DIMACS Center
Rutgers University

University-Industry Postdoctoral Fellow in Telecom/Combinatorics and Optimization

Annual Report

July 2007

Participants who spent 160 hours or more

PI: Fred Roberts, Rutgers University, DIMACS

Other Participants

The following Rutgers faculty and the following researchers at Alcatel-Lucent Bell Labs participated in the selection of the postdoctoral fellow by conducting interviews, reviewing applications, and providing feedback.

Rutgers University:
Eric Allender, Computer Science
Endre Boros, Rutgers Center for Operations Research (RUTCOR)
Anders Buch, Mathematics
Tamra Carpenter, DIMACS
Stephen Greenfield, Mathematics
Michael Grigoriadis, Computer Science
Vladimir Gurvich, RUTCOR
Jeffrey Kahn, Mathematics
Joseph Killian, Computer Science
Friedrich Knop, Mathematics
Janos Komlos, Mathematics
Brenda Latka, DIMACS
Diane Maclagen, Mathematics
Konstantin Mischaikow, Mathematics
Vladimir Retakh, Mathematics
Siddhartha Sahi, Mathematics
Michael Saks, Mathematics
Eduardo Sontag, Mathematics
Doron Zeilberger, Mathematics

Alcatel-Lucent Bell Labs:
Matthew Andrews
Yuliy Baryshnikov
Steve Fortune
Debasis Mitra
Iraj Saniee
Bruce Shepherd

Partner Organizations

Alcatel-Lucent, Bell Labs: Collaborative Research
Partner organization of DIMACS. Individuals from the organization participated in recruiting, selection and planning activities.

Activities

The DIMACS Center at Rutgers University and the Mathematical Sciences Research Center at Alcatel-Lucent Bell Laboratories will host Daniel Cranston as a postdoctoral fellow, beginning in September 2007. Cranston, who received his Ph.D. in 2007 from the University of Illinois at Urbana/Champaign, was selected following a national search that resulted in interviews of five candidates at Rutgers and Bell

Labs. This report will describe the search process that concluded in April 2007 with Cranston's acceptance of our fellowship offer. His fellowship will begin in September 2007.

Cranston received his Ph.D. in Computer Science, with advisor Douglas West, who is a professor in the Mathematics Department. Cranston's research interests lie primarily in graph theory and combinatorics, with an emphasis on coloring and labeling problems on graphs. Graph coloring problems model partitioning a set of objects into subsets subject to various constraints. These problems have direct application to many problems in scheduling, timetabling, and sequencing, and they have frequent application in telecommunications, most notably for assigning wavelengths in optical networks. Cranston is particularly interested in results that can easily be adapted to give efficient algorithms that produce the desired coloring or labeling. To date, he has produced results on several types of coloring and labeling problems, including strong edge coloring, list-coloring, edge list-coloring, (a, b)-edge list-coloring, total list-coloring, minimum-sum vertex cover, antimagic labeling, and overlap labeling. As a summer intern at Argonne National Lab, he developed a graph coloring algorithm to decrease the time needed to compute Jacobian matrices. Cranston's penchant for blending theory with practical algorithms makes him an ideal candidate for a joint industry/academia postdoctoral position. In addition to coloring and labeling problems, Cranston has interests in a wide range of structural and extremal problems in graph theory. His interests are well-aligned with many activities underway at DIMACS; indeed, Cranston has been a participant in several DIMACS workshops, and he will find many relevant applications in network design and management at Bell Labs.

DIMACS and Bell Labs began a similar search for postdoctoral candidates during Fall 2005/Spring 2006 with the intent of filling the position a year earlier, at the start of this grant. However, that search ended without offers being extended or candidates invited. Because of uncertainties surrounding the plans for merger between Lucent and Alcatel, we decided to defer any decisions on the postdoctoral position until the impact of the merger at Bell Labs was clearer. Thus, we delayed the process for a year and reinitiated it in the Fall of 2006, which resulted in the selection of Dan Cranston.

Overview

Bell Laboratories has been a DIMACS partner since the founding of the center in 1988. However, in all of those years of working together, Cranston will be the first postdoctoral fellow to be recruited and mentored jointly. University and industrial researchers have visited back and forth and have collaborated in organizing DIMACS workshops. Postdoctoral fellows hired at Rutgers have been given access to Bell Labs facilities and postdoctoral fellows hired at Bell Labs have been given access to DIMACS facilities. However, Cranston will be the first fully shared postdoctoral fellow.

The joint Bell Labs/DIMACS postdoc will focus on research problems in the broad area of combinatorics and optimization that are of particular relevance to telecommunication. Problems in combinatorics and optimization, and more particularly combinatorial optimization, are fundamental to telecommunication networks. For example, the routing of every Internet packet is based in part upon the Bellman-Ford or Dijkstra shortest-path algorithm. Total throughput and per-user fairness are balanced for wireless data by fair queueing models. Matching algorithms, implemented in parallel, are integral to very high speed data routers.

Within the next decade, growth in demand and technological innovations involving broadband multimedia intelligence will likely cause major changes in fundamental network infrastructures, including packet data, wireless, and optical networks. These changes will require novel algorithms to design, optimize and operate the resulting network and will provide challenging new mathematical problems in combinatorics and optimization.

These challenges lie at the forefront of modern telecommunications and provide significant research opportunities for recent Ph.D.s in the mathematical sciences. The Mathematical Sciences Research Center at Bell Laboratories in Murray Hill, NJ has historically been the center of mathematical research in telecommunication and has a strong group in combinatorics and optimization. The DIMACS Center based at Rutgers University has strong researchers in related areas of linear and integer programming, graph theory, and scheduling. Together, they will provide a uniquely stimulating environment in which Cranston can master an important applied area while interacting with mathematical scientists at the forefront of their discipline.

The general context of this fellowship is in combinatorics and optimization problems arising from new directions in telecommunications. This topic, however, is very broad. Our purpose is to introduce the Bell Labs-DIMACS postdoctoral fellow to novel telecommunication problems and the wide variety of related combinatorics and optimization problems by focusing, at least initially, on a particular network architecture such as the IP Multimedia Subsystem (IMS). In addition, we will encourage the Cranston to explore numerous research directions related to many projects at the interface between telecommunication and combinatorics and optimization.

The postdoctoral fellow will have mentors at both Bell Labs and DIMACS and will have access to a wide variety of researchers at the various DIMACS institutions. At Bell Labs, the primary mentors will be Matthew Andrews, Yuliy Baryshnikov, Debasis Mitra, and Iraj Saniee, while at Rutgers the primary mentors will be Endre Boros, Vladimir Gurvich, and Fred Roberts. The Bell Labs mentors bring strength in resource sharing and queuing theory (Mitra), network design and optimization (Saniee), packet scheduling and algorithms (Andrews) and probability theory and mathematical economics (Baryshnikov). The Rutgers mentors bring strength in combinatorial optimization (Boros), combinatorics and graph theory (Gurvich), and applications of graph theory, combinatorics and optimization (Roberts). Mitra and Roberts will also provide the primary career mentoring and counseling.

We anticipate that Cranston will need an introduction to the mathematics of telecommunications, and this will be provided as part of his Bell Labs experience. During the first month of his tenure, Cranston will be given an intensive introduction to the literature and practice of mathematics in telecommunication, with an emphasis on the role of combinatorics and optimization. The mentors at Bell Labs will play the lead role in this process, working together with their colleagues throughout Alcatel-Lucent.

Concurrently, Cranston will be introduced to interested faculty at Rutgers, and we will begin discussions on open problems and new directions of research that do not require a major telecom background. As the telecom introduction progresses, more telecom-related problems emanating from Bell Labs will be discussed, with Rutgers faculty participating in the discussions both at Bell Labs and Rutgers. The early involvement of teams of university faculty and industrial researchers is designed to make the entire postdoctoral experience a truly mutual experience, enabling Cranston to move seamlessly between the industrial and academic environments. A side benefit of these interactions should be new collaborations between industrial and university researchers.

Cranston was selected on the basis of a national search that began in Fall 2006 and continued through his selection in Spring 2007. We placed ads in such places as SIAM News, OR/MS Today, and Employment Information in the Mathematical Sciences (EIMS) of the American Mathematical Society (AMS). In addition, we posted ads to a variety of mailing lists including those of DMANET, math-jobs.com, and the extensive mailing lists at DIMACS. This search, combined with extensive word-of-mouth advertising, generated a number of eligible candidates. From them, we invited a total of five candidates for two-day interviews. Candidates spent one day at Bell Labs and one day at DIMACS, giving a seminar on their research at each location.

Outreach Activities

Integration of research and education is a major theme of this project. Cranston will be exposed to the wide variety of programs at DIMACS that integrate research and education, including programs introducing college faculty to current research relevant to the undergraduate classroom (the "Reconnect" program), K-12 teacher programs, and the Research Experiences for Undergraduates (REU) program. During his interview, Cranston expressed strong interest in undergraduate and K-12 education. Indeed, each of them has been actively involved with K-12 education, in addition to the more usual experiences teaching undergraduates.

We will strongly encourage Cranston to mentor a student in the summer REU program and to sample the K-12 activities by giving guest lectures in our high school programs. In addition, Cranston is interested in participating in our workshops on the Mathematics of Homeland Security for high school teachers. These workshops are part of an exciting new program designed to introduce high school mathematics teachers to mathematical methods that are applied to important problems in homeland security. Many of these applications lead to important challenges in combinatorial optimization and graph theory.

Main website

http://dimacs.rutgers.edu/Applications/

Contributions

Contributions to Human Resources Development

We believe that DIMACS and Bell Labs will provide Dan Cranston with rich environments in which to flourish as a new researcher. He will be prepared for a variety of exciting career opportunities in academic or industrial research, and he will gain invaluable experience in understanding complex real-world problems, creating viable mathematical models and obtaining mathematical results that are of immediate use. We expect that his experiences will expose him to the power of academic/industrial collaborations and will inform his career and his teaching, should he decide to pursue a career in academia.

To provide opportunities to gain undergraduate teaching experience, we made arrangements with the Mathematics Department that enabled us to offer Cranston the option to supplement his postdoc with undergraduate teaching.