PARALLEL AND DISTRIBUTED COMPUTING (U) MATHEMATICAL SCIENCES RESEARCH INST BERKELEY CA I KAPLANSKY ET AL
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NL
The Berkeley Mathematical Sciences Research Institute (MSRI) featured a focus on computational complexity during 1985-86. A substantial part of the program was devoted to parallel and distributed computing. Support for this part of the program was obtained from the present Air Force grant and a similar contract from the Army. Senior personnel supported were Dr. Karlin, Dr. Michael Rabin, Richard Anderson was a postdoctoral fellow. Nathan Linial visited for a month. A workshop on parallel and distributed computing was held from May 19 to May 23, 1986 and drew 110 participants.

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Attachments

Poster for the workshop.
List of participants.
Program of the workshop.
Form 1473.

1. Summary. This contract was entitled "Parallel and distributed computing". It provided $92,000 in partial support of the yearlong program on Computational Complexity held at the Berkeley Mathematical Sciences Research Institute during 1985-86. This was combined with a similar contract from the Army Research Office and with funding of MSRI from the National Science Foundation to budget the total program on Computational Complexity at approximately $600,000.

Initially, the co-principal investigators were Richard Karp and Calvin Moore. When, on July 1, 1985, Professor Moore left his post as Deputy Director of MSRI to become a Vice-President of the University of California system, Irving Kaplansky (the current Director of MSRI) replaced him. Professor Karp provided the scientific direction and Professor Kaplansky the administrative support.

Richard Anderson was a postdoctor fellow supported by the grant. There was partial support for Richard Karp and, in addition Michael Rabin of Hebrew University and Harvard University was a senior visitor for six months (January through June, 1986). Louis Auslander and Nathan Linial visited for a month each.

From May 19 to May 23, 1986 MSRI hosted a Workshop on Parallel and Distributed Computing, supported by the Army contract and the Air Force grant.


Michael Rabin

Rabin worked on a set of algorithms using randomness for control and load sharing in parallel computers. These algorithms are a substitute for costly hardware solutions, such as combining networks, for the same problem. The results will appear in the following paper:

Richard Karp

Karp investigated parallel algorithms for backtrack search, branch-and-bound computations, and the evaluation of game trees. An outgrowth of this work was an interesting sequential algorithm for conducting a branch-and-bound search within limited storage. He also worked on the probabilistic analysis of combinatorial algorithms, with particular emphasis on bin packing problems. The following papers resulted from this work.


Richard Anderson

In a joint paper with Alok Agarwal, Anderson settled a major open problem in the theory of parallel computation by showing that the problem of conducting a depth-first-search tree in a directed graph lies in the complexity class Random NC.

A. Agarwal and R. Anderson, "Depth-First Search is in Random NC", to appear.

Nathan Linial

In the paper cited below, it is proved that a graph is k-connected if and only, for every set S of k vertices, it is possible to place the vertices of S at the corners of a (k-1)-dimensional simplex, and the remaining vertices at distinct points in the interior of the simplex, so that, for each vertex v not in S, the interior point corresponding to v lies within the convex hull of the points corresponding to the neighbors of v in the graph. This characterization leads to an efficient randomized algorithm for computing the connectivity of a graph.
Louis Auslander

Louis Auslander studied algorithms for computing large finite Fourier transforms. There exists an algorithm due to Cooley and Tukey that is reasonably efficient. However, if the Fourier transform in question admits a crystallographic group of transformations, Auslander has devised an improved method that takes advantage of this. When tried out for a special case where the group had order 3, it was six times as fast as the Cooley-Tukey method.

Preparation of a manuscript is in progress, tentatively titled, "Fourier transforms that respect crystallographic groups". It will probably be submitted to a journal specializing in crystallography.


A workshop on the complexity of parallel and distributed computation was held at MSRI from May 19 to May 23, 1986. The workshop had 21 speakers and 141 participants; their interests ranged from practical questions about the architecture of parallel and distributed systems to highly theoretical questions about the complexity of parallel computation. A panel discussion was held on the topic "Bridging the Gap Between the Theory and Practice of Parallel and Distributed Computing".

The main focus of the workshop was a set of mathematical and algorithmic issues that underlie the efficient use of the massively parallel computers that are just beginning to come into use. Several of the lectures were concerned with efficient algorithms for such computers. Other lectures were concerned with the problems of synchronization, load-sharing, and communication between processors in such systems. A third major theme was the reliable operation of such systems in the presence of faulty processors.
The total budget for the workshop was $18,000, of which $15,150 came from the Air Force grant and $2,850 from the Army contract.

The participants supported by the Air Force grant were as follows:

1. Faith Fich $350.00
2. Zvi Galil 800.00
3. Max Garzon 350.00
4. Andrew Goldberg 350.00
5. Joe Halpern 300.00
6. Amos Israeli 350.00
7. Eric Kaltofen 350.00
8. Paris Kanellakis 350.00
9. Simon Kasif 350.00
10. Sam M. Kim 350.00
11. Dexter Kozen 650.00
12. Gad M. Landau 350.00
13. Jan Karel Lenstra 350.00
14. Franklin Luk 650.00
15. Wolfgang Maass 350.00
16. Silvio Micali 650.00
17. Gary Miller 400.00
18. Victor Pan 650.00
19. Haesun Park 300.00
20. Alex Pothen 350.00
21. Vijaya Ramachandran 350.00
22. Walter L. Ruzzo 250.00
23. Carla Savage 350.00
24. J.P. Schmidt 350.00
25. D.D. Sherlekar 350.00
26. Alan Siegel 300.00
27. G.W. Stewart 650.00
28. Eli Upfal 300.00
29. Vijay Vazirani 350.00
30. H. Venkateswaran 250.00
31. Uzi Vishkin 1,100.00
32. Paul Vitanyi 350.00
33. Joachim Von Zur Gathen 300.00
34. Wei Young 350.00
35. Moti Yung 350.00

$15,150.00
Workshop on  
PARALLEL AND DISTRIBUTED COMPUTATION  
May 19-23, 1986  
at the  
MATHEMATICAL SCIENCES RESEARCH INSTITUTE  
BERKELEY, CALIFORNIA  

As part of its yearlong 1985-86 program on Computational Complexity, the Mathematical Sciences Research Institute will host a one-week workshop on the complexity of parallel and distributed computation, May 19-23, 1986. The organizing committee consists of R.M. Karp (chairman), H.T. Kung, Michael Rabin, and J.T. Schwartz. One of the principal aims of the workshop is to bring mathematicians and computer scientists working on the theoretical aspects of these subjects into contact with numerical analysts and computer architects involved in the design and use of parallel and distributed computer systems. Major topics addressed at the workshop will include: complexity of parallel computation, combinatorial and numerical parallel algorithms, realization of parallel algorithms in hardware, abstract models of parallel computation, architecture of parallel computers, concurrency control, randomization in parallel and distributed computing, routing algorithms, and fault-tolerant computation in distributed systems.

In addition to the program committee, the following have been invited to participate:

R. Anderson   D. Hillis   E. Mayr   L. Synder  
B. Awerbuch   E. Kaltofen   G. Miller   G.W. Stewart  
A. Borodin   D. Kannan   C. Moler   L. Stockmeyer  
T. Chan   D. Koenen   K. Mulmuley   H. Stone  
A. Chandra   D. Kuck   J. Oliger   R. Strong  
M. Chandy   R. Ladner   V. Pan   R. Tarjan  
R. DeMillo   L. Lamport   C. Papadimitriou   C. Thompson  
C. Dwork   E. Lawler   G. Pister   J. Ullman  
P. Dymond   F.T. Leighton   N. Pippenger   E. Upfal
F. Fich   C. Leiserson   F. Preparata   L. Valiant  
M. Fischer   R. Lepton   J. Reif   U. Vazirani  
Z. Galil   M. Luby   W. Reza   V. Vazirani  
J. von zur Gathen  F. Luk   C. Seitz   U. Vishkin  
W.M. Gentleman   N. Lynch   D. Shmoys   A. Wigderson  
J. Halpern   G. Maggs   M. Sipser   A. Yao  

The workshop will be held at the Institute's new building at 1000 Centennial Drive. Shuttle bus service will be provided from the central campus area. The mathematical sciences community is warmly invited to attend. Additional, more detailed information will be sent to people indicating a desire to come to the workshop. There will be a limited amount of money available to provide partial support for people wishing to attend and participate. New and recent Ph.D.'s are encouraged to apply. Requests for financial support should be received by April 1, 1986. Address inquiries concerning the workshop to Program Committee: Parallel and Distributed Computing, Mathematical Sciences Research Institute, 1000 Centennial Drive, Berkeley, California 94720. Funding for the conference is provided by the Army Research Office and the Air Force Office of Scientific Research, in cooperation with the Office of Naval Research.

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COMPLEXITY ASPECTS OF PARALLEL AND DISTRIBUTED COMPUTING

May 19-23, 1986

Participant List

Selim Akl
Richard Anderson
Baruch Awerbuch
Sara Baase
Donald Beaver
Marshall Bern
Gianfranco Bilardi
Adam Bojanczyk
Michael Campbell
Larry Carter
Tony Chan
Chandran
Paul Chew
Mo-suk Chow
D. Coan
Richard Cole
Harold Cox
Narsingh Deo
Alvin Despain
Randall Dougherty
Cynthia Dwork
Jeanne Ferrante
Faith Fich

Queen's University, SRI, UC Berkeley
MSRI
MIT
UC Berkeley
Harvard
UC Berkeley
Cornell
Washington University
UC Los Angeles
UC Berkeley & IBM
Yale, RIACS
University of Maryland
Dartmouth
Northeastern University
Floating Point Systems
NYU
Washington State University
UC Berkeley
CALTECH
IBM
UC Berkeley & IBM
University of Washington
COMPLEXITY ASPECTS OF PARALLEL AND DISTRIBUTED COMPUTING

May 19-23, 1986

Participant List

Sally Floyd  
UC Berkeley

Lance Fortnow  
UC Berkeley

Zvi Galil  
Columbia, Tel-Aviv Univ.

Max Garzon  
MSU

Phil Gibbons  
UC Berkeley

Andrew Goldberg  
MIT

Shafi Goldwasser  
MIT

P.S. Gopalakrishnan  
University of Maryland

Stuart Haber  
Columbia

Ramsey Haddad  
Stanford

Joe Halpern  
IBM

Lisa Hellerstein  
UC Berkeley

David Helmbold  
Stanford

L. Higham  
University of British Columbia

Russell Hinds  
UC Berkeley

Dorit Hochbaum  
MSRI & UC Berkeley

Joan Hutchinson  
Smith College

Amos Israeli  
Harvard

Erich Kaltofen  
Rensselaer Polytechnic Inst.

Paris Kanellakis  
Brown University

Richard Karp  
MSRI

Simon Kasif  
Johns Hopkins

Zvi Kedem  
Courant

San Kim  
Rensselaer Polytechnic Inst.
### Participant List

<table>
<thead>
<tr>
<th>Name</th>
<th>Institution</th>
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<tbody>
<tr>
<td>Valerie King</td>
<td>UC Berkeley</td>
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<td>Richard King</td>
<td>Kestrel</td>
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<td>Philip Klein</td>
<td>MIT</td>
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<td>Dexter Kozen</td>
<td>Cornell</td>
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<td>Mark Krentel</td>
<td>Cornell</td>
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<td>Danny Krizane</td>
<td>Harvard</td>
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<td>Richard Ladner</td>
<td>MSRI &amp; University of Washington</td>
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<tr>
<td>Gad Landau</td>
<td>Tel Aviv University</td>
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<td>Charles Leiserson</td>
<td>MIT</td>
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<td>Jan Karel Lenstra</td>
<td>CWI, Amsterdam</td>
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<td>Nick Littlestone</td>
<td>UC Santa Cruz</td>
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<tr>
<td>Laszlo Lovasz</td>
<td>MSRI</td>
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<tr>
<td>Anna Lubiw</td>
<td>UC Berkeley</td>
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<tr>
<td>Michael Luby</td>
<td>University of Toronto</td>
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<td>George Lueker</td>
<td>UC Irvine</td>
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<td>Frank Luk</td>
<td>Cornell</td>
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<tr>
<td>Stephen Lundstrom</td>
<td>MCC</td>
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<tr>
<td>Wolfgang Maass</td>
<td>University of Illinois, Chicago</td>
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<tr>
<td>Yoni Malachi</td>
<td>IBM Almaden</td>
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<tr>
<td>Michael Matsko</td>
<td>UC Berkeley</td>
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<tr>
<td>Jill Mesirov</td>
<td>Thinking Machines Corp.</td>
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<td>Silvio Micali</td>
<td>MIT</td>
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<tr>
<td>Zevi Miller</td>
<td>UC Berkeley</td>
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<tr>
<td>Gary Miller</td>
<td>USC</td>
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</table>
COMPLEXITY ASPECTS OF PARALLEL AND DISTRIBUTED COMPUTING

May 19-23, 1986

Participant List

Ketan Mulmuley UC Berkeley
Simeon Naor UC Berkeley
Lena Nekluobova Thinking Machines Corp.
Mark Newman MIT
Noam Nisan UC Berkeley
Frank Olken Lawrence Berkeley Lab.
Victor Pan SUNY Albany
Haesun Park Cornell
Ramamohan Patiu Harvard
David Peleg IBM San Jose
Nicholas Pippenger IBM Almaden
Carl Ponder UC Berkeley
Alex Pothen Pennsylvania State
Harry Printz CMU
Michael Rabin Harvard, Hebrew Univ., MSRI
S. Rajasekaran Harvard
Vijaya Ramachandran University of Illinois, Urbana
John Reif Harvard, MSRI
Ronitt Rubinfeld UC Berkeley
Vlad Rutenburg Stanford
Larry Ruzzo Washington
Gary Sabot Harvard
Miklos Santha UC Berkeley
Uwek Sarkar Stanford
COMPLEXITY ASPECTS OF PARALLEL AND DISTRIBUTED COMPUTING

May 19-23, 1986

Participant List

Carla Savage  North Carolina State
Cathy Schevon  Brown University
J. Schmidt  NYU
Rob Schreiber  Rensselaer Polytechnic Inst.
Ed Schweichel  San Jose State University
Charles Seitz  CALTECH
Amitabm Shah  Cornell
Deepak Sherlekar  University of Maryland
David Shmcys  MIT & MSRI
Alan Siegel  NYU
Janos Simon  University of Chicago
Barbara Simons  IBM San Jose
Michael Sipser  MSRI
Bruce Smith
Rob Smith  MCC
L. Snyder  University of Washington
Danny Soroker  UC Berkeley
Helmut Stern  UC Berkeley
G.W. Stewart  University of Maryland
Larry Stockmeyer  IBM Almaden
Leen Stougie  UC Berkeley
Charlie Swart  Oregon State University
Eva Tardos  MSRI
Robert Tarjan  Princeton & AT&T Bell Labs.
Participant List

Al Thaler
Athanasios Tsantilas
Gyorgy Turan
Jeffrey Ullman
Eli Upfal
Leslie Valiant
Umesh Vazirani
H. Venkateswaran
Uzi Vishkin
Paul Vitanyi
Jeff Vitter
Joachim Von zur Gathen
John Walker
Greg Wasilkowski
Avi Wigderson
David Wolfe
Richard Wongkew
Henryk Wozniakowski
Mihaly Yeveb
Wei Young
Moti Yung
Yanjun Zhang

NSF
Harvard
University of Illinois, Chicago
Stanford
IBM Almaden
Harvard, MSRI
MSRI
University of Washington
Tel Aviv University
MIT
MSRI, Brown Univ.
University of Toronto
Stanford
Columbia
MSRI
UC Berkeley
UC Berkeley
Columbia
University of Alabama
Columbia
UC Berkeley
WORKSHOP ON
COMPLEXITY OF PARALLEL & DISTRIBUTED COMPUTATION
May 19-23, 1986

(All sessions will be held in the MSRI Lecture Hall.)

**Monday, May 19**

<table>
<thead>
<tr>
<th>Time</th>
<th>Session</th>
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<tbody>
<tr>
<td>8:30 - 9:30</td>
<td>Arrival of Participants</td>
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<tr>
<td>9:30 - 9:40</td>
<td>Opening of the Workshop</td>
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</table>
| 9:40 - 10:30 | Richard Anderson, MSRI  
A Random NC Algorithm for Depth-First Search |
| 10:40 - 11:30 | Uzi Vishkin, Tel Aviv University  
On Methods for Designing Parallel Algorithms |
| 12:30 - 2:00 | Lunch Break                                                             |
| 2:00 - 2:50 | John Reif, Harvard University and MSRI  
Efficient Parallel Algorithms – Theory and Practice |
| 3:15 - 4:00 | Tea                                                                     |
| 4:00 - 4:50 | Gary Miller, University of Southern California  
Workload Balancing in the Design of Processor-Efficient Parallel Algorithms |

**Tuesday, May 20**

<table>
<thead>
<tr>
<th>Time</th>
<th>Session</th>
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| 9:00 - 9:50 | Gianfranco Bilardi, Cornell University  
Bitonic Sorting in $O(\log^2 n)$ Time with $O(n/\log n)$ Processors |
| 10:00 - 10:50 | Nicholas Pippenger, IBM Almaden Research Center  
Parallel Comparison Problems |
| 10:50 - 11:30 | Coffee Break                                                      |
| 11:30 - 12:20 | Ketan Mulmuley, University of California at Berkeley  
Parallel Computation in Linear Algebra |
| 12:20 - 2:00 | Lunch Break                                                             |
| 2:00 - 2:50 | Franklin Luk, Cornell University  
Parallel Algorithms for Signal Processing |
| 3:15 - 4:00 | Tea                                                                     |
| 4:00 - 4:50 | Gilbert Stewart, University of Maryland  
Determinacy – Its Uses and Limitations |
| 6:30 -    | Heyns Room, Faculty Club  
Reception for all participants |
Wednesday, May 21

9:00 - 9:50  Baruch Awerbuch, MIT
            Optimal Dynamic Deadlock Resolution Protocols

10:00 - 10:50 Joseph Halpern, IBM Almaden Research Center
               Analyzing Distributed Systems via Knowledge

10:50 - 11:30 Coffee Break

11:30 - 12:20 Silvio Micali, MIT
            How to Compile Protocols for Reliable Players to Equivalent Fault-Tolerant Protocols

12:20 - 2:00 Lunch Break

2:00 - 2:50  Eli Upfal, IBM Almaden Research Center
            On the Relation Between Desirable and Feasible Models for Parallel Computation

3:15 - 4:00  Tea

4:00 - 4:50  Michael Rabin, Harvard University, Hebrew University, and MSRI
            Randomized Synchronization Primitives for Parallel Computers

Thursday, May 22

9:00 - 9:50  Larry Snyder, University of Washington
            Type Architectures

10:00 - 10:50 Charles Seitz, California Institute of Technology
               Low Latency Message-Passing Techniques for Concurrent Computers

10:50 - 11:30 Coffee Break

11:30 - 12:20 Charles Leiserson, MIT
            VLSI Theory and its Relation to Parallel Supercomputing

12:20 - 2:00 Lunch Break
Thursday, May 22 continued

2:00 – 3:15 Panel Discussion: Closing the Gap Between the Theory and Practice of Parallel and Distributed Computation

Richard Karp, University of California at Berkeley and MSRI
Charles Leiserson, MIT
Michael Rabin, Hebrew University, Harvard University, and MSRI
Charles Seitz, California Institute of Technology
Larry Snyder, University of Washington

3:15 – 4:00 Tea

4:00 – 5:00 Continuation of Panel Discussion

Friday, May 23

9:00 – 9:50 Avi Wigderson, MSRI
Lower Bounds in Parallel Computation

10:00 – 10:50 Jeffrey Ullman, Stanford University
Parallel Complexity of Logic Programs

11:00 – 11:50 Leslie Valiant, Harvard University and MSRI
Learning Algorithms for Connectionist Models

END OF WORKSHOP

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