LISA ZHANG

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RESEARCH INTERESTS

Algorithms, networking, and industrial applications of theory of computing and mathematics.
My current research broadly concerns algorithmic and complexity issues in networking, in particular network design and optimization, routing and scheduling protocols, and stability and Quality-of-Service analysis. My work is interdisciplinary, covering topics in theoretical computer science, applied mathematics, operations research and electrical engineering.

EDUCATION

- Ph.D. in Applied Mathematics, Massachusetts Institute of Technology, June 1997.
  Thesis: An Analysis of Network Routing and Communication Latency.
  Advisor: Professor Tom Leighton.
- B.A. *summa cum laude*, in Mathematics and Computer Science, Wellesley College, May 1993.
  Thesis: Topics in Generating Functions, with Applications to a Domino Problem and Regular Graphs.

EMPLOYMENT EXPERIENCE

- Member of Technical Staff. Algorithms Research, Bell Laboratories, Lucent Technologies, August 1997 - Present.
- Intern. Bell Communications Research, Summer 1996.
- Intern. JP Morgan Corporation, Summer 1992.
- Intern. Allied Signal Corporation, Summer 1990.

HONORS AND AWARDS

- Lucent Chairman's Award, 2005.
- Bell Labs President's Gold Award for innovation and technical excellence, 2000, 2004.
- Bell Labs Teamwork Award for outstanding business contribution, 2004, 2005.
- National Science Foundation Fellowship, 1994-1997.
- MIT Applied Mathematics Fellowship, 1993-1994.
- Elected to Phi Beta Kappa, Sigma Xi, 1993.
- Ranked among the top 100 nationally in the 50th Putnam Mathematics Competition.
- First Prize winner of the Chinese National Mathematics Competition.

INVITED TALKS

- *Wireless Scheduling: An Example of Algorithmic Applications in Industry*
  - A Tutorial for Women in Theory Workshop in Princeton, June 2008.
- *Some Combinatorial Issues in Multi-carrier Wireless Scheduling*
  - Allerton invited session on Stochastic Network Performance and Scheduling, September 2007.
- *Scheduling Algorithms for Single-carrier and Multi-carrier Wireless Data Systems*
  - Microsoft Research, May 2008.
  - University of Cambridge, Computer Science Seminar, February 2008.
  - McGill University, Algorithms seminar, September 2007.
- *Scheduling for Wireless Systems*
  - Bertinoro workshop on adversarial modeling and analysis of communication networks, Italy, November 2006.
- *Network Algorithms: Routing and Design.*
  - DIMACS Tutorial on Algorithms for Next Generation Networks: Special Focus on Algorithmic Foundations of the Internet, August 2007.
- *Buy-at-Bulk Network Design with Protection*
  - University of Edinburgh, Scotland, April 2007.
- *Hardness of the Directed Congestion Minimization Problem*
  - AT&T Shannon Labs Math Seminar, May 2006.
  - MIT theory group, April 2006.
  - Columbia University Theory Seminar, April 2006.
- *Complexity of Routing in Communication Networks*
  - Tsinghua University, Beijing, December 2005.
  - Fudan University, Shanghai, December 2005.
- *Design for Optical Transparency*
  - International Symposium on Math Programming, August 2006.
  - Beijing University of Posts and Telecommunications, December 2005.
  - Princeton University, November 2005.
  - New York University CS Colloquium, October 2005.
- *Combinatorial Optimization.*
  - Bell Labs Research Summit, July 2005.
- *Switch Scheduling In the Adversarial Queueing Model.*
  - INFORMS Applied Probability Conference, July 2005.
- *Hardness of the Undirected Edge-Disjoint Path and Congestion Minimization Problems.*
  - DIMACS Theoretical Computer Science Seminar Series, November 2004.
  - AT&T Shannon Labs Math Seminar, March 2005.

- *Scheduling Wireless Data in an Adversarial Environment.*
  - University of Michigan (Ann Arbor) EECS Lab Seminar, March 2004.
  - Bell Labs Research Seminar, March 2004.
- *The Complexity of Wavelength Assignment.*
  - AT&T Shannon Labs Math Seminar, April 2004.
- *Algorithmic Issues in Optical Network Design.*
  - Polytechnic University, September 2003.
  - Northwestern University, August 2003.
- *Optical Line Systems*
  - University of Maryland (College Park) CS Seminar, April 2002.
- *Optimization for GSM Wireless Networks.*
  - DIMACS Workshop on Quality of Service Issues in the Internet, February 2001.

PROFESSIONAL ACTIVITIES

- Technical program committee
  - ACM Symposium on Theory of Computing (STOC) 2009, 2001.
  - ACM-SIAM Symposium on Discrete Algorithms (SODA) 2009.
  - ACM Symposium on Principles of Distributed Computing (PODC) 2008.
  - IEEE INFOCOM 2007, 2008, 2009.
  - APPROX 2007.
  - IEEE International Conference on Distributed Computing in Sensor Systems (DCOSS) 2007.
  - International Conference on Wireless Algorithms, Systems and Applications, 2006.
  - The Resource Allocation in Wireless Networks Workshop of WiOpt 2006.
  - The Computer and Network Security Symposium of IWCMC 2006, 2007, 2008.
- Organizing committee
  - DIMACS Special Focus on Intractability, 2007-2009.
  - The summer school in wireless communications at Institute for Math and Applications (IMA), 2005.
  - Organizer of the Network Design session in the International Symposium on Mathematical Programming (ISMP), 2006.
- Editor for the Institute for Math and its Applications (IMA) workshop proceedings, 2005.
- Guest editor for Algorithmica special issue on network design, Volume 43, Numbers 1-2, August 2005.
- Member of the DIMACS postdoctoral selection committee, 2000 - 2007.
- Member of the Bell Labs graduate fellowship selection committee, 2004 - 2007.
- NSF review panelist for theory of computing grant proposals, 2003.
- NSF Theory-Matters Visioning Workshop participant, 2008.
- Panelist for CRA-W graduate student recruitment workshops, 2000, 2005.

TEACHING EXPERIENCE AND EDUCATIONAL PROGRAMS

- Mentor. Women-in-Theory's mentoring program, 2008-2010.
- Mentor. The Young Science Achievers Program, 2008.
- Mentor. Institute for Math and its Applications (IMA) workshop on Math Modeling in Industry, 2007.
- Mentor. Bell Labs summer internship program. Interns supervised:
  - Daniel Lewin (MIT) 1998
  - Serge Kreiker (McGill) 2000
  - Elliot Anshelevich (Cornell) 2003
  - Seungjoon Lee (U Maryland) 2005
  - Spyros Antonakopoulos (Columbia) 2006, 2007
- Instructor. Experimental Study Group, MIT, Spring 1996.
- Mentor. Research and Science Institute (RSI), MIT, Summer 1995.
- Instructor. Hampshire College Summer Studies in Mathematics (HCSSIM), Summer 1994.

CONFERENCE PAPERS AND SUBMISSIONS

1. The Effect of Bridge-and-Roll on Minimizing Wavelength Conversion for Dynamic Traffic. *Proceedings of ECOC 2008*. Brussels, Belgium, September 2008. Coauthored with S. Fortune.

2. Efficient Scheduling Algorithms for Real-Time Multicast Services in Wireless LANs. *Proceedings of IEEE INFOCOM (mini symposium) 2008,*. Phoenix, AZ, April 2008. Coauthored with Y. Bejerano, D. Lee and P. Sinha.

3. Satisfying Arbitrary Delay Requirements in Multihop Networks. *Proceedings of IEEE INFOCOM 2008*. Phoenix, AZ, April 2008. Coauthored with M. Andrews.

4. Creating Templates to Achieve Low Delay in Multi-Carrier Frame-Based Wireless Data Systems. *Proceedings of IEEE INFOCOM 2008*. Phoenix, AZ, April 2008. Coauthored with M. Andrews.

5. Scheduling Algorithms for Single-carrier and Multi-carrier Wireless Data Systems. *Proceedings of the 45th Annual Allerton Conference on Communication, Control and Computing (invited paper).* September 2007. Monticello, IL. Coauthored with M. Andrews.

6. Approximating Protected Buy-at-Bulk Network Design. *Proceedings of the 48th Annual IEEE Symposium on Foundation of Computer Science (FOCS)*. October 2007. Providence, RI. Coauthored with S. Antonakopoulos, C. Chekuri and B. Shepherd.

7. Heuristics for Fiber Installation in Optical Network Optimization. *Proceedings of 2007 IEEE Global Telecommunications Conference.* Washington DC, November 2007. Coauthored with S. Antonakopoulos.

8. Scheduling Algorithms for Multi-Carrier Wireless Data Systems. *Proceedings of the Thirteenth Annual International Conference on Mobile Computing and Networking (Mobicom)*. Montreal, Canada, September 2007. Coauthored with M. Andrews.

9. On Rank Aggregation of Multiple Orderings in Network Design. *Proceedings of the International Network Optimization Conference (INOC)*. Spa, Belgium, April 2007. Coauthored with H. Shachnai and T. Matsui.

10. Logarithmic Hardness for the Directed Congestion Minimization Problem. *Proceedings of the 38th Annual ACM Symposium on Theory of Computation (STOC).* Seattle, WA, May 2006. Coauthored with M. Andrews.

11. A Tool for CDMA Data Measurement and Analysis. *Proceedings of the Second International Workshop On Wireless Network Measurement.* Boston, MA, April 2006. Coauthored with M. Andrews.

12. Admission Control for Multihop Wireless Backhaul Networks with QoS Support. *Proceedings of IEEE Wireless Communications and Networking Conference 2006.* Las Vegas, NV, April 2006. Coauthored with S. Lee, G. Narlikar, M. Pal and G. Wilfong.

13. Designing Multihop Wireless Backhaul Networks with Delay Guarantees. *Proceedings of IEEE INFOCOM 2006*. Barcelona, Spain, April 2006. Coauthored with G. Narlikar and G. Wilfong.

14. Complexity of Wavelength Assignment in Optical Network Optimization. *Proceedings of IEEE INFOCOM 2006*. Barcelona, Spain, April 2006. Coauthored with M. Andrews.

15. Hardness of the Undirected Edge Disjoint Path Problem with Congestion. *Proceedings of the 46th Annual IEEE Symposium on Foundation of Computer Science (FOCS)*. October 2005. Coauthored with M. Andrews, J. Chuzhoy and S. Khanna.

16. The Master Ring Problem. *Proceedings of the 2005 International Conference on Analysis of Algorithms.* Spain, June 2005. Coauthored with H. Shachnai.

17. Hardness of the Undirected Edge Disjoint Path Problem. *Proceedings of the 37th Annual ACM Symposium on Theory of Computation (STOC).* Baltimore, MD, May 2005. Coauthored with M. Andrews.

18. Hardness of the Undirected Congestion Minimization Problem. *Proceedings of the 37th Annual ACM Symposium on Theory of Computation (STOC).* Baltimore, MD, May 2005. Coauthored with M. Andrews.

19. Bounds on Fiber Minimization in Optical Networks. *Proceedings of IEEE INFOCOM 2005*. Miami, FL, March 2005. Coauthored with M. Andrews.

20. Path Decomposition under a New Cost Metric. *Proceedings of 12th Annual European Symposium on Algorithms (ESA)*. Bergen, Norway, September 2004. Coauthored with E. Anshelevich.

21. Wavelength Assignment in Optical Networks with Fixed Fiber Capacity. *Proceedings of 31st International Colloquium on Automata, Languages and Programming (ICALP)*. Turku, Finland, July 2004. Coauthored with M. Andrews.

22. Line System Design for DWDM Networks. *Proceedings of the 11th International Telecommunications Network Strategy and Planning Symposium (Networks)*. Vienna, Austria, June 2004. Coauthored with S. Fortune and W. Sweldens.

23. DCM Selection on an Optical Line System. *Proceedings of the 11th International Telecommunications Network Strategy and Planning Symposium (Networks)*. Vienna, Austria, June 2004. Coauthored with C. Chekuri and W. Lee.

24. Scheduling over Non-stationary Wireless Channels with Finite Rate Sets. *Proceedings of IEEE INFOCOM 2004*. Hong Kong, March 2004. Coauthored with M. Andrews.

25. Routing and Scheduling in Multihop Wireless Networks with Time-Varying Channels. *Proceedings of the 15th Annual ACM-SIAM Symposium on Discrete Algorithms (SODA)*. New Orleans, LA, January 2004. Coauthored with M. Andrews.

26. Optical Line System Configuration via Dynamic Programming. *Proceedings of the International Network Optimization Conference (INOC)*. Paris, France, October 2003. Coauthored with C. Chekuri and W. Lee.

27. Wavelength Assignment and Generalized Interval Graph Coloring. *Proceedings of the 14th Annual ACM-SIAM Symposium on Discrete Algorithms (SODA)*. Baltimore, MD, January 2003. Coauthored with P. Winkler.

28. Scheduling over a Time-Varying User-Dependent Channel with Applications to High Speed Wireless Data. *Proceedings of the 43rd Annual IEEE Symposium on Foundation of Computer Science (FOCS)*. Vancouver, Canada, November 2002. Coauthored with M. Andrews.

29. The Performance of GPS and EDF with Temporary Sessions. *Proceedings of the 10th IEEE International Workshop on Quality of Service*. Miami Beach, FL, May 2002. Coauthored with M. Andrews.

30. Scheduling Protocols for Switches with Large Envelopes. *Proceedings of the 13th Annual ACM-SIAM Symposium on Discrete Algorithms (SODA)*. San Francisco, CA, January 2002. Coauthored with M. Andrews.

31. Source Routing and Scheduling in Packet Networks. *Proceedings of the 42nd Annual IEEE Symposium on Foundation of Computer Science (FOCS)*. Las Vegas, NV, October 2001. Coauthored with M. Andrews, A. Fernandez and A. Goel.

32. Achieving Stability in Networks of Input-Queued Switches. *Proceedings of IEEE INFOCOM 2001*. Anchorage, Alaska, April 2001. Coauthored with M. Andrews.

33. Blocking Estimates in a Partitioned-Sector TDMA System. *Dial M for Mobility 2000: The 4th International Workshop on Discrete Algorithms and Methods for Mobile Computing and Communications*. Boston, MA, August 2000. Coauthored with C. Chekuri, K. Ramanan and P. Whiting.

34. QoS Routing with Performance-Dependent Costs. *Proceedings of IEEE INFOCOM 2000*. Tel Aviv, Isreal, March 2000. Coauthored with F. Ergun and R. Sinha.

35. The Effects of Temporary Sessions on Network Performance. *Proceedings of the 11th Annual ACM-SIAM Symposium on Discrete Algorithms (SODA)*. San Francisco, CA, January 2000. Coauthored with M. Andrews.

36. An Augmentation Algorithm for Mincost Multicommodity Flow on a Ring. *Proceedings of 1999 IEEE Global Telecommunications Conference.* Rio de Janeiro, Brazil, December 1999. Coauthored with B. Shepherd.

37. Packet Routing with Arbitrary End-to-End Delay Requirements. *Proceedings of the 31st Annual ACM Symposium on Theory of Computation (STOC).* Atlanta, GA, May 1999. Coauthored with M. Andrews.

38. Minimizing End-to-End Delay in High-Speed Networks with a Simple Coordinated Schedule. *Proceedings of IEEE INFOCOM 1999*. New York, NY, March 1999. Coauthored with M. Andrews.

39. Fast, Fair and Frugal Bandwidth Allocation in ATM Networks. *Proceedings of the 10th Annual ACM-SIAM Symposium on Discrete Algorithms (SODA)*. Baltimore, MD, January 1999. Coauthored with Y. Bartal, M. Farach-Colton and S. Yooseph.

40. The Access Network Design Problem. *Proceedings of the 39th Annual IEEE Symposium on Foundation of Computer Science (FOCS)*. Palo Alto, CA, November 1998. Coauthored with M. Andrews.

41. Stability Results for Networks with Input and Output Blocking. *Proceedings of the 30th Annual ACM Symposium on Theory of Computation (STOC)*. Dallas, TX, May 1998. Coauthored with M. Andrews.

42. A Performance Comparison of Competitive On-line Routing and State-Dependent Routing. *Proceedings of 1997 IEEE Global Telecommunications Conference.* Phoenix, AZ, November 1997. Coauthored with W. Aiello, M. Andrews, S. Bhatt and K. R. Krishnan.

43. General Dynamic Routing with Per-Packet Delay Guarantees of $O(\text{distance} + 1/\text{session rate})$. *Proceedings of the 38th Annual Symposium on Foundations of Computer Science (FOCS)*. Miami Beach, FL, October 1997. Coauthored with M. Andrews, A. Fernandez, M. Harchol-Balter and T. Leighton.

44. New Algorithms for the Disk Scheduling Problem. *Proceedings of the 37th Annual Symposium on Foundations of Computer Science (FOCS)*. Burlington, VT, October 1996. Coauthored with M. Andrews and M. Bender.

45. Improved Bounds for On-line Load Balancing. *Proceedings of the Second International Computing and Combinatorics Conference*. Hong Kong, June 1996. Coauthored with M. Andrews and M. Goemans.

46. Efficient Execution of Nondeterministic Parallel Algorithms on Asynchronous Systems. *Proceedings of the 8th ACM Symposium on Parallel Algorithms and Architectures (SPAA)*. Padua, Italy, June 1996. Coauthored with Y. Aumann and M. Bender.

47. Open Problems for Latency Hiding in Networks of Workstations. *Proceedings of the 7th Australia Workshop on Combinatorial Algorithms*. Australia, July 1996. Coauthored with M. Andrews, T. Leighton and T. Metaxas.

48. Improved Methods for Hiding Latency in High Bandwidth Networks. *Proceedings of the 8th ACM Symposium on Parallel Algorithms and Architectures (SPAA)*. Padua, Italy, June 1996. Coauthored with M. Andrews, T. Leighton and T. Metaxas.

49. Automatic Methods for Hiding Latency in High Bandwidth Networks. *Proceedings of the 28th Annual ACM Symposium on Theory of Computing (STOC)*. Philadelphia, PA, May 1996. Coauthored with M. Andrews, T. Leighton and T. Metaxas.

JOURNAL PAPERS AND SUBMISSIONS

50. Wavelength Assignment in Optical Network Design. *Submitted.* Coauthored with B. Farrell, Y. Huang, M. Iwen, T. Wang and J. Zheng.

51. Designing Multihop Wireless Backhaul Networks with Delay Guarantees. To appear in *Springer Wireless Networks.* Coauthored with G. Narlikar and G. Wilfong.

52. A Note on Generalized Rank Aggregation. *Submitted.* Coauthored with H. Shachnai and T. Matsui.

53. Complexity of Wavelength Assignment in Optical Network Optimization. *submitted*. Coauthored with M. Andrews

54. Optical Line System Configuration via Dynamic Programming. *Submitted.* Coauthored with C. Chekuri and W. Lee.

55. Logarithmic Hardness of the Directed Congestion Minimization Problem. Accepted to *Journal of the ACM*. Coauthored with M. Andrews.

56. Exact Algorithms for the Master Ring Problem. To appear in *Networks.* Coauthored with H. Shachnai and T. Matsui.

57. Path Decomposition under a New Cost Metric with Applications to Optical Network Design. *ACM Transactions on Algorithms.* Vol. 4, No. 1, Article 15, 2008. Coauthored with E. Anshelevich.

58. Hardness of the Undirected Congestion Minimization Problem. *SIAM Journal of Computing.* Vol. 37, No. 1, pp. 112-131, 2007. Coauthored with M. Andrews.

59. Routing and Scheduling in Multihop Wireless Networks with Time-Varying Channels. *ACM Transactions on Algorithms.* Vol. 3, No. 3, Article 33, 2007. Coauthored with M. Andrews.

60. Logarithmic Hardness of the Undirected Edge-Disjoint Paths Problem. *Journal of the ACM*. Vol. 53, No. 5, pp. 745-761, 2006. Coauthored with M. Andrews.

61. Scheduling over Non-stationary Wireless Channels with Finite Rate Sets. *IEEE/ACM Transactions on Networks.* Vol. 14, No. 5, pp. 1067-1077, October 2006. Coauthored with M. Andrews.

62. Design Tools for Transparent Optical Networks. *Bell Labs Technical Journal.* Vol. 11, No. 2, pp. 129-143, 2006. Coauthored with C. Chekuri, P. Claisse, R. Essiambre, S. Fortune, D. Kilper, W. Lee, K. Nithi, I. Saniee, B. Shepherd, C. White, G. Wilfong.

63. Minimizing Maximum Fiber Requirement in Optical Networks. *Journal of Computer and Systems Sciences*. Vol. 72, pp. 171-186, 2006. Coauthored with M. Andrews.

64. Scheduling over a Time-Varying User-Dependent Channel with Applications to High Speed Wireless Data. *Journal of the ACM*. Vol. 52, No. 5, pp. 809-834, 2005. Coauthored with M. Andrews.

65. Source Routing and Scheduling in Packet Networks. *Journal of the ACM*. Vol. 52, No. 4, pp. 582-601, 2005. Coauthored with M. Andrews, A. Fernandez and A. Goel.

66. The New Paradigm for Wireless Network Optimization: A Synergy of Automated Processes and Human Intervention. *IEEE Communications Magazine.* Vol. 43, No. 3, March 2005. Coauthored with G. Hampel, D. Abush-Magder, A. Diaz, L. Drabeck, M. Flanagan, J. Graybeal, J. Hobby, M. MacDonald, P. Polakos, J. Srinivasan, H. Trickey and G. Rittenhouse.

67. The Effects of Temporary Sessions on Network Performance. *SIAM Journal on Computing.* Vol. 33, No. 3, pp. 659-673, 2004. Coauthored with M. Andrews.

68. Minimizing End-to-End Delay in High-Speed Networks with a Simple Coordinated Schedule. *Journal of Algorithms*. Vol. 52, No. 1, pp. 57-81, 2004. Coauthored with M. Andrews.

69. Scheduling Protocols for Switches with Large Envelopes. *Journal of Scheduling* Vol. 7, No. 3, pp. 171-186, 2004. Coauthored with M. Andrews.

70. Achieving Stability in Networks of Input-Queued Switches. *IEEE/ACM Transaction on Networks*, Vol. 11, No. 5, pp. 848-857, 2003. Coauthored with M. Andrews.

71. An Improved FPTAS for Restricted Shortest Path. *Information Processing Letters*, Vol. 83, No. 5, pp. 287-291, 2002. Coauthored with F. Ergun and R. Sinha.

72. Approximation Algorithms for Access Network Design. *Algorithmica*, Vol. 34, pp. 197 – 215, 2002. Coauthored with M. Andrews.

73. New Algorithms for Disk Scheduling. *Algorithmica*, Vol. 32, pp. 277-301, 2002. Coauthored with M. Andrews and M. Bender.

74. Fast, Fair and Frugal Bandwidth Allocation in ATM Networks. *Algorithmica special issue, Internet Algorithms*, Vol. 33, pp. 272-286, 2002. Coauthored with Y. Bartal, M. Farach-Colton and S. Yooseph.

75. An Augmentation Algorithm for Mincost Multicommodity Flow on a Ring. *Discrete Applied Mathematics*, Vol. 110, pp. 301-315, 2001. Coauthored with B. Shepherd.

76. General Dynamic Routing with Per-Packet Delay Guarantees. *SIAM Journal on Computing*, Vol. 30, No. 5, pp. 1594-1623, 2000. Coauthored M. Andrews, A. Fernandez, M. Harchol-Balter and T. Leighton.

77. Improved Bounds for On-Line Load Balancing. *Algorithmica*, Vol. 23, No. 4, pp. 278-301, 1999. Coauthored with M. Andrews and M. X. Goemans.

78. Automatic Methods for Hiding Latency in Parallel and Distributed Computing. *SIAM Journal on Computing*, Vol. 29, No. 2, pp. 615-647, 1999. Coauthored with M. Andrews, T. Leighton and P. T. Metaxas.

79. Efficient Execution of Nondeterministic Parallel Programs on Asynchronous Systems. *Information and Computation*, Vol. 139, No. 1, pp. 1–16, 1997. Coauthored with Y. Aumann and M. Bender.

PATENTS

1. Methods for Devices for Scheduling the Transmission of Multicast Messages in Wireless Local Area Networks. *Filed with the U.S. Patent and Trademark Office, IDS No. 128324.* Coinvented with Y. Bejerano.

2. Scheduling for Multi-Carrier Wireless Data Systems. *Filed with the U.S. Patent and Trademark Office, IDS No. 128884.* Coinvented with M. Andrews.

3. Method and Apparatus for Scheduling Data Packet Transmission over a Multihop Wireless Backhaul Network. U.S. Patent Number 7366178, issued on 4/29/2008. Coinvented with S. Lee, G. Narlikar and G. Wilfong.

4. Method for Determining a Master Ring for an Optical Communications Network. U.S. Patent Number 7349351, issued on 3/25/2008. Coinvented with H. Shachnai.

5. Methods and Apparatus for Design, Adjustment Or Operation Of Wireless Networks Using Pre-Frequency-Assignment Optimization. *U.S. Patent Number 7142523, issued on 11/28/2006.* Coinvented with C. Chekuri and L. Drabeck.

6. Methods and Apparatus for Design, Adjustment Or Operation Of Wireless Networks Using Multi-Stage Optimization. *U.S. Patent Number 6925066, issued on 08/02/2005.* Coinvented with C. Chekuri, L. Drabeck, K. G. Hampel and P. Polakos.

7. Quality Of Service Routing In Information Networks Over Paths Having Performance Dependent Costs. *U.S. Patent Number 6697335, issued on 02/24/2004.* Coinvented with F. Ergun and R. Sinha.

8. A Method for Providing Communications Network Stability. *U.S. Patent Number 6147990, issued on 03/26/2002.* Coinvented with M. Andrews.

9. Linear Programming Method of Network Design for Carrying Traffic from endnodes to a Core Network at Least Cost. *U.S. Patent Number 6363334, issued on 11/14/2000.* Coinvented with M. Andrews.

SELECTED BELL LABS PROJECTS

- *WDM (wavelength division multiplex) Network Design*

  Developed optical network optimization and planning tools for Lucent's long-haul and multi-haul transport systems. Designed and implemented effective heuristics for NP-hard problems such as routing, grooming, protection, wavelength assignment, span engineering and optimal placement of optical equipment. Tool used for responding to Requests for Information (RFI) from major domestic and international carriers.

- *3-Level Network Design*

  Developed a 3-level engineering and planning tool that handles packet, SONET and WDM traffic. The tool optimizes traffic with diverse characteristics such as multicast demands and demands that require varying level of protection.

- *Access Network and Backbone Network Optimization*

  Involved in Lucent's bidding for the design of a long distance network for a regional telephone company. Studied issues of economy of scale and technology evolvement via LP relaxation and novel rounding algorithms.

- *Wireless network optimization*

  Contributed to a wireless design tool for optimizing cell coverage and capacity. Modeled power control and antenna orientation via large scale non-linear programming in a GSM system. Studied methods for estimating blocking probabilities in the presence of multiple frequencies and developed heuristics for frequency planning.

- *CDMA Data Measurement and Analysis*

  Developed a tool that analyzes and measures the performance of CDMA data services. Studied the relationship between data throughput, latency, protocol behavior and channel quality. Tool used for testing and validating Lucent 3G products, and for comparing different CDMA technologies and network operated by different vendors.