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Inside Washington

Political Accountability and R&D

By Fred W. Weingarten

Not long ago, the U.S. supercomputer industry consisted of at most two or three firms competing in a market dominated almost completely by the government. Times have changed.

The technology has changed, both fundamentally and at the level of higher architectures, and civilian markets have grown far more important. The language of supercomputing has also changed. We now commonly use the term "high performance computers" to encompass a much wider class of machines, which includes but is not limited to the more traditional supercomputers. Not surprisingly, the industry itself has changed. Numerous firms, many of them small start-ups, have entered the market; many of them are betting a lot of money on their own views of where parallel architecture is headed.

The Advanced Research Projects Agency (ARPA) can take a lot of credit for stimulating and supporting many of these changes. Indeed, ARPA's mission in the federal High Performance Computing and Communications initiative—to push the envelope in high speed architecture—is intended to build on that success. On the other hand, the changes are also causing some heartburn and eliciting questions as to whether ARPA's traditional style of operation is still appropriate.

Those who say it is point to the successes. Those who say it isn't point to the recent changes in the industry and market structure and say a different approach is called for. The most interesting part of the debate from a policy view, however, is not whether ARPA has stepped on some toes. The issues raised may well reflect a much broader and deeper set of problems that would arise in any government attempt to move R&D closer to industrial priorities, not only in computing but in many other fields as well.

GAO Reports on ARPA

Over the last few years, some computing firms have complained that ARPA is playing favorites. They argue that ARPA will fund researchers to purchase only particular types of machines, that it restricts the flow of research results to a favored circle of grantees, and that its decision-making process is secretive and not based on broad input from the field. Finally, they argue that ARPA should be directing more attention to research on software, on how to use these hot new architectures.

Those complaints were conveyed by some firms to Congress. They were taken seriously enough by the House Committee on Armed Services that ARPA funding for architecture research was seriously threatened last year. The committee finally relented on the funding but requested in its report that the General Accounting Office (GAO) conduct a study of ARPA's high performance architecture programs. That

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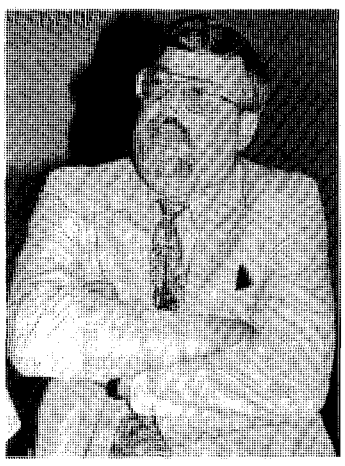
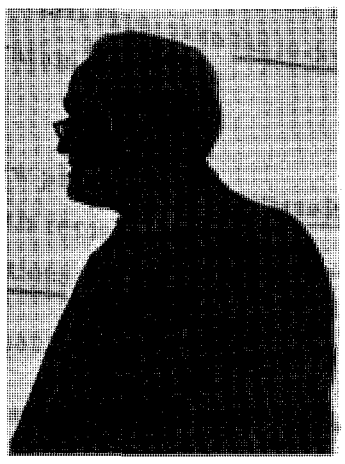
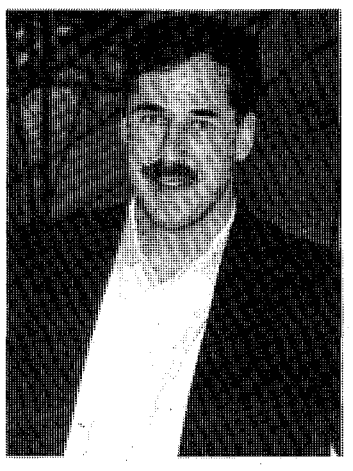


Fred W. Weingarten, *SIAM News* columnist, participated in the panel discussion "Research Support—What's in Store for Us?" at the annual meeting.

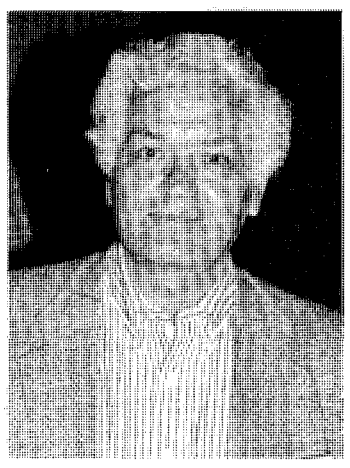


Robert E. O'Malley, Jr. dedicated his Retiring President's Address, "Supersensitive Boundary Value Problems," to I.E. Block.

SIAM's 1993 Annual Meeting



SIAM Annual Meeting organizing committee chair Gregory A. Kriegsmann of the New Jersey Institute of Technology.



James Glimm, organizer of the panel session "Linking Academe to Industry—How to Make it Work," received a special SIAM award at the meeting for his leadership in producing the 1991 NRC report *Mathematical Sciences, Technology, and Economic Competitiveness.*

See page three and upcoming issues of* SIAM News *for coverage of the meeting.

I.E. Block to Retire After 18 Years as Managing Director of SIAM

SIAM managing director I. Edward Block announced at the 1993 SIAM Annual Meeting in Philadelphia that he will be retiring on August 31, 1994. Block, who has been SIAM's managing director since 1976, has been, in fact, central to the development of SIAM from its origin in November 1951.

In his retiring president's address at the Philadelphia meeting, a few days before Block's announcement, Robert E. O'Malley, Jr. summarized Block's immeasureable contributions when he dedicated his talk to "Ed Block, 'Mr. SIAM,' for his untiring and creative work for the society and its presidents over forty years."

From the incorporation of SIAM in 1952 until his appointment as full-time managing director, Block worked on a volunteer basis to make the new society a reality. Whether recruiting speakers and generating publicity for early meetings or serving as an editor of the *Journal of the Society for Industrial and Applied Mathematics,* he worked tirelessly, then as now, to promote SIAM.

It was Block's experience as a mathematician in industry (at Philco, Burroughs, and Remington Rand Univac) that reinforced his conviction of the need for an organization that would promote the application of mathematics in industry. More than 40 years later, his enthusiasm for that mission has not diminished, as evidenced by, for example, his recent efforts to launch SIAM's Mathematics in Industry project.

"During my 25-year involvment with SIAM," says John Hopcroft, chair of the SIAM Board of Trustees, "I have always considered 'Ed' and 'SIAM' to be almost synonymous. His well-known involvement in every aspect of SIAM's activities has made SIAM what it is today. It's hard to imagine SIAM without him."

Hopcroft has appointed a committee that will be conducting a nationwide search for a new managing director. The members of the committee, which will be chaired by C. William Gear of the NEC Research Institute, are Avner Friedman (Institute for Mathematics and its Applications, University of Minnesota), James Glimm (State University of New York at Stony Brook), James McKenna (Bellcore), Robert E. O'Malley, Jr. (University of Washington), Shmuel Winograd (IBM T.J. Watson Research Center), and Margaret Wright (AT&T Bell Laboratories).

"Outreach" Is Key Word at Second SIAM Forum

Building bridges, said SIAM president Avner Friedman in his opening remarks at the Second SIAM Forum on Industrial and Applied Mathematics, is an important responsibility of the applied mathematics community. Whether between industrial and academic mathematicians, mathematicians and other scientists, pure and applied mathematicians, or research and education, bridges were the main theme of the Forum, which was held at Indiana University–Purdue University at Indianapolis, June 4 and 5.

Forum organizer Greg Forest of Ohio State University, credited by Friedman for the introduction of "lots of energy into the program," was also an energetic participant in the panel session on partnerships between national laboratories, industry, and universities. Other panels at the Forum focused on graduate and undergraduate applied mathematics curricula and on industrial postdoctoral training. Four administrators and deans, in a panel session organized by Robert E. O'Malley, Jr., of the University of Washington, provided insightful advice on generating university support for applied mathematics.

For all the focus on industry, whether as a "customer" for the students being educated at universities or as a potential source of jobs in the current employment crisis, industrial representation at the Forum was disappointingly slight. Other than the industrial speakers, and a few representatives from federal agencies and laboratories, most of the approximately 60 participants were from academia. Part of the problem, said Forest, was the lack of funds for travel expenses, which, surprisingly, was a deterrent for many of the industrial people he contacted. J. Allen Cox, a Forum participant from the Honeywell Systems and Research Center, had a more direct explanation for industry's lack of interest: "There's nothing here for us."

The industrial community has never been sufficiently involved in meetings that focus on the training of mathematicians for careers in industry, says SIAM managing director I.E. Block; the academic community does not understand the nature of the industrial environment, and the industrial community has no real understanding of how mathematics can be used to solve its problems. In short, Block says, "at many of these meetings the applied math-

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Twelfth Householder Symposium on Numerical Algebra Held in Lake Arrowhead

By Stephen Vavasis

The 12th Householder Symposium on Numerical Algebra was held in Lake Arrowhead, California, during the week of June 14. The triennial Householder Symposium, formerly known as the Gatlinburg Conference, was renamed in 1990 in honor of Alston S. Householder. Householder, who is known for his pioneering work in numerical linear algebra, organized four of the conferences at the beginning of the series. Shortly after the 1993 meeting, which he attended, his friends and colleagues received the sad news that Alston Householder had died on July 4.

The meeting, which was organized by Tony Chan of UCLA and Gene Golub of Stanford University, was the largest ever in the series, with approximately 160 participants. It has been traditional to hold the meeting in an isolated venue—Lake Arrowhead is located in the mountains, 60 miles east of Los Angeles—in order to promote informal interaction.

Two Householder Awards

A highlight of the 1993 meeting was the presentation of the Householder award, which recognizes the best PhD dissertation in numerical linear algebra completed during the preceding three years. Two winners, Barry Smith and Hong-Guo Xu, were selected for 1993.

Smith, who received his PhD in mathematics from the Courant Institute of New York University in 1990, has worked in the area of domain decomposition and finite element methods. Domain decomposition refers to a class of numerical methods for solving boundary value problems in which independent problems are solved on subdomains, followed by numerical iteration to obtain a global solution.

Smith's dissertation, which was written under the direction of Olof Widlund, contains new, optimal results on convergence rates for domain decomposition applied to problems where the subdomains do not have significant overlap and where the coefficients are varying. After receiving his PhD, Smith spent two years at Argonne National Laboratory as the Wilkinson Fellow; he is currently a member of the mathematics department at UCLA.

Xu received his PhD in mathematics from Fudan University, Shanghai, in 1991; his adviser was Jiang Erxiong. In his dissertation, which focuses on the numerical solution of the Riccati equations, Xu derived

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What's Inside

Householder Symposium,

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structured algorithms for the solution of both continuous-time and discrete-time algebraic Riccati equations. These algorithms are based on a simple but elegant proof of the existence of particular square roots of matrices with Hamiltonian or symplectic structure. Xu derived an error analysis and showed how to use iterative refinement for ill-conditioned Riccati equations. He also tested the new algorithms thoroughly to verify theoretical error bounds. Xu is currently a member of the mathematics department at Fudan University.

Beresford Parlett, speaking for the Householder award committee, said that the selection criteria for the Householder award were mathematical innovation, thoroughness of computational experiments, and applicability of the results.

Parlett said that, in addition to the two winners, the committee had selected one nominee, Ali Sayed, for special mention. Sayed received his PhD in electrical engineering from Stanford in August 1992 under the direction of Thomas Kailath. His dissertation describes how a variant of Gaussian elimination can be applied to a variety of problems in linear algebra and control theory, including Toeplitz systems and Padé tables, to yield efficient algorithms. The key concept in the dissertation is a generalization of "low displacement rank." Sayed's work unifies many previous and seemingly complicated algorithms in the literature. Sayed is headed for the electrical engineering department at the University of California, Santa Barbara.

Many Applications to PDEs, Signal and Image Processing

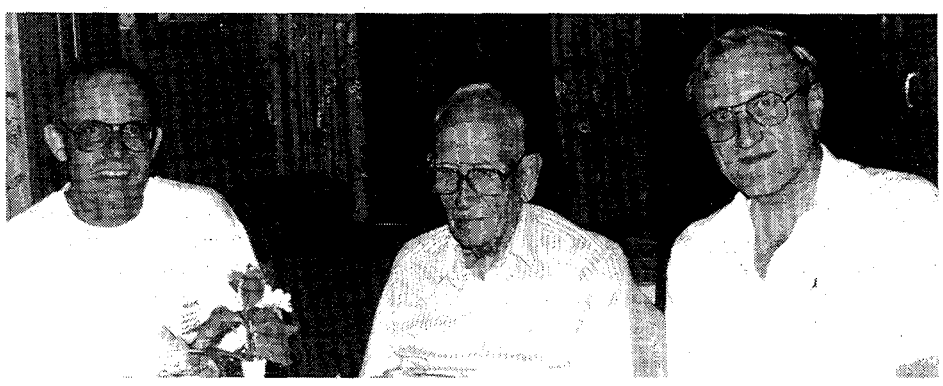
The bulk of the meeting was devoted to 30 plenary lectures, spread over five days. The lectures covered various topics of current interest, including parallel linear algebra, sparse systems, boundary value problems, updating and downdating factorizations, perturbation bounds, and structured systems. Many of the talks described applications of linear algebra, including applications to partial differential equations and signal and image processing. In addition to the plenary lectures, there were concurrent sessions in the evenings on parallel computation, multigrid and domain decomposition methods, eigenvalue algorithms, and other topics.

The meeting opened with plenary talks by Paul Van Dooren (Illinois), Hong-yuan Zha (Penn State), and Sabine Van Huffel (Leuven) on matrix factorizations arising in signal processing and statistics. Van Dooren spoke on numerically stable simultaneous factorization of a product of matrices arising in control. Algorithms for canonical correlations in statistics were the subject of Zha's presentation. Van Huffel compared structured total least squares with constrained total least squares and discussed their application to biomedical problems.

A sequence of talks by James Demmel (Berkeley), Roy Mathias (William & Mary), and Nicholas Higham (Manchester) focused on the relation between parallelism and numerical stability in linear algebra. Demmel described an eigenvalue toolkit that uses new algorithms based on the matrix sign function. Although the method is ideal for parallelism, its stability properties are weaker than those of traditional sequential methods. Mathias showed the computing of signatures by parallel prefix methods to be less stable than traditional accumulation. In his talk on parallel triangular solvers, Higham showed that several proposed algorithms are not as stable as sequential back-substitution.

Two speakers considered sparse matrix methods. John Gilbert (Xerox) described the implementation of and experimentation with geometric mesh partitioning, which is important for parallel iterative methods and sparse Gaussian elimination in finite element problems. Stanley Eisenstat (Yale) described new approaches to sparse unsymmetric factorization that attempt to incorporate successful ideas from symmetric algorithms.

Several talks focused on iterative algorithms for solving nonsymmetric and indefinite linear systems. Gerald Sleijpen (Utrecht) showed how to prevent stagnation in the BiCGSTAB iterative algorithm in an extension denoted BiCGSTAB(l). Anne Greenbaum (NYU) described a new analysis of the GMRES algorithm that can better distinguish matrices for which the method will converge quickly. Michael Saunders (Stanford) compared two iterative methods, LSQR and Craig's method, showing equivalence in some cases.



Alston Householder, with Martin Gutknecht (*left*) and Walter Gander (*right*), at the Householder meeting in Lake Arrowhead, June 1993. The photo was taken by a member of the Gander family.

Boundary value problems were the subject of three talks. Stephen Vavasis (Cornell) proposed new elimination methods for solving boundary value problems that are guaranteed to be numerically stable in the presence of wild variation in the coefficient field. Andrew Wathen (Bristol) proposed new preconditioned iterative methods for Stokes' flow with optimal bounds on the condition number. Coincidentally, both of these speakers analyzed properties of the symmetric indefinite linear system

$$\begin{bmatrix} H & A \\ A^T & 0 \end{bmatrix}$$

to obtain their results. Hans Munthe-Kaas (Bergen) showed how to unify various fast Poisson solvers in terms of Abelian groups.

A number of talks focused on updating, downdating, and rank-detection algorithms. These algorithms are very important in signal processing, where it is necessary to maintain such information as numerical rank for a time-varying signal. In a time-varying signal, "old" information must somehow be eliminated from the factorization and rank approximations as time passes. C.-T. Pan (Northern Illinois) spoke on recent progress in rank-revealing QR factorization, which is used as an efficient substitute for the full singular value decomposition.

Haesun Park (Minnesota) spoke on a hybrid, more stable method for downdating the URV decomposition, also used for monitoring numerical rank. Ming Gu (Yale) proposed new algorithms for downdating the singular value decomposition itself. Franklin Luk (RPI) derived a new factorization of matrix pairs that is amenable to updating.

Chris Paige (McGill), who delivered the plenary address at the banquet, described the history of the C–S decomposition and angles between subspaces. Tracing the history of this area back to the work of Jordan, Paige focused on recent contributions by C. Davis, W. Kahan and G.W. Stewart.

Perturbation theory was the subject of several talks. Michael Overton (NYU) discussed a new way to analyze stability in Hamiltonian systems; the stability issue can be expressed as an eigenvalue perturbation problem. Jiguang Sun (Umea) gave new backward-perturbation estimates for a wide variety of least-squares and eigenvalue problems that are the best possible estimates in many cases. Ilse Ipsen (Yale) described a new method for analyzing a variety of eigenvalue perturbation problems; her method is based on writing additive perturbations as matrix multiplications. L.N. Trefethen (Cornell) presented experimental comparisons of the effects of perturbations of the coefficients of a polynomial on its zeros and of perturbations of a companion matrix on its eigenvalues. The results seem to be very similar, but only if "balancing" is used on the companion matrix.

Three speakers discussed ill-posed problems. C.-C. Jay Kuo (USC) considered the use of wavelets in image compression and processing. Robert Plemmons (Wake Forest) described new preconditioners for iterative methods used in image recovery. Per Christian Hansen (Tech. Univ. Denmark) discussed a new analysis for determining when and how conjugate gradients can reveal a regularized solution for ill-posed problems. Three talks focused on the analysis of structured problems. Zdenek Strakos (Academy of Science, Czech Republic) spoke on the relation between numerical errors in Gaussian quadrature computation and the Lanczos iteration. Roland Freund (AT&T) discussed the stabilization of "fast" ($O(n^2)$ flops) algorithms for Toeplitz systems that use look-ahead procedures. Martin Gutknecht (ETH-Zurich) described new "superfast" ($O(n\ (\log n)^2)$ flops) algorithms for the same problems.

Leslie Foster (San Jose State) gave examples arising in differential and integral equations for which Gaussian elimination with partial pivoting (GEPP) is numerically unstable. It is known from work done by Wilkinson that, theoretically, GEPP can be unstable because of the "growth factor," but many researchers have believed that this instability does not occur in practical problems. Because of examples like Foster's and other recent work, implementors of GEPP, including the LAPACK designers, are planning to build additional safeguards into software to detect unstable behavior.

Important Role for Laptops

In addition to the plenary talks, there were a total of 18 informal sessions spread over three evenings. One very popular session was organized by Cleve Moler (MathWorks) to demonstrate upcoming developments in MATLAB, which is an interactive software package for numerical computation produced by The MathWorks, Inc. Moler demonstrated some of the features of the latest version of MATLAB and gave a preview of a toolbox under development that integrates Maple, a symbolic mathematics package from the University of Waterloo, with MATLAB.

Underscoring the informal nature of the meeting, one session (on geometry, eigenvalues, and optimization, organized by Alan Edelman of Berkeley and Michael Overton of NYU) was held at the conference center's outdoor picnic area. For the first time at a Householder meeting, laptop computers played an important scientific role as many participants demonstrated software to one another and conducted experiments during the breaks. One use of the laptops, which were provided by UCLA and Cleve Moler, was to analyze an impromptu graph made at the meeting showing co-authorship relationships among participants. The graph was started by Nick Trefethen, but most of the participants joined in. Gene Golub turned out to have by far the greatest number of co-authors.

In addition to the technical presentations, there were many recreational activities available at the scenic conference site. Boat tours for the participants showed off the beauty of Lake Arrowhead and the surrounding palatial summer homes owned by movie stars. Of the 16 people who hiked up Mount San Gorgonio with Petter Bjørstad (Bergen), six went to the summit at 11,499 feet. Finally, two milestones were celebrated at the meeting. Gene Golub was feted for his recent election to the National Academy of Sciences, and Alan Edelman turned 30 during the meeting. Congratulations to Gene and Alan!

The meeting was funded in part by the National Science Foundation and The MathWorks, Inc. Babette Dalton of UCLA helped organize much of the logistics of the meeting; Charlie Van Loan (Cornell) collected funds from participants for a gift certificate to thank her for her hard work. The next Householder meeting is scheduled for 1996 in Switzerland. As Martin Gutknecht said, the organizers of the Lake Arrowhead meeting, including Tony Chan, Gene Golub, and Babette Dalton, have set a high standard for future organizers!

Stephen Vavasis is an assistant professor of computer science at Cornell University.