

# David Paul Williamson

School of Operations Research and Industrial Engineering  
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Cornell University  
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## Research Interests

Algorithms, combinatorial optimization

## Education

*Massachusetts Institute of Technology, Cambridge, Massachusetts*

Ph.D. in Computer Science, September 1993; GPA 5.0/5.0

Thesis: "On the Design of Approximation Algorithms for a Class of Graph Problems"

Advisor: Michel X. Goemans

S.M. in Computer Science, June 1990

Thesis: "Analysis of the Held-Karp Heuristic for the Traveling Salesman Problem"

Advisor: David Shmoys

S.B. in Mathematics with Computer Science, June 1989; GPA 5.0/5.0

## Professional Experience

*Cornell University*

July 2021-present: Chair, Department of Information Science

Jan. 2004-present: Professor, School of Operations Research and Industrial Engineering

*IBM Almaden Research Center*

April 2000-Dec. 2003: Senior Manager, Computer Science Principles and Methodologies

*IBM T.J. Watson Research Center*

Jan. 1995-April 2000: Research Staff Member. Supervisor: Baruch Schieber.

*Cornell University*

1994: NSF Postdoctoral Fellow. Supervisor: Eva Tardos.

## Professional Activities

Adjunct Professor

- Columbia University Department of Operations Research (Spring 1998)
- Cornell University School of Operations Research and Industrial Engineering (Fall 1998)

Lecturer

- MIT Department of Electrical Engineering and Computer Science (Spring 2000)
- Stanford Department of Computer Science (Spring 2003)

Chair, 2003 Mathematical Programming Society/American Mathematical Society Fulkerson Prize committee.

Program Chair

- 2021 Conference on Integer Programming and Combinatorial Optimization (IPCO 2021)
- 2017 International Workshop on Approximation Algorithms for Combinatorial Optimization Problems (APPROX 2017)

Local Organizer, 2007 Mathematical Programming Society Conference on Integer Programming and Combinatorial Optimization.

Program Committee Member

- ACM Symposium on the Theory of Computing (STOC) (2012)
- Mathematical Programming Society Conference on Integer Programming and Combinatorial Optimization (IPCO) (1998, 2002, 2007, 2014)
- IEEE Symposium on the Foundations of Computer Science (FOCS) (1998, 2000, 2004)
- ACM-SIAM Symposium on Discrete Algorithms (SODA) (1997, 2020)
- International World-Wide Web Conference (WWW) (2004)
- Workshop on Approximation Algorithms for Combinatorial Optimization (APPROX) (2008, 2010, 2014, 2020)
- Foundations of Software Technology and Theoretical Computer Science (FSTTCS) (2013)
- SIAM Meeting on Algorithm Engineering and Experiments (ALENEX) (2015)
- Workshop on Approximation and Online Algorithms (WAOA) (2015)
- Symposium on Simplicity in Algorithms (SOSA) (2018)

Prize Committee Member

- INFORMS Lanchester Prize (2002, 2003)
- INFORMS Optimization Prize for Young Researchers (2001)
- Mathematical Programming Society Tucker Prize (1997)
- SIAM Polya Prize (2016)

Member at large, Mathematical Programming Society Council, 2000 – 2003.

Member, Steering Committee, Mathematical Programming Society Conference on Integer Programming and Combinatorial Optimization, 2012 -- 2018.

Member, SIAM Publications Committee, 2005 – 2012.

Editor-in-Chief, *SIAM Journal on Discrete Mathematics*, 2012 – 2016 .

Area Editor, Discrete Optimization, *Mathematics of Operations Research*, 2004 – 2007.

Associate Editor

- *ACM Transactions on Algorithms*, 2004 – 2011.
- *Journal of Algorithms*, 1998 – 2003.
- *Mathematics of Operations Research*, 1997 – 2003, 2008 – 2010.
- *SIAM Journal on Computing*, 2001 – 2012.
- *SIAM Journal on Discrete Mathematics*, 1998 – 2011, 2017 --

Member

- Association for Computing Machinery, 1997--
- Society for Industrial and Applied Mathematics, 1997--
- Mathematical Programming Society, 1996--
- Institute on Operations Research and Management Science

**Honors and Awards**

James M. and Marsha D. McCormick Award for Outstanding Advising of First-Year Engineering Students (2020)

University of California at Berkeley Chancellor's Professor (Spring 2018)

SIAM Fellow (2016)

Cornell College of Engineering Excellence in Teaching Award (2007, 2013, 2016)

Cornell School of Operations Research and Information Engineering Undergraduate Voted Professor of the Year (2015-2016, 2016-2017, 2018-2019)

ACM Fellow (2013)

2013 INFORMS Lanchester Prize, for best contribution to operations research and the management sciences, 2010-2012 (book 1).

2010 Alexander von Humboldt Research Award, for career research.

2009 Glover-Klingman Prize, for best paper published in the journal *Networks* in 2009 (journal paper 36).

2000 American Mathematical Society-Mathematical Programming Society Fulkerson Prize for outstanding paper in discrete mathematics (journal paper 10).

1999 SIAM Group on Optimization Prize, for outstanding paper in optimization, 1996-1998 (journal paper 10).

1996 Society of Industrial and Applied Mathematics (SIAM) Richard C. DiPrima Prize, awarded biennially for outstanding dissertation work in applied mathematics.

1994 George M. Sprowls Scholarship Fund, for best Ph.D. dissertation in MIT Computer Science Department.

1994 Mathematical Programming Society A.W. Tucker Prize, awarded triennially to best student paper (for doctoral dissertation).

National Science Foundation Mathematical Sciences Postdoctoral Research Fellow, 1993 to 1994.

National Science Foundation Graduate Fellowship, 1989 to 1993.

Jon A. Bucsela Prize in Mathematics, presented to top graduating senior from MIT Mathematics Department.

Phi Beta Kappa.

## **Publications**

### Books:

1. *The Design of Approximation Algorithms*, with David B. Shmoys. Cambridge University Press, New York, NY, USA, 2011.
2. *Network Flow Algorithms*. Cambridge University Press, New York, NY, USA, 2019.

### Edited Volumes:

1. *Integer Programming and Combinatorial Optimization: 12<sup>th</sup> International IPCO Conference, Ithaca, NY, USA, June 2007, Proceedings*. Edited with Matteo Fischetti. Lecture Notes in Computer Science Number 4513, Springer, Berlin, Germany, June 2007.
2. *Approximation, Randomization, and Combinatorial Optimization. Algorithms and Techniques*. (Proceedings of APPROX 2017 and RANDOM 2017). Edited with Klaus Jansen, Jose D. P. Rolim, and Santosh S. Vempala. Leibniz International Proceedings in Informatics (LIPIcs) Volume 81, August 2017.
3. *Integer Programming and Combinatorial Optimization: 22<sup>nd</sup> International Conference, IPCO 2021, Atlanta, GA, USA, May 19-21, 2021, Proceedings*. Edited with Mohit Singh. Lecture Notes in Computer Science Number 12707, Springer, Berlin, Germany, May 2021.

### Chapters in books:

1. "The Primal-Dual Method for Approximation Algorithms and Its Application to Network Design Problems," with Michel Goemans. In *Approximation Algorithms for NP-hard Problems*, Dorit Hochbaum, editor. PWS, 1997.
2. "Tools From Algorithms and Complexity Theory." In *Elements of Scheduling*. Jan Karel Lenstra and David Shmoys, editors. [www.elementsofscheduling.nl](http://www.elementsofscheduling.nl).

In refereed journals:

1. "Analyzing the Held-Karp TSP Bound: A Monotonicity Property with Application," with David Shmoys. *Information Processing Letters* 35, 281-285, 1990.
2. "Permutation vs. Non-Permutation Flow Shop Schedules," with Chris Potts and David Shmoys. *Operations Research Letters* 10, 281-284, 1991.
3. "Analysis of the Held-Karp Lower Bound for the Asymmetric TSP." *Operations Research Letters* 12, 83-88, 1992.
4. "A Note on the Prize-Collecting Traveling Salesman Problem," with Dan Bienstock, Michel Goemans, and David Simchi-Levi. *Mathematical Programming* 59, 413-420, 1993.
5. "Approximating Minimum-Cost Graph Problems with Spanning Tree Edges," with Michel Goemans. *Operations Research Letters* 16, 183-189, 1994.
6. "New 3/4-Approximation Algorithms for MAX SAT," with Michel Goemans. *SIAM Journal on Discrete Mathematics* 7, 656-666, 1994.
7. "Scheduling Parallel Machines On-line," with David Shmoys and Joel Wein. *SIAM Journal on Computing* 24, 1313-1331, 1995.
8. "A General Approximation Technique for Constrained Forest Problems," with Michel Goemans. *SIAM Journal on Computing* 24, 296-317, 1995.
9. "A Primal-Dual Approximation Algorithm for Generalized Steiner Network Problems," with Michel Goemans, Milena Mihail, and Vijay Vazirani. *Combinatorica* 15, 435-454, 1995.
10. "Improved Approximation Algorithms for Maximum Cut and Satisfiability Problems Using Semidefinite Programming," with Michel Goemans. *Journal of the ACM* 42, 1115-1145, 1995.
11. "On the Number of Small Cuts in a Graph," with Monika Henzinger. *Information Processing Letters* 59, 41-44, 1996.
12. "Computational Experience with an Approximation Algorithm on Large-Scale Euclidean Matching Instances," with Michel Goemans. *INFORMS Journal on Computing* 8, 29-40, 1996.
13. "Short Shop Schedules," with Leslie Hall, J. Hoogeveen, C. Hurkens, Jan Karel Lenstra, Sergey Sevast'janov, and David Shmoys. *Operations Research* 45, 288-294, 1997.
14. "An Approximation Algorithm for Minimum-Cost Vertex-Connectivity Problems," with R. Ravi. *Algorithmica* 18, 21-43, 1997.
15. "An Efficient Approximation Algorithm for the Survivable Network Design Problem," with Harold Gabow and Michel Goemans. *Mathematical Programming* 82, 13-40, 1998.
16. "A Primal-Dual Interpretation of Two 2-Approximation Algorithms for the Feedback Vertex Set Problem in Undirected Graphs," with Fabian Chudak, Michel Goemans, and Dorit Hochbaum. *Operations Research Letters* 22, 111-118, 1998.
17. "Primal-Dual Approximation Algorithms for Feedback Problems in Planar Graphs," with Michel Goemans. *Combinatorica* 18, 37-59, 1998.
18. "Node-Disjoint Paths on the Mesh and a New Trade-Off in VLSI Layout," with Alok Aggarwal and Jon Kleinberg. *SIAM Journal on Computing* 29, 1321-1333, published electronically February 23, 2000.
19. "A 1.47-Approximation Algorithm for a Preemptive Single-Machine Scheduling Problem," with Michel Goemans and Joel Wein. *Operations Research Letters* 26, 149-154, 2000.
20. "Gadgets, Approximation, and Linear Programming," with Gregory Sorkin, Madhu Sudan, and Luca Trevisan. *SIAM Journal on Computing* 29, 2074-2097, published electronically April 18, 2000.
21. "Two-Dimensional Gantt Charts and a Scheduling Algorithm of Lawler," with Michel Goemans. *SIAM Journal on Discrete Mathematics* 13, 281-294, published electronically May 15, 2000.
22. "Adversarial Queuing Theory," with Allan Borodin, Jon Kleinberg, Prabhakar Raghavan, and Madhu Sudan. *Journal of the ACM* 48, 13-38, 2001
23. "The Approximability of Constraint Satisfaction Problems," with Sanjeev Khanna, Madhu

- Sudan, and Luca Trevisan. *SIAM Journal on Computing* 30, 1863-1920, published electronically March 23, 2001.
24. "The Primal-Dual Method for Approximation Algorithms," *Mathematical Programming B* 91, 447-478, 2002.
  25. "Improved Approximation Algorithms for MAX SAT," with Takao Asano. *Journal of Algorithms* 42, 173-202, 2002.
  26. "Erratum: An Approximation Algorithm for Minimum-Cost Vertex Connectivity Problems", with R. Ravi. *Algorithmica* 34, 98-107, 2002.
  27. "A Primal-Dual Schema Based Approximation Algorithm for the Element Connectivity Problem," with Kamal Jain, Ion Mandoiu, and Vijay Vazirani. *Journal of Algorithms* 45, 1-15, 2002.
  28. "Approximation Algorithms for MAX 3-CUT and Other Problems via Complex Semidefinite Programming," with Michel Goemans. *Journal of Computer and System Sciences* 68, 442-470, 2004. (STOC 2001 special issue)
  29. "Approximate  $k$ -MSTs and  $k$ -Steiner Trees Via the Primal-Dual Method and Lagrangean Relaxation," with Fabian Chudak and Tim Roughgarden. *Mathematical Programming* 100, 411-421, 2004.
  30. "Improved Approximation Algorithms for Capacitated Facility Location Problems," with Fabian Chudak. *Mathematical Programming* 102, 207-222, 2005.
  31. "An Iterative Rounding 2-Approximation Algorithm for the Element Connectivity Problem," with Lisa Fleischer and Kamal Jain. *Journal of Computer and System Sciences* 72, 838-867, 2006. (FOCS 2001 special issue).
  32. "On the Relationship Between Combinatorial and LP-based Lower Bounds for NP-hard Scheduling Problems," with R.N. Uma and Joel Wein. *Theoretical Computer Science* 361, 241-256, 2006 (special issue on online and approximation algorithms).
  33. "A Simpler and Better Derandomization of an Approximation Algorithm for Single Source Rent-or-Buy," with Anke van Zuylen. *Operations Research Letters* 35, 707-712, 2007.
  34. "A Faster, Better Approximation Algorithm for the Minimum Latency Problem," with Aaron Archer and Asaf Levin. *SIAM Journal on Computing* 37, 1472-1498, 2008.
  35. "A Simple GAP-Canceling Algorithm for the Generalized Maximum Flow Problem," with Mateo Restrepo. *Mathematical Programming* 118, 47-74, 2009.
  36. "Approximating the Smallest  $k$ -edge Connected Spanning Subgraph by LP-Rounding," with Harold Gabow, Michel Goemans, and Éva Tardos. *Networks* 53:345-357, 2009.
  37. "Stackelberg Thresholds in Network Routing Games or the Value of Altruism," with Yogeshwer Sharma. *Games and Economic Behavior* 67:174-190, 2009.
  38. "Deterministic Pivoting Algorithms for Constrained Ranking and Clustering Problems," with Anke van Zuylen. *Mathematics of Operations Research* 34:594-620, 2009.
  39. "A General Approach for Incremental Approximation and Hierarchical Clustering," with Guolong Lin, Chandrashekar Nagarajan, and Rajmohan Rajaraman. *SIAM Journal on Computing* 39:3633-3669, 2010.
  40. "A Note on the Generalized Min-Sum Set Cover Problem," with Martin Skutella. *Operations Research Letters* 39:433-436, 2011.
  41. "Offline and Online Facility Leasing," with Chandrashekar Nagarajan. *Discrete Optimization* 10:361-370, 2013.
  42. "An Experimental Evaluation of Incremental and Hierarchical  $k$ -Median Algorithms," with Chandrashekar Nagarajan. *ACM Journal of Experimental Algorithmics* 18, Article 3.2, 2013.
  43. "Popular Ranking," with Anke van Zuylen and Frans Schalekamp. *Discrete Applied Mathematics* 165:312-316, 2014.
  44. "2-Matchings, the Traveling Salesman Problem, and the Subtour LP: A Proof of the Boyd-Carr Conjecture," with Frans Schalekamp and Anke van Zuylen. *Mathematics of Operations Research* 39:403-417, 2014.
  45. "A  $3/2$ -Approximation Algorithm for Some Minimum-Cost Graph Problems," with Basile Couëtoux and James M. Davis. *Mathematical Programming* 150:19-34, 2015.
  46. "On the Integrality Gap of the Subtour LP for the 1,2-TSP," with Jiawei Qian, Frans Schalekamp, and Anke van Zuylen. *Mathematical Programming* 150:131-151, 2015.
  47. "Maximizing a Submodular Function with Viability Constraints," with Wolfgang Dvořák and

- Monika Henzinger. *Algorithmica* 77:152-172, 2017.
48. “A Randomized  $O(\log n)$ -Competitive Algorithm for the Online Connected Facility Location Problem,” with Mário César San Felice and Orlando Lee. *Algorithmica* 76:1139-1157, 2016 (special issue for LATIN 2014).
  49. “Assortment Optimization Over Time,” with James M. Davis and Huseyin Topaloglu. *Operations Research Letters* 43:608-611, 2015.
  50. “Pricing Problems under the Nested Logit Model with a Quality Consistency Constraint,” with James M. Davis and Huseyin Topaloglu. *INFORMS Journal on Computing* 29:54-76, 2017.
  51. “Greedy Algorithms for the Maximum Satisfiability Problem: Simple Algorithms and Inapproximability Bounds,” with Matthias Poloczek, Georg Schnitger, and Anke van Zuylen. *SIAM Journal on Computing* 46:1029-1061, 2017.
  52. “An Experimental Evaluation of the Best-of-Many Christofides’ Algorithm for the Traveling Salesman Problem,” with Kyle Genova. *Algorithmica* 78:1109-1130, 2017 (ESA 2015 Special Issue).
  53. “An Experimental Evaluation of Fast Approximation Algorithms for the Maximum Satisfiability Problem,” with Matthias Poloczek. *ACM Journal of Experimental Algorithmics* 22, Article 1.6, 2017.
  54. “Greedy Algorithms for the Single-Demand Facility Location Problem,” with Sin-Sheun Cheung. *Operations Research Letters* 45:452-455, 2017.
  55. “Simple Approximation Algorithms for Balanced MAX 2SAT,” with Alice Paul and Matthias Poloczek. *Algorithmica* 80:995-1012, 2018 (LATIN 2016 Special Issue).
  56. “The Unbounded Integrality Gap of a Semidefinite Relaxation of the Traveling Salesman Problem,” with Samuel C. Gutekunst. *SIAM Journal on Optimization* 28:2073-2096, 2018.
  57. “Online Constrained Forest and Prize-Collecting Network Design,” with Jiawei Qian and Seeun William Umboh. *Algorithmica* 80:3335-3364, 2018.
  58. “Rank Aggregation: New Bounds for MCx,” with Daniel Freund. *Discrete Applied Mathematics* 262:28-36, 2019.
  59. “Characterizing the Integrality Gap of the Subtour LP for the Circulant Traveling Salesman Problem,” with Samuel C. Gutekunst. *SIAM Journal on Discrete Mathematics* 33:2452-2478, 2019.
  60. “Easy Capacitated Facility Location Problems, with Connections to Lot-Sizing,” with Alice Paul. *Operations Research Letters* 48:109-114, 2020.
  61. “Budgeted Prize-Collecting Traveling Salesman and Minimum Spanning Tree Problems,” with Alice Paul, Daniel Freund, Aaron Ferber, and David Shmoys. *Mathematics of Operations Research* 45:576-590, 2020.
  62. “Subtour Elimination Constraints Imply a Matrix-Tree Theorem SDP Constraint for the TSP,” with Samuel C. Gutekunst. *Operations Research Letters* 48:245-248, 2020.
  63. “Semidefinite Programming Relaxations of the Traveling Salesman Problem and Their Integrality Gaps,” with Samuel C. Gutekunst. To appear in *Mathematics of Operations Research*.
  64. “The Circlet Inequalities: A New Circulant-Based Facet-Defining Inequality for the TSP,” with Samuel C. Gutekunst. Submitted to *Mathematics of Operations Research*.
  65. “Tight Bounds for Online Weighted Tree Augmentation,” with Joseph (Seffi) Naor and Seeun William Umboh. Submitted to *Algorithmica*.

*In conference proceedings:*

1. “Scheduling Parallel Machines On-line,” with David Shmoys and Joel Wein. In the *Proc. of the 32nd IEEE Symposium on the Foundations of Computer Science*, San Juan, Puerto Rico, October 1991. Abstract in the *Proc. of the DIMACS Workshop on On-line Algorithms*, February 1991.
2. “A General Approximation Technique for Constrained Forest Problems,” with Michel Goemans. In the *Proc. of the 3rd ACM-SIAM Symposium on Discrete Algorithms*, Orlando, FL, January 1992.
3. “A New  $3/4$ -Approximation Algorithm for MAX SAT,” with Michel Goemans. In the *Proc. of the 3rd MPS Conference on Integer Programming and Combinatorial Optimization*, Erice, Italy, April 1993.

4. "An Efficient Approximation Algorithm for the Survivable Network Design Problem," with Harold Gabow and Michel Goemans. In the *Proc. of the 3rd MPS Conference on Integer Programming and Combinatorial Optimization*, Erice, Italy, April 1993.
5. "A Primal-Dual Approximation Algorithm for Generalized Steiner Network Problems," with Michel Goemans, Milena Mihail, and Vijay Vazirani. In the *Proc. of the 25th ACM Symposium on the Theory of Computing*, San Diego, CA, May 1993.
6. "Computational Experience with an Approximation Algorithm on Large-Scale Euclidean Matching Instances," with Michel Goemans. In the *Proc. of the 5th ACM-SIAM Symposium on Discrete Algorithms*, Arlington, VA, January 1994.
7. "Improved Approximation Algorithms for Network Design Problems," with Michel Goemans, Andrew Goldberg, Serge Plotkin, David Shmoys, and Eva Tardos. In the *Proc. of the 5th ACM-SIAM Symposium on Discrete Algorithms*, Arlington, VA, January 1994.
8. ".878-Approximation Algorithms for MAX CUT and MAX 2SAT," with Michel Goemans. In the *Proc. of the 26th Annual ACM Symposium on the Theory of Computing*, Montreal, Quebec, May 1994.
9. "An Approximation Algorithm for Minimum-Cost Vertex-Connectivity Problems," with R. Ravi. In the *Proc. of the 6th ACM-SIAM Symposium on Discrete Algorithms*, San Francisco, CA, January 1995.
10. "Node-Disjoint Paths on the Mesh and a New Trade-Off in VLSI Layout," with Alok Aggarwal and Jon Kleinberg. In the *Proc. of the 28th Annual ACM Symposium on the Theory of Computing*, Philadelphia, PA, May 1996.
11. "Adversarial Queueing Theory," with Allan Borodin, Jon Kleinberg, Prabhakar Raghavan, and Madhu Sudan. In the *Proc. of the 28th Annual ACM Symposium on the Theory of Computing*, Philadelphia, PA, May 1996.
12. "Primal-Dual Approximation Algorithms for Feedback Problems in Planar Graphs," with Michel Goemans. In the *Proc. of the 5th MPS Conference on Integer Programming and Combinatorial Optimization*, Vancouver, BC, June 1996.
13. "Gadgets, Approximation, and Linear Programming," with Gregory Sorkin, Madhu Sudan, and Luca Trevisan. In the *Proc. of the 37th Annual IEEE Symposium on the Foundations of Computer Science*, Burlington, VT, October 1996.
14. "A Complete Classification of the Approximability of Maximization Problems Derived from Boolean Constraint Satisfaction," with Sanjeev Khanna and Madhu Sudan. In the *Proc. of the 29th Annual ACM Symposium on the Theory of Computing*, El Paso, TX, May 1997.
15. "A Primal-Dual Schema Based Approximation Algorithm for the Element Connectivity Problem," with Kamal Jain, Ion Mandoiu, and Vijay Vazirani. In the *Proc. of the 10th Annual ACM-SIAM Symposium on Discrete Algorithms*, Baltimore, MD, January 1999.
16. "Two-Dimensional Gantt Charts and a Scheduling Algorithm of Lawler," with Michel Goemans. In the *Proc. of the 10th Annual ACM-SIAM Symposium on Discrete Algorithms*, Baltimore, MD, January 1999.
17. "Improved Approximation Algorithms for Capacitated Facility Location Problems," with Fabian Chudak. In the *Proc. of the 1999 MPS Conference on Integer Programming and Combinatorial Optimization*, Graz, Austria, June 1999.
18. "Improved Approximation Algorithms for MAX SAT," with Takao Asano. In the *Proc. of the 11th Annual ACM-SIAM Symposium on Discrete Algorithms*, San Francisco, CA, January 2000.
19. "Approximate  $k$ -MSTs and  $k$ -Steiner Trees Via the Primal-Dual Method and Lagrangean Relaxation," with Fabian Chudak and Tim Roughgarden. In the *Proc. of the 2001 MPS Conference on Integer Programming and Combinatorial Optimization*, Utrecht, The Netherlands, June 2001.
20. "Approximation Algorithms for MAX 3-CUT and Other Problems via Complex Semidefinite Programming," with Michel Goemans. In the *Proc. of the 33rd Annual ACM Symposium on the Theory of Computing*, Crete, Greece, July 2001.
21. "An Iterative Rounding 2-Approximation Algorithm for the Element Connectivity Problem," with Lisa Fleischer and Kamal Jain. In the *Proc. of the 42nd Annual IEEE Symposium on the Foundations of Computer Science*, Las Vegas, NV, October 2001.
22. "Faster Approximation Algorithms for the Minimum Latency Problem," with Aaron Archer. In the *Proc. of the 14th ACM-SIAM Symposium on Discrete Algorithms*, Baltimore, MD, January

2003.

23. "Searching the Workplace Web," with Ronald Fagin, Ravi Kumar, Kevin McCurley, Jasmine Novak, D. Sivakumar, and John Tomlin. In the *Proceedings of the 12th Annual World-Wide Web Conference*, Budapest, Hungary, May 2003.
24. "Approximating the Smallest  $k$ -Edge-Connected Spanning Subgraph by LP-Rounding," with Hal Gabow, Michel Goemans, and Eva Tardos. In the *Proceedings of the 16th ACM-SIAM Symposium on Discrete Algorithms*, Vancouver, Canada, January 2005.
25. "A Simple GAP-Cancelling Algorithm for the Generalized Maximum Flow Problem," with Mateo Restrepo. In the *Proceedings of the 17th ACM-SIAM Symposium on Discrete Algorithms*, Miami, FL, January 2006.
26. "A General Approach for Incremental Approximation and Hierarchical Clustering," with Guolong Lin, Chandrashekar Nagarajan, and Rajmohan Rajaraman. In the *Proceedings of the 17th ACM-SIAM Symposium on Discrete Algorithms*, Miami, FL, January 2006.
27. "An Adaptive Algorithm for Selecting Profitable Keywords for Search-Based Advertising Services," with Paat Rusmevichientong. In the *Proceedings of the ACM Conference on Electronic Commerce*, Ann Arbor, MI, June 2006.
28. "Deterministic Pivoting Algorithms for Constrained Ranking and Clustering Problems," with Anke van Zuylen, Rajneesh Hegde, and Kamal Jain. In the *Proceedings of the 18th ACM-SIAM Symposium on Discrete Algorithms*, New Orleans, LA, January 2007.
29. "Approximation Algorithms for Prize-Collecting Forest Problems with Submodular Penalty Functions," with Yogeshwer Sharma and Chaitanya Swamy. In the *Proceedings of the 18th ACM-SIAM Symposium on Discrete Algorithms*, New Orleans, LA, January 2007.
30. "Stackelberg Thresholds in Network Routing Games or the Value of Altruism," with Yogeshwer Sharma. In the *Proceedings of the 8th ACM Conference on Electronic Commerce*, San Diego, CA, June 2007.
31. "Deterministic Algorithms for Rank Aggregation and Other Ranking and Clustering Problems," with Anke van Zuylen. In the *Proceedings of the 5th Workshop on Approximation and Online Algorithms*, Eilat, Israel, October 2007.
32. "Offline and Online Facility Leasing," with Chandrashekar Nagarajan. In the *Proceedings of the 13th MPS International Conference on Integer Programming and Combinatorial Optimization*, Bertinoro, Italy, May 2008.
33. "Approximation Algorithms for Prize-Collecting Network Design Problems with General Connectivity Requirements," with Chandrashekar Nagarajan and Yogeshwer Sharma. In the *Proceedings of the 6th Workshop on Approximation and Online Algorithms*, Karlsruhe, Germany, September 2008.
34. "An Experimental Evaluation of Incremental and Hierarchical  $k$ -Median Algorithms," with Chandrashekar Nagarajan. In the *Proceedings of the 10th International Symposium on Experimental Algorithms*, Chania, Crete, Greece, May 2011.
35. "Popular Ranking," with Anke van Zuylen and Frans Schalekamp. In the *Proceedings of the 10th Cologne-Twente Workshop on Graphs and Combinatorial Optimization*, Rome, Italy, June 2011.
36. "An  $O(\log n)$ -Competitive Algorithm for Online Constrained Forest Problems," with Jiawei Qian. In the *Proceedings of the 38th International Colloquium on Automata, Languages, and Programming*, Zurich, Switzerland, July 2011. Submitted to *Operations Research*.
37. "A Proof of the Boyd-Carr Conjecture," with Frans Schalekamp and Anke van Zuylen. In the *Proceedings of the 23rd ACM-SIAM Symposium on Discrete Algorithms*, Kyoto, Japan, January 2012.
38. "On the Integrality Gap of the Subtour LP for the 1,2-TSP," with Jiawei Qian, Frans Schalekamp, and Anke van Zuylen. In the *Proceedings of the 10th Latin American Theoretical Informatics Symposium*, Arequipa, Peru, April 2012.
39. "A Dual-Fitting  $3/2$ -Approximation Algorithm for Some Minimum-Cost Graph Problems," with James Davis. In the *Proceedings of the 20th Annual European Symposium on Algorithms*, Ljubljana, Slovenia, September 2012.
40. "Maximizing a Submodular Function with Viability Constraints," with Wolfgang Dvořák and Monika Henzinger. In the *Proceedings of the 21st Annual European Symposium on Algorithms*, Sophia Antipolis, France, September 2013.



41. “On Some Recent Approximation Algorithms for MAX SAT,” with Matthias Poloczek and Anke van Zuylen. In the *Proceedings of the 11<sup>th</sup> Latin American Theoretical Informatics Symposium*, Montevideo, Uruguay, April 2014.
42. “The Online Connected Facility Location Problem,” with Mário César San Felice and Orlando Lee. In the *Proceedings of the 11<sup>th</sup> Latin American Theoretical Informatics Symposium*, Montevideo, Uruguay, April 2014.
43. “The Online Prize-Collecting Facility Location Problem,” with Sin Shuen Cheung, Mário César San Felice, and Orlando Lee. In the 8<sup>th</sup> Latin-American Algorithms, Graphs, and Optimization Symposium, Praia des Fontes, Brazil, May 2015.
44. “MC4, Copeland, and Restart Probabilities,” with Daniel Freund. In the 13<sup>th</sup> Cologne-Twente Workshop on Graphs and Combinatorial Optimization, Istanbul, Turkey, May 2015.
45. “An Experimental Evaluation of the Best-of-Many Christofides’ Algorithm for the Traveling Salesman Problem,” with Kyle Genova. In the *Proceedings of the 23<sup>rd</sup> Annual European Symposium on Algorithms*, Patras, Greece, September 2015.
46. “Simple Approximation Algorithms for Balanced MAX 2SAT,” with Alice Paul and Matthias Poloczek. In the *Proceedings of the 12<sup>th</sup> Latin American Symposium in Theoretical Informatics*, Ensenada, Mexico, April 2016.
47. “An Experimental Evaluation of Fast Approximation Algorithms for the Maximum Satisfiability Problem,” with Matthias Poloczek. In the *Proceedings of the 15<sup>th</sup> International Symposium on Experimental Algorithms*, St. Petersburg, Russia, June 2016.
48. “Prize-Collecting TSP with a Budget Constraint,” with Alice Paul, Daniel Freund, Aaron Ferber, and David Shmoys. In the *Proceedings of the 25<sup>th</sup> Annual European Symposium on Algorithms*, Vienna, Austria, September 2017.
49. “Tight Bounds for the Online Weighted Tree Augmentation Problem,” with Joseph (Seffi) Naor and Seeun William Umboh. In the *Proceedings of the 46<sup>th</sup> International Colloquium on Automata, Languages, and Programming*, Patras, Greece, July 2019.
50. “Learning to Solve Combinatorial Optimization Problems on Real-World Graphs in Linear Time,” with Iddo Drori, Anant Kharkar, William R. Sickinger, Brandon Kates, Qiang Ma, Suwen Ge, Eden Dolev, Brenda Dietrich, and Madeleine Udell. In the *Proceedings of the 19<sup>th</sup> IEEE International Conference on Machine Learning and Applications*, December 2020.
51. “Recursive Random Contraction Revisited,” with David Karger. In the *Proceedings of the SIAM Symposium on Simplicity in Algorithms*, January 2021.

<b>Ph.D. students</b>	Anke van Zuylen (May 2008), associate professor, William and Mary, Department of Mathematics Chandrashekhhar Nagarajan (August 2008), Facebook Yogeshwer Sharma (August 2010), Facebook Jiawei Qian (January 2012), JW Capital James Davis (August 2015), Uber Sin-Shuen Cheung (January 2016), Bank of America Alice Paul (August 2017), assistant professor, Olin College Sam Gutekunst (August 2020), assistant professor, Bucknell University Billy Jin Sotiris Ntavaras
<b>Patents</b>	US Patent 6484036, Method and Apparatus for Scheduling Mobile Agents Utilizing Rapid Two-Way Communication, granted 11/19/2002  US Patent 7257577, System, Method and Service for Ranking Search Results Using a Modular Scoring System, granted 8/2007
<b>Grants</b>	NSF CCF-2007009, “Topics in Bridging Continuous and Discrete Optimization” \$430,000, August 2020-July 2023  NSF CCF-1908517, “Looking Under Rocks: A Search for a Provably Stronger TSP Relaxation” \$104,000, October 2019-September 2020

NSF EAGER CCF-1552831, “Approximation Algorithms for the Traveling Salesman Problem”  
\$100,000, September 2015-August 2017

NSF CCF-1115256, “The Traveling Salesman Problem and Lightweight Approximation Algorithms”  
\$350,000, September 2011-August 2015

NSF CCF-0830519, “Contemporary Issues in Network Design”  
\$150,000, September 2008-August 2010

## **Courses**

INFO 2950: Mathematical Methods for Information Science (Spring 2012)  
CS/INFO 1300: Introductory Web Programming and Design (Fall 2005)  
CS/INFO 2300: Intermediate Web Programming and Design (Spring 2006, Spring 2008, Spring 2009, Spring 2010, Spring 2013)  
CS 6850: The Structure of Information Networks (Spring 2005)  
Cornell University Department of Information Science.

ORIE 1380: Data Science for All (Spring 2020, Spring 2021)  
ORIE 3310: Optimization II (Spring 2016, Spring 2017, Spring 2019)  
ORIE 4330: Discrete Methods (Fall 2011, Fall 2018)  
ORIE 6300: Mathematical Programming I (Fall 2008, Fall 2014)  
ORIE 6330: Network Flow Algorithms (Spring 2004, Fall 2007, Fall 2012, Fall 2015, Fall 2020)  
ORIE 6334: Combinatorial Optimization (Approximation Algorithms) (Fall 1998, Fall 2006, Fall 2009, Spring 2014)  
ORIE 6334: Combinatorial Optimization (Spectral Graph Algorithms) (Fall 2016, Fall 2019)  
ENGRI 1101: Engineering Applications of Operations Research (Fall 2004, Spring 2007, Fall 2013)  
Cornell University School of Operations Research and Industrial Engineering.

CS 294: Approximation Algorithms (Spring 2018)  
University of California at Berkeley Department of Computer Science.

ADM III, Approximation Algorithms (Winter 2010/2011)  
Berlin Mathematical School, TU Berlin.

CS 361B: Advanced Algorithms (Spring 2003)  
Stanford Department of Computer Science.

6.891: Approximation Algorithms (Spring 2000)  
MIT Department of Electrical Engineering and Computer Science.

IEOR 6610E: Approximation Algorithms (Spring 1998)  
Columbia University Department of Industrial Engineering and Operations Research.

## **Minicourses**

Spectral Graph Theory and Algorithms  
University of Vienna, Vienna, Austria, June 19-30, 2017.

Approximation Algorithms  
University of Vienna, Vienna, Austria, June 18-29, 2012.  
2<sup>nd</sup> International Symposium on Combinatorial Optimization, Athens, Greece,  
April 17-18, 2012.  
23rd Conference on the Mathematics of Operations Research, Lunteren, The Netherlands,  
January 13-15, 1998.  
Swiss Society of Operations Research, Zinal, Switzerland, March 4-8, 1997.  
Eindhoven University of Technology, May 6-10, 1996.

IBM Almaden (taught with Madhu Sudan), October 9-13, 1995.  
Barbados Workshop (taught with Michel Goemans, Jon Kleinberg, and David Shmoys),  
March 13-17, 1995.

**Talks  
(selected)**

- “Semidefinite Programming Relaxations of the Traveling Salesman Problem”  
Cornell University, Center for Applied Mathematics, Ithaca, NY, USA, December 2020.  
University of Waterloo, Waterloo, Canada, October 2020.  
University of Massachusetts at Amherst, October 2018.
- “An Experimental Evaluation of the Best-of-Many Christofides’ Algorithm for the Traveling Salesman Problem”  
Sixth Cargese Workshop on Combinatorial Optimization, Cargese, Corsica, Sept 2015.  
International Symposium on Mathematical Programming, Pittsburgh, PA, USA, July 2015.
- “A Simple, Greedy Approximation Algorithm for MAX SAT”  
University of Pennsylvania, April 2016.  
DIMACS Workshop in Honor of Alan Hoffman, Rutgers University, September 2014.
- “A  $3/2$ -Approximation Algorithm for Some Minimum-Cost Graph Problems”  
International Symposium on Mathematical Programming, Berlin, Germany, August 2012.
- “The Subtour LP for the Traveling Salesman Problem”  
Google, January 2018.  
University of Illinois, April 2016.  
University of Michigan, April 2015.  
Universität Wien, June 2012.  
5<sup>th</sup> International Conference on High Performance Scientific Computing, Hanoi, Vietnam,  
March 2012.  
Cornell University, November 2011.  
Georgia Institute of Technology, October 2011.  
TU Berlin, May 2011.
- “An Experimental Evaluation of Incremental and Hierarchical  $k$ -Median Algorithms”  
10<sup>th</sup> International Symposium on Experimental Algorithms, Chania, Crete, Greece, May  
2011.
- “What Computers Can Compute (Approximately)”  
University of Hawaii, January 2012.  
TU Chemnitz, Chemnitz, Germany, June 2011.  
Berlin Mathematical School, Berlin, Germany, February 2011. (von Humboldt Lecture)
- “Open Problems in Approximation Algorithms”  
APPROX 2011, Princeton, NJ, August 2011 (invited speaker).  
University of Bonn, Bonn, Germany, February 2011.  
ELTE, Budapest, Hungary, November 2010.
- “Approximation Algorithms for Prize-Collecting Network Design Problems with General Connectivity Constraints”  
2008 Workshop on Online and Approximation Algorithms, Karlsruhe, Germany, October  
2008.
- “The Rank Aggregation Problem”  
Universidade Federal de Minas Gerais, Belo Horizonte, Brazil, December 2012.  
Simon Fraser University, May 2010.  
5<sup>th</sup> Latin-American Algorithms, Graphs and Optimization Symposium (LAGOS 2009),  
Gramado, Brazil, November 2009 (invited speaker)

TU Berlin, October 2008.  
Rensselaer Polytechnic Institute, December 2007.  
University of California, Berkeley, October 2007.  
University of Waterloo 40<sup>th</sup> Anniversary of the Department of Combinatorics and Optimization, June 2007.

“A General Approach for Incremental Approximation and Hierarchical Clustering”  
Universidade de Sao Paolo, Sao Paolo, Brazil, November 2009.  
2008 Workshop on Online and Approximation Algorithms, Karlsruhe, Germany, October 2008 (invited speaker).  
Aussois Workshop on Integer Programming and Combinatorial Optimization, January 2007.  
IIT Delhi Workshop on Approximation Algorithms, October 2005 (invited speaker).

“A Simple GAP-Cancelling Algorithm for the Generalized Maximum Flow Problem”  
Mathematisches Forschungsinstitut Oberwolfach, November 2005.

“Finding Near-Optimal Solutions to Discrete Optimization Problems”  
16th Cumberland Conference on Combinatorics, Graph Theory, and Computing, May 2003 (plenary speaker).  
SIAM Conference on Discrete Mathematics, August 2002 (plenary speaker).  
SIAM 50th Anniversary Meeting, July 2002 (semi-plenary speaker).  
University of Illinois, Urbana-Champaign, March 2005.

“Searching the Workplace Web”  
University of Connecticut, November 2004.  
University of California, Berkeley, October 2003.  
Stanford University, May 2003.

“A Better, Faster Approximation Algorithm for the Minimum Latency Problem”  
Mathematisches Forschungsinstitut Oberwolfach, August 2003.

“An Application of Complex Semidefinite Programming to Approximation Algorithms”  
Carnegie-Mellon University, March 2002.  
Delft University of Technology, June 2001.  
Stanford, March 2001.  
MIT, February 2001.  
Cornell, February 2001.  
University of California, Berkeley, January 2001.

“The Primal-Dual Method for Approximation Algorithms”  
McMaster Workshop on Optimization, August 2001 (invited plenary).  
CRM/MITACS Spring School on Optimization, May 2001 (invited tutorial).  
17th International Symposium on Mathematical Programming, August 2000 (invited semi-plenary).  
MIT, September 1996.  
Carnegie Mellon University, February 1996.  
Georgia Tech, January 1996.  
Cornell University, May 1995.  
Princeton University, April 1995.

“Recent Techniques in Approximation Algorithms”  
Discrete Optimization '99, July 1999 (invited plenary).

“Two-Dimensional Gantt Charts and a Scheduling Algorithm of Lawler”  
Columbia University, February 2000.

University of California at Berkeley, January 2000.  
Fields Institute Workshop on Polyhedral and Semidefinite Methods in Combinatorial Optimization, November 1999.  
IBM Workshop on Integer Programming, August 1999.  
Cornell University, December 1998.

“Some Applications of Semidefinite Programming to Combinatorial Optimization”  
DIMACS Workshop on Semidefinite Programming, January 1999 (invited plenary).  
INFORMS, October 1998 (invited tutorial).  
Cornell University, February 1998.  
Foundations of Computational Mathematics, January 1997 (invited semi-plenary).

“Gadgets, Approximation, and Linear Programming”  
23rd International Workshop on Graph-Theoretic Concepts in Computer Science, June 1997 (invited).  
University of Texas, Austin, May 1997.  
Dartmouth College, May 1997.  
MIT, September 1996.  
Carnegie Mellon University, March 1996.

“Primal-Dual Approximation Algorithms for Feedback Problems in Planar Graphs”  
University of Maryland, College Park, December 1997.  
MIT, November 1997.  
5th MPS Conf. on Integer Programming and Combinatorial Optimization, June 1996.

“An Approximation Algorithm for General Graph Connectivity Problems”  
1996 SIAM Annual Meeting, July 1996 (DiPrima prize presentation).  
15th Mathematical Programming Symposium, August 1994 (Tucker finalist lecture).  
Stanford University, March 1994.  
Johns Hopkins University, November 1993.  
University of Wisconsin-Madison, November 1993.  
Stanford University, November 1993.  
25th ACM Symposium on the Theory of Computing, May 1993.  
University of Chicago, March 1993.  
DIMACS Workshop on Approximation Algorithms, March 1993 (invited).  
Bellcore, February 1993.  
Columbia University, February 1993.

“New Approximation Algorithms for MAX CUT and MAX SAT”  
University of Delft, May 1996.  
Rutgers University Workshop on Semidefinite Programming, April 1995 (invited).  
15th Mathematical Programming Symposium, August 1994 (invited).  
Mathematisches Forschungsinstitut Oberwolfach, August 1994.  
AT&T Bell Labs, June 1994.  
Harvard University, April 1994.  
23rd Theory Day at Columbia University, April 1994.  
Cornell University, February 1994.