Philip N. Klein
Professor
Department of Computer Science
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Education

- Ph.D. in Computer Science, Massachusetts Institute of Technology, 1988. Dissertation title: *Efficient Parallel Algorithms for Planar, Chordal, and Interval Graphs*, supervised by Professor David Shmoys. Minor in Numerical Analysis.
- S.M. in Computer Science, Massachusetts Institute of Technology, 1986. Thesis title: *An Efficient Parallel Algorithm for Planarity*, supervised by Professor David Shmoys.
- A.B., *summa cum laude* in Applied Mathematics, Harvard College, 1984. Thesis title: *Parallel Recognition of Context-Free Languages*, supervised by Professor John Reif.

Professional Appointments

- 2000—: Professor, Brown University
- 2008: Visiting Scientist, MIT CSAIL
- 2007—: Research Affiliate, MIT CSAIL
- 1994–2000: Associate Professor, Brown University
- 1989–1994: Assistant Professor, Brown University
- 1993: Visiting Scientist, Princeton University
- 1992-93: Visiting Scholar, MIT Mathematics Department
- 1992-94: Consultant, NEC Research Institute
- 1990: Consultant, Xerox Palo Alto Research Center
- 1988-89: Postdoctoral fellow, Harvard University
- Summer 1987: AT&T Bell Labs, visitor

Publications

Conference Articles

- "Node-weighted Steiner tree and group Steiner tree in planar graphs," Erik D. Demaine, MohammadTaghi Hajiaghayi and Philip Klein, *Proceedings of the 36th International Colloquium on Automata, Languages and Programming*, (2009).
- "Shortest paths in directed planar graphs with negative lengths: a linear-space $O(n \log^2 n)$-time algorithm," with Shay Mozes and Oren Weimann, *Proceedings of the 20th Annual ACM-SIAM Symposium on Discrete Algorithms* (2009), pp. 236-245.
- "The two-edge connectivity survivable network problem in planar graphs," with Glencora Borradaile, *Proceedings of the 35th International Conference on Automata, Languages, and Programming* (2008), pp. 485-501.
- "A polynomial-time approximation scheme for Euclidean Steiner forest," with Glencora Borradaile and Claire Mathieu, *Proceedings of the 49th Annual IEEE Symposium on Foundations of Computer Science* (2008), pp. 115-124.
- "Steiner tree in planar graphs: An $O(n \log n)$ approximation scheme with singly-exponential dependence on epsilon," with Glencora Borradaile and Claire Mathieu, *Proceedings of the 10th International Workshop on Algorithms and Data Structures* (2007), pp. 275-286.
- "A polynomial-time approximation scheme for Steiner tree in planar graphs," with Glencora Borradaile and Claire Kenyon-Mathieu, *Proceedings of the 18th Annual ACM-SIAM Symposium*

on Discrete Algorithms (2007), pp. 1285–1294.

- "A subset spanner for planar graphs, with application to subset TSP", *Proceedings of the 38th Annual ACM Symposium on Theory of Computing* (2006), pp. 749–756.
- "An $O(n \log n)$ algorithm for maximum st-flow in a directed planar graph," with Glencora Borradaile, *Proceedings of the 17th Annual ACM-SIAM Symposium on Discrete Algorithms* (2006), pp. 524–533.
- "A linear-time approximation scheme for TSP for planar weighted graphs", *Proceedings of the 46th Annual IEEE Symposium on Foundations of Computer Science* (2005), pp. 647–656.
- "Multiple-source shortest paths in planar graphs," *Proceedings of the 16th Annual ACM-SIAM Symposium on Discrete Algorithms* (2005), pp. 146–155.
- "Shock-based Indexing into Large Shape Databases," with Thomas Sebastian and Benjamin B. Kimia, *Proceedings of the 7th European Conference on Computer Vision, Volume III* (2002), pp. 731–746.
- "Preprocessing an undirected planar network to enable fast approximate distance queries," *Proceedings of the 13th Annual ACM-SIAM Symposium on Discrete Algorithms* (2002), pp. 820–827.
- "Recognition of shapes by editing shock graphs," with Thomas B. Sebastian and Benjamin B. Kimia, *Proceedings of the 8th International Conference on Computer Vision* (2001), pp. 755-762.
- "Alignment-based recognition of shape outlines," with Thomas B. Sebastian and Benjamin B. Kimia, *International Workshop on Visual Form* (2001), pp. 606-618.
- "Shape matching using edit-distance: an implementation,", with Thomas B. Sebastian and Benjamin B. Kimia, *Proceedings of the 12th Annual ACM-SIAM Symposium on Discrete Algorithms*(2001), pp. 781–790.
- "A tree-edit-distance algorithm for comparing simple, closed shapes," with Srikanta Tirthapura, Daniel Sharvit, and Benjamin Kimia, *Proceedings of the 11th Annual ACM-SIAM Symposium on Discrete Algorithms* (2000), pp. 696–704.
- "Finding the closest lattice vector when it's unusually close," *Proceedings of the 11th Annual ACM-SIAM Symposium on Discrete Algorithms* (2000), pp. 937–941.
- "Using router stamping to identify the source of IP packets," with Thomas Doeppner and Andrew Koyfman, *Proceedings of the 7th ACM Conference on Computer and Communication Security* (2000), pp. 184-189.
- "Constructing 2D curve atlases," with Thomas Sebastian, Joseph J. Crisco, and Benjamin Kimia, *Proceedings of the IEEE Workshop on Mathematical Methods in Biomedical Image Analysis* (2000), pp. 70–77.
- "On the number of iterations for Dantzig-Wolfe optimization and packing-covering approximation algorithms," with Neal E. Young, *Proceedings of the 7th International Conference on Integer Programming and Combinatorial Optimization* (1999), pp. 320-327.
- "Indexing based on edit-distance matching of shape graphs," with Srikanta Tirtapura, Daniel Sharvit, and Benjamin Kimia, *Proceedings of the SPIE International Symposium on Voice, Video, and Data Communications* (1998), pp. 25–36.
- "Space-efficient approximation algorithms for MAXCUT and COLORING semidefinite programs," with Hsueh-I Lu, *Proceedings, of the 9th International Symposium on Algorithms and Computation* Lecture Notes in Computer Science 1533, Springer-Verlag, pp. 387-396. (1998).
- "Computing the edit distance between unrooted ordered trees," *Proceedings of the 6th European Symposium on Algorithms* (1998), pp. 91–102.
- "A polynomial-time approximation scheme for weighted planar graph TSP," with Sanjeev Arora, Michelangelo Grigni, David Karger and Andrzej Woloszyn, *Proceedings of the 9th Annual ACM-SIAM Symposium on Discrete Algorithms* (1998), pp. 33–41.
- "Race-condition detection in parallel computation with semaphores," with Hsueh-I Lu and Robert H. B. Netzer, *Proceedings of the 4th Annual European Symposium on Algorithms* (1996).
- "Efficient approximation algorithms for semidefinite programs arising from MAXCUT and COL-

ORING," with Hsueh-I Lu, *Proceedings of the 28th ACM Symposium on Theory of Computing* (1996), pp. 338–347.

- "Finding minimum spanning forests in logarithmic time and linear work using random sampling," with Richard Cole and Robert E. Tarjan, *Proceedings of the 8th ACM Symposium on Parallel Algorithms and Architectures* (1996), pp. 243–250.
- "A linear-work parallel algorithm for finding a minimum spanning tree," with Richard Cole and Robert E. Tarjan, *Proceedings of the 6th ACM Symposium on Parallel Algorithms and Architectures* (1994), pp. 11–15.
- "A linear-processor, polylog-time algorithm for shortest paths in planar graphs," with Sairam Subramanian, *Proceedings of the 34th IEEE Symposium on Foundations of Computer Science* (1993), pp. 259–270.
- "Detecting race conditions in parallel programs that use one semaphore," with Hsueh-I Lu and Robert H. B. Netzer, *Proceedings of the 3rd Workshop on Algorithms and Data Structures* (1993), pp. 471–482.
- "Excluded minors, network decomposition, and multicommodity flow," with Serge Plotkin and Satish Rao, *Proceedings of the 25th ACM Symposium on Theory of Computing* (1993), pp. 682–690.
- "When cycles collapse: a general approximation technique for constrained two-connectivity problems," with R. Ravi, *Proceedings of the 3rd Symposium on Integer Programming and Combinatorial Optimization* (1993) pp. 39–55.
- "On Gazit and Miller's parallel algorithm for planar separators: achieving greater efficiency through random sampling," *Proceedings of the 5th ACM Symposium on Parallel Algorithms and Architectures* (1993), pp. 43–49.
- "Approximation through local optimality: designing networks with small degree," with R. Ravi and Balaji Raghavachari, *Proceedings of the Twelfth Annual Conference on Foundations of Software Technology and Theoretical Computer Science*, published as *Lecture Notes in Computer Science 652*, edited by R. Shyamasundar, Springer-Verlag, New York (1992), pp. 279–290.
- "Ordering problems approximated: register sufficiency, single-processor scheduling and interval graph completion," with Ajit Agrawal and R. Ravi, *Proceedings of the 18th International Conference on Automata, Languages, and Programming* (1991), published as *Lecture Notes in Computer Science*, vol. 510, pp. 751-762.

Refereed Journal Articles

- "Shortest paths in directed planar graphs with negative lengths: a linear-space $O(n \log^2 n)$-time algorithm," with Shay Mozes and Oren Weimann, *ACM Transactions on Algorithms*, to appear (Special Issue devoted to Selected Papers from SODA 2009).
- "A polynomial-time approximation scheme for Steiner tree in planar graphs," with Glencora Borradaile and Claire Mathieu, *ACM Transactions on Algorithms* 5 (2009), Article 31 (Special Issue devoted to Selected Papers from SODA 2007).
- "An $O(n \log n)$ algorithm for maximum st-flow in a directed planar graph," with Glencora Borradaile, *Journal of the ACM* 56 (2009).
- "A linear-time approximation scheme for TSP in undirected planar graphs with edge-weights," *SIAM Journal on Computing* 37 (2008), pp. 1926-1952 (Special Issue devoted to Selected Papers from FOCS 2005).
- "Approximation algorithms for finding low-degree subgraphs," with Radha Krishnan, Balaji Raghavachari, and R. Ravi *Networks* 44 (2004), pp. 203–215.
- "Rounding algorithms for a geometric embedding relaxation of minimum multiway cut," with David R. Karger, Clifford Stein, Mikkel Thorup, and Neal E. Young, *Mathematics of Operations Research* 29 (2004), pp. 436–460. Preliminary version appeared in *Proceedings, ACM Symposium on Theory of Computing* (1999), pp. 668–678.
- "Recognition of shapes by editing their shock graphs," with Thomas Sebastian and Benjamin

Kimia, *IEEE Transactions on Pattern Matching and Machine Intelligence* 26 (2004), pp. 550–571.

- "On aligning curves," with Thomas Sebastian and Benjamin Kimia, *IEEE Transactions on Pattern Matching and Machine Intelligence* 25 (2003), pp. 116–125.
- "Detecting race conditions in parallel programs that use semaphores," with Hsueh-I Lu and R. H.B. Netzer, *Algorithmica* 35 (2003), pp. 321-345 .
- "A fully dynamic approximation scheme for shortest paths in planar graphs," with Sairam Subramanian, *Algorithmica* 23 (1998), pp. 235-249. Preliminary version appeared in *Proceedings, Workshop on Algorithms and Data Structures* (1993), pp. 442-451.
- "Approximation algorithms for Steiner and directed multicuts," with Serge Plotkin, Satish Rao, and Éva Tardos, *Journal of Algorithms* 22 (1997), pp. 241-269.
- "A randomized parallel algorithm for single-source shortest paths," with Sairam Subramanian, *Journal of Algorithms* 25 (1997), pp. 205-220. Preliminary version appeared as "A parallel randomized approximation scheme for shortest paths," *Proceedings, 24th Symposium on Theory of Computing* (1992), pp. 750-758.
- "Faster shortest-path algorithms for planar graphs," with Satish Rao, Monika Rauch Henzinger, and Sairam Subramanian, *Journal of Computer and System Sciences* 55 (Special Issue on Selected Papers from 1994 STOC) (1997), pp. 3-23. Preliminary version appeared in *Proceedings, 26th Symposium on Theory of Computing* (1994), pp. 27–37.
- "Efficient parallel algorithms for chordal graphs," *SIAM J. Comput. 25* (1996), pp. 797-827. Preliminary version appeared in *Proceedings, 29th Annual IEEE Symposium on Foundations of Computer Science* (1988), pp. 150-161.
- "A randomized linear-time algorithm for finding minimum spanning trees," with David Karger and Robert E. Tarjan, *Journal of the ACM* 42 (1995), pp. 321-328. Preliminary version appeared in *Proceedings, 26th Symposium on Theory of Computing* (1994), pp. 9–15.
- "A nearly best-possible approximation algorithm for node-weighted Steiner trees," with R. Ravi, *Journal of Algorithms* 19 (1995), pp. 104-115. Preliminary version appeared in *Proceedings, 3rd Symposium on Integer Programming and Combinatorial Optimization* (1993), pp. 323-332.
- "When trees collide: An approximation algorithm for the generalized Steiner problem on networks," with Ajit Agrawal and R. Ravi, *SIAM J. Comput.* 24 (1995), pp. 440-456. Preliminary version appeared in *Proceedings, 23nd ACM Symposium on Theory of Computing* (1991), pp. 134-144.
- "An approximate max-flow min-cut relation for undirected multicommodity flow, with applications," with Satish Rao, Ajit Agrawal, and R. Ravi, *Combinatorica 15* (1995), pp. 187-202. Preliminary version appeared as part of "Approximation through multicommodity flow," *Proceedings, 31st Annual Symposium on Foundations of Computer Science* (1990), pp. 726-737.
- "Faster approximation algorithms for the unit capacity concurrent flow problem with applications to routing and finding sparse cuts," with Serge Plotkin, Clifford Stein, and Éva Tardos, *SIAM J. Comput. 23* (1994), pp. 466-487. A preliminary version appeared as "Leighton-Rao might be practical: faster approximation algorithms for concurrent flow with uniform capacities," with Clifford Stein and Eva Tardos, *Proceedings, 22nd ACM Symposium on Theory of Computing* (1990), pp. 310-321.
- "A data structure for bicategories, with application to speeding up an approximation algorithm," *Information Processing Letters 52* (1994), pp. 303-307.
- "Towards overcoming the transitive-closure bottleneck: efficient parallel algorithms for planar digraphs," with Ming-Yang Kao, *Journal of Computer and System Sciences 47* (Special Issue on Selected Papers from 22nd STOC) (1993), pp. 459-500. Preliminary version appeared in *Proceedings, 22nd ACM Symposium on Theory of Computing* (1990), pp. 181-192.
- "Parallelism, preprocessing, and reachability: a hybrid algorithm for directed graphs," *Journal of Algorithms 14* (1993), pp. 331-343. Preliminary version appeared in Proceedings of the AMS-IMS-SIAM Joint Summer Research Conference on Graphs and Algorithms (1987).
- "The lattice structure of flow in planar graphs," with Samir Khuller and Joseph Naor, *SIAM*

Journal on Discrete Mathematics 6 (1993), pp. 477-490.

- "A parallel algorithm for approximating the minimum cycle cover," with Clifford Stein, *Algorithmica 9* (1993), pp. 23-31.
- "On the time-space complexity of reachability queries for preprocessed graphs," with Lisa Hellerstein and Robert Wilber, *Information Processing Letters 35* (1990), pp. 261-267.
- "A parallel algorithm for eliminating cycles in undirected graphs," with Clifford Stein, *Information Processing Letters 34* (1990), pp. 307-312.
- "An efficient parallel algorithm for planarity," with John H. Reif, *Journal of Computer and System Sciences* (1988), pp. 190-246 (Special Issue on Selected Papers from 27th FOCS). A preliminary version appeared in *Proceedings, 27th Annual IEEE Symposium on Foundations of Computer Science* (1986), pp. 465-477.
- "Parallel time $O(\log n)$ acceptance of deterministic CFLs on an exclusive-write P-RAM," with John H. Reif, *SIAM J. Comput.* 17 (1988), pp. 463-485.

Chapters in Books

- "Approximation algorithms for NP-hard optimization problems," with Neal Young, Ch. 34 of *CRC Handbook on Algorithms and Theory of Computation*, CRC Press (1998).
- "Parallel algorithms for chordal graphs," *Synthesis of Parallel Algorithms*, edited by John H. Reif, Morgan-Kaufman (1993), pp. 341-407.
- "Approximating concurrent flow with uniform demands and capacities: an implementation," with James Borger and Sarah Kang, *Network Flows and Matching: First DIMACS Implementation Challenge*, edited by D. S. Johnson and C. C. McGeoch, vol. 12 of DIMACS Series in Discrete Mathematics and Theoretical Computer Science, American Mathematical Society (1993), pp. 371–381.
- "Cutting down on fill using nested dissection: provably good elimination orderings," with Ajit Agrawal and R. Ravi, *Graph Theory and Sparse Matrix Computation*, edited by A. George, J. Gilbert, and J. W. H. Liu, volume 56 in the *IMA Volumes in Mathematics and Its Applications*, Springer-Verlag (1993), pp. 31-55. Preliminary version appeared as part of "Approximation through multicommodity flow," with Ajit Agrawal, R. Ravi, and Satish Rao, *Proceedings, 31st Annual Symposium on Foundations of Computer Science* (1990), pp. 726-737.

Ph.D. students

Former

Glencora Borradaile, 2007
Hsueh-I Lu, 1996
Sairam Subramanian, 1994
R. Ravi, 1993
Ajit Agrawal, 1991

Current

Shay Mozes