ESPRIT BR Project RAND-REC
(EC-US Exploratory Collaborative Activity –
EC-US 030)

Final Progress Report

July 1, 1993 – September 30, 1997

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Annual Progress Report

July 1, 1996 – September 30, 1997

Contents

1 RAND-REC Research Sites

The research sites of RAND-REC Project were:

- University of Bonn,
- University of Edinburgh,
- University of Lund,
- University of Oxford,
- University of Paris-Sud
- International Computer Science Institute, Berkeley

  and
- University of California, Berkeley

2 Overview of Research Activities

The research within the project RAND-REC has concentrated on the following research areas (see Section 3, Research Papers):

(1) Design of Efficient Randomized and Approximative Algorithms

(2) Efficient Parallel Algorithms

(3) VC Dimension of Sigmoidal and Pfaffian Neural Networks and Volume Approximation

(4) Derandomizing Algorithms and Probabilistic Methods

(5) Erasure Resilient Codes for ATM-based Transmission

It has resulted altogether in 89 scientific publications.

3 Research Papers – Publications

1. F. Ablayev, and M. Karpinski.
   On the Power of Randomized Branching Programs, Proc. 28th ICALP (1996), Lecture Notes in Computer Science Vol. 1099, Springer Verlag, pp. 348 - 356.

2. A. Ambainis, K. Aprits, C. Calude, R. Freivalds, M. Karpinski, T. Larfeldt and I. Sala.
Effects of Kolmogorov Complexity Present in Inductive Inference, Proc. 8th Workshop on Algorithmic Learning Theory, ALT'97.

3. A. Ambainis, R. Freivalds, and M. Karpinski.
Weak and Strong Recognition by 2-Way Randomized Auotmata, Proc. 1st Symp. on Randomization and Approximation Techniques in Computer Science, RANDOM'97, Bologna, Lecture Notes in Computer Science Vol. 1269, Springer Verlag, pp. 175 - 185.

4. A. Andersson.
Faster deterministic sorting and searching in linear space. Proc. IEEE FOCS, 1996.

5. A. Andersson.
Which flavor of balanced tree? Plain vanilla! DIMACS Implementation challenge, 1996.

6. A. Andersson, T. Hagerup, S. Nilsson, and R. Raman.
Sorting in linear time? To appear in Journal of Computer and System Sciences.

7. A. Andersson and Ch. Mattsson.
Dynamic interpolation search in $o(\log\log n)$ time. To appear in Journal of Algorithms.

8. A. Andersson, co-authors P.B. Miltersen, S. Riis, and M. Thorup.
Static dictionaries on AC^0 *rams: Query time* $\theta(\sqrt{\log n/\log\log n})$ *is necessary and sufficient.* In *Proc. IEEE FOCS*, 1996.

9. A. Andersson and O. Peterson.
On-line approximate list indexing with applications. To appear in Journal of Algorithms.

10. A. Andersson and K. Swanson.
On the difficulty of range searching. *Computational Geometry: Theory and Applications*, 8(3):115–122, 1997.

11. A. Andersson and M. Thorup.
Implementing monotone priority queues. DIMACS Implementation challenge, 1996.

12. P. Berman, M. Charikar, and M. Karpinski.
On-Line Load Balancing for Related Machines, Proc. WADS'97.

13. P. Berman and A. Lingas.
A Nearly Optimal Parallel Algorithm for the Voronoi Diagram of a Convex Polygon. Theoretical Computer Science Vol. 174 No. 2-3 (1997), pp. 193-202.

14. P. Berman, M. Karpinski, L. Larmore, W. Plandowski, and W. Rytter. *On the Complexity of Pattern Matching for Highly Compressed Two-Dimensional Texts*, Proc. CPM'97.

15. G. Brassard, C. Crépeau, and M. Santha. *Oblivious transfers and intersecting codes*, IEEE Transactions on Information Theory, 42, No. 6, pp. 1769-1780, (1996).

16. A. Chistov, G. Ivanyos, and M. Karpinski. *Polynomial Time Algorithms for Modules over Finite Dimensional Algebras*, Proc. ACM Symp. ISSAC'97 and Research Report No. 85169, Univ. Bonn, 1997.

17. A. Chistov, and M. Karpinski. *Compexity of Satisfying Polynomial Equations over p-adics*, Preprint, Univ. Bonn, 1997.

18. W. Fernandez de la Vega, and M. Karpinski. *Polynomial Time Approximability of Dense Weighted Instances of MAX-CUT*, Research Report No. 85171-CS, Univ. Bonn, 1997.

19. A. Dessmark and A. Lingas. *On the power of nonconservative PRAM.* Proc. Symposium on Mathematical Foundations of Computer Science, September 1996, Lecture Notes in Computer Science, Springer Verlag.

20. A. Dessmark and A. Lingas, co-authors S.R. Arikati and M. Marathe. *Approximation algorithms for maximum two-dimensional pattern matching.* Proc. Combinatorial Pattern Matching, June 1996, Lecture Notes in Computer Science, Springer Verlag.

21. A. Dessmark, A. Lingas and A. Proskurowski. *Faster Algorithms for Subgraph Isomorphism of Partial k-Trees.* Proc. European Symposium on Algorithms, September 1996, Lecture Notes in Computer Science, Springer Verlag.

22. K. Diks, A. Lingas and A. Pelz. *Optimal multi-broadcasting in trees.* To appear in Proc. SIROCCO'97, July 1997, Lecture Notes in Computer Science, Springer Verlag.

23. C. Dorgerloh. *A Fast Randomized Parallel Algorithm for Finding Simple Cycles in Planar Graphs*, Research Report 85150-CS, Institut für Informatik der Universität Bonn, 1996.

24. C. Dorgerloh, J. Lüssem, M. Pilouk and J. Wirtgen. *Some Tools for Modeling and Analysis of Surfaces*, Proc. 9^{th} International Canadian Conference on Computational Geometry (1997), (to appear).

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using randomization, Research Report 85159-CS, Institut für Informatik der Universität Bonn, 1996.

26. C. Dorgerloh and J. Wirtgen.
Approximate Counting of Given Length Cycles, Research Report 85170-CS, Institut für Informatik der Universität Bonn, 1997.

27. C. Dorgerloh and J. Wirtgen.
Faster Finding of Simple Cycles in Planar Graphs on a randomized EREW-PRAM, Proc. 2^{nd} Workshop on Randomized Parallel Computing (1997), held in conjunction with IPPS'97.

28. C. Dorgerloh and J. Wirtgen.
Once again: Finding simple cycles, Research Report 85165-CS, Institut für Informatik der Universität Bonn, 1997.

29. C. Dürr and M. Santha.
A decision procedure for unitary linear quantum cellular automata, 37th IEEE Symposium on Foundations of Computer Science, pp. 37-45, (1996)

30. C. Dürr, H. Lê Thanh and M. Santha.
A decision procedure for well-formed linear quantum cellular automata, to appear in Random Structures and Algorithms.

31. Sergei Evdokimov and Ilia Pnomarenko.
On Primitive Cellular Algebras, Research Report No. 8516, Univ. Bonn, 1997.

32. Alan Frieze, Mark Jerrum and Ravi Kannan.
Learning linear transformations, Proceedings of the 37th IEEE Symposium on Foundations of Computer Science, IEEE Computer Society Press, 1996, pp. 359–368.

33. O. Garrido, S. Jarominek, A. Lingas and W. Rytter.
A simple randomized parallel algorithm for maximal f-matchings. Information Processing Letters 57 (1996), pp. 187-191.

34. O. Garrido, P. Kelsen and A. Lingas.
A simple NC algorithm for maximal independent set in a hypergraph of poly-log arboricity. Information Processing Letters 57 (1996), pp. 83-87.

35. L. Gasieniec, J. Jansson, A. Lingas and A. Östlin.
On the complexity of computing evolutionary trees. To appear in Proc. COCOON'97 , August 1997, Lecture Notes in Computer Science, Springer Verlag.

36. L. Gasieniec, M. Karpinski, W. Plandowski and W. Rytter.
Algorithms for Compressed Strings: the Finger-Print Approach, Proc. CPM'96.

37. J. von zur Gathen, M. Karpinski and I. Shparlinski.
Counting Curves and Their Projections, Computational Complexity 6 (1997), pp. 64-99.

38. Leslie Goldberg and Mark Jerrum.
Randomly sampling molecules, Proceedings of the 8th ACM-SIAM Symposium on Discrete Algorithms, 1997, pp. 183–192.

39. M. Goldmann and M. Karpinski.
Simulating Threshold Circuits by Majority Circuits, to appear in SIAM J. Computing, 1997.

40. Vivek Gore and Mark Jerrum.
The Swendsen-Wang process does not always mix rapidly, Proceedings of the 29th ACM Symposium on Theory of Computation, ACM Press, 1997, pp. 674–681.

41. Vivek Gore, Mark Jerrum, Sampath Kannan, Z. Sweedyk and Steve Mahaney.
A quasi-polynomial-time algorithm for sampling words from a context-free language, Information and Computation **134** (1997), pp. 59–74.

42. D. Grigoriev and M. Karpinski.
Randomized $\Omega(n^2)$ Lower Bound for Knapsack, Proc. 29th ACM STOC (1997), pp. 76 – 85.

43. D. Grigoriev and M. Karpinski.
Computing Additive Complexity of Algebraic Circuits with Root Extracting, to appear in SIAM J. Comput., 1997.

44. D. Grigoriev, M. Karpinski, F. Meyer auf der Heide and Roman Smolensky.
A Lower Bound for Randomized Algebraic Decision Trees, to appear in Computational Complexity, 1997.

45. D. Grigoriev, M. Karpinski and A. M. Odlyzko.
Short Proofs for Nondivisibility of Sparse Polynomials under the Extended Riemann Hypothesis, Fundamenta Informaticae 28 (1996), pp. 297 - 301.

46. D. Grigoriev, M. Karpinski and Roman Smolensky.
Randomizationand the computational Power of Analytic and Algebraic Decision Trees, to appear in Computational Complexity, 1997.

47. D. Grigoriev, M. Karpinski and A. Yao.
An Exponential Lower Bound on the Size of Algebraic Decision Trees for MAX, to appear in Computer Complexity, 1997.

48. J. Gudmundsson and C. Levcopoulos.
Approximation Algorithms for Covering Polygons with Squares and Similar Problems. Proc. RANDOM'97 ("Approximation and Randomized Techniques in Computer Science"), Lecture Notes in Computer Science, Springer Verlag, July 1997.

49. J. Gudmundsson and C. Levcopoulos.
A Linear-Time Heuristic for Minimum Rectangular Covering (with J. Gudmundsson). To appear in Proc. FCT'97 (Foundations of Computation Theory), LNCS, Springer Verlag.

50. J. Gudmundsson and C. Levcopoulos.
Close Approximations of Minimum Rectangular Coverings . Proc. 16th Conference on Foundations of Software Technology and Theoretical Computer Science (FST-TCS'96), Lecture Notes in Computer Science No 1180, Springer Verlag, pp. 135-146, December 1996.

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Concerning the Time Bounds of Existing Shortest Shortest Watchman Route. Proc. 11th International Symposium on Fundamentals in Computation Theory, FCT'97, Springer Verlag, Lecture Notes in Computer Science 1279, pp. 210–221, 1997.

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Sequential and Parallel Subquadratic Work Algorithms for Constructing Approximately Optimal Binary Search Trees Proc. ACM-SIAM SODA (1996).

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Short Proofs for Nondivisibility of Sparse Polynomials under the Extended Rieman Hypothesis, Fundamenta Informaticae 28 (1996), pp. 297-301.

54. M. Karpinski.
On a Sublinear Time Parallel Construction of Optimal Binary Search Tree, to appear in IPL.

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On the Complexity of Pattern Matching for Highly Compressed Two-Dimensional Texts, Proc. CPM '97.

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Polynomial Time Approximation Schemes for Some Dense Instances of NP-Hard Optimization Problems, Proc. 1st Symp. on Randomization and Approximation Techninques in Computer Science, RANDOM'97 (Invited Paper) Bologna, Lecture Notes in Computer Science Vol. 1269, Springer Verlag, pp. 1 - 14.

57. M. Karpinski and A. Macintyre.
Approximating the Volume of General Pfaffian Bodies, Lecture Notes in Computer Science Vol. 1261 (Special Volume in Honor of A. Ehrenfeucht), Springer Verlag, 1997.

58. M. Karpinski and A. Macintyre.
o-Minimal Expansions of the Real Field: A Characterization, and an Application to Pfaffian Closure, Research Report No. 85173-CS, Univ. Bonn, 1997; submitted to Trans. of AMS.

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Approximating Volumes and Integrals in o-Minimal and p-Minimal Theories, Research Report No. 85174-CS, Univ. Bonn, 1997; submitted to Discrete Comput. Geometry.

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Polynomial Bounds for VC Dimension of Sigmoidal and General Pfaffian Neural Networks, J. Comput. Syst. Sciences 54 (1997), pp. 169 - 176.

61. M. Karpinski, A. von der Poorten and I. Shparlinski.
Zero Testing of p-adic and Modular Polynomials, Research Report No. 85175-CS, Univ. Bonn; submitted to Theoretical Computer Science, 1997.

62. M. Karpinski, and W. Rytter.
Or a Sublinear Time Parallel Construction of Optimal Binary Search Trees, to appear in IPL, 1997.

63. M. Karpinski, W. Rytter, and A. Shinohara.
An Efficient Pattern-Matching Algorithm for Strings with Short Descriptions, Nordic Journal of Computing 4 (1997), pp. 172 - 186.

64. M. Karpinski, and I. Shparlinski.
On Some Approximation Problems Concerning Sparse Polynomials over Finite Fields, Theoretical Computer Science 157 (1996), pp. 259 - 266.

65. M. Karpinski, and R. Verbeek.
On Randomized versus Deterministic Computation, Theoretical Computer Science 154 (1996), pp. 23 - 39.

66. M. Karpinski and J. Wirtgen.
NP-Hardness of the Bandwidth Problem on Dense Graphs Research Report No. 85176-CS, Univ. Bonn, 1997.

67. M. Karpinski, J. Wirtgen, and A. Zelikovsky.
An Approximation Algorithm for the Bandwidth Problem on Dense Graphs, ECCC Technical Report TR 97-017. Proc. Workshop on Randomized Algorithms in Sequential, Parallel, and Distributed Computing, RALCOM'97, 1997.

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New Approximation Algorithms for the Steiner Tree Problems, J. of Combinatorial Optimization 1 (1997), pp. 47 - 65.

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Approximating Dense Cases of Covering Problems, Proc. DIMACS Workshop on Network Design: Connectivity and Facilities Location, Princeton, 1997.

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A Linear-time Randomized Algorithm for the Bounded Voronoi Diagram of a Simple Polygon. In the special SCG'93 issue of International Journal

of Computational Geometry and Applications Vol. 6, No. 3 (1996), pp. 263-278.

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Maximum packing for biconnected outerplanar graphs. Proc. TAP-SOFT'97 (CAAP) , April 1997, Lecture Notes in Computer Science, Springer Verlag.

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Optimal Algorithms for Complete Linkage Clustering in d Dimensions. To appear in Proc. MFCS'97 (Mathematical Foundations of Computer Science), LNCS, Springer Verlag. Also selected to the special MFCS issue of Theoretical Computer Science.

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A Near-Optimal Heuristic for Minimum Weight Triangulation of Convex Polygons. Proc. ACM-SIAM Symposium on Discrete Algorithms (SODA'97), pp. 518-527, New Orleans, Louisiana, January 1997.

74. D.Krznaric and C. Levcopoulos.
Quasi-Greedy Triangulations Approximating the Minimum Weight Triangulation (with). Proc. of 7th ACM-SIAM Symposium on Discrete Algorithms (SODA '96), 1996.

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A Fast Heuristic for Approximating the Minimum Weight Triangulation. Proc. SWAT'96, Lecture Notes in Computer Science No 1097, pp. 296-308, Springer Verlag, 1996.

76. D. Krznaric and C. Levcopoulos.
Fast Algorithms for Complete Link Clustering. Accepted for publication in Discrete and Computational Geometry.

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A Linear-Time Approximation Scheme for Minimum Weight Triangulation of Convex Polygons . Accepted for publication in Algorithmica.

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Tight Lower Bounds for Minimum Weight Triangulation Heuristics. Information Processing Letters Vol. 57, pp. 129-135, 1996.

79. D.Krznaric, C. Levcopoulos and B. Nilsson.
Minimum Spanning Trees in d Dimensions. To appear in Proc. ESA'97 (European Symposium on Algorithms), LNCS, Springer Verlag.

80. D. Krznaric and O. Petersson.
Exploiting few inversions when sorting: sequential and parallel algorithms. Theoretical Computer Science, Vol. 163, pp. 211-238, 1996.

81. C. Levcopoulos, Andrzej Lingas and R. Storlind, co-author B. Aspvall.
On 2-QBF Satisfiability in Parallel. Information Processing Letters 57 (1996), pp. 89-93.

82. C. Levcopoulos and A. Östlin.
A linear-time heuristic for minimum length rectangulation of polygons. Proc. SWAT'96, Lecture Notes in Computer Science No 1097, pp. 271-283, Springer Verlag, 1996.

83. A. Lingas.
Maximum Tree Packing in time $O(n^{2.5})$. To appear in the special COCOON'95 issue of Theoretical Computer Science, 1996.

84. A. Lingas and A. Maheshwari.
A Simple Parallel Algorithm for Reporting Paths in a Tree. Parallel Processing Letters Vol. 7 No. 1 (1997), pp. 3-11.

85. A. Lingas and V. Soltan.
Minimum Convex Partition of a Polygon with Holes by Cuts in Given Directions. Proc. ISAAC'96, December 1996, Lecture Notes in Computer Science, Springer Verlag, pp. 315-325.

86. M. Santha and S. Tan.
Verifying the determinant in parallel, to appear in Computational Complexity.

87. D. Welsh, J.E. Bartels and J. Mount.
The polytope of win vectors. Annals of Combinatorics **1** (1997) 1-15.

88. D. Welsh.
Approximate Counting. London Mathematical Society Lecture Notes, **187** (1997) 286-323.

89. J. Wirtgen.
Die Berechungskomplexität von Approximationsproblemen auf diskreten Strukturen, Diplomarbeit, Institut für Informatik der Universität Bonn, 1996.

Marek Karpinski (Bonn)

The research within the Project RAND-REC was carried out in the Research Areas (1) - (4) with the particular results and publications as follows.

(1) Design of Efficient Randomized and Approximative Algorithms

Papers:
[1], [2], [3], [12], [14], [16], [17], [18], [36], [39], [42], [43], [44], [45], [46], [47], [56], [61], [62], [63], [64], [65], [67], [68], [69]

(2) Effiziente Parallel Algorithms

Papers:

[39], [43], [47], [62], [63]

(3) VC Dimension of Sigmoidal and Pfaffian Neural Networks and Volume Approximation

Papers:
[57], [58], [59], [60]

(4) Derandomizing Algorithms and Probabilistic Method

Papers:
[18], [46], [56], [67], [69]

Books

M. Karpinski, and W. Rytter,
Fast Parallel Algorithms for Graph Matching Problems, Monograph, Oxford University Press, 1997, pp. 1 - 225.

Short Research Summary

The main results were obtained in the design of polynomial time approximation schemes for a number of *NP*-hard instances of combinatorial optimization problems as well in proving first randomized lower bounds for problems like Integer Programming and Knapsack. The other major progress was made in proving first randomized lower bounds for read-once branching programs.

W. Fernandez de la Vega (Paris)

During the period 96-97 I have published 3 papers:

[1] gives a randomized polynomial time approximation scheme for MAX-CUT in dense graphs. The content of this paper has been well covered by earlier reports.

[2] gives the final solution, after partial results of Frieze and Jackson, Suen, Kucera and Rödl, of a problem posed by Erdös et Palka more than ten years ago, concerning the evaluation of the maximum number of vertices of an induced tree in a random graph with fixed average degree.

In [3], M. Lamari and I study several random versions of the module allocation problem. In this problem, we are given tasks which must be allocated to processors without precedence constrains, and seeking to minimize a sum of execution costs and communication costs. We have obtained asymptotically optimum allocation algorithms in the case of a dense communication graph and an algorithm with guaranteed approximation ratio when the communication graph has a fixed degree

International Journals

- W. Fernandez de la Vega.
  MAX-CUT has an Approximation Scheme in Dense Graphs, Random Structures and Algorithms, 8 (1996) 187-198.
- W. Fernandez de la Vega.
  The Largest Tree in a Sparse Random Graph, Random Structures and Algorithms, 9 (1997) 93-97..

International Conferences

- W. Fernandez de la Vega.
  The Module Allocation Problem: An Average Case Analysis, (with M. Lamari) In Parallel Algorithms for Irregularly Structured Problems, IR-REGULAR 96, Santa Barbara, CA, USA, August 1996, LNCS 1117, 307-312.

4 Research Reports

Annual Report on RAND-REC
Edinburgh Site, 1996–97

Collaborative projects

In a previous report I mentioned some collaborative work, with Alan Frieze and Ravi Kannan, that I began during a RAND-REC funded visit to CMU, Pittsburgh, PA, in June 1994. At the time, the results were too speculative to include in the report. Since then, we have worked out the ideas in some detail, and a preliminary version has appeared as a conference paper. An instance of the computational goal we have in mind is to learn (i.e., inductively infer) an arbitrarily oriented cube in n-space, given *uniformly* distributed sample points from it; more generally, we want to learn, in polynomial time, a linear (affine) transformation of a product distribution.

Suppose x is a (hidden) n-vector whose coordinates are mutually independent random variables (r.v's) with unknown (possibly different) probability distributions, A is an unknown nonsingular $n \times n$ matrix, and b an unknown vector. Our goal is to compute approximations to A and b (modulo essential ambiguities), given polynomially many samples of the observed, linearly transformed r.v. $y = Ax + b$. If the components of x are independent r.v's uniformly distributed on $[-1, 1]$, then the goal can be interpreted geometrically as learning a parallelepiped given uniformly distributed samples from it.

Using standard linear algebra, one can learn parallelepipeds—or, more generally, linear transformations of product distributions—up to rotations. This task only involves analyzing the matrix of second moments of the observed variables y. The central problem is determining the rotation. We show that the maxima and minima of the fourth moment function give us the columns of A, provided the components of x are not "exceptional"; we then show that these maxima and minima can be found approximately by a nonlinear (fourth degree) optimization algorithm. The exceptional components are handled by perturbing the observed samples y in a controlled manner. Some tidying of the section on exceptional components needs to be undertaken before the journal version can be completed.

5 Research Stays

F. De La Vega (Paris-Orsay)

- International Computer Science Institute, University of California at Berkeley, ICSI, Sept. 1-8, 1996.
- Department of Computer Science of the University of Bonn, April 1997 (one week)

Both visits where devoted to joint work with M. Karpinski on the the extension for MAX-CUT of the concept of density to the case where the data is a weighted graph, i.e. we were looking for a characterisation of the polynomial time approximable weighted instances of MAX-CUT. We succeeded, after some effort, to obtain a nearly complete such characterisation (see [?] (to be filled)) and our work will be presented at the forthcoming RAND2 workshop in Leeds. The starting idea of this work is rather simple: we impose the condition that the standard sampling problem (evaluate the mean of a distribution from a sample) be solvable for each fixed accuracy with *uniformly* bounded sample size for each distribution within the given set of instances. It was not hard to show that there is a PTAS for any set of instances of MAX-CUT satisfying this condition. Unexpected problems occured when we tried to show that this condition is necessary. Our main tool there was to reduce (certain) sets of weighted instances of MAX-CUT to instances of 0,1 MAX-CUT. (In fact we use MAX-BISECTION as an intermediate step.) We had thus to study the approximability of MAX-BISECTION on sparse 0,1 instances and were only able to show, broadly speaking, that unapproximability obtains for sets of instances where the density does not vanish extravagantly fast.

Let me mention that our work covers also other problems than MAX-CUT, such as MAX-2SAT or MAXIMUM ACYCLIC SUBGRAPH.

6 Conferences and Workshops

M. Karpinski (Bonn)

- 23th ICALP'96, Paderborn, July 8-12, 1996.
- ICSI, Berkeley, and Princeton University, Aug. 28 - Oct. 12, 1996.
- Workshop on "The Vapnik-Chervonenskis Dimension", Edinburgh, September 9-13, 1996.
- Workshop on "Computational Complexity", Oberwolfach, November 10-16, 1996.

- Workshop on "Finite Fields: Theory and Computation", Oberwolfach, January 19-25, 1997.
- Workshop on "Computer Aided Design and Test Decision Diagrams", Dagstuhl, January 27-31, 1997.
- ICSI, Berkeley, Maquarie University, Sydney, February 25 - April 3, 1997.
- ACM STOC '97, El Paso, May 4-6, 1997.

Mark Jerrum (Edinburgh)

In the current year, I used RAND-REC funding for two conference trips:

- The first was to attend and present a paper (joint work with Leslie Goldberg, University of Warwick) at the ACM-SIAM Symposium on Discrete Algorithms (SODA) in New Orleans, LA (one of a handful of top-rate international conferences in the area of algorithms and computational complexity). The "molecules" of the title of the paper are just unlabelled multigraphs with specified degree sequences (i.e., geometrical concerns are ignored). The paper presents the first polynomial-time algorithm for sampling molecules from the uniform distribution, provided only that the maximum degree of any vertex is bounded.

  Aside from the obvious importance of one of the authors being present at the symposium to present the paper, the trip provided a valuable opportunity for me to catch up with recent developments in the design and analysis of algorithms, randomised or otherwise. En route to New Orleans, I called at Georgia Institute of Technology, Atlanta, and participated in research discussions with Neil Calkin and Dana Randall.

- The second was to attend and present a paper at the ACM Symposium on Theory of Computing in El Paso, TX. In this paper, Vivek Gore (a member of the RAND team at Edinburgh) and I considered the "Swendsen-Wang" process, which provides one possible dynamics (an ergodic Markov chain) for the Q-state Potts model in statistical physics. Computer simulations of this process are widely used to estimate the expectations of various observables (random variables) of a Potts system in the equilibrium (or Gibbs) distribution. The legitimacy of such simulations depends on the rate of convergence of the process to equilibrium, often known as the mixing rate.

  Empirical observations suggest that the Swendsen-Wang process mixes rapidly in many instances of practical interest although no proofs of rapid mixing are known even for special cases. We show that there are occasions on which the Swendsen-Wang process requires exponential time (in the size of the system) to approach equilibrium. This turns out to be related to the phenomenon of first-order phase transitions in Potts systems, which is a major area of research in statistical physics. We conjecture that the impact of first order phase transitions on mixing rate will justify further study.

Mark Jerrum, August 1997.

Arne Andersson and Kurt Swansson (Lund)

- attended FOCS'96 where Arne presented his papers *Faster Deterministic sorting and Searching in Linear Space* and *Static dictionaries on* ac^0 *rams: Query time* $\theta(\sqrt{\log n / \log\log n})$ *is necessary and sufficient* Oct. 12-14, 1996.

Drago Krznaric and Christos Levcopoulos (Lund)

- attended SODA'97 in New Orleans where they presented their paper *A Near-Optimal Heuristic for Minimum Weight Triangulation of Convex Polygons*, January 1997.

D. Welsh (Oxford)

In my visit to Princeton in March 23-27, 1997 I collaborated with Professor Paul Seymour and his students. We worked mainly on a specific version of the matroid basis conjecture namely that for any partition of the basis graph the number of cross edges was at least as big as the minimum of the two vertex sets. This was new to Seymour's group but it was a salutary experience to see how little progress we made. Even proving that it is preserved under direct sums seems highly nontrivial. However this has now been done by my student Criel Merino-Lopez working with Paco Santos from Santander. I also gave a seminar to the Princeton department - title and abstract below.

Random Colourings, Subgraphs and Lattice Points
Abstract

I shall discuss various problems both computational and structural related to problems arising in the generation of random subgraphs or colourings of a given graph. These are related to generating lattice points in polymatroids. Some of the work is joint with E. Bartels and J. Mount, other parts with A. Denise and M. Vasconcellos.

In my visit to Rutgers I spent most of the time working on problems of approximating the partition function of the q-state Potts model for q ≥ 3. I also was one of the principal speakers at the workshop on Statistical Physics Methods in Discrete Probability, Combinatorics and Theoretical Computer Science organised by Jennifer Chaye and Dana Randall which was held at the Institute of Advanced Study Princeton and the DIMACS centre at Rutgers University. I was asked to give a survey lecture with title Computational Complexity of the Tutte Polynomial. This workshop was one of the best I have ever been to. Almost every talk was excellent. There was genuine interaction between physicists and computer science oriented mathematicians and I got a much better insight into how the physicist views problems which are common to both disciplines.

Computational Complexity of the Tutte polynomial
DIMACS, Thursday 27 March 1997
Abstract

I will first relate the Tutte polynomial to more well known topics in statistical physics such as the percolation (reliability) probability the Ising and q-state Potts models and the random cluster model, and a recent connection with sandpiles and chip firing due to my student Merino-Lopez. I then give a complete characterisation of which points are hard and which are easy with respect to deterministic computation. The second half of the lecture surveys the current state of randomised approximation schemes. In particular, it will describe new relationships with the Ehrhart polynomial which counts lattice points in convex polytopes and goes some way to explaining why these counting problems are so hard.

M. Santha (Paris-Orsay)

The Thirty-seventh Annual Symposium on Foundations of Computer Science (FOCS), sponsored by the IEEE Computer Society Technical Committee on Mathematical Foundations of Computing, was held in Burlington, Vermont on October 14-16, 1996. The symposium, as usual, was of quite high level. I have presented a joint paper with my student Christophe Dürr: "A decision procedure for unitary linear quantum cellular automata." I include here the abstract of the paper.

Abstract:
Linear quantum cellular automata were introduced recently as one of the models of quantum computing. A basic postulate of quantum mechanics imposes a strong constraint on any quantum machine: it has to be *unitary*, that is its time evolution operator has to be a unitary transformation. In this paper we give an efficient algorithm to decide if a linear quantum cellular automaton is unitary. The complexity of the algorithm is $O(n^{\frac{3r-1}{r+1}}) = O(n^3)$ in the algebraic computational model if the automaton has a continuous neighborhood of size r.

F. De La Vega (Paris-Orsay)

- Communication at the conference IRREGULAR 96 on Parallel Algorithms for Irregularly Structured Problems, Santa Barbara, CA, USA, August 1996.
- ICSI, Berkeley, March 8-14, 1997.

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