

DIMACS Center
Rutgers University

**DIMACS/LAMSADE PARTNERSHIP on Computer Science and
Decision Theory: Applications of Notions of Consensus**

Annual Report

October 2004

Ia. Participants in the program

Senior Leadership:

PI: Fred Roberts, DIMACS
Endre Boros, Rutgers University
Peter Fishburn, AT&T Labs – Research
Mel Janowitz, DIMACS
Brenda Latka, DIMACS
David Madigan, Rutgers University
S. Muthukrishnan, Rutgers University
Co-PI: Alexis Tsoukiàs, LAMSADE
Denis Bouyssou, LAMSADE
Vincent Mousseau, LAMSADE
Bernard Roy, LAMSADE
Daniel Vanderpooten, LAMSADE

DIMACS/LAMSADE Workshop on Computer Science and Decision Theory

Organizers:

Mel Janowitz, DIMACS
Fred Roberts, DIMACS
Alexis Tsoukiàs, LAMSADE

Local Organizing Committee:

Denis Bouyssou, CNRS-Lamsade, Universite Paris Dauphine
Bruno Escoffier, CNRS-Lamsade, Universite Paris Dauphine
Meltem Ozturk, CNRS-Lamsade, Universite Paris Dauphine

Other Participants:

Brenda Latka, DIMACS

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 research.

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 and research.

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 and research.

LAMSADE (*Laboratoire d'Analyse et Modélisation de systèmes pour l'aide à la décision*),
Université Paris Dauphine

Partner organization of DIMACS. Individuals from the organization participated in the program planning and research.

The French National Center for Scientific Research (CNRS)

Funded the French site.

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

Two leading research centers, DIMACS (the Center for Discrete Mathematics and Theoretical Computer Science, based at Rutgers University), and LAMSADE (the Laboratoire d'Analyse et Modélisation de Systèmes pour l'Aide à la Décision, based at Université Paris IX - Dauphine) have initiated an international collaboration organized around modern computer science applications of methods developed by decision theorists, in particular methods involving consensus and associated order relations. The project is exploring the connections between

computer science and decision theory, developing new decision-theory-based methodologies relevant to the scope of modern CS problems, and investigating their applications to problems of computer science and also to problems of the social sciences that could benefit from new ideas and techniques. The project features exchange visits of graduate students and junior researchers and a workshop that will introduce a broader community to the topics of the collaboration. The project emphasizes computer science problems that arise in meta-search (combining the outputs of several search engines); collaborative filtering (using learning algorithms to make recommendations for books, movies, etc.); finding centrally located items in large databases, in particular biological ones and ones that arise in homeland security applications; combining ratings of software or hardware; in distributed computing when some processors fail and we seek to reach “agreement” among the remaining processors; finding efficient ways to compute consensus functions; and learning about individuals' preferences as they are revealed gradually in situations of economic cooperation and competition using the Internet.

The project is already having impact well beyond the small number of people participating in the exchange visits through a center-to-center exchange that involves a large number of scientists associated with the two centers in the related scientific discussions and interchanges. Moreover, the impact will be broadened through the workshop that will introduce many of those both associated with and outside the two collaborating centers to this new field. The results should be broadly useful in emerging information technology applications, in areas of economics and political science where methods of decision theory have traditionally been applied, and in new areas of application of decision theory such as to problems of epidemiology and bio-terrorism.

A workshop in this collaboration was held as follows:

DIMACS - LAMSADE Workshop on Computer Science and Decision Theory held October 27 – 29, 2004, at the Université Paris Dauphine. There were 36 participants.

The workshop focused on modern computer science applications of methods developed by decision theorists, in particular methods involving consensus and associated order relations. The broad outlines concern connections between computer science and decision theory, development of new decision-theory based methodologies relevant to the scope of modern computer science problems, and investigation of their applications to problems of computer science and also to problems of the social sciences which could benefit from new ideas and techniques. Here is a list of main themes that were covered:

- preference modeling;
- social choice;
- knowledge extraction;
- fusion of information;
- issues involving artificial intelligence;
- large databases and inference;
- computational intractability of consensus functions;
- axiomatics: approaches and algorithms for consensus functions;
- order relations and revealed preferences.

Christophe Gonzales and Patrice Perny, University Paris, began the workshop with their presentation on preference representation and elicitation in the context of multi-attribute utility theory under risk. Assuming the decision maker behaves according to the Expected Utility model, they investigated the elicitation of generalized additively decomposable utility functions on a product set (Generalized Additive Independence (GAI)-decomposable utilities). They proposed a general elicitation procedure based on a new graphical model called a GAI-network. The latter is used to represent and manage independences between attributes, as junction graphs model independences between random variables in Bayesian networks. It is used to design an elicitation questionnaire based on simple lotteries involving completely specified outcomes. Their elicitation procedure is convenient for any GAI-decomposable utility function, thus enhancing the possibilities offered by UCP-networks.

Olivier Gauwin, Sebastien Konieczny and Pierre Marquis, CRIL-CNRS, Université d'Artois, introduced two conciliation processes for intelligent agents based on an iterated merge-then-revise change function for belief profiles. The first approach is *skeptical* in the sense that at any revision step, each agent considers that her current beliefs are more important than the current beliefs of the group, while the other case is considered in the second, *credulous* approach. They gave several perspectives on this work. One of them concerns the stationarity conjecture related to credulous CHIMC operators (it would clearly be nice to have a formal proof of it, or to disprove it). A second perspective is about rationality postulates for conciliation operators. Such postulates should reflect the fact that at the end of the conciliation process, the disagreement between the agents participating in the conciliation process is expected not to be more important than before. A difficulty is that it does not necessarily mean that this must be the case at each step of a conciliation process. A last perspective is to enrich the framework in several directions. One of them consists in relaxing the homogeneity assumption. In some situations, it can prove sensible to consider that an agent is free to reject a negotiation step, would it lead her to a belief state "too far" from its original one. It would be interesting to incorporate as well such features in this approach.

The program of talks was as follows:

Graphical Models for Utility Elicitation

Christophe Gonzales and Patrice Perny, University Paris

A Computational Study of the Kemeny Rule for Preference Aggregation

Andrew Davenport and Jayant Kalagnanam, IBM

Computation of Median Orders: Complexity Results

Olivier Hudry, Ecole Nationale Supérieure des Telecommunications

The Majority Rule and Combinatorial Geometry (via the Symmetric Group)

James Abello, DIMACS

What Can We Learn from the Transitivity Parts of a Relation?

Jean Paul Doignon, Université Libre de Bruxelles and Jean-Claude Falmagne, University of California, Irvine

- Differential Approximation for MinSAT, MaxSAT and Related Problems
Bruno Escoffier and Vangelis T. Paschos, Lamsade
- Continuous Ordinal Clustering: A Mystery Story
Mel F. Janowitz, DIMACS
- A Complete Description of Comparison Meaningful Functions
Jean-Luc Marichal, University of Luxembourg and Radko Mesiar, Slovak Technical University
- On Some Ordinal Models for Decision Making Under Uncertainty
Denis Bouyssou, CNRS and Marc Pirlot, Faculte Polytechnique de Mons, Belgium
- Preference Aggregation with Multiple Criteria of Ordinal Significance
Raymond Bisdorff, University of Luxembourg
- Conciliation and Consensus in Iterated Belief Merging
Olivier Gauwin, Sebastien Konieczny and Pierre Marquis, CRIL-CNRS, Universit'e d'Artois
- Compact Preference Representation and Computational Complexity in Social Choice
Jerome Lang, IRIT
- An Algorithmic Solution for an Optimal Decision Making Process within Emission Trading Markets
Stefan Pickl, University of Cologne, Germany
- May's Theorem for Trees
F.R. McMorris, Illinois Institute of Technology and R.C. Powers, University of Louisville
- On the Consensus of Closure Systems
Bruno Leclerc, Centre d'Analyse et de Mathematique Sociales
- Characterizing Neutral Aggregation on Restricted Domains
Eyal Beigman, Hebrew University
- Lattices of Choice and Consensus Problems
Bernard Monjardet and Vololonirina Raderanirina, CERMSEM
- Competition Graphs of Semiorders
Fred Roberts, DIMACS
- Multiagent Resource Allocation with k-additive Utility Functions
Yann Chevaleyre, Sylvia Estvie and Nicolas Maudet, Lamsade Ulle Endriss, Imperial

College

Preferences on Intervals: A General Framework
Alexis Tsoukiàs and Philippe Vincke, Lamsade

III. Project Findings

The first year has been spent primarily in organizing the exchange program and the first workshop. It should be noted that LAMSADE was not officially granted the project by CNRS until April 2004.

IV. Project Training/Development

The graduate students Bruno Escoffier and Meltem Ozturk will be visiting DIMACS within the next year. Bruno Escoffier is currently a PhD student at Lamsade, University Paris Dauphine. He will visit DIMACS in November 2004, December 2004 and January 2005. His research deals with complexity theory, combinatorial optimization and, more specifically, polynomial approximation of optimization problems. Meltem Ozturk is also a PhD student at Université Paris Dauphine. Her research is on the use of non-classical logics in preference modelling.

Rutgers students are also scheduled to visit LAMSADE in the coming year.

V. Outreach Activities

Discussions between DIMACS and LAMSADE have led to the beginning of collaborations on the topic of IT support for government decisionmaking and public participation. Topics of interest include information sharing among government agencies, introducing automatic decisionmaking in government action, and intelligent information retrieval.

VI. Papers/Books/Internet

There will be a volume of "Annals of LAMSADE" containing all the papers of the October 27-29, 2004 workshop.

The main web site for the DIMACS/LAMSADE PARTNERSHIP on Computer Science and Decision Theory: Applications of Notions of Consensus

<http://dimacs.rutgers.edu/Workshops/Lamsade/index.html>

VII. Other Products

The main web sites for the workshop DIMACS/LAMSADE Workshop on Computer Science and Decision Theory

<http://dimacs.rutgers.edu/Workshops/DecisionTheory/>
<http://11.lamsade.dauphine.fr/dimacs/index.html>

VIII. Contributions within Discipline

Probably the most important contribution of this project is the example it is setting for international collaborations among the senior and junior researchers of the United States and France in such an interdisciplinary area. While this project is in a very early stage, we expect that the work of this project will lead to many of these collaborations in the future.

IX. Contributions -- other Disciplines

This is an inherently interdisciplinary project. We expect that the connections between computer science, mathematics, statistics, decision theory, economics, psychology, etc. will be brought to light.

We will involve LAMSADE researchers in the use of order theory in public health/epidemiology. A DIMACS “Working Group” on this topic will meet in March and both Rutgers graduate students and LAMSADE researchers will collaborate through this venue. In particular, student Paul Raff, working with Fred Roberts, will be included.

X. Contributions -- Human Resource Development

This project provides support for an interchange of graduate students. We expect that interchange to have a major impact on the research and careers of these students.

XI. Contributions to Resources for Research and Education

XII. Contributions Beyond Science and Engineering