DIMACS Center
Rutgers University

DIMACS Satellite Reconnect 2003 Program

Report

March 2004

The DIMACS Reconnect Program aims to reconnect to the mathematical sciences research enterprise faculty whose primary responsibility is teaching undergraduates. A leading expert introduces participants to a current research topic relevant to the classroom through a series of lectures. The participants are involved in writing materials useful in the classroom, with the possibility of following up by preparing these materials for publication in the DIMACS Educational Modules Series.

This program, organized primarily around summer conferences, offers the opportunity for junior faculty as well as mid-level and senior faculty to advance to research questions in a new area of the mathematical sciences. Participants also acquire materials and gain ideas for seminar presentations and for undergraduate research projects.

The Reconnect Program is also aimed at reconnecting faculty to the mathematical sciences research enterprise by involving them in a leading research center. There are opportunities to follow up after the summer conference by getting connected to DIMACS researchers and other DIMACS programs throughout the year.

The program features a ``satellite" component whereby the programs run at DIMACS become the training ground for other college faculty to observe the program and subsequently run a similar program at their own institutions in the succeeding summer. There are currently seven institutions that have run or have agreed to run Satellite Reconnect programs: Salem State College and the Illinois Institute of Technology in summer 2003, Lafayette College and St. Mary's College in summer 2004, Montclair State University and Spelman College in summer 2005, and Morgan State University in summer 2006. The program through summer 2005 are funded in the current grant and we have requested a supplement for the summer 2006 program at Morgan State.)

Ia. Participants from the 2003 program

Participants:

Salem State College Program

Anusha Anantharaju, *Salem State College*,
Julie Belock, *Salem State College*,
Christopher Boucher, *Salem State College*,
Zhongyuan Che, *Wesleyan University*,
Yong S. Colen, *Hawken School*,
Joyce Blair Crowell, *Belmont University*,
Pranava K. Jha, *St. Cloud State University*,
Matthew Koetz, *University of Nebraska, Lincoln*,
Martha Kuklinski, *Salem State College*,
Steven Leonhardi, *Winona State University*,
Jillian McLeod, *Mount Holyoke College*,
Ann Moskol, *Rhode Island College*,
Sarah Newcomb, *Salem State College*,
Peter Ohring, *Purchase College, SUNY*,
Sharon Persinger, *Bronx Community College*,
Jenny Salazar, *Texas Lutheran University*,
Gary Salazar, *Trinity University*,
Jim Sauerberg, *Saint Mary's College*

Illinois Institute of Technology Program

Atif Abueida, *University of Dayton*,
Michael Ackerman, *Bellarmine University*,

Erin M. Boyer, *Dartmouth College*,
Sul-young Choi, *LeMoyne College*,
Peter R. Christopher, *Worcester Polytechnic Institute*,
Yong S. Colen, *Hawken School*,
Benjamin V.C. Collins, *University of Wisconsin-Platteville*,
Dawit Haile, *Virginia State University*,
Daniel J. Hrozencik, *Chicago State University*,
Pranava K. Jha, *St. Cloud State University*,
Mark A. Mills, *Central College*,
Oscar Ortega, *Illinois Institute of Technology*,
Michael Pelsmajer, *Illinois Institute of Technology*,
Shrisha Rao, *Mount Mercy College*,
Shane Redmond, *Southeastern Louisiana University*,
Zhizhang Shen, *Plymouth State College*,
Boting Yang, *University of Regina*

DIMACS (Rutgers University) Program

Atif Abueida, *University of Dayton*,
Mark Bollman, *Albion College*,
Jie Chen, *Princeton University*,
Mike Daven, *Mount Saint Mary College*,
Mike Gargano, *Pace University*,
Charles Hamaker, *Saint Mary's College of California*,
Edwin Hong, *University of Washington, Tacoma*,
Dan Ilaria, *Rutgers University*,
Martha Kosa, *Tennessee Technological University*,
Lorraine Lurie, *Pace University*,
Michael Olan, *Richard Stockton College*,
Krishnan Pillaipakkamnatt, *Hofstra University*,
Kulathur Rajasethupathy, *SUNY College at Brockport*,
Anthony Scime, *SUNY College at Brockport*,
William Slough, *Eastern Illinois University*,
Dawn Strickland, *Winthrop University*,
Sehwan Yoo, *University of Maryland Eastern Shore*

Organizers:

Salem State College Program

Maura Murray, Salem State College
Fred S. Roberts, DIMACS, Rutgers University
Christine Spassione, Reconnect Program Coordinator, DIMACS

Illinois Institute of Technology Program

F.R. McMorris, Illinois Institute of Technology
Fred S. Roberts, DIMACS, Rutgers University
Christine Spassione, Reconnect Program Coordinator, DIMACS

DIMACS (Rutgers University) Program

Rochelle Leibowitz, Wheaton College
Fred S. Roberts, Rutgers University
Christine Spassione, Reconnect Program Coordinator, DIMACS

Main Speakers:

Salem State College Program
Judy Walker, University of Nebraska - Lincoln
Illinois Institute of Technology Program
K. Brooks Reid, California State University San Marcos
DIMACS (Rutgers University) Program
Greg Plaxton, University of Texas at Austin

Guest Speakers:
Illinois Institute of Technology
Martyn Mulder, Erasmus University, Rotterdam

2004 Satellite Reconnect Organizers:
Jonathan Berry, Lafayette College
Lidia Luquet, St. Mary's College

Consultants from Minority Institutions
Ermelinda De La Vina, University of Houston-Downtown
Yewande Olubummo, Spelman College

Ib. Participating Organizations

Rutgers, The State University of New Jersey, Princeton University, AT&T Labs – Research, Bell Labs, NEC Laboratories America, Telcordia Technologies, Illinois Institute of Technology, and Salem State College, Lafayette College, St. Mary's College.

II. Project Activities

During this year of the grant, we ran a summer 2003 program at DIMACS (Rutgers University) and two summer 2003 satellite Reconnect programs were held at Salem State and Illinois Institute of Technology. We followed up the summer 2002 DIMACS (Rutgers) program by staying in touch with the participants and helping them with the modules they started in summer 2002. We worked with the organizers of summer 2003 satellite programs, "training" them and guiding them, and also worked with the organizers of the summer 2004 satellite programs.

The Summer 2003 Program at Salem State: Some Current Problems in Coding Theory

The topic for the Satallite Reconnect 2003 at Salem State was Some Current Problems in Coding Theory. The main speaker was Judy Walker of University of Nebraska - Lincoln.

Whenever information is transmitted across a channel, errors are bound to occur. It is the goal of coding theory to find efficient ways of adding redundancy to the information so that the errors can be detected and even corrected. The first few lectures of this workshop were devoted to a general introduction to the theory of error-correcting codes. The remaining lectures were devoted to a survey of some current topics in coding theory research, including a discussion of several recent papers on the subject.

Because of its immediate real-world applications, coding theory is a topic with great appeal to undergraduates. It can be worked into undergraduate linear algebra, abstract algebra, and number theory courses.

The Reconnect Program devoted a great deal of time to these connections to the undergraduate curriculum.

The Summer 2003 Program at Illinois Institute of Technology: Centrality in Graphs with Applications to the Theory of Location of Facilities

The topic for the Satellite Reconnect 2003 at Illinois Institute of Technology was Centrality in Graphs with Applications to the Theory of Location of Facilities. The main speaker was K. Brooks Reid of California State University San Marcos.

Graphs are used to model many real life situations, and in such circumstances graph theory serves as a foundational structure to help explain the world in which we live. One very interesting application of graph theory is in the theory of the location of facilities in networks. The theory of location of facilities in networks combines tools from graph theory, basic analysis, optimization, and complexity theory. In this series of lectures Reid used the motivation from the theory of the location of facilities on networks to concentrate on some of the underlying graph theory. The goal of this series of talks was to convey the idea that this subject is a very accessible branch of applicable combinatorics, rich in problems, and offering an occasional surprise. Parts of the subject can be incorporated into the undergraduate classroom, both to illustrate a modern application of graph theory and to illustrate how applied problems can give rise to new questions in pure mathematics. The content is very suitable for stimulating departmental seminars and/or undergraduate lectures.

The major focus of the theory of location of facilities on networks is to determine where to locate facilities of some sort in a network of sites that include both potential facility sites and facility user sites. Facilities might be emergency installations, supply depots, switching stations, pumping stations, power facilities, transfer stations, communication devices, obnoxious facilities, or the like. Location(s) are required that "best" serve the users, where "best" is measured by criteria given in each particular example, some of which are required to be optimized over the network. Optimality depends on criteria usually involving some ideas of distance and costs, and varies according to the application. Weighted graphs, often referred to as networks, provide a context for studying these types of problems. Vertices and edges are assigned weights representing certain parameters (often some sort of costs) according to the application. Usually, special sets of points in the network are sought that are either "central" or "peripheral." Results in the literature range from the descriptions of optimal locations, to algorithms for locating optimal locations, to the computational difficulty in actually determining these optimal locations. Considerable study has been focused on weighted trees. These issues have motivated graph theorists to probe many different notions of central sets of vertices and notions of the "outer fringes" in ordinary (unweighted) graphs, particularly trees. In such models, users and facility locations are thought to be restricted to vertices. However, the graph theoretical origins of centrality precede the advent of modern location theory as C. Jordan introduced the concepts of the center of a tree and the branch weight centroid of a tree in 1869.

An important example of a question that Reid focused on during these lectures was: Where is the middle of a tree? There can be many different descriptions of the middle of a tree, some of which describe the same set. However, many descriptions lead to different central sets. Reid discussed multiple centers, central sub-structures, anti-centrality, axiomatics, and some work on user preferences in determining locations. In addition, he covered extensions of these ideas to graphs in general, and in some cases treated the network analogs.

The Summer 2003 Program at DIMACS (Rutgers University): Internet Algorithms: Towards Scalable Resource Sharing Protocols

The topic for the Reconnect 2003 at DIMACS was Internet Algorithms: Towards Scalable Resource Sharing Protocols. The speaker was Greg Plaxton of University of Texas at Austin.

By allowing arbitrary collections of users to share various computational resources, the Internet has enabled a wide range of interesting new applications. Unfortunately, current Internet protocols are not well designed for supporting certain applications (e.g., Web TV). Thus it is desirable to design scalable resource sharing protocols that support as wide a range of applications as possible given the available hardware.
In order to guide the design of newer and more efficient resource sharing protocols, it is useful to study the theoretical complexity of such protocols with respect to first-order abstract models of the Internet. In this program, the participants studied a number of recent research results in this direction. Apart from a brief overview lecture on the first evening, and a summary lecture on the last day, the material was divided into five modules. In the first module Plaxton introduced the concepts of on-line computation and competitive analysis, and considered problems related to the design of efficient caching protocols in wide-area networks. In the second module he introduce the metric space model of internet computation, and reviewed a number of important theoretical results concerning metric spaces, including the probabilistic approximation of metric spaces and its algorithmic applications. In the third module he presented various popular interconnection schemes for parallel computers, and demonstrated that dynamic versions of these schemes provide a plausible foundation for coordinating a dynamic collection of machines in the Internet. In the fourth module he discussed algorithms for clustering large data sets. He presented recent algorithms for clustering metric data sets and for clustering the (non-metric) Web graph. In the fifth module he introduced basic notions from the field of mechanism design, and applied these notions to develop cost sharing protocols that behave well even in the presence of "selfish" participants, that is, participants who wish to maximize their own benefit rather than the common good.

"Training" Satellite Reconnect Organizers and Planning Summer 2004 Programs

In addition to working closely with organizers of summer 2003 satellite programs, a good deal of this second year of the project was spent "training" Satellite Organizers for the third year. We worked with them to describe our publicity, application procedures, acceptance decisions, and program planning. We also helped them select topics for their programs and identify potential speakers. Plans for year 3 of Reconnect have been made as follows:

Reconnect Conference 2004 at DIMACS (Rutgers University)
Topic: Integrating Information from Sequence and Evolution: An Introduction to Computational Biology
Main Speaker: R. Ravi, Carnegie Mellon University
Organizers:
Rochelle Leibowitz, Wheaton College
Fred S. Roberts, DIMACS Rutgers University

The field of computational biology has evolved in the past two decades as a scientific discipline in its own right with textbooks, college degrees and placement opportunities unique to it. This workshop will cover material fundamental to this field that is accessible at the undergraduate level, with the aim of providing solid background and a glimpse of research avenues in this area; much of this material could be incorporated into relevant courses in discrete mathematics and computer science at the undergraduate

level providing both material to motivate fundamental concepts as well as exposure to undergraduates about this potentially exciting career track.

The thrust of this Reconnect program will be problems involving the integration of information from genetic sequences and evolutionary heritage. Each day of the week will focus on one topic, with three lectures and a group problem solving session per day. Here are some details of the plans:

Day 1: Sequence alignment and Dynamic programming technique: (i) Maximum Score Segment and 2-sequence alignment (ii) Local versus global alignments, multiple sequences and objective functions (iii) Gaps, affine penalties, parametric variants.

Day 2: Character-based methods for reconstructing phylogeny: (i) Perfect phylogeny - the Boolean case (ii) General case and Parsimony (iii) Gene trees versus species trees.

Day 3: Distance-based methods for reconstructing phylogeny: (i) Ultrametric and additive reconstruction algorithms (ii) Finding closest fit evolutionary trees (iii) Maximum likelihood method.

Day 4: Integrating alignments and phylogeny reconstruction: (i) Tree alignment (ii) Multiple sequence alignments via trees (iii) Lawler's taxonomy of problems involving trees and alignment.

Day 5: Problems in SNP analysis: (i) Haplotyping via perfect phylogeny (ii) Blocks and their determination.

Reconnect Satellite Conference 2004: Lafayette College
Topic: Experimental Algorithmics, with a Focus on Branch and Bound for Discrete Optimization Problems
Main Speaker: Cynthia Phillips, Sandia National Laboratories
Organizers:
Jonathan Berry, Lafayette College
Fred S. Roberts, DIMACS Rutgers University

Large instances of hard discrete mathematical problems must be addressed in practice. Often, the most likely avenue to an optimal solution, or even a good bounded solution, is integer programming.
We will study:

* The mathematical foundations of integer programming, including
  - review of linear programming,
  - IP formulation techniques,
  - polyhedral theory
  - separation,
  - approximation algorithms

* Some software systems that are used to develop integer programming solutions such as:
  - AMPL,
  - PICO, and
  - MINTO

* Some basic applications of integer programming, such as scheduling and sensor placement

* Experimental algorithmics, and specifically, fair comparisons of integer programming solutions.

Reconnect Satellite Conference 2004: St. Mary's College
Topic: Folding and Unfolding in Computational Geometry
Main Speaker: Joseph O'Rourke, Smith College
Organizers:
Lidia Luquet, St. Mary's College
Fred S. Roberts, DIMACS Rutgers University

The folding of flat material (e.g., paper or metal), and the unfolding of a surface in 3D to a planar state, are complementary processes of increasing importance at the nexus between pure mathematics and a variety of application areas. Folding one-dimensional (1D) "linkages" is a model for protein folding. Designing origami foldings of (2D) flat paper from the desired final folded shape is an ancient problem with recent advances. Unfolding a (3D) polyhedron to a non-overlapping piece is a first step in manufacturing objects by bending aluminum.

This lectures will cover the mathematical and algorithmic issues of folding and unfolding, touching upon the application areas as appropriate. Five novel features of the material to be presented are:

- Most of the material is accessible with only high-school mathematics, much of the remainder is accessible to students who have been exposed to algorithm analysis, and only a fraction requires advanced mathematics or computer science training.
- The material has an immediate physical, nearly visceral appeal, as it involves thinking about material of common everyday experience (i.e., paper folding, or crushing boxes) in novel ways. Thus students can use their intuitions as firm bases (supplemented by model building) from which to jump into new areas.
- The topic has real-world practical applications, as indicated above, so it touches reality directly.
- The frontier is proximate: Students can, in a just an hour or two, so thoroughly grasp the issues that they can actively work on unsolved problems.
- Although the open problems are accessible, they seem to be deep, so that their pursuit will naturally draw students deeper into mathematics and computer science.

The lectures will start with 1D linkages, paying particular attention to "locked linkages," which have a relation to protein folding. Next they will explore 2D, in particular, computational origami, including the difficulty of folding a map and flattening a box. Lastly they will explore unfolding 3D polyhedra to flat "nets," and the reverse process of folding polygons to polyhedra, an area with application to manufacturing. In all three areas the most prominent unsolved problems will be highlighted.

There is room in these topics for both pure mathematical research, and pure computer science theory research, but the richest aspects lie at the junction between the two: Progress on the mathematical questions seems to demand computation, and algorithmic progress is impossible without geometric understanding. Participants who bring expertise in either area will benefit from the cross exposure.

III. Project Findings

Although work on specific research projects is not a main goal of the Reconnect program, we do hope that some of the participants will be stimulated to return to research activity. We have some indication that this has indeed happened. A few examples are given below.

The Reconnect 2003 conference held at the Illinois Institute of Technology led to a research collaboration between Jonathan Berry (Lafayette College), Daniel Hrozencik (Chicago State University), and Shrisha

Rao (Mount Mercy College). They explored a research problem in the field of facility location. During the conference they developed prototype synchronous algorithms to find centers and medians in parallel, and since then have revised these algorithms significantly and submitted the paper "Finding Central Sets in Synchronous Distributed Systems" to the 19th International Conference on Computers and Their Applications.

The Reconnect 2003 conference held at DIMACS led to a research collaboration between Mike Gargano and Lorraine Lurie, both of Pace University. They developed a new hybrid method of classification based on self-ordering maps and swarm intelligence. They will be submitting the paper “Swarm Intelligence, Self Organizing Maps, and a New Hybrid Method” to the Proceedings of the 35th Southeastern International Conference on Combinatorics, Graph Theory, and Computing.

At the 2003 Illinois Institute of Technology conference, Shrisha Rao (Mount Mercy College), Martyn Mulder (Erasmus University Rotterdam), and K. Brooks Reid (California State University San Marcos) started research on a project on central forests in trees.

IV. Project Training/Development

Training and career development were major goals of the program. See section on Human Resource Development for comments of participants on the impact Reconnect had on their careers.

On of the major goals of this project is to involve others in learning how to run such “reconnect” experiences. Many of our organizers have never run a conference or a summer program before and the first time is a real learning experience. Our first satellite Reconnect conference, at Salem State, is a case in point. It was very interesting (and at times amusing) to hear about the experiences that new organizers like Professor Maura Murray of Salem State had in putting on her first-ever conference. Here is an excerpt from her message to Buck McMorris, who was scheduled to organize a following Reconnect conference, passing on some of what she learned.

> “Thanks, I did survive and in the end we had a really good week.
>
> I have many logistical things to warn you about. Beware, some of this reads like a comedy of errors. We had a lot to figure out! I've copied Fred and Christine for future Reconnects too.
>
> My first logistical item concerns the dorm, so this might not apply to your housing. I wrote the participants about the dorms and let them know we were providing linens and to bring a fan. Little did I know that our res life hands them to the participants in a trash bag! If I'd known that I would have had my student workers make up the beds to set a better tone at the beginning! But, what I didn't count on was that some people in the group did not bring soap and shampoo. We ran out and bought some because they weren't real close to a store where they were. Some participants also didn't bring alarm clocks and wondered how they were going to get up in the morning. I politely told them to make friends with someone in their suite and also knocked on a few doors in the beginning. I was pretty shocked that people came that unprepared, but I guess you have to be extremely explicit.
>
> Our dorms were really bad at the beginning of the week. The issue has been addressed with res life (by the president of the college!), but, for example, when they arrived the bathrooms did not have toilet paper! We ran and got that too. (Did I mention Sunday was a fiasco??) Anyways, I looked at the dorms ahead of time and didn't even notice this, so I am to blame in this too.

The dorms where our participants stayed have living rooms and I didn't get a "hospitality suite" ahead of time because I imagined they would work together in the living rooms. Lidia Luquet, an observer [future Reconnect program organizer and past Reconnect program participant] who was a HUGE help to me, helped me see they needed a common space at night big enough for everyone. So, we got that for them too and they worked there every night from Tuesday on. Snacks were key here too.

I put them into writing groups on Wednesday morning. The groups were pretty easy to form based on responses to Rochelle's [Rochelle = Shelly Leibowitz, overall program coordinator for Reconnect] list of questions: topic, audience, with whom, departure date and anything else? Rochelle walked me through all this with much more detail than I'm providing now. I can do that later or talk to Rochelle too.

I had my dean welcome the group and she was key when we had logistical issues. For example, the participants complained that they couldn't read in the dorms on Sunday night because the light was bad. My dean stole lamps from the biology dept and delivered them to me the very next day. The participants were amazed at our responsiveness and I think this was a turning point for some of our logistical snafus.

An extremely helpful thing that just worked out, but is a nice idea for future Reconnects, was Judy Walker's (my speaker) grad student attended and was a huge help in the problem sessions and at night. I put him in a writing group, but after wondered if he would have been better used as a floater among the groups. He commented though that the week was a great learning experience for him in a different way than it was for everyone else.

This list of things is just the tip of the iceberg. We really did have a good week and the evaluations were very positive in the end. The group bought Judy, Matt (her grad student) and me presents at the end of the week- I got two things...a lamp and a bar of soap! So, they had a sense of humor about the kinks we had to work out.

I'll think some more and make a list of other helpful hints,”

V. Outreach Activities

Many of the activities that Reconnect participants have taken back to their campuses are of an outreach nature, involving interdisciplinary programs and seminars, with clubs, talks, etc. (See the section on Human Resource Development and on Contributions within Discipline.)

A major emphasis in the project is to reach out to minority faculty and minority institutions. Each summer, we have had two observers from schools with a heavy minority enrollment. In summer 2003, these observers were Ermelinda De La Vina, University of Houston-Downtown, and Yewande Olubummo, Spelman College. In summer 2002, the observers were Sylvia Bozeman, Spelman College, and Asamoah Nkwanta, Morgan State College. This aspect of the project has been highly successful. It led to Professor Bozeman asking if she could run a Reconnect program at Spelman. This was arranged for summer 2005 when the organizer of a satellite program scheduled for Oakland University moved to another university and took a dean’s position. We replaced the Oakland program with a Spelman program. Professor Nkwanta has also asked if he could run a satellite program at Morgan State. We have submitted a request for supplement to our grant so as to work with him to develop such a program for summer 2006.

Our 2003 consultants, Ermelinda De La Vina and Yewande Olubummo, were full participants in the summer program. They also advised us about ways to include more minority faculty and provided us with a long list of contacts, suggestions for publicity, etc. that should help a lot in our recruitment. They also left as enthusiastic supporters of the Reconnect concept and prepared to spread the word about it to others.

We also had this comment from Sylvia Bozeman, a consultant from Reconnect 2002: "I was not a real participant in the summer program--just an observer. However, I did try to read many of the papers and attend most of the lectures because I found the topic interesting. In fact, it was so interesting that I returned and developed a Power Point presentation on the topic which I gave in the Mathematics Department Colloquium series. Since that time I have been attempting to resurrect my own research project. I think that the Reconnect workshop does inspire faculty, so I hope that we can get the same results when we conduct one at Spelman in summer of 2005." Sylvia T. Bozeman, Spelman College

VI. Papers

Darren Narayan, "An application of perfect matchings to surface reconstruction," to appear, *Bulletin of the Institute of Combinatorics and its Applications*.

The referee's report included the statement "We need more papers like this that deal with actual problems."

Jonathan Berry, Daniel Hrozencik, and Shrisha Rao, "Finding Central Sets in Synchronous Distributed Systems," submitted to the 19th International Conference on Computers and Their Applications.

Mike Pelsmajer, Martyn Mulder, and K. Brooks Reid, "Characterization of the center function, and some other centrality measures," in preparation.

Mike Gargano and Lorraine Lurie, "Swarm Intelligence, Self Organizing Maps, and a New Hybrid Method," to be submitted to the Proceedings of the 35th Southeastern International Conference on Combinatorics, Graph Theory, and Computing.

Jie Chen, "Mathematics of Auction Theory, its Application on Ebay," in preparation.

VII. Other Products

<u>Modules</u>

The participants produced first drafts of classroom modules. Here is a list of topics and authors for each conference:

Salem State College Program

Pranava Jha, Gary Salazar, Peter Ohring
"Low Density Parity Check Codes"

Sharon Persinger, Joyce Blair Crowell
"What makes a code graph-decodable? An introduction to Coding Theory
featuring Graph Decoding"

Yong Colen

"An Introduction to the Hamming Code"

Matthew Koetz, Jillian McLeod, Zhongyuan Che
"Comparison of Decoding Algorithms in Coding Theory"

Steven Leonhardi, Jim Sauerberg, Lidia Luquet
"Reed Solomon Codes: An Application of Linear Algebra"

Ann Moskol, Jenny Salazar
"A connection between Hamming Codes and the Hat Problem using Venn diagrams."

Illinois Institute of Technology Program

Atif Abueida, Mike Ackerman, Sul-Young Choi
"Centrality and anti-centrality in trees"

Pranava K. Jha, Oscar Ortega, Boting Yang
"Algorithms for finding the center and median of a tree network"

Erin Boyer, Benjamin V. C. Collins, Mark A. Mills
"An examination of 2-centers and 2-medians of graphs"

Jonathan Berry, Daniel Hrozencik, Shrisha Rao, Zhizhang Shen
"Finding central sets in a synchronous distributed system"

Peter Christopher, Dawit Haile, Michael Pelsmajer, Shane Redmond
"Central sets in trees (Where is the 'middle' of a tree?)"

Yong S. Colen
"An introduction to center and median of the graph and some real-world applications"

DIMACS (Rutgers University) Program

Atif Abueida, Mike Daven, Dan Ilaria
"Motivational examples for introducing and teaching Discrete Math"

Mark Bollman, Jie Chen, William Slough, Dawn Strickland
"Introduction to Auction Theory"

Charles Hamaker, Martha Kosa, Michael Olan
"Chord: A Case Study Utilizing Data Structures to Support Scalable P2P Internet Applications"

Krishnan Pillaipakkamnatt, Edwin Hong, Sehwan Yoo
"The Plaxton Conjecture: Ward's Algorithms Approximation Ratio is Constant"

Lorraine Lurie, Michael Gargano
"Swarm Intelligence and Self Organizing Maps for Clustering"

Kulathur Rajasethupathy, Anthony Scime
"Small World Phenomenon"

Websites

http://dimacs.rutgers.edu/reconnect/

VIII. Contributions within Discipline

The "discipline" of this project is computer science, broadly speaking, with related areas of the mathematical sciences. Most of the research results discussed were in the fields of discrete mathematics and theoretical computer science, broadly defined. While research results are a contribution of course, the main results that have come out of the program are lectures by participants back on their own campuses or at professional meetings, new courses or pieces of courses, undergraduate research projects, new seminar series, etc. These bring current research in computer science and related mathematics into the classroom and extra-classroom educational programs. The most important contribution to the disciplines of discrete math and theoretical computer science in particular, and to the discipline of mathematical sciences broadly speaking (including all areas of mathematics, computer science, operations research, statistics, etc.) was the opening up of new horizons to some very dedicated college professors and, in turn, their students of all backgrounds.

Many faculty gave talks based on their Reconnect experiences.

Darren A. Narayan, Rochester Institute of Technology (2002 DIMACS program) gave a powerpoint presentation, "Real World Applications of Higher Mathematics," at the Fall 2003 MAA Seaway meeting that included some material on Voronoi diagrams from the Reconnect Program.

Steve Morics and Colleen Livingston (2002 DIMACS program) followed up with a talk at the north central section MAA meetings about Voronoi Diagrams and their project in particular and Colleen Livingston gave a talk to faculty at her home institution of Bemidji State University about Voronoi diagrams. In the long run Colleen Livingston says that she wants to give some other talks. "Potential audiences include: our students here, high school students during our math contest, our Rotary Club. I would very much like to offer a Computational Geometry class, but think it will take a couple years for me to get prepared to teach that."

In Fall, 2003, Joyce Blair Crowell, Belmont University (2003 Salem State program), presented a "convocation" talk about error correcting codes subtitled "why your CD sounds so good." Joyce commented that, "While my whole 45 minute talk did not come from our work this summer, my confidence in doing it and many of the anecdotes did come from our discussions and certainly the idea for the subtitle (which brought in the students) was from this summer."

Some further comments we received about follow up talks:

"I gave 2 presentations related to Voronoi Diagrams -- Stockton College Math Seminar, and Stockton College Day of Scholarship." Michael Olan, Stockton College (2002 DIMACS program)

"I conducted two departmental colloquiums on Voronoi diagrams and their applications. As a result of these talks, a colleague of mine who is teaching [a] Modern Geometry course for Education Majors (in the teachers endorsement program) indicated to me that she is intended in incorporating a lecture and a student project on Voronoi diagram when she teaches the course Fall 2003." Dawit Haile, Virginia State University

This fall I gave a colloquium aimed at the general undergraduate audience, freshmen included, about the material from the DIMACS conference: concepts of 6 degrees of separation and Chord (the peer-to-peer resource sharing protocol). About 40 students attended, and I believe the talk was generally well-received. The experience gives me more ideas about how to bring CS concepts to a larger audience." Charles Hamaker, St. Mary's College (2003 DIMACS program)

We received a variety of other comments from participants about follow-up activities. Here are some examples that illustrate the continuing impact of Reconnect, even on those who participated in earlier years.

"In a course on Discrete Mathematics for CS majors, I included one lecture on Intro. to Voronoi diagrams and Delaunay Triangulations. I also gave my students group projects:

(i) to explore if some of the graph theoretic properties discussed in class hold with Delaunay triangulation (treated as a finite graph with a possibility of a node at infinity)
(ii) to collect URLs of websites and the titles of the articles published on those websites on Voronoi diagram and Delaunay Triangulations.
(iii) to find and report on good java applets available on the Internet for constructing Voronoi diagrams and Delaunay Triangulations.

The result as you may imagine was overwhelming." Dawit Haile, Virginia State University (2002 DIMACS program)

"I teach a problem solving course during our May term. The content is optional; the point is the process, introducing mathematics to students as a process of experimentation, conjecture, and proof. I teach combinatorics, and include a large project component. I will offer a Voronoi diagrams project as an option to the students (along with Nim, a historical project, and a card-shuffling project)." Steve Morics, University of Redlands (2002 DIMACS program)

"The experience and introduction to resource sharing algorithms will affect how I teach in specific CS courses, providing both new material and perspectives for several upper division courses. It broadened my outlook on what concepts are needed by students -- notably use of probability theory in analyzing and designing algorithms came to the forefront." Charles Hamaker, St. Mary's College (2003 DIMACS program)

"I am writing a small MAA summer undergraduate research grant proposal. I have already identified two students who have the capability and interest to work on such research. The topic will be exploring some graph properties and questions from networks as related to Voronoi graphs." Dawit Haile, Virginia State University (2002 DIMACS program)

"I have been a participant in Reconnect 2000 and Reconnect 2003, and I have been able to incorporate material from both workshops in my own teaching. The material from both Reconnect workshops has been an excellent resource for classroom and homework activities. Since Reconnect 2000, I often include material on cellular automata. The students are excited by the simplicity of these "robots", and then surprised by how very complex they may become. Since Reconnect 2003, I have included material on the "small world phenomenon", which claims that unrelated persons are a surpisingly short "distance" from one another. This makes for a very nice transition into graph theory in my Discrete Math class, and I intend to include some "small world" experiments in my Seminar class this spring. Most of my students are math majors who are pursuing their teaching certification (either secondary or elementary school), so I feel it is important to see new and current topics in mathematics to pass along to their own students." Mike Daven, Mount St. Mary College (2002 and 2003 DIMACS programs)

“Mike Gargano and I will be working on completing our paper on "Swarm Intelligence and Self - Organizing Maps" for the Dimacs Module. We have added some additional research to our paper, a "New hybrid method" that we developed recently and will be included in our finished paper. The "Hybrid method" combines the best of both the Swarm Intelligence and Self-Organizing Maps algorithms-in terms of visualization and speed. I presented the new algorithm at the Boca Raton Combinatorics Conference at FAU last week (March 2004), with a completed paper to follow, by May 1… I networked at the Boca conference, and one person from John Hopkins wants a copy and more info on my paper, and the possibility of working with us. Lorraine Lurie, Pace University (2003 DIMACS program)

“i have adapted what i had learned for classroom use. my students and i have benefitted, and we are exploring ways to apply new mathematical tools in different situations. i'm pursuing a way for students and i to publish an article.” Yong Colen, Hawken School (2003 Illinois Institute of Technology program)

“I plan on using the module written by my group as a resource while teaching an Introduction to Finite Math course this spring. This is a course for non-math majors and we will be doing a section on graph theory, and in particular, spending a few days on the concept of centrality in graphs.” Erin Boyer, Dartmouth College (2003 Illinois Institute of Technology program)

“I now host the Pace Math Seminars. I invite the speakers, many of whom I have met at Dimacs Conferences, as well as my professional contacts. So far, my seminars have been very successful and popular among many of my students in the math, computer science and business departments.
The Chairman of the Math dept at Pace University is very pleased with the quality of the speakers and the information about current research in the math and computer science fields. (I have especially benefited from running the seminars in that I have invited many of the speakers who have helped my research!)
The Chairman is also thrilled that I was doing math research at DCI and that I was presenting my paper at the Boca Raton Combinatorics Conference.I love the work that Dimacs does. It inspires me. The networking is especially invaluable. One of the topics … this summer -"Mathematics of Auction Theory, its application on Ebay"- will be presented at one of my math seminars April 8, 2004, by … participant-Jie Chen. Jie is thrilled to be invited-it has inspired her to finish her paper, and we are thrilled to have a really relevant topic that was developed … this summer-Hot off the Press research! delivered to Pace. I just hope that auditorium has enough seats!” Lorraine Lurie, Pace University (2003 DIMACS program)

“My participation at the Reconnect at IIT has had a positive impact on me so far. I've included some of the material in my Combinatorics course that I taught in the Fall. I also got a colloquium talk and a plan for future research from the conference. Also, I am in the process of editing my group's module for submission. It should be sent within the next month.” Michael Ackerman, Bellarmine University (2003 Illinois Institute of Technology program)

"The 2003 Reconnect Coding Theory workshop has given me a "jump start" on learning enough about a new area of mathematics so that I can share it with my students as part of an upper level course. Although our group module is far from complete, I have already used a combination of our group's writing and other sources to spend the final two weeks of my Abstract Algebra course on this topic this fall. Students seemed very interested, and the topic has provided an accessible example of current applications of finite fields and cosets, as well emphasizing connections between abstract algebra concepts and linear algebra concepts. I also plan to include this topic the next time I teach Advanced Linear Algebra. I have invited several students to consider a semester-long independent study course with me on Coding Theory, and I am considering preparing and offering a semester-long special topics course. I probably would not have attempted this without the knowledge and resources I gained at the Reconnect workshop. Thank you for this program!" Steve Leonhardi, Winona State University (2003 Salem State College program)

“My group is embarking on the third draft of a module on Reed-Solomon codes. We have spoken about another module on Projective Geometry and Coding Theory. This spring I will be teaching "The Art and Practice of Mathematics"; about 25% of the course will be devoted to coding theory, a subject that is new to me.” Lidia Luquet St. Mary’s College (2003 Salem State College program)

“The Reconnect program has impacted me in two ways:

1. I have incorporated ideas from the workshop in my Discrete Mathematics class and
2. I have a student working on senior research project on a topic that grew out of the workshop; I expect to have other students to do similar projects in the future.”

Peter Ohring, Purchase College, SUNY (2003 Salem State College program)

IX. Contributions -- other Disciplines

A major area of emphasis in the Reconnect program is on applications of methods of computer science and, more generally, of the mathematical sciences, to other disciplines. The tone was set with the summer 2002 program on Voronoi diagrams and applications. The lectures by Scot Drysdale (Dartmouth College) emphasized applications to such areas as Archaeology and Anthropology, Astronomy, Biology, Ecology and Forestry, Cartography, Crystallography and Chemistry, Geography, Geology, Geometric Modeling, Marketing, Metallurgy, Meteorology, Pattern Recognition, Physiology, Robotics, and Zoology. The summer 2003 programs all had interdisciplinary components. The centrality topic at Illiniois Institute of Technology featured a major emphasis on facility location problems. The coding theory topic at Salem State is a fundamentally interdisciplinary one with connections to many disciplines in engineering, for example. The resource sharing protocols topic at DIMACS (Rutgers) dealt with applications such as Web TV and “small world” networks which arise in the social sciences, the biological sciences, etc. The summer 2004 programs will also have major interdisciplinary components. The program on computational biology at DIMACS is interdisciplinary by its very nature. The experimental algorithmics topic will include real-world discrete optimization problems arising in problems ranging from transportation to manufacturing. The folding and unfolding topic will include real-world materials applications.

Not surprisingly, the emphasis on interdisciplinarity is reflected in some of the follow-up activities reported by Reconnect participants. Here are just a few examples:

Darren A. Narayan, Rochester Institute of Technology (2002 DIMACS program) gave a powerpoint presentation, “Real World Applications of Higher Mathematics,” at the Fall 2003 MAA Seaway meeting that included some material on Voronoi diagrams from the Reconnect Program. The talk included examples of real world applications of mathematics from Avaya Communications, JetBlue Airways, Level 3 Communications, and Microsoft Research.

Steve Morics (University of Redlands) (2002 DIMACs program reported: “I'm intrigued with the idea of using Voronoi diagrams to create congressional districts. Of course, this would involve creation of an algorithm to create diagrams over regions of varying density. Probably out of my reach, but I have been in contact with our Environmental Studies department about GIS implementations of Voronoi diagrams. We have connections with ESRI. makers of ArcView, since they're located here in town. There's a lot of GIS to learn, but the implementations seem very inefficient, so perhaps I can help out there.”

This was reported by Lorraine Lurie, Pace University (2003 DIMACS program): “Next term I will be doing a learning community course in Statistics in conjunction with the English Department. The Chairman suggested it, since some of my research consisted of doing the "Stats" after I completed the computations (using graph theory) for a Medical Journal Paper. He wants research and paper writing

taught. I know it will be a lot of work, but very rewarding in that I hope to inspire our students to do math research."

X. Contributions -- Human Resource Development

A major emphasis in the project is to reach out to minority faculty and minority institutions. We expand on our efforts in this direction in the section on Outreach Activities.

The Reconnect program has already had an effect on the lives and careers of many participants. Here is a sample of feedback we got about this.

"I am actually really wanting to think about new mathematical problems for the first time in ages. I like teaching but I'm actually regaining some hunger to do math and have some problems to work on this summer." Colleen Livingston, Bemidji State University (2002 DIMACS program)

"Attending the DIMACS 2002 Reconnect Workshop was a wonderful experience for me. This workshop provided me the opportunity to be exposed to an exciting new area of mathematics. It also helped me to focus on some new teaching ideas I have concerned in teaching combinatorics to chemistry and biology undergraduate students. I have started working on a teaching module related to these areas. I am also interested in organizing a future reconnect workshop at my institution. I enjoyed the participants and DIMCAS was a wonderful host. I would recommend this workshop to any mathematician looking to get connected to a new area of mathematics." Asamoah Nkwanta, Morgan State University (2002 DIMACS program and potential organizer for 2006 Morgan State University program)

"The Reconnect program gave me an opportunity to learn about a field in which I had had limited experience. I had done a little work on computational geometry in the context of teaching courses in algorithms but even though I found the material interesting because of my mathematics background I just did not have sufficient time to pursue it. The project we chose had to do with using triangulations to support surface reconstruction in the area of computer graphics. We have a good start on the materials but part of the work is incomplete. I have hope of returning to it late this spring and summer. As far as I know, our team does intend to complete the writing project. It is now pretty certain that I will be developing a computer graphics course in the next year and I see this as a nice contribution to that effort. In a rather serendipitous turn of events our mathematics program has hired a new mathematician whose research area is computational geometry. I think her decision to accept the job was influenced by the fact that I was interested in the work she was doing. I look forward to collaborating with her." Christine Shannon, Centre College (2002 DIMACS program)

"The DIMACS conference has been very helpful to me, both in concrete ways, providing something new to think about, write about, and present about. But I have appreciated most the less-measurable effect of inspiring me to do some mathematics." Colleen Livingston, Bemidji State University (2002 DIMACS program)

"As a mathematician teaching CS in a small program, I'm fairly isolated. Rubbing shoulders with lots of CS profs was a valuable experience, one that let me view firsthand how practitioners in the field think about it. I found they had something to offer me, and I think I had some useful perspectives to offer them." Charles Hamaker, St. Mary's College (2003 DIMACS program)

"Although the bottom line, as it were, is not yet known, I think RECONNECT 2003 already has had quite a positive impact on me personally both as an instructor and a researcher, and also indirectly on my students and my academic program. As an instructor who mainly teaches computer science classes

(especially at the junior or senior level), it was instructive for me to interact with other teaching faculty who teach discrete mathematics and other applied mathematics areas. Doing this helped me learn about specialized teaching styles, and also broadened my understanding of applied math curricula (a very important benefit, since at my present position I am also responsible for curricular development). I was thus able to make some revisions to the syllabus and teaching style in my Fall 2003 class in discrete mathematics. That same semester, I also wrote a successful course proposal for a new class in graph theory which will be taught by me in the Spring of 2005, and regularly thereafter. (This class will be an elective for the math major at my institution, and will fulfill one of three math requirements for the computer science major.) I am sure my students and program have, and will continue to, benefit from these efforts that grew out of my RECONNECT 2003 experience. As a researcher, I had the pleasure of interacting with the RECONNECT 2003 featured speakers K.B. Reid and H.M. Mulder, and am presently involved in some investigations involving centrality (nothing has been published or accepted yet, however, so I would prefer not to say more). Last but not least, I would like to mention that my RECONNECT experience was a very positive one in large part owing to the professionalism, courtesy, and friendliness of Buck McMorris and his team; I express my thanks again to all of them." Shrisha Rao, Mount Mercy College (2003 Illinois Institute of Technology program)

"Two things that are immediate benefits of the Reconnect program:
1. Making connections
    a. Each yearly cohort "know" each other and often "hang out" together at meetings. Reconnect provides another way to connect into the mathematical community.
    b. At meetings, if I introduce two Reconnectors from different years, I think they feel a certain camaraderie for having "survived" the same summer experience.
2. Research enterprise

Even if Reconnectors don't do research right away or don't do research at all, this experience revitalizes their interest in math and theoretical computer science and (re)awakens their excitement of learning new things. This certainly helps them in their teaching." Shelly Leibowitz, Wheaton College (Reconnect Program coordinator)

"I believe my participation in last summer's Reconnect program had a positive impact on my professional life. Being able to set aside a week to focus on one research area was very stimulating. Attending lectures and receiving lecture notes and research papers was particularly helpful, as I would not have been able to identify these papers/ideas on my own." William Slough, Mathematics and Computer Science, Eastern Illinois University (2003 DIMACS program)

"It is hard to describe the mathematical vigor of Reconnect, partly because it is such a unique program. A long jumper runs, leaps and measures. To prepare for Salem Reconnect '03 I read in advance, absorbed the intellectual leadership and inmersed myself in the dialog. I am now looking at an enriched year with a concrete project and continued dialog. Reconnect programs tap into the unused intellectual resources of the mathematical community in a way that few other workshps (if any) do. At Salem Reconnect Judy L. Walker talked to us in the language of the frontier of knowledge. My background in projective geometry hooked on to a topic and a project took shape. Reconnect faculty leaders are creating a style of engaging participants tailored to the mathematics they create that deserves attention." Lidia Luquet, St. Mary's College (2003 Salem State College program and organizer of 2004 St. Mary's College program)

"i attended two workshops in 2003, and they have helped me a great deal…i feel i have more confidence to teach the area related to the workshop topics. in the past i was somewhat hesitant due to lack of familiarity. while i did not learned all the details needed to teach competently, i have, nevertheless, been rejuvenated to explore further my career is at a higher plane due to this reconnecting." Yong Colen, Hawken School (2003 Illinois Institute of Technology and Salem State programs)

Several graduate students participated in Reconnect, sitting in on the lectures and interacting with the participants. This had an important impact on their plans for finishing their degrees and their future careers. For instance, Oscar Ortega, Illinois Institute of Technology, participated in the IIT program and wrote: "I am a graduate student at IIT. I will finish my Master degree in the fall semester of 2004. My participation in the Reconnect program was a great experience for me. It gave me the opportunity to meet important researchers in the area of graph theory. Also, I was able to work and share ideas about graph theory with professors of other universities. This was encouraging for me because I want to obtain my Ph.D degree in Applied Mathematics and especially in graph theory. During the fall semester of 2003, I was enrolled in a graduate Discrete Applied Mathematics course. Several topics of graph theory were discussed in the second part of that class. The experience I had from the Reconnect program help me to understand better some of the concepts I had to learn in that course; besides, it was interesting for me to see how some of the techniques I learned in the Reconnect program let me solve easily several homework problems. Next year I am going to begin the investigation in graph theory that will allow me to write a thesis and obtain my Ph.D degree. I do not know at this moment the problem or problems that I will be trying to solve, but I am sure I will be using in my research some of the results and the techniques discussed in the Reconnect program."

"I am preparing a talk to be given at Pace University in early April...the talk would be an expanded version of the talk i gave at RECONNECT last summer...mainly on applications of auction theory to ebay and related research problems...Thanks Lorraine Lurie for inviting me to give the talk...I am very happy that it is my first invited talk (i am still a grad student)...and that comes out of RECONNECT! so thanks you guys for giving me the opportunity to participate in the activities of DIMACS...i certainly did not expect this would happen when i gave the talk last summer...
Greg was an excellent lecturer. He is active in the research front and therefore i learned many new theoretical development from him. He is friendly and open to discussions. We have talked on some clustering problems which i was working on then. I got very good pointers to papers and he answered many of my longtime questions. It was an intense week with lectures and readings and homework. But it was well worth the time for the new algorithms i have learned, the new topic that intrigues me. My fellow participants are from all over and i feel myself getting a insider look into the liberal arts college life, which is very helpful since i am going to graduate soon and looking for jobs now. I love the RECONNECT program and pity that i have other obligations this summer that i cannot go to the programs this year." Jie Chen, Princeton (2003 DIMACS program)