Parallel and Distributed Computing (Unclassified)

Kaplansky, Irving and Karp, Richard

Final Technical

The Berkeley Mathematical Sciences Research Institute (MSRI) featured a program in 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 Army contract and a similar grant from the Air Force. Personnel supported on this grant were Leslie Valiant of Harvard University and postdoctoral fellows David Shmoys and Umesh Vazirani. A workshop on parallel and distributed computing was held from May 19 to May 23, 1986 and drew 141 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 $46,000 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 grant for $92,000 from the Air Force Office of Scientific Research 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.

David Shmoys and Umesh Vazirani were postdoctoral fellows supported by the contract; Leslie Valiant of Harvard University was a senior visitor for four months (April 15 - July 15, 1986).

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.


Leslie Valiant

Leslie Valiant worked on the problem of inferring a rule or computer program from examples of its behavior. The problem has applications in fields such as artificial intelligence and pattern recognition. The mathematical problem is to identify classes of rules or programs that can be inferred in a provably convergent sense from reasonably few examples. At the MSRI Workshop on Complexity of Parallel and Distributed Computation he presented a talk entitled "Learning Algorithms for Connectionist Models". He also spoke at UC Irvine on "A Theory of the Learnable".
David: Shmoys


Umesh Vazirani

Umesh Vazirani in joint work with Vijay Vazirani, investigated the computation power of randomized algorithms when the generator of random bits is imperfect, and may even be controlled by an intelligent and devilish adversary. It is only required that, for every bit generated, the probability of generating a 1 is uniformly bounded away from both zero and one. The main result of this investigation is that any problem that can be solved in polynomial time using a perfect generator of unbiased, independent bits can also be solved in polynomial time using an imperfect generator.

In the reference cited below, Vazirani and his co-authors developed an efficient randomized algorithm for constructing a maximum matching in a graph.

K. Mulmuley, U.V. Vazirani and V.V. Vazirani, "Matching is as Easy as Matrix Inversion", MSRI Preprint 06318-86.


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 $2,850 came from the Army contract, and $15,150 from the Air Force grant.

The participants supported by the Army contract were as follows:

Dharma Agrawal $350
Baruch Awerbuch 650
Gianfranco Bilardi 650
Mo-Suk Chow 350
Patrick Dymond 400
Charles Seitz 450

$2,850

Appended as attachments to this report are the widely distributed poster for the workshop, the complete list of participants, and the program.
4. **Financial Report.**

Salary (Valiant) $19,000

Postdoctoral fellowships:

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<tbody>
<tr>
<td>Shmoys</td>
<td>8,500</td>
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<tr>
<td>Vazirani</td>
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Travel allowances:

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<tr>
<td>Shmoys</td>
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<td>Vazirani</td>
<td>564</td>
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Workshop 2,850

Fringe Benefits 900

Health Insurance (Vazirani) 780

Telephone 760

Supplies, preprints 1,240

Technical typing 1,300

Computer charges 950

$46,000
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. Snyder
B. Awerbuch  E. Kaltofen  G. Miller  G.W. Stewart
A. Borodin  R. Kannan  C. Moler  L. Stockmeyer
T. Chan  D. Kuck  J. Oliger  H. Stone
A. Chandra  D. Kuck  V. Pan  R. Strong
M. Chandy  R. Ladner  R. Tarjan
R. DeMillo  L. Lampert  C. Thompson
C. Dwork  E. Lawler  J. Ullman
P. Dymond  F.T. Leighton  C. Thompson
F. Fich  C. Leiserson  F. Preparata  L. Valiant
M. Fischer  R. Lipton  J. Reif  U. Vazirani
Z. Galil  M. Luby  W. Ruzzo  V. Vazirani
J. von zur Gathen  F. Luk  C. Seitz  U. Vishkin
W.M. Gentleman  N. Lynch  D. Shmoys  A. Wigderson
J. Halpern  G. Mago  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.

Please Post
COMPLEXITY ASPECTS OF PARALLEL AND DISTRIBUTED COMPUTING
May 19-23, 1986
Participant List

Selim Akl
Queen's University, SRI, UC Berkeley
Richard Anderson
UC Berkeley
Baruch Awerbuch
MIT
Sara Baase
UC Berkeley
Donald Beaver
Harvard
Marshall Bern
UC Berkeley
Gianfranco Bilardi
Cornell
Adam Bojanczyk
Washington University
Michael Campbell
UC Los Angeles
Larry Carter
UC Berkeley & IBM
Tony Chan
Yale, RIACS
Chandran
University of Maryland
Paul Chew
Dartmouth
Mo-suk Chow
Northeastern University
D. Coan
Floating Point Systems
Richard Cole
NYU
Harold Cox

Narsingh Deo
Washington State University
Alvin Despain
UC Berkeley
Randall Dougherty
CALTECH
Cynthia Dwork
IBM
Jeanne Ferrante
UC Berkeley & IBM
Faith Fich
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
Sam Kim Rensselaer Polytechnic Inst.
COMPLEXITY ASPECTS OF PARALLEL AND DISTRIBUTED COMPUTING

May 19-23, 1986

Participant List

Valerie King       UC Berkeley
Richard King       Kestrel
Philip Klein       MIT
Dexter Kozen       Cornell
Mark Krentel       Cornell
Danny Krizanc      Harvard
Richard Ladner     MSRI & University of Washington
Gad Landau         Tel Aviv University
Charles Leiserson  MIT
Jan Karel Lenstra  CWI, Amsterdam
Nick Littlestone   UC Santa Cruz
Laszlo Lovasz      MSRI
Anna Lubiw         UC Berkeley
Michael Luby       University of Toronto
George Lueker      UC Irvine
Frank Luk          Cornell
Stephen Lundstrom  MCC
Wolfgang Maass     University of Illinois, Chicago
Yoni Malachi       IBM Almaden
Michael Matsko     UC Berkeley
Jill Mesirov       Thinking Machines Corp.
Silvio Micali      MIT
Zevi Miller        UC Berkeley
Gary Miller        USC
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
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

AMITABH SHAH
Cornell

DEEPAK SHERLEKAR
University of Maryland

DAVID SHMOYS
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 STOOGIE
UC Berkeley

CHARLE SWART
Oregon State University

EVA TARDOS
MSRI

ROBERT TARJAN
Princeton & AT&T Bell Labs.
# Participant List

<table>
<thead>
<tr>
<th>Name</th>
<th>Institution</th>
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<tbody>
<tr>
<td>Al Thaler</td>
<td>NSF</td>
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<tr>
<td>Athanasios Tsantilas</td>
<td>Harvard</td>
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<tr>
<td>Gyorgy Turan</td>
<td>University of Illinois, Chicago</td>
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<td>Jeffrey Ullman</td>
<td>Stanford</td>
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<tr>
<td>Eli Upfal</td>
<td>IBM Almaden</td>
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<tr>
<td>Leslie Valiant</td>
<td>Harvard, MSRI</td>
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<tr>
<td>Umesh Vazirani</td>
<td>MSRI</td>
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<tr>
<td>H. Venkateswaran</td>
<td>University of Washington</td>
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<td>Uzi Vishkin</td>
<td>Tel Aviv University</td>
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<tr>
<td>Paul Vitanyi</td>
<td>MIT</td>
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<tr>
<td>Jeff Vitter</td>
<td>MSRI, Brown Univ.</td>
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<tr>
<td>Joachim Von zur Gathen</td>
<td>University of Toronto</td>
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<td>John Walker</td>
<td>Stanford</td>
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<tr>
<td>Greg Wasilkowski</td>
<td>Columbia</td>
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<td>Avi Wigderson</td>
<td>MSRI</td>
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<td>David Wolfe</td>
<td>UC Berkeley</td>
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<td>Richard Wongkew</td>
<td>UC Berkeley</td>
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<td>Henryk Wozniakowski</td>
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<td>Mihaly Yeveb</td>
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<td>Wei Young</td>
<td>University of Alabama</td>
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<td>Moti Yung</td>
<td>Columbia</td>
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<tr>
<td>Yanjun Zhang</td>
<td>UC Berkeley</td>
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</table>
# 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>
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<tr>
<th>Time</th>
<th>Event</th>
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<tbody>
<tr>
<td>8:30</td>
<td>Arrival of Participants</td>
</tr>
<tr>
<td>9:30</td>
<td>Opening of the Workshop</td>
</tr>
<tr>
<td>9:40</td>
<td>Richard Anderson, MSRI A Random NC Algorithm for Depth-First Search</td>
</tr>
<tr>
<td>10:40</td>
<td>Uzi Vishkin, Tel Aviv University On Methods for Designing Parallel Algorithms</td>
</tr>
<tr>
<td>12:30</td>
<td>Lunch Break</td>
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<tr>
<td>2:00</td>
<td>John Reif, Harvard University and MSRI Efficient Parallel Algorithms - Theory and Practice</td>
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<tr>
<td>3:15</td>
<td>Tea</td>
</tr>
<tr>
<td>4:00</td>
<td>Gary Miller, University of Southern California Workload Balancing in the Design of Processor-Efficient Parallel Algorithms</td>
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### Tuesday, May 20

<table>
<thead>
<tr>
<th>Time</th>
<th>Event</th>
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<tbody>
<tr>
<td>9:00</td>
<td>Gianfranco Bilardi, Cornell University Bitonic Sorting in $O(\log^2 n)$ Time with $O(n/\log n)$ Processors</td>
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<tr>
<td>10:00</td>
<td>Nicholas Pippenger, IBM Almaden Research Center Parallel Comparison Problems</td>
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<tr>
<td>10:50</td>
<td>Coffee Break</td>
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<tr>
<td>11:30</td>
<td>Ketan Mulmuley, University of California at Berkeley Parallel Computation in Linear Algebra</td>
</tr>
<tr>
<td>12:20</td>
<td>Lunch Break</td>
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<tr>
<td>2:00</td>
<td>Franklin Luk, Cornell University Parallel Algorithms for Signal Processing</td>
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<tr>
<td>3:15</td>
<td>Tea</td>
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<tr>
<td>4:00</td>
<td>Gilbert Stewart, University of Maryland Determinancy - Its Uses and Limitations</td>
</tr>
</tbody>
</table>

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

PLEASE POST