DIMACS Center
Rutgers University

Special Focus on Computation and the Socio-Economic Sciences

Annual Report

January 2005

Ia. Participants from the program

Participants:

PI: Fred Roberts

Co-chairs:

Lance Fortnow, CS, University of Chicago
Fred Roberts, DIMACS/Rutgers University
Rakesh Vohra, Kellogg School of Management

Organizing Committee:

Joan Feigenbaum, Yale University
Jayant Kalagnanam, IBM Watson Labs
Eric Maskin, School of Social Science, Institute for Advanced Study
Christos Papadimitriou, University of California, Berkeley
Aleksandar Pekec, Duke University
David Pennock, Overture Services
Michael Rothkopf, Rutgers University
Michael Trick, Carnegie Mellon University
Vijay Vazirani, Georgia Tech

DIMACS Tutorial on Social Choice and Computer Science
Date: May 10 - 14, 2004
Location: DIMACS Center, CoRE Building, Rutgers University

Organizers:

Kevin Chang, University of Illinois
Michel Regenwetter, University of Illinois

DIMACS Workshop on Electronic Voting -- Theory and Practice
Date: May 26 - 27, 2004
Location: DIMACS Center, CoRE Building, Rutgers University, Piscataway, NJ

Organizers:

Markus Jakobsson, RSA Laboratories
Ari Juels, RSA Laboratories

DIMACS Working Group on The Mathematics of Web Search and Meta-Search
Date: June 19 - 26, 2004
Location: Bertinoro International Center for Informatics, Bertorino, Italy

Organizers:

Cynthia Dwork, Microsoft
Andrew Gelman, Columbia University
D. Sivakumar, IBM Almaden

DIMACS Workshop on Computational Issues in Auction Design
Date: October 7 - 8, 2004
Location: DIMACS Center, CoRE Building, Rutgers University

Organizers:
Jayant Kalagnanam, IBM Watson Lab
Eric Maskin, School of Social Science, Institute for Advanced Study
David Parkes, Harvard University
Aleksandar Pekec, Duke University
Michael Rothkopf, Rutgers University

DIMACS Workshop on Bounded Rationality
Dates: January 31 - February 1, 2005
Location: DIMACS Center, CoRE Building, Rutgers University

Organizers:
Lance Fortnow, University of Chicago
Richard McLean, Rutgers University
Daijiro Okada, Rutgers University

DIMACS Workshop on Markets as Predictive Devices (Information Markets)
Dates: February 2 - 4, 2005
Location: DIMACS Center, CoRE Building, Rutgers University

Organizers:
Robin Hanson, George Mason University
John Ledyard, California Institute of Technology
David Pennock, Overture Services

DIMACS Workshop on Large-Scale Games
Dates: April 17 - 19, 2005
Location: Evanston Campus, Northwestern University, Evanston, Illinois

Organizers:
Lance Fortnow, University of Chicago
Rakesh Vohra, Northwestern University

Participants: Registration is still open for this activity.

Ib. Participating Organizations

Telcordia Technologies: Collaborative Research
Partner organization of DIMACS. Individuals from the organization participated in the program planning.

AT&T Labs - Research: Collaborative Research
Partner organization of DIMACS. Individuals from the organization participated in the program planning and workshop.

NEC Laboratories America: Collaborative Research
Partner organization of DIMACS. Individuals from the organization participated in the program planning.

Lucent Technologies, Bell Labs: Collaborative Research
Partner organization of DIMACS. Individuals from the organization participated in the program planning.

Princeton University: Collaborative Research
Partner organization of DIMACS. Individuals from the organization participated in the program planning.

Avaya Labs: Collaborative Research
Partner organization of DIMACS. Individuals from the organization participated in the program planning.

HP Labs: Collaborative Research
Partner organization of DIMACS. Individuals from the organization participated in the program planning.

IBM Research: Collaborative Research
Partner organization of DIMACS. Individuals from the organization participated in the program planning.

Microsoft Research: Collaborative Research
Partner organization of DIMACS. Individuals from the organization participated in the program planning.

Stevens Institute of Technology: Collaborative Research
Partner organization of DIMACS. Individuals from the organization participated in the program planning.

Newsfutures: Collaborative Research

Support of Workshop on Markets as Predictive Devices (Information Markets).

Yahoo! Research Labs: Collaborative Research
Support of Workshop on Markets as Predictive Devices (Information Markets).

Northwestern University: Collaborative Research
Support of DIMACS Workshop on Large-Scale Games.

1c. Other Collaborators

The project involved scientists from numerous institutions in numerous countries. The resulting collaborations also involved individuals from many institutions in many countries.

II. Project Activities

Partnerships between mathematicians and social scientists have existed for a long time, but partnerships between computer scientists and social scientists are relatively new. In the past five years, they have begun to sprout and several important new fields of research are already thriving as a result. The topic of game theory and mechanism design has involved many leading computer scientists with economists and, as a result, for the first time many computer scientists are taking serious note of both the problems and the methods of economics. Analysis of the analogies between the growth of social networks and the development of the Internet have led to important insights about both areas and serious interactions between computer scientists and sociologists. Problems of metasearch have engaged computer scientists with political scientists and economists working on voting and social choice. The objective of the Special Focus on Computation and the Socio-Economic Sciences is to build on these early and exciting connections.

Partnerships between computer scientists and biologists are somewhat of a model for what we are doing. These partnerships have flourished in the past 15 years. They have played a critical role in the human genome project, have led to a major emphasis on information processing in the biological organism, have spawned intriguing new areas of research in computer science such as DNA computing, and have contributed to major developments in tree reconstruction and pattern matching algorithms in computer science. In short, they have had a profound effect on both biology and computer science. There may not be a specific “big science” challenge such as the human genome project in the case of computer science and the social sciences, but the opportunities for real and significant progress both in the computing and social sciences as a result of new interdisciplinary partnerships are upon us. In fact, the interaction between computer science and the social sciences is changing in dramatic ways that can be expected to have lasting impacts on both disciplines. Many applications in computer science and information technology (IT) involve issues and problems that social scientists (economists, political scientists, sociologists, psychologists and others) have addressed for years, issues of preference, utility, decision making, conflict and cooperation, incentives, auctions, bidding, consensus, social choice, and measurement; and the methods social scientists have developed for dealing with

these issues and problems form an impressive toolkit. At the same time, with the widespread availability of today's powerful computers and new and exciting data sets, work in economics, political science, sociology and psychology that was only a theoretical possibility a few years ago is becoming a reality. Applying methods of social science to CS/IT problems requires new computational tools and the development of new variants of these methods. Applying computational methods to the solution of modern social science problems requires the development of new data structures, algorithms, and other tools that are in the domain of the computer scientist.

We have begun to see the use of methods developed by social scientists in a variety of IT applications. The requirements associated with these applications place great strain on the social science methods because of the sheer size of the problems addressed, issues involving computational power of agents, limitations on information possessed by players, and the sequential nature of repeated applications. Hence, there is a great need to develop a new generation of methods to satisfy these CS/IT requirements. In turn, these new methods will provide powerful new tools for social scientists. At the same time, great progress is being made on the problems traditionally of interest to social scientists through the use of new methods for finding patterns in data, searching through databases, computing solutions, and testing models. This Special Focus seeks to develop the new "social-science-based" CS methodologies and to investigate their application to problems of information technology and to problems of the social sciences of fundamental importance to modern society. It also seeks to investigate computer science tools that are especially relevant to emerging problems of the socio-economic sciences. Research into issues of the type we envision requires new interdisciplinary partnerships among computer scientists, mathematicians, operations researchers, economists, experts in business applications, political scientists, psychologists, sociologists, and researchers specializing in the handling of information. Several major research themes span the Special Focus. They include:

- **Computational Tractability/Intractability**. Limits on what can be efficiently computed are very important in social-science-based CS applications and applications of CS methods to the social sciences.
    - Can our understanding of computational complexity help us to build computational tools that will enlarge the set of social science models that can be analyzed and to adapt social-scientific concepts to solve problems of information technology?
    - How can we characterize situations where intractability is a good thing, as for example when we use it to protect privacy or make it difficult to manipulate the outcome of an election?
- **Limitations on Computational Power/Information**. Increasingly, economic decisions have to be made in situations where there are many "actors" each having partial information or where there are limits to computation that prevent actors from obtaining needed information. Limitations include:
    - informational asymmetries
    - computational limits to extracting information that is available (perhaps in large data sets)
    - cognitive limitations on the part of agents.

- **The Impact on New Methodologies of the Sheer Size of CS/IT Applications**. The sheer size of CS/IT applications requires new methods/protocols where efficiency is a central focus and where issues of scalability and robustness with respect to errors in data are prominent.
- **Learning through Repetition**. Issues of learning, taking advantage of repeated games or auctions or through combining repeated inputs, arise in CS/IT applications in fascinating ways. Some tasks may be delegated to software agents and one needs to understand how they should be designed to "learn" user preferences and how to bid and trade.
- **Security, Privacy, Cryptography**. The need for secure communication and privacy sparks the need for cryptographic methods in the analysis and design of voting procedures, games, and decision processes. Such issues arise in areas like electronic commerce and electronic voting, and many are being discussed in detail in a parallel special focus program on "Communication Security and Information Privacy" at DIMACS. (For more detail about that program, and in particular a list of planned workshops and working groups, see http://dimacs.rutgers.edu/SpecialYears/2003_CSIP/.)
- **Game-theoretic Solution Concepts**. As we consider larger and larger games in modern economic applications, Nash equilibria, solution concepts in cooperative games, and other game-theoretic solution concepts applied in a variety of settings become harder and harder to compute.
- **Markets as Information Sources**. Increasingly individuals and firms are using markets to learn about their competitors' preferences and to aggregate and combine information, for example through the generation of prices. These developments can benefit from methods of distributed computing and combinatorial exchange.
- **Implementation of Auctions**. While dramatic changes in availability of information technology have allowed us to expedite increasingly complex business transactions, for example complex auctions, the ability to implement such transactions often puts a strain on existing computational methods.
- **Designing Markets**. How do we design markets for the exchange of complicated assets like spectrum, stock portfolios, landing rights, and airline routes? The problems involved are different from those of traditional auctions, as there are multiple owners whose assets interact in complex ways.
- **Dynamic Markets**. Ever-more-powerful computers make it increasingly possible to develop sophisticated algorithms that allow actors to adjust prices, bandwidth, etc. in a dynamic way, as well as adjust schedules and allocations in response to changing market conditions or unforeseen events.
- **Computing Utilities**. Utility functions, which have been studied for a long time by economists and psychologists, are increasingly important in considerations of interest to computer scientists. For both groups, there is the need to compute utilities in larger and larger environments and under conditions of distributed information. These call for new models, tools, and algorithms such as the use of polyhedral combinatorial methods, which are so central to computer science.

The tutorials, workshops, and working group meetings that have been held during the first year of this project are as follows:

DIMACS Tutorial on Social Choice and Computer Science

Date: May 10 - 14, 2004
LocationL DIMACS Center, CoRE Building, Rutgers University
Organizers:
Kevin Chang, University of Illinois
Michel Regenwetter, University of Illinois
Attendance: 23

The theory of social choice and voting has had a long history in the social sciences, dating back to early work of Condorcet and others in the 18th century. Some modern issues facing the theory of social choice relate heavily to computer science. Often we need to determine preferences for an individual or group, while maintaining accuracy, fairness and security, sometimes with only limited information and/or computational power. This tutorial considered computer science and social science issues in insuring the best choices given limited information and computation. It built on early work on the computational complexity of computing the winner of an election. Moreover, the tutorial considered voting/social choice issues arising in strictly computer science applications such as database and information retrieval, Internet search and meta-search, and collaborative filtering. The tutorial presented an introduction to the concepts and models of individual preference or utility as well as social choice theory and introduced participants to a variety of modern computational issues and computer science applications.

DIMACS Workshop on Electronic Voting -- Theory and Practice
Date: May 26 - 27, 2004
Location: DIMACS Center, CoRE Building, Rutgers University, Piscataway, NJ
Organizers:
Markus Jakobsson, RSA Laboratories
Ari Juels, RSA Laboratories
Attendance: 74

To many technologists, electronic voting represents a seemingly simple exercise in system design. In reality, the many requirements it imposes with regard to correctness, anonymity, and availability pose an unusually thorny collection of problems, and the security risks associated with electronic voting, especially remotely over the Internet, are numerous and complex, posing major technological challenges for computer scientists. The problems range from the threat of denial-of-service-attacks to the need for careful selection of techniques to enforce private and correct tallying of ballots. Other possible requirements for electronic voting schemes are resistance to vote buying, defenses against malfunctioning software, viruses, and related problems, audit ability, and the development of user-friendly and universally accessible interfaces.

The goal of the workshop was to bring together and foster an interplay of ideas among researchers and practitioners in different areas of relevance to voting. For example, the workshop investigated prevention of penetration attacks that involve the use of a delivery mechanism to transport a malicious payload to the target host. This could be in the form of a “Trojan horse” or remote control program. It also investigated vulnerabilities of the communication path between the voting client (the devices where a voter votes) and the server (where votes are tallied).

Especially in the case of remote voting, the path must be “trusted” and a challenge is to maintain an authenticated communication linkage. Although not specifically a security issue, reliability issues are closely related and were also considered. The workshop considered issues dealing with random hardware and software failures (as opposed to deliberate, intelligent attack). A key difference between voting and electronic commerce is that in the former, one wants to irreversibly sever the link between the ballot and the voter. The workshop discussed audit trails as a way of ensuring this. The workshop also investigated methods for minimizing coercion and fraud, e.g., schemes to allow a voter to vote more than once and only having the last vote count.

This workshop was sponsored jointly with the Special Focus on Communication Security and Information Privacy.

This workshop followed a successful first WOTE event, organized by David Chaum and Ron Rivest in 2001 at Marconi Conference Center in Tomales Bay, California (http://www.vote.caltech.edu/wote01/). Since that time, a flurry of voting bills has been enacted at the federal and state levels, including most notably the Help America Vote Act (HAVA). Standards development has represented another avenue of reform (e.g., the IEEE Voting Equipment Standards Project 1583), while a grassroots movement (http://www.verifiedvoting.org) has arisen to promote the importance of audit trails as enhancements to trustworthiness.

DIMACS Working Group on The Mathematics of Web Search and Meta-Search
Date: June 19 - 26, 2004
Location: Bertinoro International Center for Informatics, Bertorino, Italy
Organizers:
Cynthia Dwork, Microsoft
Andrew Gelman, Columbia University
D. Sivakumar, IBM Almaden
Attendance: 37

In an election, each of a large number k of voters ranks a small number n of candidates. The rankings are then combined in some fashion to elect either a single or several candidates. The formal analysis of voting began in France in the latter half of the eighteenth century with two seminal, but conflicting, approaches proposed, respectively, by Jean Charles de Borda and Marie J. A. N. Caritat, the Marquis de Condorcet. This laid the groundwork for an extensive literature on the mathematics of voting. Fast-forwarding to a more modern problem: In web meta-search, in response to a given query, each of a small number k of search engines (voters) ranks a (subset of a) large number n of candidates (pages). The results are then combined in some fashion to produce a ranking that is in some sense “better” than the results produced by any single search engine. The precise definition of “better” may vary; for example, assuming that different search engines have different databases of pages (resulting from different web crawls), “better” might mean “resulting from broader coverage.” Or, if we assume that different search engines are susceptible to different types of search engine “spam” -- intuitively, arranging for one's page to have unreasonably high rank in response to some query -- rank aggregation can produce results that are less vulnerable to spam. (Search engine spam is, in fact, rampant.) As phrased here, the

connection between voting, analysis of rank data, and the mathematics of (web) search and meta-search is patent. Indeed, the voting literature inspired several of the meta-search results.

Statistically, this problem of ranking latent parameters given unbalanced discrete data arises in many contexts, most notably in psychometrics, for ranking abilities of students, animals, and sports teams. Much recent work has gone into generalizing these models to apply to more flexible data structures. Statistical models of Web connections (which are relevant to understanding the workings of the individual search engines) have been constructed by Sen and Hansen and also Baldi, Frasconi and Smyth. Connections between meta-search and learning have been established as well. Finally, the database community has been exploring usage of rank-like information in the context of search: personal preference data for improving search outcomes and page importance for guiding crawls. The working group brought together researchers from the voting theory, statistics, psychometrics, learning theory, database, and web search communities, with the goal of obtaining new algorithms for search and meta-search.

DIMACS Workshop on Computational Issues in Auction Design
Date: October 7 - 8, 2004
Location: DIMACS Center, CoRE Building, Rutgers University
Organizers:

Jayant Kalagnanam, IBM Watson Lab
Eric Maskin, School of Social Science, Institute for Advanced Study
David Parkes, Harvard University
Aleksandar Pekec, Duke University
Michael Rothkopf, Rutgers University

Attendance: 66

Recent advances in information technology and its rapid acceptance by the business community have allowed for expediting of complex business transactions. The most prominent example involves use of auctions in corporate procurement and in government deregulation efforts. When many items with interrelated values are being sold, allowing bids on combinations of items can increase economic efficiency. Procedures for auctioning combinations of items have inherent computational problems to overcome, and the emergence of these issues has sparked considerable research activity in the computer science and combinatorial optimization communities. The most prominent example is combinatorial auctions in which multiple goods are auctioned and bidders have and wish to express different valuations on which goods complement each other and which goods substitute for each other. Allowing bidders to submit “all-or-nothing” bids for combinations of goods yields NP-complete allocation problems that need to be solved efficiently when proper care is given to designing an auction. Furthermore, bidders face computational and communication problems in combinatorial auctions since they might not be feasibly able to express all possible preferences for all subsets of goods. Another area of auction design that has been developing rapidly in research and in practice is short-term electricity auctions in which allowing bidders to make bids that reflect their nonconvex costs requires solving large mixed integer programming problems and finding prices that support decentralized generation and transmission operations.

In addition to the research community, these combinatorial and optimization problems that are involved with auction design and general microeconomic considerations have generated interest from IT businesses such as IBM, industrial users of combinatorial procurement auctions such as Mars, Inc., and government agencies such as the FCC [FCC Combinatorial Bidding Conference (2000), FCC Second Combinatorial Bidding Conference (2001), The Federal Communications Commission Public Notice (2002)] and the FERC-regulated electricity system operators PJM and NYISO (see www.pjm.com, and www.nyiso.com). This workshop brought together researchers in computer science, optimization, operations research and economics who are working on computational aspects of auction design. The aim was to discuss the most prominent issues in auction design and try to design implementable and efficient auction procedures that allow for a large preference space while maintaining several desirable properties such as fairness, failure-freeness, and computational feasibility for all participants.

DIMACS Workshop on Bounded Rationality
Dates: January 31 - February 1, 2005
Location: DIMACS Center, CoRE Building, Rutgers University
Organizers:

Lance Fortnow, University of Chicago
Richard McLean, Rutgers University
Daijiro Okada, Rutgers University

Attendance: 30, Registration is still open for this activity.

Traditionally, economists and game theorists have assumed that strategic agents are fully rational, but in the last few decades a number of game theorists have argued that human players do not behave in a way consistent with theoretical predictions. Questions have been raised regarding the postulate of full rationality and some have proposed formalizations of partially or boundedly rational players and games played by such players. If one takes the view that a process of decision-making in economic or other social situations constitutes computation in a formal sense of theoretical computer science, then one is naturally led to some notion of bounded computational power as a formal expression of bounded rationality. Two important and complementary questions in this line of inquiry are (1) What is the computational power required in order to play a game in a way consistent with full rationality? (2) If players are limited in their computational power, how different will equilibrium outcomes be from the fully rational case? This workshop will bring together economists and game theorists interested in bounded rationality, as well as theoretical computer scientists with experience in limited computational models.

Topics of interest include:

- Bounded recall and bounded complexity in repeated games
- Strategic aspects of machine learning
- Game theoretic applications of cryptography

DIMACS Workshop on Markets as Predictive Devices (Information Markets)
Dates: February 2 - 4, 2005

Location: DIMACS Center, CoRE Building, Rutgers University
Organizers:

Robin Hanson, George Mason University
John Ledyard, California Institute of Technology
David Pennock, Overture Services

Attendance: 80, registration is still open for this activity.

For decades, economists have studied an astonishing "side effect" of financial and wagering markets: their ability to serve as highly accurate forecasting devices. This workshop aims to explore the use of markets as a substitute for, or complement to, more traditional forecasting tools. We will examine how information flows from traders to the market and back again, how market mechanisms process information, how market prices communicate information and forecasts, and what mechanisms best foster accurate and statistically-testable predictions. The workshop will bring together researchers and practitioners from a variety of relevant fields, including economics, finance, computer science, and statistics, in both academia and industry, to discuss the state of the art today, and the challenges and prospects for tomorrow.

A market designed from the outset for information gathering and forecasting is called an *information market*. Information markets can be used to elicit a *collective* estimate of the expected value or probability of a random variable, reflecting information dispersed across an entire population of traders. The market prediction is not usually an average or median of individual opinions, but is a complex summarization reflecting the game-theoretic interplay of traders as they obtain and leverage information, and as they react to the actions of others obtaining and leveraging their own information, etc. In the best case scenario, the market price reflects a forecast that is a perfect Bayesian integration of all the information spread across all of the traders, properly accounting even for redundancy. This is the equilibrium scenario called *rational expectations* in the economics literature, and is the assumption underlying the strong form of the *efficient markets hypothesis* in finance.

The degree to which market forecasts approach optimality in practice, or at least surpass other known methods of forecasting, is remarkable. Supporting evidence can be found in empirical studies of options markets, commodity futures markets, political stock markets, sports betting markets, horse racing markets, market games, laboratory investigations of experimental markets, and field tests. In nearly all these cases, to the extent that the financial instruments or bets are tied to real-world events, market prices reveal a reliable forecast about the likely unfolding of those events, often beating expert opinions or polls.

Despite a growing experimental literature, many questions remain regarding how best to design, deploy, analyze, and understand information markets, including both technical challenges (e.g., designing combinatorial exchanges) and social challenges (e.g., overcoming legal and ethical concerns). The search for answers will benefit from input from economists (including specialists in mechanism design, experimental economics, financial markets, wagering markets, and rational expectations theory), statisticians and decision theorists (including experts in forecasting, belief aggregation, group decision making, Bayesian updating, and opinion polling), and computer scientists (including experts in combinatorial exchanges, distributed computing, information theory, and mixing worst-case and Bayesian analysis). This workshop will seek to bring together

a variety of experts representing these fields, to engage in a dialog describing current and future research directions to facilitate the design, refinement, and proliferation of markets as predictive devices.

As part of the workshop, one or more tutorials are planned for the benefit of students and other newcomers to the field; little or no background knowledge will be assumed.

DIMACS Workshop on Large-Scale Games
Dates: April 17 - 19, 2005
Location: Evanston Campus, Northwestern University, Evanston, Illinois
Organizers:
Lance Fortnow, University of Chicago
Rakesh Vohra, Northwestern University
Attendance: Registration is still open for this activity

On the Internet we have games with a large number of agents, asynchronous play, and an absence of full knowledge about the number of agents one is playing against or the beliefs they possess. The Internet is not the only institution to possess these features nor the first. Markets for traditional goods and services as well as travel networks all possess these features.

This workshop is devoted to the analysis of large scale games of the kinds inspired by the Internet and other computer networks, markets, traffic networks and other large systems. We invite papers that will show how to adapt and extend classical game theoretic models to deal with a large number of players, accommodate the absence of common knowledge, common priors, asynchrony in play and distributed computation.

Examples of the kind of work that would be suitable for this workshop include price of anarchy models, robust and on-line mechanism design, timing games, asymptotic analysis of traditional auctions, continuous double auctions (two-sided markets) and network formation.

This workshop will consist of 5 invited overview talks (hour long) and a collection of submitted talks (half hour). The overview talks are listed below. This workshop is supported by DIMACS, the Managerial Economics and Decision Sciences Department of the Kellogg School (http://www.kellogg.nwu.edu/meds/index.htm) and Northwestern University's Institute for Complex Systems (http://ccl.northwestern.edu/nico/).

The workshop will take place at Northwestern University's Evanston Campus.

OVERVIEW TALKS:

- Network and Coalition Formation: Matthew Jackson, California Institute of Technology
- Price of Anarchy Models: Tim Roughgarden, Stanford University
- Equilibrium Notions for Games with Many Players: Ehud Kalai, Northwestern University
- Mechanism Design Models without the Common Prior: Jason Hartline, Microsoft Research

- Asymptotic Analysis of Market Mechanisms: Mark Satterthwaite, Northwestern University

III. Project Findings

In elections, it is important that voters be able to verify that the tally reflects the sum of the votes that were actually cast, as they were intended to be cast. It is also important that voters not be subject to coercion from adversaries. Currently most proposed voting systems fall short: they either do not provide both properties, or require the voter to be a computer. Partly as a result of her participation in the Workshop on Electronic Voting, Anna Shubina, Department of Computer Science, Dartmouth College, developed a new voting system that uses voter knowledge to allow voter verification by using a receipt that is uninformative for a coercer without access to the voting machine or the contents of the cast ballots. Her system does not assume any trust in the voting machine, but requires a few other assumptions, which she believes to be reasonable in the real-world situation. A basic prototype of this system is available on the website http://althing.dartmouth.edu/cgi-bin/electme2/master.pl

The theory of social choice and voting has had a long history in the social sciences, dating back to early work of Condorcet and others in the 18th century. Some modern issues facing the theory of social choice relate heavily to computer science. Often we need to determine preferences for an individual or group, while maintaining accuracy, fairness and security, sometimes with only limited information and/or computational power. Moreover, we are also seeing voting/social choice issues arising in strictly computer science applications such as database and information retrieval, Internet search and meta-search, and collaborative filtering. These are the types of problems addressed in the tutorial on Social Choice and Computer Science in May 2004. Participants explored computer science and social science issues in insuring the best choices given limited information and computation. It introduced participants to the concepts and models of individual preference or utility as well as social choice theory and a variety of modern computational issues and computer science applications. The result of bringing together such a diverse group was the start of a collaboration among Arnold Urken, Professor of Political Science, Stevens Institute of Technology, Michel Regenwetter, Professor of Psychology, University of Illinois, and Fred Roberts, Professor of Mathematics, Rutgers University. They have already outlined a generalization of Regenwetter's stochastic token model, a model that demonstrates that randomly gathering information about candidates changes the ranking of the candidates.

IV. Project Training/Development

One of the major objectives of the special focus is to provide opportunities for junior researchers to develop interdisciplinary collaborations early in their careers. Even this early in the project, we are already getting indications that the special focus is successful in this regard. Here are some comments from participants:

"I'm a PhD candidate at Univ. of South Carolina. My dissertation research focuses on the computation side of 'distributed auctions.' Having an undergrad & masters in Comp Sci, I had

absolutely no knowledge about the economics issues involved in the problem. The DIMACS workshop titled “Workshop on Computational Issues in Auction Design” (Oct. 5-6, 2004) really helped me understand the economics side of auctions.

My secondary area of research interest is Computational Biology. My work in this area is really minimal. While attending the DIMACS WS, I was pleasantly surprised to know that DIMACS also has a special focus in this area. In fact, if possible, after finishing my PhD I'd like to join DIMACS as a post-doc to work simultaneously in these two areas.” Muralidhar V Narumanchi, Phd Candidate, MultiAgent Dynamics Laboratory Computer Science & Engineering, University of South Carolina

“I participated in the special focus on Computation and the Socio-Economic sciences as a co-organizer of the DIMACS Workshop on Computational Issues in Auction Design. I have also sent a number of recommendations for computer science students that wish to be PostDoc's as part of this focus. The focus is certainly very timely, coming just as computer scientists become increasingly aware of results in economics and economists become increasingly aware of the need for computational methodologies and considerations.” David Parkes, Department of Computer Science, Harvard University

V. Outreach Activities

VI. Papers/Books/Internet

Books

Internet

Main web site for the Special Focus on Computation and the Socio-Economic Sciences
http://dimacs.rutgers.edu/SpecialYears/2004_CSEC/

Journal Articles

Shubina, Anna M. and Sean W. Smith, “Design and Prototype of a Coercion-Resistant, Voter Verifiable Electronic Voting System,” Proceedings of the **Second Annual Conference on Privacy, Security and Trust, University of New Brunswick Fredericton, New Brunswick, Canada**, October, 2004.

McGaley, Margaret, “Report on DIMACS Workshop on Electronic Voting – Theory and Practice,” http://dimacs.rutgers.edu/Workshops/Voting/e-voting-final.pdf

Talks

“Design and Prototype of a Coercion-Resistant, Voter Verifiable Electronic Voting System,” Anna M. Shubina and Sean W. Smith, Second Annual Conference on Privacy, Security and Trust, University of New Brunswick Fredericton, New Brunswick, Canada, October 14, 2004.

VII. Other Products

Main web site for the Tutorial on Social Choice and Computer Science
http://dimacs.rutgers.edu/Workshops/SocialChoice/

Main web site for the Workshop: Electronic Voting: Theory and Practice
http://dimacs.rutgers.edu/Workshops/Voting/

Main web site for the Working Group: The Mathematics of Web Search and Meta-Search
http://dimacs.rutgers.edu/Workshops/WGWebSearch/

Main web site for the Workshop: Computational Issues in Auction Design
http://dimacs.rutgers.edu/Workshops/AuctionDesign/

Main web site for the Workshop: Bounded Rationality
http://dimacs.rutgers.edu/Workshops/Bounded/

Main web site for the Workshop: Markets as Predictive Devices (Information Markets)
http://dimacs.rutgers.edu/Workshops/Markets/

Main web site for the Workshop: Large-Scale Games
http://dimacs.rutgers.edu/Workshops/Games/

VIII. Contributions within Discipline

The special focus is by nature both multidisciplinary and interdisciplinary. We mention some of the important interdisciplinary accomplishments in the section on Contributions – Other Disciplines. Several collaborations between individuals within the same discipline have already resulted from the special focus.

At the workshop on Computational Issues in Auction Design, Sushil Bikhchandani, The Anderson School at UCLA, and Rakesh V. Vohra, John L. and Helen Kellogg Professor of Managerial Economics and Decision Science, Kellogg School of Management, Northwestern University began a collaboration that arose from Bikchandani's talk. Here is Bikchandani's description of their project:

"It is well known that an efficient incentive compatible mechanism does not exist when agents have interdependent values and multi-dimensional information. We plan to investigate the extent of the inefficiency. Three questions in this regard are: What is the interim-efficient ex post incentive compatible mechanism? How inefficient is it? If one requires the mechanism to be almost (rather than exactly) ex post incentive compatible, do we get back efficiency?" Sushil Bikhchandani, The Anderson School at UCLA

Here is another telling comment from a participant.

“I doubt you would have any use for the following note, but here it is anyway. One of the great people (Chaum or Rivest, I think it was Chaum), said, at the workshop, something very important to me: that he now believes that in a critical system like an e-voting application correctness is all-important whereas privacy might be only computational. In a way, it is a trivial statement, but I found that it defined my way of thinking about many problems.” Anna Shubina, Department of Computer Science, Dartmouth College

IX. Contributions -- other Disciplines

The special focus is by design interdisciplinary. One of the main objectives is to facilitate interactions and collaborations across disciplines by introducing people with common research interests but in different disciplines who may not otherwise have met. Several of these interactions and collaborations have already begun. Rakesh V. Vohra, John L. and Helen Kellogg Professor of Managerial Economics and Decision Science, Kellogg School of Management, Northwestern University, met Michael Saks, Department of Mathematics, Rutgers, for the first time and learned from him that they have been working on the same problem (characterizing dominant strategy mechanisms), Saks using geometric methods and Vohra algebraic. This gave Vohra a new way to approach this problem that he expects to be useful. Vohra also met Jennifer Chayes and Christian Borgs (Microsoft) and discovered some auction issues facing Google and Microsoft that may lead to some interesting research problems. Vohra and Lance Fortnow are working together as co-chairs of the special focus. As a result of this, Vohra learned about Kolmogoroff complexity, something that would not have been likely without Fortnow's presence. They are now collaborating on the connections between Kolmogoroff complexity and calibration.

The following sums up very well the interdisciplinary nature of the special focus:

“While I agree that it is too early to judge the impact of the focus, let me make a few comments about the couple of days of my own workshop (DIMACS Workshop on Computational Issues in Auction Design.) First, the attendees were truly interdisciplinary. We had a good number of economists, computer scientists, and people from operations research. DIMACS was also able to support the attendance of a number of graduate students. For me, the most useful thing to come out of the workshop was a simple observation that we're all interested in many of the same problems. Talks focused on extended auction results to multi-dimensional problems, the issues surrounding costly preference elicitation, and characterizations of truthful auctions.

While at the workshop I had an opportunity to discuss some issues in auction design for an airport take off and landing slot problem with colleagues in economics and operations research, and we all engaged in a spirited discussion on the computational and economic properties of “proxied” auctions.

Although it is perhaps not fair to pinpoint one particular result from the workshop, in my view the main up shot was confirmation that there is a big open problem that everyone agrees is

important and unsolved—providing necessary and sufficient characterizations of truthful mechanisms for structured problem domains. I had gone to the workshop thinking this was an important problem, and left convinced after having the opportunity to talk with a number of other people at the event." David Parkes, Department of Computer Science, Harvard University

X. Contributions -- Human Resource Development

Many graduate students have participated in the special focus programs. We set aside funds in each workshop budget for support of students. A partial list of graduate student participants is the following:

DIMACS Tutorial on Social Choice and Computer Science

- Moshe Babaioff, Hebrew University
- Edith Elkind, Princeton University
- Timothy Richard Gall, Colorado State University
- Ron Lavi, Hebrew University of Jerusalem
- Lan Yu, Rutgers University

DIMACS Workshop on Electronic Voting – Theory and Practice

- Ammar Alkassar, German Research Institute for Artificial Intelligence
- Xuhui Ao, Rutgers University
- Arati Baliga, Rutgers University
- Jong Youl Choi, New York University
- Edith Elkind, Princeton University
- Sudhakar Govindavajhala, Princeton University
- Benjamin Hosp, The George Washington University
- Hong Jiang, Yale University
- Pandurang Kamat, Rutgers University
- Andis Chi-Tung Kwan, Graduate Center & Baruch College
- Jose Luis Barcelon Lacson, University of Tokyo
- Antonina Mitrofanova, Rutgers University
- Xinming Ou, Princeton University
- Manaj Prabhakaran, Princeton University
- Shyaam Sundhar Rajamadam Srinivasan, George Washington University
- Anna Shubina, Dartmouth College
- Julie Ann Staub, University of Maryland
- Wei Zhuang, Rutgers University

DIMACS Working Group on the Mathematics of Web Search and Meta-Search

- Nicole Immorlica, MIT

DIMACS Workshop on Computational Issues in Auction Design

- Diogo V. Andrade, Rutgers University
- Vincent Conitzer, Carnegie Mellon University

- Rajdeep K. Dash, University of Southampton
- Shahar Dobzinski, Hebrew University
- Edith Elkind, Princeton/UCLA
- Andrew Gilpin, Carnegie Mellon University
- Rica Gonen, The Hebrew University of Jerusalem
- Navin Goyal, Rutgers University
- Elena Grigorieva, University Maastricht
- Mohammad Taghi Hagiaghayi, MIT
- Nicole Immorlica, MIT
- Aaron Michael Johnson, Yale University
- Anuj Kumar, Columbia University
- Sebastien Michel Lahaie, Harvard University
- Anton Likhodedov, SCS, Carnegie Mellon University
- Muralidhar V. Narumanchi, Univ. of South Carolina
- Evdokia Velinova Nikolova, MIT
- Abhishek Pani, University of Maryland College Park
- David Phillips, Columbia University
- Sujay R. Sanghavi, ECE, UIUC
- Michael Schapira, Hebrew University
- Arun Sen, Princeton University
- Jeffrey Shneidman, Harvard University
- Levent Ulku, Rutgers University
- Lan Yu, Rutgers University
- Hairong Zhao, NJIT

DIMACS Workshop on Bounded Rationality
- Colleen E.H. Berndt, George Mason University
- Varsha Dani, University of Chicago
- Chetan V. Mannige, Rutgers University
- Ravinder K. Minhas, University of Toronto
- Devang Thakkar, Columbia University
- Ehud Vaks, Interdisciplinary Center Hertzeliya
- Lan Yu, Rutgers University

DIMACS Workshop on Markets as Predictive Devices (Information Markets)
- Colleen E.H. Berndt, George Mason University
- Yiling Chen, Penn State University
- McGregor (Greg) John Collie, Monash University
- Varsha Dani, University of Chicago
- Sandip Debnath, Penn State University
- Kevin Terence Fenwick, CUNY Graduate Center
- Anish Ghosh, Brandeis University
- Rica Gonen, Hebrew University
- Joel Simon Grus, Caltech

- Shankar Kalyanaraman, California Institute of Technology
- Ian M. Levitt, Rutgers University
- Chris Mesterharm, Rutgers University
- Ravinder K. Minhas, University of Toronto
- Ryan David Oprea, George Mason University
- David Hampton Perry, Trevecca University
- Mary Kate Preziosi, AT&T Research
- Gasper Tkacik, Princeton University
- Ehud Vaks, Interdesciplinary Center, Hertzeliya
- Annie C. Yang, University of California, San Diego
- Yoav Zingher, London Business School

DIMACS Workshop on Large-Scale Games
We expect to have a significant number of graduate students in this workshop. A list of participants is not yet available.

There was synergy between this project and the DIMACS collaboration with the Laboratory for Analyzing and Modeling Decision-Aid Systems (LAMSADE) at University of Paris IX, supported by a different NSF grant. The LAMSADE collaboration deals with computer science and decision theory. Two graduate students from LAMSADE, Meltem Ozturk and Bruno Escoffier, spent two months each at DIMACS in the Fall of 2004 and interacted with this project too. In turn, two Rutgers graduate students, Tiberius Bonates and Marcin Kaminski will be returning to Paris to visit LAMSADE in Spring 2005.

Meltem Ozturk's work is especially close to this special focus. She is working in decision analysis, constructing models to represent the problem situation (set of alternatives, criteria, attributes etc.) and the vision of the decision maker (his or her preferences, definition of rationality, etc.). She attempts to account for the dubious, uncertain, imprecise, inconsistent information and the complex nature of a decision maker's preferences (like hesitation between preference and indifference). In her models, uncertainties of information are represented by intervals and some extended preference structures to deal with the complex nature of preferences. Such orders introduce a third relation, “weak preference,” which permits the decision maker to express hesitation between preference and indifference. She has used non-classical logics (especially a four valued one and its continuous extension) and fuzzy set theory to characterize such structures. Clearly her visit influenced her direction of work and her interactions with Rutgers students participating in our special focus clearly influenced their research directions as well.

XI. Contributions to Resources for Research and Education

XII. Contributions Beyond Science and Engineering

To many technologists, electronic voting represents a seemingly simple exercise in system design. In reality, the many requirements it imposes with regard to correctness, anonymity, and availability pose an unusually thorny collection of problems, and the security risks associated

with electronic voting, especially remotely over the Internet, are numerous and complex, posing major technological challenges for computer scientists. This is the problem addressed by the special focus workshop on Electronic Voting -- Theory and Practice in May 2004. This workshop brought together researchers and practitioners in several different areas of relevance to voting, creating a lively interplay of ideas. One of the outcomes of the meeting (and its predecessor called WOTE) was a new organization of members of the technical community to establish specific performance rating guidelines for voting systems. Voting Systems Performance Rating (VSPR) is expected to be launched early in 2005. VSPR will greatly improve the quality of our election systems by providing objective measures of voting system performance, thus encouraging competition in the marketplace to produce systems with the highest rankings. Features of voting systems will be rated much as automobile safety and fuel efficiency are now. A set of well-defined properties would encourage the development and commercialization of better voting systems, especially when combined with objective ways to measure performance with respect to those properties. The overall result would then resemble the quantitative federal ratings for automobiles, where features such as vehicle safety and fuel efficiency form a basis for *Consumer Reports*-style comparative tables. This also meets the request to the technical community of the U.S. Federal Election Assistance Commission (EAC) for help in defining standards.