D I M A C S
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COVER PAGE

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1 Summary of Research

DIMACS continues to serve as a major catalyst for research in the diverse areas which comprise discrete mathematics and theoretical computer science. Through a variety of activities, DIMACS stimulates information exchange and collaboration among an extensive community of researchers and educators, including its approximately 120 permanent members at the four participating institutions, Rutgers University, Princeton University, AT&T Bell Laboratories, and Bellcore; and its visitors, postdoctoral fellows, and graduate students. The types of activities sponsored by DIMACS are listed below. Important results that grew out of such activities are described in the sections below; lists of visitors, students workshops, and seminars can be found in the appendices.

- *Visitor and Postdoctoral Programs* DIMACS hosts both long-term and short-term visitors, including postdoctoral fellows, industry researchers, and 4-year college faculty. Such visits often result in fruitful collaborations, which are sustained long after a visitor has left DIMACS.
- *Special Years* A DIMACS Special Year acts as a focal point that encourages both formal and informal interactions between researchers studying different aspects of the same problem. Each special year consists of a number of related activities.
  - *Workshops* Workshops allow researchers to communicate work in progress and debate the importance of past and current work. DIMACS workshops often bring together theorists and practitioners and can either highlight important disagreement or generate consensus on the direction that a given research area should take. There is frequently animated discussion, often extending late into the evening. Workshop proceedings are normally published as volumes in the DIMACS/AMS series or as technical reports.
  - *Seminars* Special Year Seminars, scheduled monthly, offer DIMACS members and visitors further opportunity to meet informally to learn about current results.
  - *Implementation Challenges* These offer researchers from across the country an opportunity to test algorithms for important problems; participants are provided with bibliographical information, testbeds of instances and codes, and continuing feedback. A refereed volume of results is published after each Challenge.
- *Ongoing Topics Seminars* In five different seminar series, members and others at local institutions can come to a variety of research and expository talks each week at DIMACS.
- *Topical Workshops* Workshops unrelated to the Special Year bring new participants and short-term visitors, enriching the research environment.

1.1 Research Accomplishments

1.1.1 Special Year 1992-93 - Combinatorial Optimization

This special year, directed by László Lovász (PU and Budapest) and Paul Seymour (BC), extended from September 1, 1992 through August 31, 1993. The organizing committee consisted of V. Chvátal (RU), W. Cook (BC), L. Hall (Princeton), P.L. Hammer (RU), D.S. Johnson (BL), W.R. Pulleyblank (IBM), and A. Schrijver (Amsterdam).

ABBREVIATIONS: Throughout this annual report, we use several abbreviations: PU (Princeton University), RU (Rutgers University), BL (AT&T Bell Laboratories), BC (Bellcore), PM (permanent member of DIMACS), V (short- or long-term visitor to DIMACS), PD (DIMACS postdoc), GS (DIMACS graduate student), DTR (DIMACS Technical Report).

The theme of the Special Year was combinatorial optimization, broadly interpreted, and included research activity, both theoretical and practical, on such topics as the travelling salesman problem (particularly fast heuristics for its solution in practice, but also theoretical approaches); linear programming; integer programming and the variety of techniques for this (approximation methods, heuristic methods, random methods, as well as the deterministic); perfect graphs; network flows, disjoint path problems and VLSI design; matching theory; and related minimax theory from combinatorics.

During the second half of this Special Year, which coincides with the first half of the 1994 DIMACS fiscal year, the focal points were three full-scale workshops:

- *Probabilistic algorithms for combinatorial optimization*, February 22-27, 1993.

  This workshop, organized by Laszlo Lovász (PU and Budapest), Ravi Kannan (PM,BC), Michael Saks (PM,RU) and Peter Winkler (PM,BC), dealt with a variety of techniques that involve randomization in combinatorial optimization. In the focus were random walk (Markov chain) techniques, which have recently found important applications in sampling, integration and volume computation, but also are the the underlying mathematical procedures for simulated annealing and other randomized search algorithms. Many talks reflected an attempt to understand and analyse the performance of simulated annealing and its relatives. Another field represented by several talks that reflected important development following a recent breakthrough was the area of randomized simplex algorithms.

- *Solving hard combinatorial optimization problems*, March 29-April 2, 1993.

  The focus of the workshop, organized by Robert Bixby (Rice Univ.), William Cook (PM,BC), and David Johnson (PM,BL), was on computational advances in the solution of hard combinatorial optimization problems. Both exact solution methods and approximation methods were covered. The topics included general mixed integer programming, cutting plane methods for combinatorial optimization problems, fast heuristic methods for combinatorial problems, and tools used in the solution of hard problems. There was also a session devoted to the topics of the Second DIMACS Implementation Challenge (Maximum Independent Set, Graph Coloring, and Satisfiability). The meeting was very successful in bringing together groups working on solving practical problems and groups working on the fundamental combinatorial approaches to these problems.

- *Perfect graphs*, June 10-14, 1993.

  This workshop, organized by Vašek Chvátal (PM,RU), Laszlo Lovász (PU and Budapest), and Bruce Reed (V), had an unorthodox format. In February, some 120 potential participants were presented with a list of open problems and a rudimentary bibliography on the subject; they were invited to add to both and to suggest other potential participants. In this way, around 150 people were eventually contacted; many of those who could not come to Princeton in June chose to remain on the mailing list and participated in the e-mail session that lasted over three months. Through their collective effort, the bibliography grew to more than 300 items by the end of May. The e-mail problem session was a success: Frédéric Maire, Irena Rusu, and Stefan Hougardy found counterexamples to Bruce Reed's conjectures concerning even pairs in perfect graphs; Bruce Reed found counterexamples to Zsolt Tuza's conjectures concerning decompositions of arbitrary graphs into perfect subgraphs; most significantly, Irena Rusu constructed an infinite family of perfect graphs G such that each of G and $\overline{G}$ contains an induced diamond, neither G nor $\overline{G}$ has a star-cutset, neither G nor $\overline{G}$ has a stable cutset, and neither G nor $\overline{G}$ has an even pair. The actual workshop drew over sixty participants, with half from the U.S.A. and the others representing fixteen other countries.

There was a series of instructional lectures by Michele Conforti, Gérard Cornuéjols, Ajai Kapoor, and Kristina Vušković on a recent breakthrough, a polynomial time algorithm to recognize balanced matrices. Besides some further survey-type talks, there were six long problem sessions, which were very popular and lead to successful collaboration in solving some more of the problems. A DIMACS volume arising from the workshop, with the working title "*Handbook of Perfect Graphs,*" is in preparation.

Another successful component of the Special Year was smaller workshops and mini-conferences on selected topics of current interest. Three were particularly noteworthy.

- *Approximation algorithms*, March 24-26, 1993. This "mini"-workshop organized by Philip Klein (Brown Univ.) attracted an audience comparable with the audience of the main workshops. It was devoted to the exciting new developments in the field of approximation algorithms, both in the "positive" direction (new techniques for the design of heuristic/approximation algorithms, using linear programming, randomization, and other methods), and in the "negative" direction (establishing the impossibility of certain approximation tasks, based on techniques using the theory of interactive proofs: It should be remarked that these techniques were first developed during the DIMACS special year on Complexity Theory in 90/91).
- *The Quadratic Assignment Problem*, May 24-25, 1993. The Quadratic Assignment Problem (QAP) is a very general combinatorial optimization problem that includes the traveling salesman problem and the max-cut problem, two of the practically most important combinatorial optimization problems, as special cases. Other applications include scheduling, manufacturing, the backboard wiring problem in electronics, parallel and distributing computing, and statistical data analysis. The workshop on QAP, organized by Panos Pardalos (V) and Henry Wolkowitz (V), focused on recent computational approaches and applications. About twenty invited speakers presented results on new techniques and applications. The techniques included eigenvalue estimates for lower bounds, parallelization, genetic algorithms, polyhedral approaches, greedy, and adaptive algorithms. The applications included graph bandwidth problems, telecommunications network design, load balancing, VLSI design, data association problems, and multidimensional assignment problems. A proceedings for the conference is being prepared.
- *Perfectly orderable graphs*, June 16-19, 1993.

  This small meeting, organized by Vašek Chvátal (PM,RU) was devoted to joint research and brainstorming on several long-standing open problems in the theory of perfect graphs. One of the results of this workshop was a proof by Vašek Chvátal and Irena Rusu of a conjecture of R. Sritharan on the structure of graphs with no chordless cycles of length at least five.

In addition to the workshops, there was a regular seminar meeting (on the average) bi-weekly, with (on the average) two talks each time. A list of talks given in these seminars is included in the appendix. Below we list some topics which came up in different workshops and seminars, and where the interaction of mathematicians, made possible by DIMACS, has lead to substantial new results and insight.

- *Approximate Max-flow Min-cut Theorems.* This important and fast-developing area was featured in several seminar talks, workshop discussions, and informal research. Several important new results were obtained and presented by Satish Rao (PM,NEC), Special Year visitors Eva Tardos, Vijay Vazirani, Serge Plotkin, and others. Strong connections with other themes of the Special Year, like properties of the cut cone and mixing properties of Markov chains, were discovered. The mixing rate of Markov chains was also the central theme of one of the workshops, several seminar talks, and on-going research.

- *Hilbert bases, Gröbner bases, and test-sets in integer programming.* It has turned out that bases of polynomial ideals, minimal TDI descriptions of polytopes, and test-sets of optimality in integer programming called neighbors, are closely related. In particular, computational algebra packages can be used to solve integer linear programs, as a group at Cornell discovered. Several seminar talks and a mini-workshop were devoted to this discovery.

- *On-line algorithms.* On-line algorithms provide an important new framework for many combinatorial optimization problems, applicable in many real-world situations like operating systems of computers, optimum control, scheduling etc.

A major feature of this Special Year was the Implementation Challenge.

- *2nd DIMACS Implementation Challenge*, Oct., 1992-Oct., 1993.

  This Challenge was devoted to algorithms for three infamous hard combinatorial optimization problems: CLIQUE (finding the largest set of pairwise adjacent nodes in a graph), COLORING (determining the minimum number of colors needed to color the nodes of a graph so that no edge is incident to two nodes with the same color) and SATISFIABILITY (determining whether or not a boolean formula has a satisfying truth assignment). These problems, while interesting in their own right, served as surrogates for the broad range of difficult optimization problems. Michael Trick of GSIA-CMU came to DIMACS on sabbatical to serve as Challenge Coordinator, leading a steering committee consisting of Vašek Chvátal (PM,RU), Bill Cook (PM,BC), David Johnson (PM,BL), Catherine McGeoch (Amherst College, Coordinator of the first Challenge), and Robert Tarjan (PM,PU).

  The workshop of the Second DIMACS Challenge was held from October 11 through October 13, 1993, at Rutgers University and organized by Michael Trick (Carnegie Mellon University) and David Johnson (PM,BL). Approximately 100 researchers attended the conference, which consisted of 38 presentations and poster sessions, two invited survey talks, and three panel discussions. Significant improvements on the state-of-the-art for the three Challenge problems were reported, as well as interesting phenomena worthy of further study. A sample of the conclusions presented follows: finding the maximum clique in graphs with approximately 400 nodes could be done routinely by a variety of techniques, none of which works regularly in 1000 node problems (see, for example, the work of Balas and Jue, and Mannino and Sassano); general 100 node graph coloring problems seem very difficult to solve, while much larger problems generated from real-life register allocation problems are much easier (see, for example, the work of Lewandowski and Condon); exact methods for satisfiability, based on improvements to the basic Davis-Putnam procedure, are able to solve problems (random instances in the so-called "critical region") up to 400 variables, but fail to terminate in a reasonable amount of time shortly thereafter (see many papers, including those by Van Gelder and Tsuji, and Pretolani); general heuristic approaches, such as tabu search and simulated annealing, seem to be robust, practical methods for all of these problems. In the panel discussions, much time was spent on the difficulties faced in doing computational work, from finding interesting real-world problems to the need for sophisticated statistical analysis. A refereed proceedings consisting of the best papers, updated in response to what is learned at the workshop, will be published by the American Mathematical Society as part of their DIMACS series that should appear within a year. The proceedings for the 1st Implementation

Challenge (1990-91), devoted to the combinatorial optimization problems of network flows and matching has recently appeared (Vol. 12, DIMACS Series).

The Special Year hosted a large number of visitors. Several important results were obtained by these visitors and by members collaborating with these visitors. Below some of these results are mentioned; but it should be emphasized that the longer-term impact of the collaboration and exchange of ideas between participants of the special year is equally, or perhaps more, important.

- The celebrated Four Color Theorem asserts that every planar graph is four-colorable. Some find the statement displeasing since it mixes a relatively complex topological notion (planarity) with a relatively simple combinatorial notion (colorability). Hadwiger proposed a purely combinatorial conjecture, whose validity would make the Four Color Theorem just the tip of an iceberg (seen through fog): if a graph is not k-colorable then it can be contracted (by shrinking connected subgraphs onto single vertices) onto a complete graph with k vertices. The Four Color Theorem follows instantly from the special case of this conjecture, where k=5; conversely, Wagner had shown that this special case can be derived from the Four Color Theorem. Paul Seymour (PM,BC) and DIMACS visitors Neil Robertson and Robin Thomas made an impressive breakthrough by proving Hadwiger's conjecture with k=6. They also proved the so-called Heesch conjecture concerning reducible configurations in the theory of 4-colorability of planar graphs.

- Ravi Kannan (PM,BC) and Laszlo Lovász (PU and Budapest), together with Special Year visitor M. Simonovits, obtained an improvement in the running time of the randomized volume, sampling and integration algorithms. Refinements of this technique, which have started with the pioneering work of Dyer, Frieze and Kannan in 1988-89, have often been sponsored by DIMACS. Due to these improvements, the original running time of $O(N^{27})$ (which was of theoretical interest) was reduced to $O(n^7)$ at the time of our last annual report, and has since been reduced to $O(n^6)$, which is now near the range where practical implementations may be feasible.

- Special Year visitor A. Barvinok extended his "exponential sum method" to the travelling salesman problem. With Special Year visitor Bert Gerards and Shmuel Onn (PD), he applied this to derive an approximation scheme for the longest Hamilton cycle with respect to any polyhedral norm. This new approach to TSP and other combinatorial optimization problems is certainly worthy of extensive further study.

- For over a decade, computer codes for solving the notorious Traveling Salesman Problem have been tested on a standard set of problems, now available to the public under the name of TSPLIB. This discipline is sometimes reminiscent of a competitive sport. In the spring of 1992, a team consisting of David Applegate (PM,BL), Vašek Chvátal (PM,RU) and William Cook (PM,BC) along with Robert Bixby (Center for Research on Parallel Computation, Rice University) claimed a gold medal by solving fifteen previously unsolved problems from TSPLIB with sizes ranging from 417 to 3038 cities (for comparison, the largest previously solved TSPLIB problem had 2392 cities). In June 1993, the team broke its own record by solving a TSPLIB problem with 4461 cities. The computations took about 27 days *in parallel* on a network consisting of fifty-eight Sparc 10/30's, thirteen Sparc 2's and four DEC 5000's; an estimated running time on a *single* workstation comes to about eighteen months.

1.1.2 Special Year 1993-94 - Massively Parallel Computing

This Special Year is made possible with the support of the NSF and the NJ Commission on Science and Technology. The year is under the direction of a distinguished organizing committee chaired by Thomas Leighton (MIT) and Bruce Maggs (NEC; CMU), and including Alok Aggarwal (IBM), Sandeep Bhatt (PM,BC, RU), James Flanagan (CAIP-RU), Albert Greenberg (PM,BL), Richard Karp (Berkeley), Ken Kennedy (Rice), Janos Komlos (PM,RU), Andrew Ogielski (PM,BC), Robert Sedgewick (PM,PU), and Chuck Seitz (CalTech).

Massive parallelism, or supercomputing, is an emerging technology that may prove vital to our continuing world leadership in science and engineering. Supercomputing technology is at a stage in its development where a vigorous dialogue between theoreticians, computer architects, and applications designers is of crucial importance. DIMACS has a unique ability to bring together the top researchers in these areas: DIMACS has obvious clout with theory community, but is also able to draw architects, application researchers, and commercial vendors as illustrated by the attendance at the first workshop.

Although a Special Year at DIMACS generally lasts for 12 months, this special year had an early kick-off with two workshops in the spring of 1993.

- *Future Directions for Parallel Optimization*, April 30 - May 1, 1993.

  This workshop, organized by David Applegate (PM,BL), John Dennis (Center for Research in Parallel Computation (CRPC), Rice University), and Irving Lustig (PU), studied the application of parallel computing to optimization. Optimization provides a particular challenge for parallel computing, since problems in optimization don't usually have nice regular structures which make them ammenable to data-parallel programming. Highlights of the meeting included an opening address by Ken Kennedy (Center for Research in Parallel Computing (CRPC), Rice University) giving an overview of the present state of parallel computing and a vision for its future and a lively panel discussion on this topic chaired by Robert Schnabel (Colorado University) with scientists from Cray Research, Intel, Thinking Machines, and Convex.

- *Parallel Algorithms for Unstructured and Dynamic Problems*, June 2-4, 1993.

  This workshop was organized by Alberg G. Greenberg (PM,BL), and Andrew T. Ogielski (PM,BC). In many important mathematical, scientific, and industrial problems, data dependencies are highly irregular and/or evolving at run time. Outstanding examples of such problems involve discrete event simulations, branch and bound techniques, and adaptive grid methods. The workshop brought together researchers from a wide variety of fields in order to explore the existing algorithms, heuristics, and systems, to suggest new methods, and to identify some common strategies. There were over 100 attendees, including representatives of such companies as IBM, AT&T, Bellcore, NEC, and Thinking Machines, and a large number of students.

  In solving irregularly structured problems efficiently, a key task is to increase locality in the computation, trading off bandwidth, latency, and memory. The two main strategies were highlighted at the meeting. Algorithms that exploit locality and structure in the interconnect of the machine have the best performance but may be criticized as being impractically hard to program and as being non-portable; algorithms written at a higher level, ignoring the interconnect and leaving such problems to compiler, runtime, and memory system support, are portable across a wide range of architectures but have uneven performance.

The main portion of the Special Year began in September, as postdoctoral fellows and visitors began to arrive.

- *Models, Architectures, and Technologies for Parallel Computation*, September 20-22, 1993.

  This workshop was held under the direction of Phillip B. Gibbons (BL), Richard M. Karp (U.C. Berkeley, ICSI), Charles E. Leiserson (MIT), and Gregory M. Papadopoulos (MIT, Thinking Machines). The workshop focused on how to model the state-of-the-art parallel computers of today and of the near future. This workshop provided an all-too-rare opportunity for experts in parallel hardware, software, and theory to interact, and work together for new insights into modeling parallel computers. The workshop featured 43 talks by leading researchers in the areas of parallel architectures, compilers, technology and theory. Keynote addresses were provided by David Patterson (U.C. Berkeley), Thomas Knight (MIT), and Phillip Gibbons. Representatives from Intel, IBM, Cray, and Thinking Machines presented talks on their recent and forthcoming parallel machines. Because of the interest in this area and the quality of speakers, the workshop attracted nearly 200 participants, including many students. Several participants remarked that this was the best workshop they had ever attended, commenting in part on the usefulness of extended communication and discussion specifically aimed at bridging the various areas represented.

- *Parallel Algorithms: From Solving Combinatorial Problems to Solving Grand Challenge Problems*, November 17-19, 1993.

  This workshop was organized by James Flanagan (CAIP-Rutgers), Yossi Matias (PM,BL), and Vijaya Ramachandran (U. Texas at Austin). The workshop featured 38 talks by leading researchers in parallel algorithms. Topics that were covered include: scientific computation, string matching, computer graphics, N-body problems, combinatorial problems, linear algebra, graph algorithms (theory, approximation, and implementation), models for more effective parallel algorithms, basic primitives for parallel computation, approximation for problems that are hard to parallelize, domain decomposition techniques in numerical analysis, platforms for implementing parallel algorithms, computational biology, randomized algorithms, computation geometry, hypercube algorithms, distributed memory algorithms, image processing, search trees algorithms, derandomization techniques, and simulated annealing.

In connection with the Special Year there is also a monthly seminar series. Programs for the first two seminars in the monthly Special Year series are included in the appendix.

A number of research results have been obtained by DIMACS members, postdoctoral fellows and visitors in the area of high performance computing, which we sample here.

- Hot potato routing algorithms on meshes and hypercubes are the method of choice in practice for meshes and tori because they are easy to implement. Christos Kaklamanis (PD,RU) and Satish Rao (PM,NEC) have achieved the first exact analysis of hot potato routing on the torus in three dimensions. Kaklamanis has also obtained results on emulating planar graphs on fixed-connection networks that allow him to give efficient implementations of finite element computations on hypercubic computers.

- Edith Cohen (PD,PU) has developed new methods for reducing the numbers of processors and total work needed in parallel algorithms for network flow, matching, and shortest path problems, by trading work for accuracy. Her results find solutions that are provably "near"-optimal.

- David Johnson (PM,BL), Edward Coffman(PM,BL), and Peter Shor (PM,BL), together with Richard Weber (Cambridge University) and with programming advice from David Applegate (PM,BL), have exploited the large random-access memory of modern (high performance) computers to prove theorems that resolve long-standing open problems about average-case performance of algorithms for the classical bin packing problem, in which one wants to pack items into unit capacity containers so as to minimize the number of containers used.

1.1.3 Other Workshops and Seminars

During the current fiscal year that contained two pre-Special Year workshops, there was only one workshop unrelated to a Special Year.

- *Partitioning Data Sets: With Applications to Psychology, Vision and Target Tracking*, April 19-21, 1993.

  This workshop, organized by Ingemar Cox (PM,NEC) and Pierre Hansen (PM,RU) brought together about 40 participants from the Cluster Analysis, Target Tracking, Computer Vision and Psychology fields. Theoretical, tutorial presentations were interleaved with those focusing on recent research and applications. The workshop explored connections between graph clustering, partitioning and image processing techniques, and the use of methods from combinatorial optimization, such as quadratic and dynamic programming. In particular, the first, and very successful, application of unconstrained quadratic 0-1 optimization to image enhancing was discussed by Endre Boros (PM,RU).

In addition to workshops, there are a variety of seminar series, whose programs are included in the appendix.

- *Mixer Series* In the fall of each year, DIMACS sponsors a Mixer Series: there are four afternoon events within the first month or so of the academic year, one at each DIMACS site. Newcomers to DIMACS give talks at sites other than their own base site. In this way, senior members can get a sampling of who is around for the year, and visitors and postdocs get to meet senior members at all four institutions. The Mixer Series this year was organized by Christos Kaklamanis (PD).

- *DIMACS Series* The Theory of Computation Series and the Discrete Mathematics Series, both organized by Michael Saks (PM,RU) and originating in Fall, 1993, each convene weekly over lunch and provide an informal and high level research forum for DIMACS members, visitors, and graduate students. The DIMACS-RUTCOR industrial problem seminar organized by Michael Rothkopf (PM, RU) meets periodically in conjunction with his graduate course in case studies. A new bi-weekly series in Mathematics Education was also originated in Fall, 1993.

- *Biomathematics/Biocomputing Seminar Series* This series, now completing its second year, is part of DIMACS' expanding involvement in the biological sciences. This series of talks, which are held on an approximately monthly basis, exposes the DIMACS community to problems with biology, particularly within molecular biology. The talks are also advertised within the biology community and we often find that a significant fraction of the audience are working biologists.

1.1.4 Research Breakthroughs and Ongoing Projects

It would be impossible to give a complete account of the large number of research results obtained at DIMACS or engendered by DIMACS programs in the past year. A selection of this research is published in the DIMACS 1993 Technical Report Series. A list through the end of November appears in the appendix. Many research results, however, particularly those by our permanent members, are submitted directly to journals without first appearing as DIMACS Technical Reports. A true picture of DIMACS' total research accomplishments should include these articles as well. In this section, we report on some of the continuing effects of workshops offered in previous years, a selection of research results by our members and visitors, and ongoing projects within the Center.

The success of a Special Year or even a single workshop cannot be measured immediately upon its conclusion, nor even a year or two later. A main feature of DIMACS workshops is to focus attention on open problems whose solutions will require new insight and will influence the field. Various teams of participants work on one problem or another during the course of the workshop and then continue to collaborate after its conclusion. Some problems are solved during a workshop, some soon after, some much later, and some remain open.

- Recently, Ikebe, Perles (V), Tamura and Tokunaga solved a problem on embedding rooted trees in the plane, posed by Micha Sharir (V) during a workshop in the 1989-90 DIMACS Special Year on Discrete and Computational Geometry. They proved that any rooted tree of n vertices can be straight-line embedded into any set S of n points in the plane in general position so that the image of the root is arbitrarily specified.

- The work that began in that same Special Year at the workshop on Probabalistic Methods in Discrete & Computational Geometry led to a flurry of remarkable new results. R. Seidel (V) presented the "backwards analysis technique" which simplified the analysis of randomized geometric algorithms. He showed there how to use it in linear programming, and later, in several other contexts. Since then this idea, invented as a method of analyzing algorithms, has evolved into a tool for *devising* randomized algorithms. The ground-breaking work of J. Matousek (V) on cuttings, epsilon approximations, and epsilon-nets although it is a break-through in the area of *derandomization* of randomized algorithms, it is also of fundamental theoretical interest in combinatorics and combinatorial geometry, together with the seminal work of Kenneth Clarkson (PM,BL) and Peter Shor (PM,BL) on incremental randomized algorithms, the derandomization ideas provided some of the tools for new developments. Such as the recent discovery by Bernard Chazelle (PM,PU) of the first optimal (deterministic) algorithms for computing convex hulls and Voronoi diagrams in any fixed dimension: this successfully ended a 20-year old quest for an optimal solution to one of the most central but elusive problems in computational geometry. The same derandomization techniques play the major role in settling the complexity question for other problems, such as the diameter in dimension 3. Finally, the work of Chazelle, Matousek, and others reveals the fundamental relationship between epsilon nets and epsilon approximations and discrepancy theory. This major line of research owes its start, and much of its development, to the first DIMACS special year, and the collaborations that grew out of it.

- Error-correcting and error-detecting codes have played important roles in applications ranging from data networking to satellite communication to compact disks. The October, 1992, Workshop on *Coding and Quantization* sponsored jointly by DIMACS and the IEEE led to results reported in the October, 1993, issue of *Science* (a copy of which is included in the Appendix.) Most work on cyclic codes has emphasized "linear codes". consisting of all vectors x over some finite field (commonly the integers mod 2, "binary codes") such that $Ax = 0$, for some matrix A. These codes have a clean structure that makes them simple to discover, to understand, and to encode and decode. Two codes which were assumed to be non-linear, the Kerdock and Preparata codes, have long been known to be "dual" to one another in a particular formal sense, even though mathematical *duality* is defined only for linear codes. For roughly 20 years this curious observation left coding theorists with the open question of whether these non-linear codes might not be duals in some stronger sense. Robert Calderbank (PM,BL), Hammons, Kumar, Neil Sloane (PM,BL) and Solé [DTR 93-50] recently resolved this question by showing that the Kerdock and Preparata codes are in fact linear, if one views them in the right way over the ring of integers mod 4 instead of mod 2, and that, over this larger alphabet, the two codes *are* mathematical duals. The mapping between the mod 2 and mod 4 versions of the codes is extremely simple.

Twenty-four papers presented at the 25th ACM Symposium on Theory of Computing (STOC), San Diego CA, May 1993, held as part of the Federated Computer Research Conference (FCRC), were authored or co-authored by a DIMACS members, postdoctoral fellow or graduate student. Numerous others were authored by visitors to DIMACS. Here, we highlight three of these papers.

- The problem of building evolutionary trees is a fundamental problem in computational biology. No efficient algorithm for building evolutionary trees was known, until DIMACS postdoc Martin Farach, former DIMACS postdoc Sampath Kannan and DIMACS visitor Tandy Warnow developed the algorithm presented in the paper "A Robust Model for Finding Optimal Evolutionary Trees" (DTR 93-22). This was one of two papers from STOC that was was selected as an "ACM Impact Paper" at FCRC, an award for papers that promote technology transfer. The techniques developed for this problem have important applications to problems beyond relationships among species. For example, the multiple alignment problem is central to the Human Genome Project, but no efficient algorithms are known to solve it. The clustering techniques developed for evolutionary tree constructions have proved to be useful heuristics in attacking this alignment problem.

- Anne Condon, Joan Feigenbaum (PM,BL), Carsten Lund (PM,BL), and Peter Shor (PM,BL) presented a STOC paper (DTR 93-10) giving a new characterization of $PSPACE$ that is used to show that certain $PSPACE$-hard functions are as hard to approximate as they are to compute exactly. They investigated properties of the "probabilistically checkable debate system" (PCDS), a natural generalization of the probabilistically checkable proof system studied recently by Babai et al., Feige et al., and Arora et al. A PCDS for a language L consists of a probabilistic polynomial-time verifier V and a debate between player 1, who claims that the input x is in L, and player 0, who claims that the input x is not in L. They show that there is a PCDS for L in which V flips $O(logn)$ random coins and reads $O(1)$ bits of the debate if and only if L is in $PSPACE$.

- Michael Saks (PM,RU) and F. Zaharoglou (GS,V) presented the paper "Wait-free k-set agreement is impossible: the topology of distributed knowledge". Much of the theory of distributed computing is concerned with problems of coordinating a set of processors. Various problems have been proposed to model simple coordination tasks. A famous result of Abu Amara-Loui and Herlihy (based on a previous result of Fisher-Lynch-Patterson) says that, in the standard asynchronous shared-memory with atomic read/write, a very basic coordination task called "consensus" is impossible to do with absolute reliability. S. Chaudhuri conjectured that the same impossibility result extends to a weaker coordination task called "k-set consensus". Here this conjecture was proved by showing that the structure of the problem can be represented by topological space and the impossibility result follows from a fixed point theorem on that space.

Other notable papers and results include:

- In an invited address at the bi-annual Workshop on Algorithms and Data Structures at Montreal in August 1993, Robert Tarjan (PM,PU) presented his dramatic new result with Philip Klein (V), a randomized linear-time algorithm for finding a minimum spanning tree in a connected graph with edge weights (DTR 93-71). The algorithm is a modification of one proposed by Karger and uses random sampling in combination with a recently discovered linear-time algorithm for verifying a minimum spanning tree.

- As one of ten papers presented by DIMACS authors or co-authors at 34th Annual IEEE Conference on Foundations of Computer Science (FOCS), November 3-5, 1993 in Palo Alto, California, H. Hampapuran (GS,RU) and Michael Fredman (PM,RU) presented their result on optimal bi-weighted binary trees and the complexity of maintaining partial sums. The *partial sum problem* concerns the design of a data structure for implementing the following operations on an array A. The operation $update(j, x)$ has the effect, $A[j] \leftarrow A[j] + x$, and the query operation $sum(j)$ returns the partial sum, $\sum_{i=1}^{j} A[i]$. Hampapuran and Fredman derive new upper and lower bounds for the optimal efficiency with which sequences of such operations can be performed in the semi-group model of computation. An important application of this problem arises in maintaining empirical cumulative distribution functions for statistical databases that are periodically updated. The new results concern the design of data structures that have optimal efficiency, taking into account the frequency with which the various update and query operations are performed.

- R.H. Hardin and N.J.A. Sloane (PM,BL) have shown that it is possible to find I-, D- and A-optimal (or nearly optimal) designs for a wide range of response-surface problems (DTR 93-47). The algorithm handles continuous or discrete variables, linear equality or inequality constraints, and a response surface that is any low degree polynomial. The algorithm has been implemented in a program called Gosset, which has been used to compute extensive tables of designs. Many of these are more efficient than the best designs previously known.

- Another advance was made on understanding random matchings in graphs. With a simple graph G associate the random variable $\xi(G)$, defined as the size of a matching chosen uniformly at random from the set of all matchings of G, and write $\mu(G)$ and $\sigma^2(G)$ for the mean and variance of $\xi(G)$. For a vertex x, write $p(\overline{x})$ for the probability that the random matching does not cover x. Jeff Kahn (PM,RU) and J.H. Kim (GS, RU) showed that for a regular G the values $p(\overline{x})$, $\mu(G)$ and $\sigma^2(G)$ are remarkably well determined just by the degree and number of vertices. In particular, for any d-regular, n-vertex simple graph G, and $x \in V(G)$: (a) $p(\overline{x}) \sim d^{-1/2}$, and consequently $n - 2\mu(G) \sim nd^{-1/2}$, and (b) $\sigma^2(G) \sim n/(4\sqrt{d})$. The rates of convergence in these limiting statements depend only on d.

- In DTR 93-56, John Hershberger and Subhash Suri (PM,BC) propose a very simple ray shooting algorithm, whose only data structure is a triangulation. The query algorithm, after locating the triangle containing the origin of the ray, walks along the ray, advancing from one triangle to a neighboring one until the polygon boundary is reached. The key result of the paper is a Steiner triangulation of a simple polygon with the property that a ray can intersect at most $O(\log n)$ triangles before reaching the polygon boundary. The triangulation can be computed in linear sequential time, or in $O(\log n)$ parallel time using $O(n/\log n)$ processors. This gives a simple, yet optimal, ray shooting algorithm for a simple polygon. Using a well-known technique, the triangulation procedure can be extended to a multi-connected polygon with k components and n vertices, so that a ray intersects at most $O(\sqrt{k}\log n)$ triangles.

- Mikkel Thorup (V) reported a new approach to ambiguity of context-free grammars (DTR 93-61). This allows the LL and LR techniques to be generalized to solve the following problems for large classes of ambiguous grammars: construction of a parser that accepts all sentences generated by the grammar, and which always terminates in linear time; construction of a finite set of pairs of partial parse trees such that, if for each pair the two partial parse trees are semantically equivalent, the ambiguity of the grammar is semantically irrelevant.

Twenty-three DIMACS gradstudents earned Ph.D.s since the last NSF annual report. Here we highlight notable results from three of the dissertations.

- Graduate student I. Bjorling-Sachs and advisor Diane Souvaine (PM,RU) solved a long-standing open problem by proving that every simple polygon with n vertices and h holes can be guarded using at most $\lfloor (n+h)/3 \rfloor$ guards. They also provided an $O(n^2)$ algorithm for placing the guards.

- Graduate student A. Buchsbaum and advisor Robert Tarjan (PM,PU) introduced *data-structural bootstrapping*, a technique to design data structures recursively, and used it to design confluently persistent deques. This data structure requires $O(\log^* k)$ worst-case time and space per deletion, where k is the total number of deque operations, and constant worst-case time and space for other operations.

- Graduate student Vivek Gore and advisor Eric Allender (PM,RU) proved an exponential lower bound on the size of constant-depth circuits of AND, OR, and MOD gates computing the permanent of a matrix. One striking thing about this result is that it holds only for circuits with an efficient rule telling how to construct the circuits (so-called "uniform" circuits). This is the first time that uniformity has been used to advantage in a circuit lower bound proof. Furthermore, Allender and Gore also show that the complexity class ACC is properly contained in the classes PP and $C_{=}P$.

1.2 Research Plans For Coming Year

1.2.1 Special Year 1993-94 - Massively Parallel Computing

Four more workshops are planned in the coming year, as well as an Implementation Challenge.

- "Organizing and Moving Data in Parallel Machines.", January 26-28, 1994.

  This workshop is being organized by Christos Kaklamanis (PD,RU), Kai Li (PU), Greg Plaxton (U. Texas), and Abhiram Ranade (U.C. Berkeley). The workshop will cover topics including memory management in parallel computers, hierarchical memory systems, cache coherence, I/O, and algorithms for routing and sorting in parallel machines.

- "Interconnection Networks & Mapping and Scheduling Parallel Computations", Feb 7-9, '94.

  This workshop is being organized by Frank Hsu (Fordham), Arnold Rosenberg (U. Massachusetts), and Dominique Sotteau (LRI, U. Paris-Sud). One of the central problems in parallel computing is the task of mapping a collection of processes onto the processors and routing network of a parallel machine. Once processors are mapped onto the physical processors, scheduling communication is critical. The workshop will focus on the interconnection networks of parallel architectures of today and of the near future, examining the task of mapping and scheduling parallel computations on these parallel machines.

- "Parallel Processing of Discrete Optimization Problems", April 28-29, 1994.

  This workshop is being organized by P.M. Pardalos (University of Florida), M.G.C. Resende (BL), and K.G. Ramakrishnan (BL). This workshop will cover, but is not limited to, topics in parallel formulations of depth-first and best-first search algorithms and dynamic programming, parallel algorithms for 0-1 linear programming, quadratic integer programming (including nonlinear assignment problems), load balancing techniques, and software issues.

- "Specification of Parallel Algorithms.", May 1994.

  This is a joint workshop with the Center for Research in Parallel Computation (CRPC). The workshop is being organized by Guy Blelloch (CMU), Mani Chandy (CRPC, Caltech), and Suresh Jagannathan (NEC). This workshop will cover the design and implementation of parallel programming languages, and programming language standards.

- "Parallel Implementation Challenge." Oct. 1993-Oct. 1994

  The Challenge is being organized by a committee consisting of Sandeep Bhatt, chair, (BC,RU), David Culler (U.C.Berkeley), John Dennis (CRPC, Rice), David Johnson (BL), Lennart Johnsson (Thinking Machines, Harvard), and Charles Leiserson (MIT). The use of massive parallelism in discrete combinatorial applications has received far less attention than in numerical applications. Despite the large body of theoretical work on parallel algorithms for combinatorial problems, it is unclear what kinds of parallel algorithms will be most effective in practice. The goal of this challenge is to provide a forum for a concerted effort to study effective algorithms for combinatorial problems, and to investigate the opportunities for massive speedups on parallel computers. The challenge will include at least two problem areas for research study: tree searching algorithms (e.g. game trees, combinatorial optimization); parallel algorithms for sparse and dynamic graphs (e.g. minimum spanning trees, shortest paths).

1.2.2 Special Year 1994-95 - Mathematical Support For Molecular Biology

DIMACS is planning a 1994-95 "Special Year" on the topic Mathematical Support for Molecular Biology. The program will start in August, 1994, and run through August, 1995, with some supplementary activities scheduled for the 1995-96 year. The Special Year is intended to expose a large portion of the community of discrete mathematicians and theoretical computer scientists to the problems of molecular biology that seem to be fundamentally problems of their field; to provide an opportunity for intensive collaboration to those discrete mathematicians and theoretical computer scientists who have already discovered these problems; to introduce some outstanding young people in the community to the field of mathematical/computational biology in a very concentrated way; and to develop a long-term base and model for interdisciplinary research in this field.

The DIMACS Special Year will be chaired by Joachim Messing and Fred Roberts of Rutgers University. It will be co-chaired by Lawrence Shepp (PM,BL) and Michael Waterman (USC). In addition, the steering committee includes David Axelrod (RU), Martin Farach (PM,RU), Daniel Gusfield (UC Davis), Leroy Hood (U. of Washinton), Richard Karp (UC Berkeley), Eric Lander (MIT), Eugene Lawler (UC Berkeley), Joshua Lederberg (Rockefeller), Joseph Naus (RU), Michiel Noordewier (PM,RU), Wilma Olson (RU), David B. Searls (U. Penn), William Sofer (RU), Tandy Warnow (U. Penn), Peter Winkler (PM,BC), and Andrew Yao (PM,PU). The program will include extensive collaboration with biologists through the participation of the Waksman Institute for Molecular Genetics at Rutgers, the Center for Molecular Biotechnology at the University of Washington, and the Genome Center at the University of Pennsylvania.

Visitors, postdoctoral fellows, and ongoing seminar series form an important part of every special year. Due to the interdisciplinary nature of this special year, we hope to lengthen the fellowship period for special year postdocs to 25 months, including a preliminary month, August, 1994. The fellowship period will be augmented with several intensive periods of training in the biological sciences. (Many of the postdoc training activities will also be open to those in the community who wish to participate.) Several prominent researchers in Biocomputing and Biomathematics have already planned long-term visits during the special year; they include Dan Gusfield, Gene Lawler and Michael Waterman. During the Special Year, there will be a regular research-oriented seminar series and DIMACS will also host a distinguished lecture series. Among those who have already accepted invitations to participate in the series are Daniel Gusfield, Leroy Hood, Samuel Karlin, Joshua Lederberg, Joachim Messing and Michael Waterman.

The Special-Year program will be centered around a series of workshops, open to the entire community. Although the exact titles and dates are not yet finalized, the plans are to have a workshop on Sequencing and Mapping in October, 1994, one on Sequence Alignment in November, 1994, one on Evolution and Phylogeny in February, 1995, and a week-long program on Protein Structure and on Sequences of Proteins and Antibodies in March, 1995. We will also be running the fourth in a series of "DIMACS Algorithm Implementation Challenges," to culminate in a workshop in September, 1995.

There will be a series of one-day mini-workshops, organized around topics of current interest, and frequently scheduled at the last minute. Among the topics already tentatively scheduled are programs on RNA Structure in the Fall of 1994, Combinatorial Structures in Molecular Biology in the Fall of 1994, DNA Structure and Regulation in the Spring of 1995, HIV Sequence Data in the Spring of 1995, and Gross and Fine Structure of DNA in the Spring of 1995. Other potential topics for mini-workshops include Database Aspects of Biological Data, DNA Fingerprinting, Information Theory, as well as topics outside of molecular biology such as Interacting Particle Models of Ecological Systems and Competition Graphs/Niche Graphs.

In addition to the many technical reports, journal articles, and conference volumes that usually result from a DIMACS special year, we plan to produce a volume of papers (many of them expository) by leaders of the field.

1.2.3 Other Workshops and Projects

Two additional workshops are scheduled for the Spring of 1994:

- *Geometric Group Theory*, March 17-20, 1994.

  In recent years investigation of geometric and language-theoretic aspects of finitely presented groups has engendered a remarkable interplay between group theory, geometry, and the theory of automata and formal languages. Perhaps the best known result of this interplay has been the introduction of automatic groups, which include the hyperbolic groups of M. Gromov. Computational considerations, both practical and theoretical, have played an important role in these developments. There have been many conferences on geometric group theory, but none has yet focussed on the computational side of the subject. DIMACS and the Geometry Center at the University of Minnesota will jointly sponsor two workshops on computational and combinatorial aspects of geometric group theory. A small workshop will be held first at the Geometry Center from January 3-14, 1994, to focus on programming and practical computation. The DIMACS workshop, in addition to communicating the relevant results of the first workshop, will cover a wider range of topics. The organizers for this pair of workshops are Gilbert Baumslag (CCNY), David Epstein (U. of Warwick), Robert Gilman (Stevens Institute of Technology), Hamish Short (CCNY), and Charles Sims (PM,RU).

- *Formal Power Series And Algebraic Combinatorics*, May 23-27, 1994.

  DIMACS will host the 6th International Conference on Formal Power Series and Algebraic Combinatorics (FPSAC '94). The conference focuses on algebraic combinatorics and its connections with enumeration, topology, geometry and theoretical computer science. The conference will include invited survey lectures, contributed presentations, problem session, software demonstrations. Invited speakers include Anders Bjorner (Sweden), Ruth Charney (USA), Maylis Delest (France), Philip Hanlon (USA), David Jackson (Canada), Gil Kalai (Israel), Sergei Kerov (Russia), Christophe Reutenauer (Canada), Sheila Sundaram (USA). The organizers of this conference are Louis Billera (Cornell University), Curtis Greene (Haverford College), Rodica Simion (The George Washington University, Chair), Richard Stanley (MIT).

Plans for two additional (non-Special-Year) workshops are underway, including new visits to past workshop topics. DIMACS sponsored a workshop on Combinatorics and Optimization in Science and Technology (COST) in March, 1991, that drew 70 researchers from over a dozen countries. The focus of a new COST workshop in 1994 will be the applications of combinatorics and optimization in science and technology, with the aim of exposing the research community to the latest advances in this area, to induce collaboration, and to promote cross-fertilization. Planning is also underway for a workshop to follow up on the first Special Year in *Discrete and Computational Geometry*, possibly in collaboration with the Geometry Center and the Graphics Center.

1.3 Major Changes In Direction/Pace Of Research

With the exception of Special Year visitors and postdocs, DIMACS does not ordinarily target specific fields; DIMACS normally selects the visitors, graduate students, and postdoctoral fellows to be funded based on their excellence in any field traditionally associated with DIMACS, with the added goal of developing talent in groups traditionally underrepresented in the field and encouraging interaction with faculty in non-Ph.D. granting institutions. Workshops are funded based on their timeliness and their potential to impact the future directions of the fields involved.

Nonetheless, within the past year or so, DIMACS has begun to encourage applications for additional funding for interdisciplinary and interinstitutional research projects to be based at DIMACS and for special types of postdoctoral fellows and visitors. The first such project has already received partial funding from NSF. Because of the widespread interest in the use of computers as a tool in doing experimental analysis of algorithms and even as a tool in doing theoretical research, DIMACS is pleased to host an ongoing activity in computational support for research in discrete mathematics. This activity is a joint project of DIMACS member Nathaniel Dean (PM,BC) and Mark Goldberg (RPI), Gregory Shannon (Indiana University), and Steven Skiena (Stony Brook). Because of the importance of this work for computational biology, the Los Alamos National Laboratory has agreed to support this activity by providing a full-time programmer and graduate student support.

DIMACS also hopes to host a multi-institutional ongoing research project on simulations of intelligent network systems. For example, *Broadband Integrated Services Digital Networks (B-ISDN)* will combine traffic with highly diverse communication demands (telephone voice traffic, fax images, data transmission between computers, and video transmissions for conferencing) over a common broadband digital network that covers a wide geographical area. Similarly, intelligent vehicle highway systems (IVHS) have been proposed to dynamically manage traffic to minimize congestion and delay. Unlike conventional models of physical systems, models of communications and vehicular networks involve components that operate asynchronously and at time scales that may span several orders of magnitude. In addition, component interactions are usually highly irregular and dynamically changing. The appropriate models are discrete event systems: the system trajectory jumps forward from event to event, rather than evolving continuously in time. A collection of DIMACS members, their current collaborators, and their potential collaborators have drafted a research proposal addressing these issues.

In September, 1994, DIMACS hopes to welcome several new types of postdoctoral fellows. In the hopes of increasing our ties with industry, DIMACS is exploring relationships with various companies, including CuraGen, Sarnoff, Merck, Hoechst Celanese, Siemens, and NEC, who might want to sponsor joint University-Industry Postdoctoral Fellows, recent Ph.D.s who will work 50% of the time in an industrial environment and 50% of the time in an academic setting. Similarly, two different programs for Research-Education Fellowships are being drafted. Both new Ph.D.s and more experienced faculty from other institutions would be welcomed to DIMACS to work 50% of the time on their own research and 50% of the time on projects within education. This concept is currently undergoing a successful dry run with a single fellow, Yanxi Liu, funded by an NSF Small Grant for Exploratory Research.

2 Budget

2.1 Budget Justification

Main Grant

Senior Personnel: Dr. Diane L. Souvaine, the Acting Director of DIMACS, will not receive any support in her role as the Principal Investigator of this project. Support for the Senior administrative personnel will happen as payments to instructors who are classroom replacements for these DIMACS administrators. The Others listed under personnel represent long- and short-term visitors selected by the DIMACS Members in each of the three subgroups at Rutgers: the Mathematics Department, the Computer Science Department, and RUTCOR. The current fringe rate for such appointments is 16.05%

Other Personnel: Three Post Doctoral Associates, each at an annual stipend of $40,000, are included in the fiscal year 1995 budget. Each appointment is for 12 months, beginning September and is exempt from fringe charges. Instead, such appointments are charged the actual health costs (listed under G6); these health costs are exempt from indirect costs. There are three members of the DIMACS Professional Staff – consisting of the Assistant Director (Carol Rusnak), Business Manager (Maryann Holtsclaw), and Systems Programmer (Jennifer Katinsky). All three appointments are full time, 12 month. These appointments currently have assigned a 30% fringe rate. Also budgeted are 1.5 secretarial personnel which also include a 30% fringe rate. A total of 6 Graduate Assistants have been budgeted full-time for the academic years, again beginning September 1, 1994. This equates to 15 hours per week for a 10 month period. There is no summer salary. However, tuition remission and full health benefits (included in the fringe rate) are mandatory and included. The maximum allowable hours for graduate assistant work is governed by the representative union agreements. On June 30, 1992, fringe benefit rates were negotiated by the University and the DHHS. The negotiated fringe rate as of that time is 21.16%, and is charged for the student academic year salaries. The indirect costs rate was also agreed upon at 59% of Modified Total Direct Costs (MTDC) which include all costs except equipment, maintenance, tuition, subcontractual amounts exceeding the first $25,000 of each subcontract, and post-doctoral health costs.

Permanent Equipment: The budget of $10,000 will allow us only to make the most with existing equipment. DIMACS' goal is to provide a SPARCstation on every desktop. While this small budget does not achieve this goal, it does help to make computing more accessible for our visitors. The money will be used to purchase X-terminals and disk space.

Travel: The budget of $15,000 ($10,000 domestic travel and $5000 foreign travel) includes a modest travel allowance of $2000 to each Post Doctoral Associate as well as up to $500 to each Graduate Assistant. Also included in this budget are the costs of travel directly related to DIMACS among the administrative and professional staff as well as some travel for members of the Advisory Board.

Participant Support Costs: The participant support budget is divided among a multitude of DIMACS programs ranging from Short and Long Term Visitor Programs, the Special Year which consists of visitors, workshops, and special events, as well as other related expenses.

Supplies, Publications: Supplies and publications are budgeted to provide adequate funding for small software items, postage, photocopying, purchase of research related books, telephones, miscellaneous supplies, and page overrun charges.

Subcontracts: There is a subcontract with Princeton University budgeted annually at $600,000. Since this subcontract has been in existence for 5 years and exceeded $25,000 there are no indirect cost charges. The purpose of this subcontract remains unchanged in that it is to continue to strengthen the development of new thrusts in Discrete Mathematics and Theoretical Computer Science between the two institutions on research activity in promising areas of these fields.

Tuition: Costs of the tuition associated with the graduate assistantships are budgeted at $8100 per person. This is based on costs related to out-of-state student rates.

Post Doctoral Health: Costs of Post Doctoral Health mandatory with each Post Doctoral Associate appointment are budgeted using the actual annual rates. There is a 10% increase each year which is based upon historical precendents.

Equipment Maintenance: The annual equipment maintenance exceeds the $25,000 budgeted. These annual costs are shared between two accounts. Equipment covered by maintenance agreements include Sun stations, pc stations, photocopy machines, printers.

Subcontract at Princeton University

Senior Personnel: Dr. Robert E. Tarjan, the Co-Director of DIMACS, will not receive any support in his role as the Principal Investigator of this subcontract. The section marked "Others" has been budgeted $70,000 to cover the payroll of the "DIMACS Long Term Visitors." Because of the requirement to handle such visitors via payroll, the standard fringe benefit rate has also been included, which is 33.3%

Other Personnel: One Post-Doctoral Associate, at an annual stipend of $40,000, has been budgeted for fiscal year 1995. This appointment is for a 12 month period, beginning in September. A total of 2.5 Graduate Assistants have been budgeted for the academic year, beginning September. This equates to 20 hours per week for full time appointments. Tuition remission at half the normal rate and full health benefits (included in the fringe rate) are mandatory and included. The fringe rate for 1994-95 is 33.3%, and is charged to all salaries. The indirect costs rate was agreed upon at 59% of Modified Total Direct Costs (MTDC) which include all costs except capital equipment ($500 or over), the amount in excess of $25,000 for a subcontract, charges from the Computer Center, and graduate student tuition.

Travel: The budget of $7000 includes a travel allowance of $2000 for the Post- Doctoral Associate, round-trip travel expenses incurred by the Long-Term Visitors, and a small allowance to the Graduate Assistants. Also included in this budget are the costs of travel directly related to DIMACS by the co-director.

Participant Support Costs: This budget funds a multitude of DIMACS-related programs including Short-Term visitors, the DIMACS Special Year expenses, DIMACS seminars, and travel.

Supplies: Supplies are budgeted to provide adequate funding for basic office supplies, postage, photocopying, telephones, and small software items.

Computer Services: DIMACS at Princeton is housed in the Department of Computer Sciences. DIMACS is charged for the students associated with the program an annual fee of $3400 and $1700 for the postdoc to use the computer facility.

3 STC Database - Submitted Separately

4 Outreach Activities

4.1 Education

DIMACS' educational programs, which identify and train leaders in both research and education in mathematics and computer science, have continued to win national praise. Our Leadership Program for high school and middle school teachers has expanded to reach more teachers and school districts, and has led to several projects for reaching a much broader community, including workshops, a newsletter, a classroom activities book, and participation in curriculum development. Our Young Scholar's program for outstanding New Jersey high school students has continued with much success. We recently introduced a research program for undergraduates (REU), which we hope to expand in coming years. We continue to support outstanding graduate students and postdoctoral fellows at DIMACS and participating institutions; moreover, we have introduced new models for postdoctoral fellowships to support and recognize cross-disciplinary activities. We are editing a volume of significant articles on implementing discrete mathematics in the schools, to appear in our book series. These activities are described in more detail below.

4.1.1 Teacher Leadership Program in Discrete Mathematics

Since 1989, this highly successful program has expanded and continued to develop a community of teachers who are knowledgeable about discrete mathematics and its applications, use it effectively in their classrooms, and teach it to their colleagues. The program is directed by Joseph G. Rosenstein (PM, RU) and funded by the NSF. A major evaluation and dissemination project is now underway. The components of the program are described below.

- *Residential Institutes* In the summer of 1993 DIMACS hosted two three-week introductory institutes, one primarily for high school teachers and one primarily for middle-school teachers, and two two-week advanced institutes for past participants. Each institute includes intensive courses taught by college and university faculty, with support from lead teachers; topics this year included Graph Theory: Applications and Algorithms, Mathematics of Fairness, and Fractals. To date, over 240 teachers from 30 states (primarily New Jersey, New York, and Pennsylvania) have participated in the summer institutes.

- *Followup Activities* Each Institute participant can attend up to four Saturday sessions per year, featuring discussion, a distinguished lecturer, and teacher presentations. These have been crucial to the success of the program, and many teachers continue to come year after year to these highly stimulating events. Over 35 of the teachers are now connected to the Internet and can keep in touch through our new teachers@dimacs email group.

- *In-Service Workshops* Participating teachers who attend a special one-week "Workshop-Workshop" conduct full-day inservice workshops in school districts. During 1992-93, 9 participants conducted 22 full-day workshops, reaching a total of 425 teachers. They have also produced a large collection of materials for use in these workshops. In addition, since the program began, at least 50 participants have given over 200 informal workshops, reaching over 4300 teachers.

- *Greatest Hits in the Classroom Project* In the summer of 1993, DIMACS teachers began to compile and write up their most successful classroom activities in discrete mathematics from the last several years, to be published as a resource for teachers of grades 7-12. Over

15 teachers have joined the editorial board, and many more have signed up to write units. Deborah Franzblau (RU) is coordinating this project.

- *Curriculum and Software Evaluation Teams* Currently we have a team testing modules in their classrooms from the CoMap ARISE project, which is funded by the NSF to develop an innovative mathematics curriculum for grades 9-11. We have also started a team to work with and give feedback to the developers of LINK, a software project for research and visualization in combinatorics and graph theory which is funded by the NSF and the Los Alamos NL.

4.1.2 Young Scholars Program in Discrete Mathematics

This is a four-week residential program for 40 mathematically talented students entering grades 11-12, with four follow-up sessions during the year. Week-long workshops are given by college and university faculty on topics ranging from number theory to fractals, designed to excite and challenge the students, motivate them to continue their study of mathematics, and consider careers in the mathematical sciences. Rutgers undergraduates and graduate students serve as group leaders and mentors. Maintaining diversity has been a priority: the program has maintained a 50/50 balance between females and males, and approximately 20% of the students are minorities. The program has run since 1990 at Rutgers University, is funded by the NSF, and is co-directed by Robert B. Davis (RU), and Michael O'Nan (PM,RU) and Joseph G. Rosenstein (PM,RU).

4.1.3 Research Experience for Undergraduates

DIMACS has introduced a NSF Research Experiences for Undergraduates (REU) program, coordinated by William Steiger (PM,RU). This year, four talented Rutgers undergraduates were selected to work under the mentorship of senior DIMACS researchers for eight weeks during the summer, and to enjoy the stimulating and supportive environment at DIMACS. The students' results were impressive and a few will be published in journal articles. Three are continuing their projects during the academic year for course credit. The purpose of this program is to bring together mathematically talented undergraduates and experienced mathematical scientists in order to discover new results in mathematics and computer science. DIMACS members from each participating institution have expressed an interest in becoming mentors; our goal now is to expand the number of students in the program, recruit undergraduates nationwide, and recruit women and others in underrepresented groups.

4.1.4 Bell Labs/BellCore/DIMACS Program for Underrepresented Groups.

Since 1990, DIMACS has provided computing courses, mentoring, and career counseling for undergraduates in the ongoing AT&T Bell Labs/Bellcore Summer Training Program for Women and Minority Students. These courses give students a strong start for their summer projects, and help students learn to work with one another. The courses and other DIMACS activities are coordinated by Nathaniel Dean (PM,BC).

4.1.5 K-12 Education Network Project

The Network Project has two components:

- *Newsletter for Teachers* "In Discrete Mathematics", edited by Joseph G. Rosenstein, includes short articles and bibliographies, teacher's reports on classroom activities, and topical cartoons. The newsletter is available on request, and now has a mailing list of over 2550 educators nationwide. The third issue was published in September, 1993.

- *Working Group in Discrete Mathematics* Our 1992 Conference, "Discrete Mathematics in the Schools: How Do We Make an Impact?" led us to create a group of national leaders in discrete mathematics education to share information and support and coordinate nationwide efforts to teach discrete mathematics in the K-12 curriculum. One of the recommendations from the first meeting in January 1993 was a refereed volume of articles on the conference theme; the volume is currently being edited by Deborah Franzblau (RU), Fred Roberts (PM,RU), and Joseph G. Rosenstein (PM,RU), with the Working Group serving as the editorial board. These activities, as well as the teacher's newsletter are funded by the NSF.

4.1.6 Graduate Students

Each year, DIMACS directly supports outstanding graduate students doing research in DIMACS areas, at the cooperating departments of Rutgers University and Princeton University. The support includes tuition remission and a 10-month salary. (A list of supported students is included in the appendices.) In addition, all graduate students working with a DIMACS faculty member are considered "DIMACS-Affiliated Graduate Students" and regularly participate in DIMACS activities, for example by lecturing in seminars. We also set aside funds to assist graduate students from other institutions to attend DIMACS workshops and to assist DIMACS Graduate Students to attend conferences elsewhere.

4.1.7 Postdoctoral Fellows

A few postdoctoral fellowships are available each year to young researchers of outstanding ability in discrete mathematics or theoretical computer science. (A list of postdoctoral fellows is in the appendices.) Because of past underrepresenation, whenever applicants have had approximately comparable abilities, we favor those who are women or U.S. citizens. Some of the postdocs are selected specifically to support the Special Year initiatives. We also now have two joint IAS/DIMACS fellowships. This year we also introduced major initiatives to support more postdoctoral fellows in important areas whose work crosses traditional boundaries. Our proposal for the 1994-95 Special Year on Mathematical Support for Molecular Biology includes two-year fellowships for mathematicians and computer scientists which include significant training in laboratory biology, in collaboration with the Center for Molecular Biotechnology. We plan to sponsor one or more University-Industry Postdoctoral Research Associates, who will engage in research both at DIMACS and in an industrial setting. A 1993-94 NSF SGER grant currently supports a postdoc for a pilot program of Research and Education Fellowships, enabling postdoctoral researchers to spend approximately half their time on research at DIMACS and the other half learning about educational research, observing K-12 teaching practice, and participating in projects to improve mathematics education. We are currently preparing a proposal to extend the pilot program, and to include projects in undergraduate as well as K-12 education.

4.2 Other Sectors

4.2.1 General Communications

Almost all researchers in discrete mathematics and computer science use e-mail, so DIMACS can reach this community through regular e-mail and hard-copy announcements, which include the **Monthly Calendar**, **Next Week at DIMACS**, and **Calls for Papers or Participation**. These are supplemented by announcements on DM-Net, Theory-Net, and in AMS and ACM publications.

Participants in the Leadership Program for teachers are now offered computer accounts at DIMACS, and can use e-mail to keep in touch with one another, or use the "teachers@dimacs" bulletin board to ask questions or report on things they have tried in their classrooms.

To expand the DIMACS Center as a resource for the broader scientific and educational community, many DIMACS research results, conference proceedings, and surveys by leaders in DIMACS areas are published as **DIMACS Technical Reports** (which are also available on-line), or as volumes in the **DIMACS/AMS Book Series**. (A list of recent titles is given in the appendices.) We also have a **Newsletter** to report on scientific achievements and member activities. The Center now has its own **Gopher Server** (called the DIMACS Info. Service). The Server provides information about current and upcoming visitors, a full calendar of events, and a complete listing of all technical reports with abstracts. It also provides access points to other servers on the Internet at sites such as the National Science Foundation (NSF), the Society for Industrial and Applied Mathematics (SIAM), the Association for Computing Machinery (ACM), and the U.S Department of Education. In addition, the Server provides access to on-line journals, such as several *SIAM* Journals, and *SIGACT News*. In the future, DIMACS hopes to expand the Gopher Server to utilize Mosaic as a World Wide Web (WWW) Server.

4.2.2 Linkages with Other Organizations

In addition to our industrial partners, AT&T Bell Laboratories and Bellcore, other companies, research centers, and government agencies actively participate in and support DIMACS programs. Scientists from IBM, the Institute for Mathematics and its Applications (IMA), Los Alamos, and the National Security Agency (NSA) serve on the DIMACS External Advisory Board (EAB). On the other hand, our members are active in other centers. For example, Diane Souvaine, Acting Director at DIMACS, is on the Executive Committee of the CMSCE; Ronald Graham, Consulting Director, is President of the AMS; Fred Roberts, past Acting Director, is on the EAB for the Center for Theoretical Studies of Physical Systems (CTSPS); Joseph Rosenstein, Associate Director for Education, is Director of the New Jersey Mathematics Coalition (NJMC); Ram Gnanadesikan (PM, RU) is also on the Board of Governors of the NJMC. David Dobkin (PM, PU) is on the Executive Committee of the Geometry Center. We also receive financial and scientific support from a variety of organizations as described below.

- *Support for Postdoctoral Fellows, Visitors, and Graduate Students.* DIMACS and the Institute for Advanced Study (IAS) in Princeton currently co-sponsor two postdoctoral fellows (Kequan Ding, and Araavind Srinivasan) and the IAS is sponsoring a distinguished senior visitor in Discrete Mathematics. The Center for Communications Research (CCR)(IDA, Princeton) has also supported postdoctoral fellows.a Special-Year postdoctoral fellow (Christos Kaklamanis), and supported two graduate students last spring. The Los Alamos National Laboratory is supporting our initiative on computational support for research and education in discrete mathematics (LINK) with funding for a programmer and graduate students, as well as consulting support for the LINK PI's. The Office of Naval Research (ONR) is supporting a long-term visit to DIMACS by Boris Mirkin, and supported our workshop on "Partitioning Data Sets".

- *Support for Special Year* DIMACS received $100,000 from the The New Jersey Commission on Science and Technology in each of fiscal 1993 and fiscal 1994 to support the Special Year on Massively Parallel Computing and pre-Special-Year activities. DIMACS expects to receive a comparable amount in fiscal 1995 to support the Special Year on Mathematical Support for Molecular Biology.

  Co-chair of the current Special Year (on massively parallel computing) is Bruce Maggs of NEC; co-organizers include Ken Kennedy, the Director of the CPCR (who was the keynote speaker at our workshop on the "Future of Parallel Optimization"); Alok Aggarwal of IBM; and James Flanagan, Director of Center for Computer Aids to Industrial Productivity (CAIP).

The co-chair for the Special Year on Mathematical Support for Molecular Biology is Joachim Messing (RU) of the Waksman Institute for Molecular Genetics. The steering committee includes Michiel Noordewier (PM, RU) and William Sofer (RU), who are also members of the Waksman Institute. This Special Year features significant collaboration with biologists at the Genome Center (U. Penn.) and the Center for Molecular Biotechnology (U. Washington).

- *Education Partnerships*

  Major support for all our K-12 programs is provided by the Rutgers Center for Mathematics, Science, and Computer Education (CMSCE). DIMACS has joined in planning for the New Jersey Statewide Strategic Initiative (SSI) for school reform, and plans to serve as a statewide resource for curriculum development and teacher preparation in mathematics; Gerald Goldin (PM, RU) directs both the CMSCE and the SSI, which is funded by the New Jersey State Department of Education and the NSF. In the future we hope to build more such linkages.

5 Management Planning

5.1 Organization Chart for Center Personnel as of 12/1/93

Permanent Members of DIMACS

Princeton Computer Science
B. Chazelle
D. Dobkin
J. Friedman
A. LaPaugh
R. Lipton
E. Ristad
A. Rogers
R. Sedgewick
K. Steiglitz
R. Tarjan
A. Yao

Rutgers Mathematics
J. Beck
R. Bumby
G. Cherlin
I. Gelfand
S. Gindikin
J. Kahn
J. Komlos
R. Lyons
M. O'Nan
F. Roberts
J. Rosenstein
M. Saks
S. Shelah
C. Sims
E. Sontag
S. Thomas
W. Vasconcelos

Rutgers Computer Science
E. Allender
V. Chvatal
M. Fredman
M. Grigoriadis
H. Hirsh
B. Kalantari
L. Khachiyan
M. Noordewier
D. Souvaine
W. Steiger
E. Szemeredi
A. Yasuhara

RUTCOR
A. Ben-Israel
E. Boros
P. Hammer
A. Hoffman
A. Kogan
A. Prekopa
M. Rothkopf
D. Shanno
A. Williams

RU Center for Math., Science & Computer Ed.
G. Goldin

RU Statistics Dept.
R. Gnanadesikan

Princeton Mathematics Dept.
J. Conway
H. Kuhn

Princeton Civil Eng. Dept.
R. Vanderbei

DIMACS Programs in Pre-College Mathematics
J. Rosenstein
D. Franzblau

Bell Labs
Mathematics and Computer Science

R. Alur
D. Applegate
B. Baker
J. Bentley
A. Buchsbaum
J. Bruno
R. Calderbank
K. Clarkson
E. Coffman
E. Cohen
J. Feigenbaum
P. Fishburn
S. Fortune
M. Garey
R. Giancarlo
R. Graham
A. Greenberg
F. Hwang
D. Johnson
N. Karmarkar
M. Kearns
R. Kurshan
J. Lagarias
D. Lee
C. Lund
Y. Matias
M. Merritt
A. Netravali
A. Odlyzko
A. Orlitsky
N. Reingold
R. Schapire
R. Sethi
L. Shepp
P. Shor
N. Sloane
G. Wilfong
P. Wright
M. Yannakakis

Bellcore
Mathematics & Computer Science

A. Aho
B. Aiello
S. Bhatt
T. Carpenter
F. Chung
W. Cook
N. Dean
D. Durand
S. Haber
R. Jain
A. Lenstra
J. McKenna
M. Mihail
C. Monma
A. Ogielski
J. Schotland
P. Seymour
S. Suri
T. Trotter
V. Venkatesan
V. Wei
P. Winkler

NEC Research Institute, Inc.

E. Baum
I. Cox
C. Giles
S. Jagannathan
J. Kilian
K. Lang
N. Littlestone
Y. Lyuu
B. Maggs
J. Philbin
S. Rao
W. Smith

Executive Committee

Endre Boros - Rutgers University
Michael Fredman - Rutgers University
Michael Garey - AT&T Bell Labs
Ran Gnanadesikan - Rutgers University
Gerald Goldin - Rutgers University
Ronald Graham - AT&T Bell Labs
Peter Hammer - Rutgers University
Jeffrey Kahn - Rutgers University
Leonid Khachiyan - Rutgers University
Richard Lipton - Princeton University
Clyde Monma - Bellcore
Joseph Rosenstein - Rutgers University
Michael Saks - Rutgers University
Robert Sedgewick - Princeton University
Diane Souvaine - Rutgers University
Robert Tarjan - Princeton University
William Trotter - Bellcore
Peter Winkler - Bellcore
Mihalis Yannakakis - AT&T Bell Labs

DIMACS Director Search Committee

Felix Browder, Chair (Rutgers)
Zvi Galil (Columbia)
David Johnson (PM,BL)
Jeff Kahn (PM,RU)
László Lovász (former PM, Yale)
Clyde Monma (PM,BC)
Endre Szemerédi (PM,RU)
Robert Tarjan (PM,PU)

5.2 Membership of External Advisory Board

1994	1995	1996
Dr. Maria Klawe Dept. of Comp. Sci. 6356 Agricultural Rd. Univ. of British Columbia Vancouver, V6T 1W5 Canada klawe@cs.ubc.ca	Dr. Ray Miller Dept. of Comp. Sci. A.V. Williams Bldg. Room 3233 Univ. of Maryland College Pk., MD 20742 miller@cs.umd.edu	Dr. Avner Friedman, Chair University of Minn. Inst. for Mathematics and its Applications 514 Vincent Hall Minneapolis, MN 55455 friedman@ima.umn.edu
Dr. Henry Pollak 40 Edgewood Road Summit, NJ 07901	Dr. David Sanchez Research and Education Directorate Mail Stop A-104 Los Alamos National Lab Los Alamos, NM 87545	Dr. Richard Karp Univ. of California, Berkeley Div. of Comp. Sci. 573 Evans Hall Berkeley, CA 94720 karp@cs.berkeley.edu
Dr. Gian-Carlo Rota M.I.T. Cambridge, MA 02139 rota@bourbaki.mit.edu	Dr. Shmuel Winograd IBM, Thomas Watson Res. Ctr. P.O. Box 218 Yorktown Hts., NY 10598 swin@watson.ibm.com	Dr. Daniel J. Kleitman M.I.T. Room 2-347 Cambridge, MA 02139 djk@math.mit.edu
Dr. Richard J. Shaker National Security Agency Fort Meade, MD 20755-6000 Attn: R51, B2B37		

5.3 Director's Narrative of Operational Aspects of Center (Major Issues)

After Daniel Gorenstein, founding director of DIMACS, died suddenly in August, 1992, Fred Roberts, who had been Associate Director, took over as Acting Director. The search committee charged with finding a permanent director was unable to agree on a candidate, and in April, 1993, the Executive Committee asked Diane Souvaine to serve as Acting Director for 1993-94, while another search was begun. Although the Center continued to run smoothly where its course was already charted, many decisions were made *ad hoc* roughly along the lines that Dr. Gorenstein was thought to have chosen. Since Dr. Gorenstein led largely through his personal contacts, charismatic appeal, and horse sense, the path was hard to find, let alone follow. Dr. Roberts and Dr. Souvaine have of necessity spent much of their time trying to formalize and clarify arrangements at DIMACS – in areas ranging from the budgeting and accounting to secretarial routines – so that the new permanent director might have a clear field in which to operate. At the same time, it seemed advantageous to compensate for the loss of such a strong, internationally known director, by appointing consulting directors, associate directors, and committee members who would not only give their valuable advice but would also, by giving their member institutions a clearer voice and a stronger interest at the core of the center, counteract the sort of centrifugal forces that could quickly undo much of what Dr. Gorenstein had accomplished. In any event, the current search committee (listed in the appendix) has acted expeditiously this fall, and we expect that a permanent director will be named in January to begin serving in June, 1994.

6 International Contacts/Visits

During FY94, DIMACS has hosted many international visitors. A list of all visitors to DIMACS who stay beyond the length of a single workshop is included in the appendix. DIMACS has also enjoyed a cooperative relationship with NEC, similar to those it has had with IDA in the past and with IAS currently. Bruce Maggs of NEC is the co-chair of this years DIMACS Special Year entitled, "Massively Parallel Computation." Satish Rao of NEC has served on our postdoctoral fellow selection committee. During the Spring of 1993, NEC helped to support V. Gupta and S. Wei as graduate assistants. During the academic year 1993-94, NEC is underwriting 50% of the cost for the appointment of postdoctoral fellow C. Kaklamanis.

A List of Publications

Volumes

Thirteen hard bound volumes have been published in the DIMACS Series to date, the most recent (this year) being:

- * *Planar Graphs*(Vol. 9)
  Editor: William T. Trotter
- * *Expanding Graphs* (Vol. 10)
  Editor: Joel Friedman
- * *Groups and Computation* (Vol. 11)
  Editors: Larry Finkelstein and William M. Kantor
- * *Network Flows and Matching* (Vol. 12)
  Editors: David S. Johnson and Catherine C. McGeoch
- * *Advances in Computational Complexity Theory* (Vol. 13)
  Editor: Jin-Yi Cai

Technical Reports (through November, 1993)

(93-01) *A Randomized Algorithm for Finding Maximum with $O((\log n)^2)$ Polynomial Tests.*
Hing F. Ting and Andrew C. Yao

(93-02) *Projective Orientations of Matroids.*
I.M. Gelfand, G. Rybnikov, D. Stone

(93-03) *k-Neighborhood Covering and Independence Problems.*
Shiow-Fen Hwang and Gerard J. Chang

(93-04) *A Polynomial-Time Algorithm for the Phylogeny Problem When the Number of Character States is Fixed.*
R. Agarwal and D. Fernandez-Baca

(93-05) *Monotone Gray Codes and the Middle Levels Problem.*
Carla D. Savage and Peter Winkler

(93-06) *Optimal Compression of Propositional Horn Knowledge Bases: Complexity and Approximation.*
Peter L. Hammer and Alexander Kogan

(93-07) *On Computing Algebraic Functions Using Logarithms and Exponentials.*
Dima Grigoriev, Michael Singer, Andrew Yao

(93-08) *Hilbert Series of Group Representations and Grobner Bases for Generic Modules.*
Shmuel Onn

(93-09) *Asymptotic Results for Permutation Groups*
László Pyber

*(93-10) *Probabilistically Checkable Debate Systems and Approximation Algorithms for PSPACE-Hard Functions.*
Anne Condon, Joan Feigenbaum, Carsten Lund, Peter Shor

(93-11) *The L(2,1)-Labeling Problem on Graphs*
Gerard J. Chang and David Jul

(93-12) *A Tight Bound for Edge Guards in Rectilinear Monotone Polygons.*
Iliana Bjorling-Sachs

(93-13) *Combinatorial Optimization and Computations in the Ring of Polynomials.*
Alexander I. Barvinok

(93-14) *Testing Simple Polygons.*
Esther Arkin, Patrice Belleville, Joseph Mitchell, David Mount, Kathleen Romanik, Steven Salzberg, Diane Souvaine,

(93-15) *Enumerating Consecutive and Nested Partitions for Graphs.*
F.K. Hwang, G.J. Chang

(93-16) *Confluently Persistent Dequeues via Data-Structural Bootstrapping.*
Adam L. Buchsbaum and Robert E. Tarjan

(93-17) *On the Structure of Co-Critical Graphs.*
Anna Galluccio, Miklos Simonovits and Gábor Simonyi

(93-18) *Convex Relaxation of 0-1 Quadratic Programming.*
S. Poljak and Henry Wolkowicz

(93-19) *Indefinite Trust Region Subproblems and Nonsymmetric Eigenvalue Terturation.*
Ronald J. Stern and Henry Wolkowicz

(93-20) *A First-Order Isomorphism Theorem.*
Eric Allender, Jose Balcazar, Neil Immerman

(93-21) *Depth Reduction for Noncommutative Arithmetic Circuits.*
Eric Allender and Jia Jiao

(93-22) *A Robust Model for Finding Optimal Evolutionary Trees.*
Martin Farach, Sampath Kannan, Tandy Warnow

(93-23) *Consecutive Cuts and Paths, and Bounds on k-Terminal Reliability.*
Heidi J. Strayer and Charles J. Colbourn

(93-24) *Weighted Independent Perfect Domination on Cocomparability Graphs.*
Gerard J. Chang, C. Pandu Rangan, Satyan R. Coorg

(93-25) *The Russian Option: Reduced Regret.*
Larry Shepp and A.N. Shiryaev

(93-26) *A Dual Russian Option for Selling Short.*
Larry Shepp and A.N. Shiryaev

(93-27) *Non-Stanley Bounds for Network Reliability.*
Jason I. Brown and Charles J. Colbourn

(93-28) *Some Open Problems on Reliability Polynomials.*
Charles J. Colbourn

(93-29) *Combinatorial Optimization: A Survey.*
Martin Grotschel and László Lovász

(93-30) *Lazy Structure Sharing for Query Optimization.*
Adam L. Buchsbaum, Rajamani Sundar, Robert E. Tarjan

(93-31) *Constructing Language Instances Based on Partial Information.*
Laura A. Sanchis

(93-32) *Research Problems in Discrete Geometry: Packing and Covering.*
William Moser, Janos Pach

(93-33) *Inverse Theorems in Additive Number Theory.*
Melvyn B. Nathanson

(93-34) *Trust Regions and the Quadratic Assignment Problem.*
Stefan E. Karisch, Franz Rendl, Henry Wolkowicz

(93-35) *Entropy Splitting Hypergraphs.*
Gábor Simonyi

(93-36) *Workshop on Parallel Algorithms for Unstructured and Dynamic Problems.*
Bill Aiello, Albert G. Greenberg, Andrew Ogielski

(93-37) *Quasi-Acyclic Propositional Horn Knowledge Bases: Optimal Compression.*
Peter L. Hammer and Alexander Kogan

(93-38) *Parallel Processing of Discrete Optimization Problems.*
Grama Y. Ananth, Vipin Kumar, Panos Pardalos

(93-39) *The Simplex Algorithm with a New Primal and Dual Pivot Rule.*
Hsin-Der Chen, Panos Pardalos, Michael A. Saunders

(93-40) *On Lattice-Free Polytopes.*
Michel Deza and Shmuel Onn

(93-41) *On Edge Bijections of Graphs.*
A.K. Kelmans

(93-42) *On a Covering Property of Maximal Sperner Families.*
Péter L. Erdős and Niall Graham

(93-43) *Relationships Among PL, #L, and the Determinant.*
Eric Allender and Mitsunori Ogiwara

(93-44) *Half-integral Flows in a Planar Graph with Four Holes.*
Alexander V. Karzanov

(93-45) *An Efficient Algorithm for Dynamic Text Indexing.*
Ming Gu, Martin Farach, Richard Beigei

(93-46) *Fast Comparison of Evolutionary Trees.*
Martin Farach and Mikkel Thorup

(93-47) *A New Approach to the Construction of Optimal Designs.*
R.H. Hardin and N.J.A. Sloane

(93-48) *Covering Arrays and Intersecting Codes.*
N.J.A. Sloane

(93-49) *The Nordstrom-Robinson Code is the Binary Image of the Octacode.*
G.David Forney,Jr., N.J.A. Sloane and Mitchell D. Trott

*(93-50) *A Linear Construction for Certain Kerdock and Preparata Codes.*
A.R.Calderbank, A.R.Hammons, Jr., and P. Vijay Kumar

(93-51) *Operating Manual for Gosset: A General-Purpose Program for Constructing Experimental Designs (Second Edition).*
R.H.Hardin and N.J.A. Sloane

(93-52) *The Z sub 4-Linearity of Kerdock, Preparata, Goethals and Related Codes.*
A.R.Hammons,Jr., P.Vijay Kumar, A.R.Calderbank, N.J.A. Sloane, and Patrick Sole

(93-53) *Quaternary Constructions for the Binary Single-Error-Correcting Codes of Julin, Best and Others.*
J.H. Conway and N.J.A. Sloane

(93-54) *Expressing* $(a^2 + b^2 + c^2 + d^2)^3$ *as a Sum of 23 Sixth Powers.*
R.H. Hardin and N.J.A. Sloane

(93-55) *D sub 4, E sub 8, Leech and Certain Other Lattices are Symplectic.*
J.H. Conway and N.J.A. Sloane

(93-56) *A Pedestrian Approach to Ray Shooting: Shoot a Ray, Take a Walk.*
John Hershberger and Subhash Suri

(93-57) *Finding a Shortest Diagonal of a Simple Polygon in Linear Time.*
John Hershberger and Subhash Suri

(93-58) *Matrix Searching with the Shortest Path Metric.*
John Hershberger and Subhash Suri

(93-59) *Can Visibility Graphs Be Represented Compactly?.*
Pankaj K. Agarwal, Noga Alon, Boris Aronov, Subhash Suri

(93-60) *Shortcutting Planar Digraphs.*
Mikkel Thorup

(93-61) *Controlled Grammatic Ambiguity.*
Mikkel Thorup

(93-62) *Minors and the Chromatic Index of r-graphs.*
K. Kilakos and B. Shepherd

(93-63) *A Note on a Conjecture of Toft.*
T. R. Jensen and F. B. Shepherd

(93-64) *On Enumeration of Near to Best Solutions in Discrete and Dynamic Programming.*
Joseph V. Romanovsky

(93-65) *Instance-Hiding Proof Systems.*
D. Beaver, J. Feigenbaum, R. Ostrovsky, and V. Shoup

(93-66) *The Least Possible Value at Zero of Some Nonnegative Cosine Polynomials.*
Szilárd Gy. Révész

(93-67) *Approximation Clustering for Homogeneous Data Tables.*
Boris Mirkin

(93-68) *Generalization of the Tetrad Representation Theorem.*
Glenn Shafer, Alexander Kogan and Peter Spirtes

(93-69) *Some Experimental and Theoretical Results on Test Case Generators for the Maximum Clique Problem.*
Laura A. Sanchis and Arun Jagota

(93-70) *Eigenvalues and Expansion of Regular Graphs.*
Nabil Kahale

*(93-71) *A Randomized Linear-Time Algorithm for Finding Minimum Spanning Trees.*
Philip N. Klein and Robert E. Tarjan

(93-72) *Symmetric Quasi-Definite Matrices.*
Robert J. Vanderbei

(93-73) *Affine-Scaling Trajectories Associated with a Semi-Infinite Linear Program.*
Robert J. Vanderbei

(93-74) *Brownian Bandits.*
Avi Mandelbaum and Robert J. Vanderbei

(93-75) *Interior-Point Methods for Max-Min Eigenvalue Problems.*
Franz Rendl, Robert J. Vanderbei, and Henry Wolkowicz

(93-76) *Bipartite Dimensions and Bipartite Degrees of Graphs.*
Peter C. Fishburn and Peter L. Hammer

Selected Significant Publications by DIMACS Members

We list here two articles by DIMACS permanent members and visitors which prove particularly significant results but have not (or not yet) appeared in DIMACS' technical report series. These articles are discussed under Research Accomplishments.

* Bernard Chazelle, "An Optimal Convex Hull Algorithm in Any Fixed Dimension", *Discrete and Computational Geometry*, **10**, (1993), pp. 377–409.
* Neil Robertson, Paul Seymour and Robin Thomas, "Hadwiger's conjecture for K_6-free graphs", *Combinatorica* **13**, (1993), pp. 279–361.

B Summary of External Advisory Board Meeting 03/8-9/1993

Members Present: Avner Friedman, Richard Karp, Maria Klawe, Ray Miller, David Sanchez, Shmuel Winograd.

1. **Director Search** The SAB discussed the criteria for choosing a new director, met four director candidates, interviewed three of them (the fourth was unable to be present for the interview), and made its recommendations to the Search Committee.

2. **DIMACS Programmatic Budget** The SAB noted that we are running an impressive program on a flat budget; they were concerned that DIMACS was unable to fund more postoctoral fellows, a key factor in creating a fertile research environment. Some suggestions were offered, such as sharing postdocs with the IAS or replacing graduate students with postdocs. The SAB suggested that the major scientific funding priority should be the Special Year (including workshops, seminars, visitors, and postdocs). They recommended that the Executive Committee review their procedures for all funding decisions (in particular those to support graduate students, visitors at participating institutions, and workshops), to insure that all funded programs contribute fully to the overall goals of DIMACS. They suggested that all supported visitors and graduate students be strongly encouraged to publish their results, or theses, as DIMACS volumes or tech. reports.

3. **Special Years and Workshops** The SAB expressed support for innovative topics that relate to national goals, such as transportation systems or manufacturing, and in particular expressed enthusiasm for a proposed special year in computational biology. They recommended introducing pilot workshops now for proposed Special Years, and suggested adding shorter focus periods, such as Special Months.

4. **New Programmatic Initiatives** The SAB was supportive of all of our current programmatic initiatives, including computational biology, massively parallel computing, computational support for research and education in discrete mathematics, and algorithmic implementation challenges. There was a great deal of interest in this increased emphasis on experimental computing. An algorithm implementation challenge focusing on a real-world problem such as airline scheduling was suggested.

5. **Educational Programs** The SAB supported our two proposed programs involving education/research postdocs, and encouraged us to use base funds for startup of these activities, if necessary. They encouraged us to find ways to link our educational and research programs, such as inviting visitors and postdocs to give lectures to high school students in the Young Scholars Program, as well as to involve more DIMACS members in our educational programs.

   The SAB also recommended that we start a videotape library of our educational lectures, and publish materials developed in our educational programs. Making strong and visible contributions to education is both valuable in itself and good for the future of DIMACS.

6. **Technology Transfer/Industrial Participation** The SAB strongly supports the theoretical, basic research that is the focus and strength of DIMACS, and believes that the Center should not radically change its currently successful programs. At the same time they recognize that our future success will require reaching a broader community, for example by becoming more involved in areas of practical application at Bell Labs, Bellcore, and other industries.

C List Disclosures Of Inventions, Patent Applications, And Patents

None.

D List of Awards/Prizes & Names of Recipients

A variety of awards have been won by DIMACS members.

Larry Shepp (AT&T Bell Labs) was been elected to the Institute of Medicine, National Academy of Medicine.

Saharon Shelah (Rutgers University) received the Polya Prize in Combinatorics from the Society for Industrial and Applied Mathematics.

Ronald Graham (AT&T Bell Labs and Rutgers) became President of the American Mathematical Society in January.

András Prékopa (Rutgers) became the honorary president of the Hungarian Operations Research Society.

Steve Skiena of SUNY Stony Brook, one of the organizers of the DIMACS project on Computational Support for Research and Education in Discrete Mathematics, won a President Young Investigator Award from the Office of Naval Research.

DIMACS postdoc Gábor Tardos won one of the main prizes at the European Congress of Mathematicians in Paris.

DIMACS member and Special Organizer László Lovász received the Brouwer Medal of the Dutch Mathematical Society, an award given only once every three years.

DIMACS postdocs Martin Farach and Sampath Kannan and DIMACS visitor Tandy Warnow won the ACM "Impact Award" at the May 1993 Federated Computer Science Conference in San Diego for their paper on evolutionary trees.

Angus Macintyre, a sporadic visitor to DIMACS over a three-year period, was awarded a 5-year research fellowship by the British SERC. This is a prestigious award at the full professor level.

Joan Feigenbaum (AT&T Bell Labs) was appointed to the Editorial Board of SIAM Journal on Computing

Eduardo Sontag (Rutgers Univ.) was elected a Fellow of the IEEE.

Larry Shepp (AT&T Bell Labs) was elected to the American Academy of Arts and Sciences.

The International Congress of Mathematicians in August will include an invited address by Jeff Kahn (Rutgers Univ.), Fan Chung (Bellcore), Joel Spencer, Zoltan Füredi, Gil Kalai (DIMACS visitors) and plenary addresses by Paul Seymour (Bellcore), László Babai and Ingrid Daubechies (DIMACS visitors).

Robert Tarjan (Princeton University) received honorable mention, Lanchester Prize of the Operations Research Society of America, 1993.

DIMACS in the News

The scientific achievements at DIMACS were featured in a Star Ledger column by Kitta McPherson on May 31. Copy of article included.

This article from the October 1993 issue of *Science* features the research result which was prompted by the October 1992 DIMACS Workshop on Coding and Quantization.

E List of Workshops

"Randomized Algorithms for Combinatorial Optimization"
Feb. 22-26, 1993, Princeton University

Organizers: Ravi Kannan, Laszlo Lovasz, Mike Saks, Peter Winkler

Speakers *Title of the talk.*

Ravi Kannan *Convergence of a geometric random walk*

John Mount *Optimization and random walks*

Aravind Srinivasan *Randomness-optimal unique element isolation, with applications to perfect matching and related problems*

Bernard Chazelle *A Simple Proof Technique for Geometric Discrepancy*

Andres Fundia *Finding independent sets in uncrowded hypergraphs*

Dominic Welsh *Randomised Approximations and the Tutte plane*

David Johnson *Random starts for local optimization*

Ronitt Rubinfeld *A New Interpolation Algorithm for Factoring Multivariate Polynomials*

Jiri Matousek *Algorithms for abstract linear programming – lower bounds and experiments*

Bernd Gärtner *A Subexponential Algorithm for Abstract Optimization Problems*

Noga Alon *Routing and random walks*

Miklós Simonovits *Random walks in convex bodies*

David Gillman *A Chernoff Bound For Random Walk On An Expander Graph*

Gregory Sorkin *Simulated Annealing for Bisection of Random Graphs*

Mark Jerrum *Large cliques elude the Metropolis process*

Josh Alspector *A Parallel Gradient Descent Method for Learning*

Mike Molloy *A Model for Regular Random Graphs*

Alessandro Panconesi *Randomized edge coloring*

Yuri Rabinovich *Nonlinear Mixing and Evolution of Combinatorial Structures*

Bart Selman *Local Search for Satisfiability Testing*

Bob Beals *Las Vegas Algorithms for Matrix Groups*

J. Michael Steele *The 'Objective Method' and Euclidean Optimization Problems*

Jerzy W. Jaromczyk *On evaluation of kth momenta of binary quadratic forms*

L. Lovász *Some thoughts on the Metropolis algorithm*

DIMACS Workshop on
Solving Hard Combinatorial Optimization Problems
March 29 - April 2, 1993

Martin Savelsbergh (Georgia Tech) *Solving Hard Combinatorial Optimization Problems Using MINTO, A Mixed INTeger Optimizer*

Michael Juenger (Koeln) *Branch and cut: overview*

Stefan Thienel (Koeln) *Branch and cut: implementation*

Denis Naddef (Grenoble) *Using Path inequalities in a Branch and cut code for the symmetric TSP*

Mauricio Resende (AT&T Bell Labs) *GRASP*

Sebastian Ceria (Carnegie Mellon) *A lift-and-project cutting plane algorithm for mixed 0-1 programs*

Seh-Woong Jeong and Fabio Somenzi (Boulder) *An algorithm for 0-1 programming based on binary decision diagrams*

Chun-Wa Ko (DIMACS), Jon Lee (Yale), and Mauric Queyranne (UBC) *An exact algorithm for maximum entropy sampling*

Francisco Barahona (IBM) *Experiments on max cut problems*

Jon Bentley (AT&T Bell Labs) *Environments for experiments on algorithms*

Clyde Monma (Bellcore) *Survivable networks of high connectivity I*

Mechthild Stoer (Berlin) *Survivable networks of high connectivity II*

Karla Hoffman (George Mason) *Solving very-large set-partitioning problems arising in airline crew-scheduling*

Victor Milenkovic (Harvard) *NP-hard problems in clothing manufacturing*

Qun Deng and David Simchi-Levi (Columbia) *Valid inequalities, facets and computational results for the capacitated concentrator location problem*

B.N. Khoury and P.M. Pardalos (Florida) *A heuristic and a test problem generator for the Steiner problem in graphs*

Mike Trick (Carnegie Mellon/DIMACS) *Introduction to DIMACS Challenge II*

Egon Balas (Carnegie Mellon) *Finding weighted and unweighted maximum cliques in a graph*

Endre Boros, P.L. Hammer, and A. Kogan (Rutcor) *An exact algorithm for SAT with computational experience*

Richard J. Wallace and Eugene C. Freuder (New Hampshire) *Conjunctive width heuristics for maximal constraint satisfaction*

Alan Kaufman and Jim Orlin (MIT) *Rejectionless Simulated Annealing and the Max Independent Set Problem*

Yves Pochet (CORE) *Soving some Multi-item Capacitated Production Planning Problems*

Laurence Wolsey (CORE) *Solving some Telecommunications/Clustering Problems*

Dan Bienstock (Columbia) *Computational experience with a strong formulation of a difficult network design problem*

Tom Magnanti (MIT) *Network design problmes: they are hard aren't they?*

George Nemhauser (Georgia Tech) *Solving Integer Cutting Stock Problems*

Jan Karel Lenstra (Eindhoven) *Job shop scheduling by local search*

Carlos Ferreira (Berlin) *Multidimensional knapsack problems I*

Robert Weismantel (Berlin) *Multidimensional knapsack problems II*

Manfred Padberg (NYU) *Polyhedral cutting plane approaches to hard 0-1 problems*

Ellis Johnson (Georgia Tech/IBM) *Airline crew scheduling*

Han Hoogeveen (Princeton) *Stronger Lagrangian bounds by use of slack variables: applications to machine scheduling problems*

Andy Boyd (Texas A&M) *Solving integer programs with Fenchel cutting planes and preprocessing*

Don Goldfarb (Columbia) *Solving large and difficult linear programs using steepest-edge simplex methods*

Irv Lustig (Princeton) *Basis recovery and warm starts for interior points*

Martin Groetschel *Steiner tree packing I*

Alexander Martin *Steiner tree packing II*

Partitioning Data Sets: With Applications To Psychology, Vision And Target Tracking April 19-21, 1993

David S. Matula (Southern Methodist University, Dallas) *Efficient Graph Algorithms for Clustering, Point Partitioning, and Characterizing the Absence of Clusters*

Melvin F. Janowitz (University of Massachusetts) *A Classification Scheme for Cluster Algorithms*

Yaakov Bar-Shalom (University of Connecticut) *Precision Tracking Based on Segmentation with Optimal Layering for Image Sensors*

Aubrey B. Poore (Colorado State University) *Multidimensional Data Assignments*

Irving Biederman (University of Southern California) *Shape Recognition in Mind and Brain*

Bela Julesz (Rutgers University) *Subjective Contours in Early Vision and Beyond*

Endre Boros et al. (Rutgers University) *Unconstrained Quadratic 0-1 Optimization with Applications in Image Processing and Clustering*

Mireille Gettler-Summa and E. Diday (Universit Paris IX-Dauphine) *Generating Higher Level Features by Symbolic Data Analysis*

Jean-Pierre Barthelemy (Telecom Bretagne, Brest) *The Median Procedure for Partitions I: Combinatorial and Algorithmic Aspects*

Bruno Leclerc et al. (Centre d'Analyse et de Math matique Sociales, EHESS, Paris) *The Median Procedure for Partitions II: Contributions of the Lattice Approach*

David Jacobs (NEC Research Institute, Princeton) *Robust and Efficient Detection of Convex Groups*

Alan Jepson and W. Richards (University of Toronto) *Inferences Based on Key Features*

Alain L. Yuille (Harvard University) *Two Approaches to Binocular Stereo*

Steven W. Zucker (McGill University, Canada) *On the Computational Neurobiology of Early Vision*

Fionn Murtagh (Garching/Munich, Germany) *Contiguity-Constrained Agglomerative Clustering: Between Theory and Practice*

Brigitte Jaumard et al. (Ecole Polytechnique de Montreal) *Maximum Split Clustering under Connectivity Constraints*

Jacob Feldman (Rutgers University) *Causal Models of Dot Groupings*

Dan Kersten (University of Minnesota) *The Perception of Objects and Their Properties*

F.R. McMorris et al. (University of Louisville) *Agreement Subtrees, Metrics and Consensus for Labelled Binary Trees*

W. Cai (Southern Methodist University, Dallas) *Partitioning by Maximum Adjacency Search of Graphs*

Patrice Bertrand (Universite Parix IX-Dauphine, Paris) *Pyramidal Clustering: Structural properties and clustering methods*

Ingemar J. Cox et al. (NEC Research Institute, Princeton) *A Bayesian Multiple Hypothesis Approach to Contour Segmentation*

Pierre Hansen et al. (Ecole des Hautes Etudes Commerciales, Montreal) *How to Choose p Objects Among N*

DIMACS Workshop
on Parallel Algorithms for Unstructured and Dynamic Problems
June 2-4, 1993

Organizers: Bill Aiello (Bellcore) [aiello@bellcore.com], Albert Greenberg (AT&T Bell Laboratories) [albert@research.att.com], Andrew Ogielski (Bellcore) [ato@bellcore.com]

Joel Saltz (University of Maryland.) *Adaptive Problems and High Performance Fortran Compilers*

Gary Miller (Carnegie Mellon University.) *Towards an Automated Approach to the Simulation of 3D Problems*

Vijay Naik (IBM Research) *Are Scalable Methods for Sparse Computations Practical?*

Calvin Lin, Larry Snyder, Derrick Weathersby (University of Washington.) *An Experimental Comparison of Algorithms for Sparse Cholesky Factorization*

Thomas Scheffler (Carnegie Mellon University.) *Match and Move: Parallel Constructs for Sparse Matrix and Graph Algorithms*

Bert Halstead (DEC CRL.) *Dynamic Scheduling in Multilisp*

Apostolos Gerasoulis (Rutgers University) *(with Tao Yang, Rutgers). PYRROS: Scheduling and Code Generation of Irregular Task Graphs for Distributed Memory Parallel Architectures.*

Abhiram Ranade (UC Berkeley.) *Exploiting locality in certain geometric algorithms*

Larry Rudolph (Hebrew University.) *TBA (optical networks)*

Ulf Hanebutte (NASA ICASE.) *Software Support for Parallel Adaptive Mesh Refinement*

L. Kale (University of Illinois.) *A Portable Software Support System for Irregular Computations*

Sushant Patnaik (University of Massachusetts.) *Dyn-FO: A parallel, dynamic complexity class*

Jan Prins (University of North Carolina.) *Work-Efficient Techniques for the Parallel Execution of Sparse Grid-Based Computations*

Neelakantan Sundaresan (Indiana University.) *Dynamic Data Structures and Adaptive Computation in pC++, An Object Oriented Parallel Language*

Ricardo Telichevesky (MIT.) *O^2SA Arrays for Parallel Sparse Matrix Factorization*

Jeffrey Westbrook (Yale.) *Adaptive Parallelism with Piranha*

Jianping Zhu (Mississippi State.) *TBA (field simulations)*

Richard Fujimoto (Georgia Tech.) *Performance/Memory Tradeoffs in Time Warp*

Sandeep Bhatt (with Pangfeng Liu, Yale) (Bellcore) *Efficient Parallel N-body Simulations*

Arjen Lenstra (Bellcore.) *Factoring Integers using SIMD Sieves*

David Nicol (with Dimitri Mavriplis, NASA ICASE) (College of William and Mary) *On Load Balancing Irregular Mesh Problems Using Field Functions*

Arvind Krishnamurthy (with K. Yelick, et al. (UC Berkeley) *Data Structures for Irregular Applications*

Suresh Jagannathan (with J. Philbin, M. Rauch) (NEC Research) *Runtime Support for Symbolic Parallel Algorithms*

Barbara Ryder (Rutgers University.) *Experiences with a Parallel Data Flow Analysis Algorithm*

Baruch Awerbach (MIT.) *Dynamic Network Algorithms*

Bruce Maggs (NEC Research.) *Recovering Structure in Damaged Networks*

Tarek Abdelrahman (University of Toronto) *Mapping of Branch and Bound Algorithms onto Shared and Distributed Memory Multiprocessors*

Bernard Mans (Carleton University.) *Performances of Parallel Branch and bound Algorithms with Best-First Search*

Srinivas Aluru (Iowa State University.) *SIMD Tree Search: The Untold Story*

Bruce Char (University of Delaware.) *Systems and Algorithms for Parallel and Distributed Symbolic Algebraic Computation*

David Cohen and Daniel Heyman (Bellcore.) *An Almost Regenerative Simulation of Video Teleconferencing*

M. Durand (Bellcore.) *Impact of Memory Contention on Dynamic Scheduling on NUMA Multiprocessors*

Yu Gong (Auburn University.) *Time Warp Performance on Shared Memory Multiprocessors*

Bojana Obrenic (University of Massachusetts.) *Communication Structures for Parallel Computing in Graphs*

Robert Schreiber (NASA Ames.) *Unstructured Meshes via Adaptive Routing on SIMD Grid Machines*

David Applegate (AT&T Bell Labs.) *Very Large Traveling Salesman Problems*

Vipin Kumar (University of Minnesota.) *Scalable Parallel Search Algorithms for Combinatorial Problems*

Christos Kaklamanis (DIMACS.) *Branch-and-Bound and Backtrack Search on Processor Arrays*

B. Narendran and Prasoon Tiwari (University of Wisconsin.) *Min-Cost Flows: A Case Study in Increasing Parallelism in Solving Unstructured Graph Algorithms*

Richard Anderson (with Joao Setubal) (University of Washington) *Shared Memory Implementation of Network Flow Algorithms*

Phil Gibbons (with Mike Merritt, AT&T Bell Labs) (AT&T Bell Labs) *Shared Memory Support for Unstructured Problems*

Clyde Kruskal (University of Maryland.) *Designing Algorithms for a General Model of Parallel Computation.*

“Perfect Graphs”
June 10-14, 1993, Princeton University

Gerard Cornuejols *Polyhedral Results Related To Balanced Matrices*

Bruce Reed *Problem Session On Parity Problems*

Vasek Chvatal *Problem Session On P4-Structure And Decompositions*

Michele Conforti *Decomposition Theorem For Balanced Matrices*

Claude Berge *Problem Session On Berge Graphs Not Known To Be Perfect*

Alan Tucker *Problem Session On The Structure Of Minimal Imperfect Graphs*

Gábor Simonyi *Perfect Graphs And Entropy*

László Lovász *Perfect Graphs And Polynomials*

Frederic Maffray *Problem Session On Partitionable Graphs*

Ajai Kapoor *Balanced Matrices And Regular Matroids*

András Sebő *Problem Session On Unique Colorability*

Kristina Vuskovic *Polynomial-Time Algorithm To Recognize Balanced Matrices*

Stefan Hougardy *Problem Session On Anything*

DIMACS Workshop on
Models, Architectures, and Technologies for Parallel Computation
September 20-22, 1993

Co-organizers:

Phillip B. Gibbons (AT&T Bell Laboratories)
Richard M. Karp (U.C. Berkeley, ICSI)
Charles E. Leiserson (MIT)
Gregory M. Papadopoulos (MIT, Thinking Machines)

Phil Gibbons (AT&T Bell Laboratories) *Models of Parallel Computation: An Overview*

Dave Patterson (U.C. Berkeley) *Observations on Massively Parallel Processors*

Marc Snir (IBM) *A Parallel Computer and a Workstation Cluster in a Box – Can a System Be Both?*

Jim Smith (Cray Research Inc.) *An Overview of the Cray Research MPP Project*

Mark Hill (Wisconsin) *Theoretical Models are Necessary but not Sufficient*

Uzi Vishkin (Maryland and Tel-Aviv) *On the Case for Having the PRAM as a Standard Programmer's Model*

Greg Papadopoulos (MIT and Thinking Machines) *Constant Factors Matter: Putting Communication on the Computation Power Curve*

Larry Carter (IBM) *Unifying Communication and Memory Models*

Jeff Vitter (Duke) *Models for Parallel Secondary and Hierarchical Storage*

Alok Aggarwal (IBM) *Optimal Parallel Sorting in Multi-Level Storage*

Chip Martel (U.C. Davis) *Modeling Asynchronous Shared Memory Systems*

Michael Rabin (Hebrew U. and Harvard) *Executing Large-Grained Parallel Programs on Asynchronous Machines*

Charles Leiserson (MIT) *Space-Efficient Scheduling of Multithreaded Computations*

Tom Knight (MIT) *Technology - Where next ?*

John Reif (Duke) *The Proteus System for Prototyping and Implementation of Algorithms*

Clark Thomborson (Minnesota) *On Visualizing the Flow of Information in a Supercomputer*

Larry Snyder (Washington) *Three Levels of Abstraction – Machine Model, Programming Model, Programming Language*

Guy Blelloch (Carnegie-Mellon) *Language Based Complexity.*

Rob Schreiber (REACS) *A Model for Compile-Time Optimization of Data-Parallel Programs*

Anant Agarwal (MIT) *How to Choose the Grain Size of a Parallel Computer*

Jim Larus (Wisconsin) *Compiling for Shared-Memory and Message-Passing Machines*

Thomas Gross (Carnegie-Mellon) *A Compiler Perspective on Comminucation.*

Yossi Matias (AT&T Bell Laboratories) *The QRQW PRAM: Accounting for Contention in Parallel Algorithms*

Tsan-sheng Hsu (U. Texas at Austin) *Mapping the PRAM onto a Massively Parallel SIMD Computer*

Todd Heywood (U. Edinburgh) *Models of Parallelism*

Charles Stirk (U. Colorado) *What Will Free-Space Optical Interconnects Be Good For? And How Do We Know?*

Phil MacKenzie (U. Texas at Austin) *Optical Communication and ERCW PRAMs*

Reinhard Luling (U. Paderborn) *A Realizable Efficient Parallel Architecture*

Abhiram Ranade (U.C. Berkeley) *The Right Parallel Computing Model?*

Anoop Gupta (Stanford) *Single-Address-Space Multiprocessors: Communications Architecture and Modeling Issues*

Michel Dubois (USC) *Relaxed Consistency and Asynchronous Iterative Algorithms*

Joe Brandenburg (Intel) *Technology Advances in the Intel Paragon System*

Bob Cypher (IBM) *Message-Passing Models for Blocking and Nonblocking Communication*

Arny Rosenberg (U. Mass) *Parallel Computing in a Heterogeneous Environment*

Maurice Herlihy (DEC Cambridge) *Transactional Memory: Architectural Support for Lock-Free Data Structures*

Marios Dikaiakos (Princeton) *Functional Algorithm Simulation: Implementation and Experiments*

Sanguthevar Rajasekaran (U. Penn) *Mesh Connected Computers with Fixed and Reconfigurable Buses*

Shlomo Kipnis (IBM) *The Postal Model for Message Passing Systems*

Pangfeld Liu (Yale) *An Atomic Model for Message-Passing*

Second DIMACS Implementation Challenge
Clique, Graph Coloring, and Satisfiability
October 11-13, 1993

Advisory Board:

Vasek Chvatal, Rutgers University
Bill Cook, Bell Communications Research
David Johnson, AT&T Bell Laboratories
Cathy McGeoch, Amherst College
Bob Tarjan, Princeton University
Michael Trick, DIMACS Visiting Fellow/Carnegie Mellon University (Coordinator).

Clique Papers

M. Brockington and J.C. Culberson *Camouflaging Independent Sets in Quasi-Random Graphs*

S. Homer and M. Peinado *On the Performance of Polynomial Time Clique Approximation Algorithms on Very Large Graphs*

M.K. Goldberg and R. Rivenbergh *Constructing Cliques Using the Near Greedy Algorithm*

E. Balas and W. Niehaus *Finding Large Cliques by Bipartite Matching*

J.M. Bourjolly, P. Gill, G. Laporte, and H. Mercure *Two Exact for the Stable Set Problem*

E. Balas, S. Ceria, G. Cornuejols, and G. Pitaki *Linear Programming Methods for the Clique Problem in Graphs*

C. Mannino and A. Sassano *An Exact Algorithm for the Maximum Cardinality Stable Set Problem*

E. Balas and J. Xue *Weighted and Unweighted Maximum Clique Algorithms with Upper Bounds from Fractional Coloring*

T. Grossman *Applying the INN Model for the MaxClique Problem*

A. Jagota, L. Sanchis, and R. Ganesan *Approximately Solving Maximum Clique using Neural Network and Related Heuristics*

Graph Coloring Papers

J.C. Culberson and F. Luo *Exploring the k-colorable Landscape with Iterated Greedy*

C. Morganstern *A Distributed Coloration Neighborhood Search Algorithm*

G. Lewandowski and A. Condon *Experiments with Parallel Graph Coloring Heuristics*

Satisfiability Papers

O. Dubois, P. Andre, Y. Boufkhad, and J. Carlier *SAT versus UNSAT*

A. Van Gelder and Y.K. Tsuji *Satisfiability Testing with More Reasoning and Less Guessing*

D. Pretolani *Solving Satisfiability Problems: An Algorithm Implementation Challenge?*

B. Jaumard, M. Stan, and J. Desrosiers *Tabu Search and a Quadratic Relaxation for the Satisfiability Problem*

M.G.C. Resende and T.A. Feo *A GRASP for MAX-SAT*

B. Selman and H.A. Kautz *Local Search Strategies for Satisfiability Testing*

S. Hampson and D. Kilber *Plateaus and Plateau Search in Boolean Satisfiability Problems*

R.J. Wallace and E.C. Freuder *Applying Algorithms for Constraint Satisfaction to Maximum Satisfiability Problems*

J. Cheriyan, W.H. Cunningham, L. Tuncel, and Y. Wang *The Maximum 2–Satisfiability Problem*

DIMACS Workshop on Parallel Algorithms:
From Solving Combinatorial Problems to Solving
Grand Challenge Problems
November 17-19, 1993

Co-organizers:

Jim Flanagan (CAIP-Rutgers) [flanagan@caip.rutgers.edu]
Yossi Matias (AT&T Bell Labs) [matias@research.att.com]
Vijaya Ramachandran (U. Texas) [vlr@cs.utexas.edu]

Gary Miller (CMU) *Numeric and Combinatorial Aspects to Parallel Scientific Computation*

Richard Cole (NYU) *2-D Pattern Matching*

Uzi Vishkin (Maryland & Tel Aviv) *Efficient Labeling of Substrings*

Pierre Kelsen (U British Columbia) *Constant Time Parallel Indexing of Points in a Triangle*

Pangfeng Liu (DIMACS) *Experiences with Parallel N-body simulations*

Victor Pan (CUNY) *Efficient Parallel computations in Linear Algebra with Applications*

Roland Wunderling (Berlin) *On the Impact of Communication Latencies on Distributed Sparse LU Factorization*

Ian Parberry (North Texas U) *Algorithms for Touring Knights*

Phil Klein (Brown) *A Linear-Processor Polylog-Time Parallel Algorithm for Shortest Paths in Planar Graphs*

Edith Cohen (Bell Labs) *Undirected Shortest Paths in Polylog-Time and Near-Linear Work*

Lin Chen (USC) *Graph Isomorphism and Identification Matrices: Parallel Algorithms*

Vijaya Ramachandran (U Texas at Austin) *Parallel Graph Algorithms: Theory and Implementation*

Zvi Kedem (NYU) *Towards High-Performance Fault-Tolerant Distributed Processing*

Torben Hagerup (Max Planck Inst) *Fast Deterministic Compaction and its Applications*

Phil Gibbons (Bell Labs) *Efficient Low Contention Parallel Algorithms*

Paul Spirakis (Patras) *Paradigms for Fast Parallel Approximations for Problems that are Hard to Parallelize*

Olof Widlund (NYU) *Some Recent Results on Schwarz Type Domain Decomposition Algorithms*

Jan Prins (U North Carolina at CH) *The Proteus System for the Development of Parallel Algorithms*

Yuefan Deng (SUNY at Stony Brook) *Parallel Computing Applied to DNA-protein Interaction Study: A Global Nonlinear Optimization Problem*

Rajeev Raman (Maryland) *Optimal Parallel Algorithms for Searching a Totally Monotone Matrix*

Teresa Przytycka (Odense) *Trade-offs in Parallel Computation of Huffman Tree and Concave Least Weight Subsequence*

Vijay Vazirani (DIMACS & IIT) *A Primal-dual RNC Approximation Algorithm for (multi)-Set (multi)-Cover and Covering Integer Programs*

Mike Goodrich (Johns Hopkins) *Parallel Methods for Computational Geometry*

Yossi Matias (Bell Labs) *Highly Parallel Randomized Algorithms - Some Recent Results*

Dina Kravets (NJIT) *All Nearest Smaller Values on Hypercube with Applications*

Mike Atallah (Purdue) *Optimal Parallel Hypercube Algorithms for Polygon Problems*

Ernst Mayr (Munich) *Optimal Tree Contraction on the Hypercube and Related Network*

David Haglin (Mankato State U) *Evaluating Parallel Approximation Algorithms: With a Case Study in Graph Matching*

Jesper Traff (Copenhagen) *A Distributed Implementation of an Algorithm for the Maximum Flow Problem*

Joseph JaJa (Maryland) *Efficient Parallel Algorithms for Image Processing*

Rainer Feldmann (Paderborn) *Game Tree Search on Massively Parallel Systems*

Stefan Tschoke (Paderborn) *Efficient Parallelization of a Branch & Bound Algorithm for the Symmetric Traveling Salesman Problem*

Erik Tarnvik (Umea, Sweden) *Solving the 0-1 Knapsack Problem on a Distributed Memory Multicomputer*

Aravind Srinivasan (Institute for Advanced Study and DIMACS) *Improved parallel algorithms via Approximating Probability Distributions*

Per Laursen (Copenhagen) *Parallel Simulated Annealing Using Selection and Migration – an Approach Inspired by Genetic Algorithms*

Zvi Galil (Columbia U & Tel Aviv) *From the CRCW-PRAM to the HCUBE via the CREW-PRAM and the EREW-PRAM or In the Defense of the PRAM*

F List of Seminars

Special Year

February 8

Subspace Arrangements - A Survey.
Anders Bjorner, Royal Institute of Technology, Stockholm

Hilbert Bases and Higher Strong Connectivity.
Martin Loebl, DIMACS and Charles University, Prague

Hilbert Series of Group Representations and Grobner Bases for Generic Modules.
Shmuel Onn, DIMACS

March 8

Ramsey-type problems and results.
András Hajnal, Mathematical Institute of the Hungarian Academy of Sciences, Budapest, Hungary

On shortcutting digraphs.
Mikkel Thorup,

(Short communication).
Alexander Barvinok, Royal Institute of Technology, Stockholm, Sweden

March 16

Some of my favorite problems in combinatorics.
Paul Erdős, Hungarian Academy of Sciences

Approximately Counting Hamilton Cycles in Dense Graphs.
Martin Dyer, Carnegie Mellon University, Pittsburgh and Univ. of Leeds, UK

On the Expansion of the Bases-Exchange Graph of Matroids .
Milena Mihail, Bellcore

Characterizing the edges of connected graphs with a given domination number.
Laura Sanchis, DIMACS and Comp. Sci. Department, Colgate Univ.,Hamilton, NY

The L(2,1)-Labeling Problem on Graphs .
Gerard J. Chang, DIMACS and Department of Applied Mathematics, National Chiao Tung University, Hsinchu 30050, Taiwan, ROC

May 11

Some Remarks on Random Maximal Graphs.
Peter Winkler, Bellcore

Discrepancy of trees.
Martin Loebl, DIMACS and Charles University, Prague

Bounds on the max-flow min-cut ratio for directed multicommodity flows.
Éva Tardos, DIMACS and Cornell University

Oriented matroids and topology.
Grigori L. Rybnikov, Research Institute for System Studies, Russian Academy of Sciences

Sparse dynamic programming for evolutionary tree comparisons.
Mikkel Thorup, DIMACS and Oxford University

May 25

The fusion method in complexity theory.
Avi Wigderson, Hebrew University of Jerusalem

Additive number theory and combinatorics.
Vera T. Sós, Mathematical Institute of the Hungarian Academy of Sciences

June 3

Covering pairs of sets and connectivity augmentation.
A. Frank and T. Jord'an, Univ. of Bonn and Eötvös University, Budapest

June 16

From statistics to toric varieties and back.
Persi Diaconis, Harvard University

October 20

Protocol Compilation: High-Performance Communiction for Parallel Programs.
Ed Felten, Princeton University

Optimal Parallel Two Dimensional Pattern Matching.
S. Muthukrishnan, Courant Institute, NYC

November 24

Bounds on the Efficiency of Message-Passing Protocols for Parallel Computers.
Robert Cypher, IBM Watson

New Graph Decompositions and Fast Emulations in Hypercubes and Butterflies.
Satish Rao, NEC

Biocomputing Series

March 22

The Computational Challenges of BioMolecular Structure/Function Identification.
Temple Smith, Boston University

October 25

Reconstructing Strings from Substrings.
Steven S. Skiena, Dept of Computer Science, SUNY

November 15

Detecting Repeats in Genetic Sequences.
Gary Benson, USC

November 30

Faster Genetic Linkage Analysis Computations.
Alejandro Schaffer, Rice University

December 10

To be Announced.
Pavel Pevzner, Penn State

Theory of Computation Series

September 27

The Fusion Method for Lower Bounds in Circuit Complexity.
Avi Wigderson, Hebrew University, Jerusalam

October 18

Further Deterministic Simulation in Logspace, Part I.
Endre Szemerédi, Rutgers University

October 25

On Representations by Low-Degree Polynomials .
Roman Smolensky, Department of Computer Science, Rutgers

November 1

More deterministic simulations, Part II .
Endre Szemerédi, Rutgers University

November 8

More deterministic simulations, Part III .
Endre Szemerédi, Rutgers University

November 15

Bi-weighted binary trees and the partial sum problem.
Hari Hampapuram, Rutgers University

November 22

On the Optimal Alphabetic Tree Problem.
Teresa M. Przytycka, Odense University and DIMACS

November 29

The Determinant, Probabilistic Logspace and Counting.
Eric Allender, Rutgers University

Mixer Series

October 1 - Rutgers

Primal-dual RNC approximation algorithms for (multi)-set (multi)-cover and covering integer programs.
Vijay Vazirani, Indian Inst. of Technology & DIMACS

A better algorithm for an ancient scheduling problem.
Steven Phillips, AT&T Bell Laboratories

Mathematical classification and clustering.
Boris Mirkin, Central Economics-Mathematics Inst., Moskow & DIMACS

October 8 - Bell Labs

New results on approximating probability distributions, and algorithmic applications.
Aravind Srinivasan, Institute for Advanced Study and DIMACS

Scalable Parallel Geometric Algorithms for Coarse Grained Multicomputers.
Andrew Rau-Chaplin, DIMACS

Efficient enumeration of clique trees of a chordal graph.
C.E. Veni Madhavan, Indiana Institute of Science and DIMACS

October 22 - Princeton

Experiences with Parallel N-Body Simulations.
Sandeep Bhatt, Bellcore

Partition Varieties: The Geometric Aspect of Rook Placements.
Kequan Ding, Institute for Advanced Study & DIMACS

A Geometric Approach for Denoting and Intersecting TR Subgroups of the Euclidian Group.
Yanxi Liu, Univ. of Massachusetts & DIMACS

October 27 - Bellcore

Derandomization of Geometric Algorithms: the Convex Hull and the Diameter.
Herve Bronnimann, Princeton University

Bounds on the Chromatic Polynomial and on the Number of Acyclic Orientations of a Graph.
Nabil Kahale, DIMACS

On the Diameter of Polyhedra Associated to Network Optimization Problems.
Fred Rispoli, DIMACS

Feedforward Boolean Neural Networks with Discrete Weights: Computational Power and Training.
Eddy Mayoraz, RUTCOR & DIMACS

Discrete Math Series

September 23

Cycles through specified vertices.
Robert Hochberg, Rutgers University

September 30

On the fractional dimension of partially ordered sets.
Tom Trotter, Bellcore

October 7

Functions with prescribed marginals.
Ron Aharoni, The Technion and U. Penn

October 14

Computing the degrees of freedom of a frame.
Deborah Franzblau, DIMACS

October 21

On Laczkovich's Equidecomposition Theorem.
József Beck, Rutgers University

October 28

Totally Nonnegative Matrices and Planar Algebraic Computation.
Yuri Rabinovich, Univ. of Toronto

November 4

Plunnecke's Graph-Theoretic Method & Its Applications.
Imre Ruzsa, Hungarian Academy of Science

November 11

A Lattice Point Problem and Expansion of Cayley Graphs.
Noga Alon, Tel Aviv University & Inst. for Advanced Study

December 2

Reversibility and Reciprocity.
Prasad Tetali, Bell Labs

Math Education Series

September 28

Overview of NCTM Standards.
Warren Crown, Rutgers Graduate School of Education

Overivew of Math Sciences Education Board Activities.
Joseph Rosenstein, Rutgers University

October 13

Leadership Program in Discrete Mathematics.
Joseph Rosenstein, Rutgers University

October 28

Innovative Mathematics Program in Schools (MAPS).
Carolyn Maher and Robert Davis, Rutgers GSE

November 16

New Jersey "Statewide Systemic Initiative" (SSI).
Gerald Goldin, Rutgers University

December 2

The New Jersey Mathematics Coalition and the Mathematics Curriculum Framework.
Joseph Rosenstein, Rutgers University, Carolyn Maher and Robert Davis, Rutgers GSE

G Postdocs

Spring, 1993	Fall, 1993
Martin Farach (Univ. of Maryland)	Kequan Ding (Univ. of Wisconsin)
Christos Kaklamanis (Harvard University)	Martin Farach (Univ. of Maryland)
Shmuel Onn (Cornell University)	Christos Kaklamanis (Harvard University)
Gabor Simonyi (Hungarian Academy of Science)	Pangfeng Liu (Yale University
Ran Raz (Hebrew University)	Yanxi Liu (Univ. of Massachusetts)
Prasad Tetali (Courant Inst. of Math. Sciences)	Prasad Tetali (Courant Institute of Math. Sciences)
Tamra Carpenter (Bellcore)	Ran Raz (Hebrew University)
	Aravind Srinivasan (Cornell University)
	Seth Teller (Hebrew University)
	Motakuri Venkata Ramana (Johns Hopkins Univ.)

H Graduate Students - Supported

Spring, 1993

Rita Csakany	Math
Boris Furchin	RUTCOR
Anastasia Grandbois	RUTCOR
Haripriyan Hampapuram	CS
Taehyung Park	RUTCOR
John Shareshian	Math
Ileana Streinu	CS
Fuan Zhao	RUTCOR
Brandon Dixon	Princeton
Dimitrios Gunopulos	Princeton

Fall, 1993

Lars Nordmann	RUTCOR
Gretchen Ostheimer	Math
Claudia Polini	Math
Haripriyan Hampapuram	CS
Ayellet Tal	Princeton

I Research Experience for Undergraduates (REU)

Student	(Mentor)	– project
Andrew Biderman	(Hayam Hirsh, RU, CS)	– theory of algorithms.
Richard Hom worked	(Michiel Noordewier, RU, CS)	– computational biology.
Chih Liu	(William Steiger, RU, CS)	– combinatorial geometry.
Joel Sokel	(Endre Boros, RUTCOR)	– combinatorial optimization.

J Visitors – Long-Term and Short-Term

Alexander Barvinok	Royal Inst. of Tech.	1 month
Boris Cherkassky	Inst. of Economica, Academy of Sciences Russia	1 month
Charles Colbourn	Univ. of Waterloo	1 months
Michele Conforti	Univ. degli Studi di..,France	1 month
Gerard Cornuejols	Carnegie Mellon Univ.	1 month
Guoli Ding	Louisiana State Univ.	1 month
Efim Dinitz	The Technion	1 month
Peter Dolan	Bard College	6 months
Péter L. Erdős	CWI, Amsterdam	1 month
Stefan Felsner	Technical Univ., Berlin	7 months
Bruno Gaujal	U.C.B.L. Magna Cumlaude	4 months
Bert Gerards	CWI, Amsterdam	4 months
Luis Goddyn	Simon Fraser Univ.	1 month
Michel Goemans	M.I.T.	2 month
Nabil Kahale	MIT	4 months
Alexander V. Karzanov	Russian Academy of Sci.	1 month
Phil Klein	Brown Univ.	4 months
Jan-Karel Lenstra	Eindhoven Tech. Univ.	1 month
Wolfgang Maass	TU Graz	1 month
Veni Madhavan	Indian Inst. of Science	1 month
Eddy Mayoraz	Ecole Rolytech. Fed. de Lausanne, Switzerland	3 months
Boris Mirkin	International Energy Agency, France	3 months
Roy Meshulam	The Technion, Israel	1 month
Seffi Naor	The Technion, Israel	3 weeks
Panos Pardalos	Univ. of Florida	1 month
Teresa Przytycka	Odense Univ. Denmark	1 month
Serge Plotkin	Stanford Univ.	2 weeks
Yuri Rabinovich	Univ. of Toronto	1 month
Andrew Rau-Chaplin	Carleton Univ. Canada	12 months
Bruce Reed	Waterloo, U.	1 month
Franz Rendl	Technische Universitat Graz	2 weeks
Szilárd Révész	Hungarian Academy of Sci.	1 month
Fred Rispoli	Dowling College	10 months
Neil Robertson	Ohio State Univ.	2 months
Joseph Romanovsky	St. Petersburg State Univ., Russia	1 month
Imre Ruzsa	Hungarian Academy of Sci.	1 month
Laura Sanchis	Colgate Univ.	6 months
Daniel Sanders	Georgia Tech	6 weeks
Carla Savage	North Carolina State Univ.	1 week
Bruce Sheperd	Universitat Bonn	1 month
David Shmoys	Cornell Univ.	6 months
M. Simonovits	Mathematics Research	1 month
Roman Smolensky	Hebrew University	1 month
Sergey Tarasov	Univ. of Ottawa	3 weeks
Éva Tardos	Cornell Univ.	5 months

This list does not include those who visited DIMACS just for the duration of a workshop.

Robin Thomas	Georgia Inst. of Tech.	3 months
Mikkel Thorup	Univ. of Oxford	7 months
Mike Trick	Carnegie Mellon Univ	7 months
Joel Wein	Polytechnic Univ.	6 months
Henry Wolkowicz	Univ. of Waterloo	5 months
Suzanne Wetzel	Univ. of Karlsruhe, Germany	4 months
Cun-Quan Zhang	West Virginia Univ.	1 month

K Ph.D.s - Affiliated Graduate Students

Herana Abeledo - Advisor: Uri Rothblum - 1/93
Thesis: *The Stable Matching Problem*

Francesa Albertini - Advisor: Eduardo Sontag - 10/93
Thesis: *Controllability of Discrete-Time Nonlinear Systems and Some Related Topics*

David Arasmith -Advisor: Peter Winkler - 5/93
Thesis: *Disjoint Maximal Independent Sets*

Iliana Bjorling-Sachs - Advisor: Diane Souvaine - 5/93
Thesis: *Variations of the Art Gallery Theorem*

A.L. Buchsbaum - Advisor: R.E. Tarjan - 6/93
Thesis: "D*ata-Structural Bootstrapping and Catenable Deques*

Pey-Chun Chen - Advisor: Pierre Hansen - 1/93
Thesis: *Vertex Enumeration Methods and Continuous Location Theory*

Vivek Gore - Advisor: Eric Allender - 5/93
Thesis: *Title of thesis: Lower Bounds for Uniform Constant Depth Circuits*

Celina Imielinska - Advisor: Bahman Kalantari - 10/93
Thesis: *A general class of Heuristics for Constrained Forest and Cycle Problems*

Xin Ke - Advisor: József Beck - 4/93
Thesis: *On Ramsey theory*

Janice Kim -Advisor: B. Avi-Itzhak - 10/93
Thesis: *Optimal Design and Control of Production Queueing Network*

Jeong Han Kim - Advisor: Jeff Kahn - 6/93
Thesis: *Non-combinatorial approaches to two combinatorial problems*

Keh-Wei Lih - Advisor: Pierre Hansen - 1/93
Thesis: *Applications of Zero-One Linear Programming with Multiple-Choice Constraints*

Lorien Pratt -Advisor: Haym Hirsh - 3/93
Thesis: *Transferring Previously Learned Back-Propagation Neural Networks to New Learning Tasks*

M.H. Rauch - Advisor: R.E. Tarjan - 1/93
Thesis: *Fully Dynamic Graph Algorithms and Their Data Structure*

Denise Sakai - Advisor: Fred Roberts - 1/93
Thesis: *Generalized Graph Colorings and Unit Interval Graphs*

H.T. Siegelmann - Advisor: Eduardo Sontag - 10/93
Thesis: *Theoretical Foundations of Recurrent Neural Networks*

R.K. Sitaraman - Advisor: R.E. Tarjan - 6/93
Thesis: *Communication and Fault Tolerance in Parallel Computers*

Xiaorong Sun - Advisor: P.L. Hammer - 1/93
Thesis: *Combinatorial Algorithms for Boolean and Pseudo-Boolean Functions*

Hing Fung Ting - Advisor: Andrew Yao - 1/93
Thesis: *Computational Complexity for Selection Problems with Parity-Like Tests.*

Junjie Xiong - Advisor: Pierre Hansen - 10/93
Thesis: *The Remainder Form and Cord-Slope Form in Global Optimization with Interval Methods*

Yudi Yang - Advisor: Hector Sussmann - 8/93
Thesis: *Global Stabilization of Linear Systems with Bonded Feedback*

Fotis Zaharoglou - Advisor: Michael Saks - 9/93
Thesis: *Distributed Data Structures and Wait-Free Computation*