli</td>
<td>Princeton University</td>
</tr>
<tr>
<td>James Clausing</td>
<td>Muskingum College</td>
</tr>
<tr>
<td>Mark Handley</td>
<td>Eastern Montana College</td>
</tr>
<tr>
<td>Peter Newton</td>
<td>University of Michigan, Ann Arbor</td>
</tr>
<tr>
<td>Tom Nohel</td>
<td>University of Wisconsin, Madison</td>
</tr>
<tr>
<td>Rick Stevens</td>
<td>Western Michigan University</td>
</tr>
<tr>
<td>Janet Walz</td>
<td>Michigan State University</td>
</tr>
</tbody>
</table>

### Co-op Employees

<table>
<thead>
<tr>
<th>Name</th>
<th>Institution</th>
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<tbody>
<tr>
<td>Steven Ehrlich</td>
<td>Illinois Institute of Technology</td>
</tr>
<tr>
<td>David Henderson</td>
<td>The Queen's University of Belfast</td>
</tr>
<tr>
<td>Gwendolyn Hines</td>
<td>DePaul University</td>
</tr>
<tr>
<td>Timothy Lindholm</td>
<td>Carleton College</td>
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</tbody>
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### Pre-College Program in Science and Engineering

<table>
<thead>
<tr>
<th>Name</th>
<th>Institution</th>
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<tbody>
<tr>
<td>Louis Kuchnir</td>
<td>York Community High School</td>
</tr>
</tbody>
</table>
Appendix F

MEETINGS AND WORKSHOPS

1. Toolpack Meeting — October 13-14, 1983

Toolpack participants met at Argonne for a two-day meeting to discuss the architecture and operation of the command interpreter, the TIE library, the editors, and the command language. An overview of the project's technical objectives was presented to members of the Mathematics and Computer Science Division, and two subsystems were demonstrated. The meeting was coordinated by the council chairman W. Cowell.


Argonne hosted the second annual workshop on automated reasoning. The workshop, which consisted of lectures presented as tutorials, was very well received: more than 60 people attended.

3. SLATEC Library Committee Meeting — July 28-29, 1983

The purpose of this meeting, held at Argonne, was to discuss development of a library that could be used as a standard for all DOE laboratories. Approximately half a dozen of the national laboratories attended the meeting.


A meeting of the DOE Language Working Group was held at San Mateo, California. Two topics were discussed: 1) the S7 document accepted by X3J3 in August 1983, and 2) extensions to Fortran for parallel- and multi-processing systems.


The Mathematics and Computer Science Division, together with four area universities, sponsored a one-day consortium at Argonne. Professor William C. Reynolds of Stanford University presented two lectures, the first on large eddy simulation and the second on turbulence modeling.

6. Argonne Workshop on Programming the Next Generation of Supercomputers — February 27-28, 1984

Argonne hosted a two-day workshop on future supercomputers. The purpose of the workshop was threefold: 1) to have researchers and systems developers at the DOE laboratories relate their experiences with programming multiprocessors, 2) to learn about pertinent experiences of others in writing software in Fortran and other languages for multiprocessors, and 3) to formulate appropriate recommendations (for vendors and the Fortran standards committee) about what is needed in order to write reliable and efficient software.
7. **Language Working Group — February 29-March 2, 1984**

A meeting of the DOE Language Working Group was held at Albuquerque, New Mexico. Included were discussions of issues raised during the workshop on programming parallel computing (see above) and interactions with X3J3.

8. **Automated Reasoning Workshop — March 8-9, 1984**

The Automated Reasoning group from Argonne National Laboratory presented a two-day tutorial/workshop at Argonne. The workshop, which was sponsored in part by the Argonne Division of Educational Programs, was intended primarily for university participants. Topics included discussion of reasoning puzzles, choices of strategies and inference rules, an introduction to logic programming, and potential applications such as circuit design and validation. The automated reasoning systems AURA and LMA were also demonstrated.
Appendix G

SEMINARS

During the period April 1, 1983 - March 31, 1984, the Mathematics and Computer Science Division continued to sponsor numerous seminars in mathematics and computer science. In addition, a new series of seminars was begun on high-performance computing, sponsored jointly by the MCS and Computing Services divisions; these are listed separately at the end of this appendix.

Trond Steihaug
Inexact Ideas: An Efficient Implementation of Newton and Gauss-Newton Methods
Rice University
April 28, 1983

Reinhard Illner
Recent Results in Discrete Kinetic Theory
Duke University
May 17, 1983

George Byrne
A View of Applied Mathematics at Exxon Research and Engineering Company
Exxon Research and Engineering Company
May 18, 1983

Howard Blair
Validity in Logic Programming
University of Connecticut
June 21, 1983

J. Wilkinson
Sensitivity of Eigenvalues and Eigenvectors - Part I
Stanford University
June 23, 1983

J. Wilkinson
Sensitivity of Eigenvalues and Eigenvectors - Part II
Stanford University
June 27, 1983

Thomas Coleman
Bipartite Matching and Sparse Rectangular Systems
Cornell University
August 5, 1983
Bruce Char
*Maple: A Computer Algebra System*
University of Waterloo, Ontario
August 16, 1983

Olvi Mangasarian
* Sufficiency of Exact Penalty Minimization*
University of Wisconsin
September 13, 1983

Howard Elman
* Iterative Methods for Large Sparse Nonsymmetric Systems of Linear Equations*
Yale University
December 5, 1983

Charles Roten
*Limiting Behavior of a System of Reaction Diffusion Equations*
University of Arizona
December 13, 1983

Peter Henrici
*Recent Progress in Numerical Conformal Mapping*
ETH-Zentrum
December 15, 1983

Michael Overton
*Projected Hessian Updating Algorithms for Nonlinearly Constrained Optimization*
Courant Institute of Mathematical Sciences
January 18, 1984

John Wisniewski
*An Overview of the Sandia Layout System: Algorithms and Methodology*
Sandia National Laboratories - Albuquerque
March 8, 1984

W. C. Davidon
*Can Unconstrained Optimization Algorithms Be Much Better?*
Haverford College
March 9, 1984

Alex Pothen
*Sparse Null Bases and Marriage Theorems*
Cornell University
March 15, 1984
Seminars on High-Performance Computing

G. W. Stewart
Data Flow Algorithms for Parallel Matrix Computations
University of Maryland
June 23, 1983

Charles Van Loan
Computing the Singular Value Decomposition with Mesh-Connected Processors
Cornell University
June 28, 1983

Tilak Agrawala
How Fast Can a Single Instruction Counter Machine Execute?
IBM, Thomas J. Watson Research Center
July 6, 1983

Ray Hagstrom
Prospects for the Gigacomputer Project at Argonne
Argonne National Laboratory
July 7, 1983

Burton Smith
Architecture and Applications of the HEP Multiprocessor Computer System
Denelcor Inc.
July 13, 1983

Bill Buzbee
Supercomputers: Values and Trends
Los Alamos National Laboratory
July 20, 1983

Steven Chen
Large-Scale and High-Speed Multiprocessor System for Scientific Applications
Cray Research
July 29, 1983

Phil Cannon
The ST-100—A Million Floating Point Operations per Second Array Processor
Star Technologies
August 4, 1983
Hideo Wada
The Fujitsu Vector Processor
Fujitsu America, Inc.
August 26, 1983

Loyce Adams
Algorithms for the Finite Element Machine
NASA Langley Research Center
August 30, 1983

Paul Frederickson
Parallel Three-Dimensional Computation of the Earth's Free Oscillations
Los Alamos National Laboratory
September 8, 1983

Neil Lincoln
Future Directions of Supercomputing: An ETA Systems Perspective
ETA Systems
September 15, 1983

J. C. Brown
The Texas Reconfigurable Array Computer and a Language for Parallel Computation Structures
University of Texas, Austin
September 19, 1983

James Moore
The Parallel Microprocessor System—the PuPS Project
Los Alamos National Laboratory
September 22, 1983

Tony Terrano
Lattice Gauge Theories and Special Purpose Computers
Columbia University
September 29, 1983

Albert Erisman
Supercomputing in the 1980's
Boeing Computer Services Company
September 30, 1983

David Kuck
The Parafrase System
University of Illinois
October 7, 1983

Jack Schwartz
Parallel Supercomputer Developments
New York University
October 21, 1983
Wayne Ray  
*Cyberplus: A Multi-Parallel Processor System*  
Control Data Corporation  
November 3, 1983

Charles Seitz  
*Experiments with VLSI Ensemble Machines*  
California Institute of Technology  
November 14, 1983

Joseph Fisher  
*The ELI: A Very Long Instruction Word Architecture*  
Yale University  
November 17, 1983

Alistair McAulay  
*Parallel Computation for Finite Elements*  
Texas Instruments  
November 22, 1983

Harry Jordan  
*Effective Utilization of a Pipelined Multiprocessor*  
Aberdeen Proving Ground and University of Colorado  
November 28, 1983

Irwin Gaines  
*The Fermilab Advanced Computer Program*  
Fermi National Accelerator Laboratory  
December 8, 1983

Robert Babb II  
*Software Tools for Parallel Processing on Super-Computers with Large Grain Data Flow Techniques*  
Oregon Graduate Center  
January 27, 1984

Donna Bergmark  
*GIBBS: A Programming Environment for Scientists*  
Cornell University  
February 2, 1984

John Levesque  
*Using the CRAY and CYBER 205 as Vector Processors*  
Pacific-Sierra Research Corp.  
February 22, 1984
Bertrand Meyer
*Approaches to Vector Programming: A Software Engineering View*
University of California - Santa Barbara
March 1, 1984

Daniel Slotnick
*Time-Constrained Computation*
University of Illinois
March 5, 1984

Jay Iambiotte
*Efficient Sparse Matrix Multiplication Scheme for the CYBER-203*
NASA Langley Research Center
March 23, 1984

Frank Jeschonnek
*A New Type of Parallel Computer Using Microprocessors*
Free University of Berlin, West Germany
March 27, 1984

Duncan Lawrie
*CEDAR, A Large Shared-Memory Multiprocessor*
University of Illinois
March 30, 1984
Distribution for ANL-84-32

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P. C. Messina (85)
D. M. Pahis
T. M. Woods (2)
G. W. Pieper (86)

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