DIMACS Center
Rutgers University

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

Final Report

April 2007

Ia. Participants in the program

Senior Leadership:

PI: Fred Roberts, DIMACS
Co-PI: Alexis Tsoukiàs, LAMSADE

Endre Boros, Rutgers University
Peter Fishburn, AT&T Labs – Research
Mel Janowitz, DIMACS
Brenda Latka, DIMACS
David Madigan, Rutgers University
S. Muthukrishnan, Rutgers University
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 Öztürk, CNRS-Lamsade, Universite Paris Dauphine

Speakers:

James Abello, DIMACS
Eyal Beigman, Hebrew University
Raymond Bisdorff, University of Luxembourg
Denis Bouyssou, CNRS
Yann Chevaleyre, LAMSADE
Andrew Davenport, IBM
Jean Paul Doignon, Universite Libre de Bruxelles
Ulle Endriss, Imperial College
Bruno Escoffier, LAMSADE
Sylvia Estivie, LAMSADE
Jean-Claude Falmagne, University of California, Irvine
Olivier Gauwin, CRIL-CNRS, Universite d'Artois
Christophe Gonzales, University Paris

Olivier Hudry, Ecole Nationale Superieure des Telecommunications
Mel F. Janowitz, DIMACS
Jayant Kalagnanam, IBM
Sebastien Koniezny, CRIL-CNRS, Universite d'Artois
Jerome Lang, IRIT
Bruno Leclerc, Centre d'Analyse et de Mathematique Sociales
Jean-Luc Marichal, University of Luxembourg
Pierre Marquis, CRIL-CNRS, Universite d'Artois
Nicolas Maudet, LAMSAD
F.R. McMorris, Illinois Institute of Technology
Radko Mesiar, Slovak Technical University
Bernard Monjardet, CERMSEM
Vangelis T. Paschos, LAMSADE
Patrice Perny, University Paris
Stefan Pickl, University of Cologne, Germany
Marc Pirlot, Faculte Polytechnique de Mons, Belgium
R.C. Powers, University of Louisville
Vololonirina Raderanirina, CERMSEM
Fred Roberts, DIMACS
Alexis Tsoukiàs, LAMSADE
Philippe Vincke, LAMSADE

DIMACS/LAMSADE Workshop on Voting Theory and Preference Modelling

Organizers:

Denis Bouyssou, CNRS-Lamsade
Mel Janowitz, DIMACS
Fred Roberts, DIMACS
Alexis Tsoukiàs, LAMSADE
Philippe Vincke, SMG

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.

Alcatel-Lucent 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 involves scientists from numerous institutions in numerous countries. The resulting collaborations also involve 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) 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 explored the connections between computer science and decision theory, developed new decision-theory-based methodologies relevant to the scope of

modern CS problems, and investigated 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 featured exchange visits of graduate students and junior researchers and two workshops that introduced a broader community to the topics of the collaboration.

The project emphasized 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 has had 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 has been broadened through the workshops that introduced 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.

Workshops

During the first year of the project the DIMACS - LAMSADE Workshop on Computer Science and Decision Theory was 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. The proceedings of the workshop were published as *Annales du LAMSADE No 3*, Universite Paris Dauphine, October, 2004, and was edited by the graduate students Meltem Öztürk and Bruno Escoffier. As a result of the workshop there will be a special issue of *Annals of Operations Research* on decision theory and computer science, edited by Fred Roberts (PI) and Alexis Tsoukiàs (Co-PI). This special issue is described in detail below.

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 intractablity 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 Koniezny and Pierre Marquis, CRIL-CNRS, Universit´e 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 Superieure 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, Universite 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 Koniezny 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 Estivie and Nicolas Maudet, Lamsade Ulle Endriss, Imperial College

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

During the third year of the project the DIMACS/LAMSADE Workshop on Voting Theory and Preference Modelling was held October 25 - 28, 2006 at University Paris Dauphine, France. Voting theory and preference modelling are particularly relevant as far as political science and governance are concerned (fair representation, participation in the democratic process, transparency of public decision processes, etc.), but surprisingly they also result from several modern computer science applications. We know that several problems which arise in fusion of information, knowledge extraction, distributed planning and pattern recognition can ultimately be considered as social choice and preference aggregation problems. At the same time such new areas of application represent new challenges for voting theory and preference modelling, for example: automatic decision processes, very large data sets, combinatorial structure of the alternatives, efficiency in computing. This workshop introduced PhD students to these exciting areas through five tutorials at the beginning of the workshop, showed the state of the art in these areas, shaped future research directions, and brought together social scientists, decision theorists and computer scientists in an interdisciplinary meeting.

A volume of Annals of LAMSADE will be edited (as for the previous workshop). A special issue of the Journal of Mathematical Social Science is being prepared.

Topics of the workshop included
- computational issues in voting procedures
- voting procedures in automatic decision making
- social choice and artificial intelligence
- fair allocation of resources
- fair partitioning
- electronic voting
- preference models in decision making, reasoning and knowledge extraction
- preference aggregation

Robert C. Powers, Buck McMorris addressed the issue of the roles of a decisive family of voters in the analysis of various consensus functions defined on preference profiles. This role remains when the domain shifts to profiles of hierarchical classifications. Their main result is a characterization of consensus rules defined on hierarchies where the output clusters are determined by a decisive family of sets.

Jean-Francois Laslier presented three examples of approval voting games. The first one illustrates that a stronger solution concept than perfection is needed for a strategic analysis of this type of games. The second example shows that sophisticated voting can imply that the Condorcet winner gets no vote. The third example shows the possibility of insincere voting being a stable equilibrium.

Olivier Hudry provided a discussion of the complexity of the most common methods for deciding the winner in a round robin tournament. In voting theory, the result of a paired comparison method can be represented by a tournament, i.e., a complete asymmetric directed graph. When there is no Condorcet winner, i.e., a candidate preferred to any other candidate by a majority of voters, it is not always easy to decide who is the winner of the election. Different methods, called tournament solutions, have been proposed to define the winners. They differ by their properties and usually lead to different winners.

The program of talks was as follows:

Tutorial I: Computer Science and Decision Making
Fred Roberts, DIMACS

Tutorial II: Behavioral Social Choice: Probabilistic Models, Statistical Inference, and Application
Mike Regenwetter

Tutorial III: Using Mathematics to Explain Surprises in Voting Theory
Donald Saari

Tutorial IV: Voting Systems That Combine Approval and Preference
Steve Brams

Tutorial V: A Conjoint Measurement View on Fuzzy Integrals
Denis Bouyssou, Thierry Marchant, Marc Pirlot

Removal Independence for ß-closed Systems of Sets
Gary D. Crown. Melvin F. Janowitz, R.C. Powers

Condorcet Domains and Distributive Lattices
Bernard Monjardet

Consensus Hierarchies Defined by Decisive Families
Robert C. Powers, Buck McMorris

Approval Voting: Three Examples
Francesco De Sinopoli, Bhaskar Dutta and Jean-Francois Laslier

Approval Voting for Committees: Threshold Approaches
Peter Fishburn, Aleksandar Pekec

On the Difficulty of Computing the Winners of a Tournament
Olivier Hudry

Vote and Aggregation in Combinatorial Domains with Structured Preferences
Jérôme Lang

Preference Aggregation and Elicitation: Tractability in the Presence of Incompleteness and Incomparability
M.S. Pini, F.Rossi, K. Venable, T. Walsh

Collective Decision Making Using GAI Networks
C. Gonzales, P. Perny, S.Queiroz

Reasoning about Controllable and Uncontrollable Variables
Souhila Kaci and Leendert van der Torre

A Minimax Procedure for Electing Committees
Steve Brams, Marc Kilgour and Remzi Sanver

An Axiomatic Characterization of the Prudent Order Preference Function
Claude Lamboray

The Unexpected Empirical Consensus among Consensus Methods
Mike Regenwetter

Multilayered Decision Problems
Dmitrii Lozovanul, Stefan Pickl

Some Comments on Strategic Voting
Eric Pacuit, Rohit Parikh

The Polyhedron of all Representations of a Semiorder
Barry Balof, Jean-Paul Doignon and Samuel Fiorini

On Influence and Power Indices
Michel Grabisch, Agnieszka Rusinowska

A Simple Bayes Factor for Testing Measurement-Theoretic Axioms
Thierry Marchant

Geometric Approach to Paradoxes of Voting Power
Michael Jones

New Results on Intervals Comparison
Meltem Öztürk, Alexis Tsoukiàs

On Enumerating the Kernels in a Bipolar-Valued Outranking Digraph
Raymond Bisdorff

Better Ways to Cut a Cake
Steve Brams, Michael Jones and Christian Klamler

Expressive Power of Weighted Propositional Formulas for Cardinal Preference Modelling
Yann Chevaleyre, Ulle Endriss, Jérôme Lang

Student Exchange

There was an exchange of four graduate students during year 2005 of the project and another three during the year 2006. Bruno Escoffier and Meltem Öztürk visited DIMACS during the period November 2004 to January 2005. Tiberius Bonates and Marcin Kominski visited LAMSADE during the period May 2005 to June 2005. Rutgers students, Milanic Martin, Nilay Nogan, and Gabor Rudolf visited LAMSADE in 2006. This has already resulted in the establishment of international Ph.D committees. Fred Roberts, PI, Rutgers, served on Meltem Öztürk's committee; Peter Hammer, Rutgers, served on Bruno Escoffier's committee; Alexis Tsoukiàs, Co-PI, LAMSADE, will serve on Tiberius Bonates' committee. Moreover, Escoffier has already prepared two joint papers, one with Hammer on polynomial approximation of the quadratic set covering problem and one with James Abello, DIMACS, on applying consistent sets to voting. Details of these exchanges are given in the Project Training/Development section.

Alexis Tsoukiàs visited DIMACS in October 2005 to begin the collaboration with the PhD students who visited LAMSADE in 2006, coordinate with Fred Roberts on the future activities of the program, and work with Tibrius Bonates on his Ph.D thesis as well as their joint paper on "Logical Analysis of Data and Rough Sets Theory."

III. Project Findings

Vote manipulation in the presence of multiple sincere ballots

A classical result in voting theory, the Gibbard-Satterthwaite Theorem, states that for any nondictatorial voting rule for choosing between three or more candidates, there will be situations that give voters an incentive to manipulate by not reporting their true preferences. However, in the form it is usually stated, this theorem does not immediately apply to a range of voting rules that are used in practice. For instance, it makes the implicit assumption that there is a unique way of casting a sincere vote, for any given preference ordering over candidates. Approval voting is an important voting rule that does not satisfy this condition. In approval voting, a ballot consists of the names of any subset of the set of candidates standing; these are the candidates the voter approves. The candidate receiving the most approvals wins. A ballot is considered sincere if the voter prefers any of the approved candidates over any of the disapproved candidates. Ulle Endriss, Institute for Logic, Language and Computation, University of Amsterdam, explored to what extent the presence of multiple sincere ballots allows us to circumvent the Gibbard-

Satterthwaite Theorem. His results show that there are several interesting settings in which no voter will have an incentive to vote with an insincere ballot.

Multiagent resource allocation in k-additive domains: preference representation and complexity

Yann Chevaleyre, Sylvia Estivie, and Nicolas Maudet, LAMSADE, Universite Paris-Dauphine (France) collaborated with Ulle Endriss, ILLC, Universiteit van Amsterdam (The Netherlands), in studying a framework for multiagent resource allocation where autonomous software agents negotiate over the allocation of bundles of indivisible resources. Connections to well-known combinatorial optimisation problems, including the winner determination problem in combinatorial auctions, shed light on the computational complexity of the framework. They gave particular consideration to scenarios where the preferences of agents are modelled in terms of k-additive utility functions, i.e. scenarios where synergies between different resources are restricted to bundles of at most k items. They showed that in cases where the utility functions used by agents to model their preferences over alternative bundles of resources are additive, it is sufficient to use very simple negotiation protocols that only cater for deals involving a single resource at a time. This result suggested that they investigate generalizations of the notion of additivity, hence they considered the case of k-additive functions, as studied, for instance, in the context of fuzzy measure theory. The notion of k-additivity suggests an alternative representation of utility functions. They showed that this representation is as expressive as the "standard" representation (which involves listing the utility values for all possible bundles) and that it often allows for a more succinct representation of preferences. They showed that, despite the positive expectations raised by their result on negotiation in additive domains, the structural complexity of the negotiation protocol required to agree on a socially optimal allocation does not necessarily decrease for problems with k-additive utility functions when k gets smaller (as long as $k > 1$). On the other hand, representing utility functions in the k-additive form rather than the bundle form can be significantly more succinct, particularly in cases where a representation with a small value for k is possible. They explored connections to well-known combinatorial optimization problems, establishing complexity results for the problem of finding a socially optimal allocation with respect to different representations of utility functions. In this context, they also studied the relation of their negotiation framework to combinatorial auctions for different kinds of bidding languages. While their negotiation framework is clearly not an auction (it is, for instance, not concerned with the aspect of agreeing on the price for a set of items), the abstract "centralized" problem of finding a socially optimal allocation (which is not itself a problem faced by the agents participating in a negotiation process) directly corresponds to the winner determination problem in combinatorial auctions. Under this view, the languages used to represent utility functions correspond to bidding languages for such auctions. The high complexity of the distributed negotiation framework does not, at least not necessarily, mean that it cannot be usefully applied in practice. In recent years, several algorithms for winner determination in combinatorial auctions, a problem of comparable complexity, have been proposed and applied successfully. Their work is part of a wider research trend, which brings together ideas from different areas including microeconomics, operations research, decision theory, game theory, social choice, artificial intelligence, complexity theory, and algorithm design.

Modeling player preferences with weighted formulas

Sets of weighted formulas---known as goal bases---are a useful formalism for representing agent preferences. Joel Uckelman, a PhD student working with Ulle Endriss at the Institute for Logic, Language, and Computation at the University of Amsterdam, established restrictions on formulas or weights that correspond to well-known classes of utility functions. He proved that a particular fully expressive language (positive clauses, arbitrary weights) admits of only a single representation for each utility function, and thereby shows this language to be strictly less succinct than one of its superlanguages (clauses, arbitrary weights). He developed Max-Util, the decision version of the problem of finding states with optimal utility, and compiled known complexity results for different goal base languages. He applied goal bases to committee elections, where they may be used as a voting language.

Expressive power of weighted propositional formulas for cardinal preference modelling

A set of propositional formulas, each associated with a numerical weight, can be used to model the preferences of an agent in combinatorial domains. If the range of possible choices can be represented by the set of possible assignments of propositional symbols to truth values, then the utility of an assignment is given by the sum of the weights of the formulas it satisfies. Yann Chevaleyre, LAMSADE, Universite Paris-Dauphine, Ulle Endriss, ILLC, University of Amsterdam, and Jerome Lang, IRIT, Universite Paul Sabatier, established correspondences between certain types of weighted formulas and well-known classes of utility functions (such as monotonic, concave or k-additive functions) and obtained results on the comparative succinctness of different types of weighted formulas for representing the same class of utility functions.

Condorcet domains; a geometric perspective

One of several topics in which Peter Fishburn has made basic contributions involves finding maximal Condorcet Domains. To explain "Condorcet Domains" and why they are of interest, first notice that when using pairwise majority vote comparisons to make a decision, we hope to have decisive outcomes where one candidate is victorious when compared with any other candidate. This is called the Condorcet winner, a central concept in voting theory. Condorcet proved that pairwise rankings could define cycles, where a Condorcet winner cannot exist. The actual complexity is worse because the various ways in which cyclic behavior can be manifested extend beyond frustrating majority vote decision processes to cause fundamental theoretical concerns. A way to handle these difficulties is to restrict the preferences voters can have. This leads to the Condorcet Domain problem: it is to identify sets of preference rankings whereby, no matter how many voters have each ranking, the outcome never admits a cycle. A goal is to find or characterize all such domains and to find which ones have the maximum number of rankings. Monjardet's presentation of this problem at the October 2006 DIMACS/LAMSADE conference in Paris awakened the interest of Donald G. Saari, Institute for Mathematical Behavioral Sciences, University of California, Irvine. Saari formulated a restricted version of the Condorcet Domain problem, Fishburn's alternating scheme, in a geometric framework with the hope that the symmetries, which become apparent with geometry, would suggest other mathematical tools that could be brought to this workbench full of projects. He showed how the geometric approach fits into a broader research theme and reformulated the Condorcet Domain problem by placing it into a structure where the revised problem can be completely solved.

Using the approval voting paradigm to create decision aiding methods

Raymond Bisdorff, Applied Mathematics Unit, University of Luxembourg is transposing the approval voting paradigm into the decision aiding methodology framework. The very notion of criterion-function, as used in the outranking methodology, has therefore to be lifted on a new abstract foundation, allowing for the construction of choice approval criteria. This new idea has led to to new algorithimc developments as well as new algorithmic problems. The choice problem gets an algorithmic answer in computing outranking kernels on a bipolar-valued digraph obtained from majority aggregation of classical criterion-functions. This is known to be an NP-complete computational problem. Still open is the question of whether this is still the case if one proceeds instead with choice approval criterion-functions.

On the complexity of the exact weighted independent set problem

Martin Milanic RUTCOR, Rutgers University, and Jerome Monnot, CNRS-LAMSADE, Universite Paris-Dauphine, were motivated by the fact that the deterministic complexity of the exact perfect matching problem is still unsettled, to introduce and study the exact weighted independent set problem. The exact weighted independent set problem (EWIS) consists of determining whether a given weighted graph contains an independent set whose weight equals a given integer. Milanic and Monnot studied the problem of determining the complexity of the exact weighted independent set problem, and its restricted version EWIS_\alpha (where the independent set is required to be of maximum size), for particular graph classes. They proved that these problems are strongly NP-complete for cubic bipartite graphs and extended this result to a more general setting. They distinguished several graph classes where EWIS and EWIS_\alpha can be solved in pseudo-polynomial time.

Simple and fast reoptimizations for the Steiner tree problem

Bruno Escoffier, LAMSADE, University of Paris-Dauphine, Martin Milanic, RUTCOR, Rutgers University, and Vangelis Paschos, LAMSADE, University of Paris-Dauphine addressed reoptimization issues for the Steiner tree problem. Assuming that an optimal solution is given for some instance of the problem, the objective is to maintain a good solution when the instance is subject to minor modifications, the simplest modifications being vertex insertions and deletions. They proposed fast optimization strategies for the case of vertex insertions and showed that maintenance of a good solution for the "shrunk" instance, without ex nihilo computation, is impossible when vertex deletions occur. They also computed lower bounds for the approximation ratios of their reoptimization strategies.

Applying four valued logics to decision models

As a result of her DIMACS visit, jointly sponsored by DIMACS and LAMSADE, Meltem Öztürk, a graduate student at the time, completed work in modeling continuous positive and negative reasons in decision aiding. A language enabling one to explicitly take into account such reasons is Belnap's logic and the four valued logics derived from it. Öztürk explored the interpretation of a continuous extension of a four-valued logic as a necessity degree (in

possibility theory). She found that "sub-normalized" necessity measures need to be considered in order to take full advantage of the four values. Four-valued logics are the natural logical frame for such an approach.

Modeling uncertainty in information

In decision analysis, models are constructed to represent the set of alternatives, the preferences of the decision maker, and the definition of rationality. Models need to account for imprecise and inconsistent information and decision makers who hesitate or are indifferent between preferences. Graduate student Meltem Öztürk constructed models where the uncertainty of information is represented by intervals. In such models, some extended preference structures such as PQI interval orders are used to deal with the complex nature of decision maker preferences. Such orders introduce a third relation, weak preference, which models the decision maker's hesitation or indifference.

Polynomial approximation techniques for separating data into classes

Bruno Escoffier, a graduate student at the time, was another visitor to DIMACS jointly sponsored by DIMACS and LAMSADE. Escoffier collaborated with Peter Hammer, RUTCOR, on approximating the Quadratic Set Covering Problem. Their main motivation came from Logical Analysis of Data, which is a methodology, based on a logical analysis, to detect structural information about datasets. A medical example is typical of the type of application of this research. You want to determine if an illness can be related to some other medical parameters of patients, such as finding a correlation between heart attack and cholesterol for instance. To analyze this, you collect data on these parameters for both ill and healthy people. More formally, each person gives data on several criteria (weight, cholesterol,...) and is represented as a point in p dimensional space. You have a set of positive points (ill people) and a set of negative points (healthy people). A first step in the analysis of this data produces a collection of positive and negative patterns. A positive (respectively, negative) pattern is a hypercube in p dimensional space that contains no negative points (respectively, no positive points). This collection is such that every point is covered. From a medical point of view, you would like to find a sub-collection of patterns such that: every point is covered and the volume of intersections between positive and negative patterns is as small as possible. This problem is NP-hard but several heuristic techniques have been used to solve it. Escoffier and Hammer showed that polynomial techniques can give good approximations in certain cases.

Applying consistent sets to voting

Graduate student Bruno Escoffier also collaborated with James Abello, DIMACS, on a problem in social choice theory. Given a set of voters and a set of candidates in an election, voters' preferences can be represented as permutations. Of interest are consistent sets of permutations, that is, sets with no 3 x 3 embedded Latin Square. This ensures that the majority rule is transitive. Escoffier and Abello studied maximal consistent sets and the properties of such sets and related this to the complexity of some voting procedures that are in general NP hard, for example Caroll's voting system. Escoffier and Abello first met and began collaborating at the DIMACS/LAMSADE Workshop on Computer Science and Decision Theory, October 2004.

Online algorithms for covering problems

One of the projects of Tiberius Bonates, Rutgers graduate student, Pierre Tolla, LAMSADE, and Dominique Quadri, University of Paris graduate student, was to find online algorithms with non-trivial competitive ratios for the weighted versions of problems such as set covering and vertex covering and to obtain differential approximation results on the online versions of unweighted set covering and vertex covering problems, either under the existing online models or under new models. Bonates, Tolla, and Quadri found a way of adapting an existing algorithm to the solution of the weighted vertex and set covering problems under a slightly different online model than the one used for the unweighted case. The resulting algorithm is efficient both in terms of memory usage and number of operations and has a non-trivial competitive ratio, while the underlying online model is still realistic.

A Lagrangean relaxation algorithm for a quadratic knapsack problem

Bonates, Tolla, and Quadri investigated the application of Lagrangean relaxation to a quadratic separable integer problem with knapsack constraints. They applied a new Lagrangean decomposition approach to this problem. This idea is now being implemented and they expect to have the first numerical results soon. This work was started while Bonates visited LAMSADE and continued during a visit by Quadri to the United States in August 2005.

A new approach to the maximum cut problem

While Marcin Kaminski, Rutgers graduate student, was at LAMSADE he worked with Vangelis Paschos and Federico Della Croce, LAMSADE, on algorithmic aspects of the maximum cut problem. They studied exact algorithms for this problem and developed a new approach. A cut in an undirected simple graph is a partition of the vertex set into two disjoint subsets. Given a function that assigns weights to the edges of a graph, the weight of a cut is the sum of weights of the edges that have one endpoint in each subset of the cut. The maximum cut problem is to find a cut in the graph that has maximum weight. Known to be NP-hard for a long time, the problem received attention mainly in the context of approximation algorithms. Very little is known about classes of graphs where the problem can be solved in polynomial time, and not much research has been done on exact algorithms for maximum cut. Developing a new technique, Kaminski, Paschos, and Della Croce obtained an algorithmic scheme solving the maximum cut problem for graphs with bounded maximum degree Δ. The algorithm runs in time poly(n) * $O(2^{(1-2/\Delta)n})$ and uses polynomial space (where n is the number of vertices in the graph). This improves the previously known bounds for $\Delta \geq 8$. The same algorithmic technique applied to general graphs yields an algorithm running in time poly(n) * $O(2^{mn/(m+n)})$ and using polynomial space. This improves previously known bounds for $3 < m < 7n/5$ (where m is the number of edges in the graph).

IV. Project Training/Development

This project placed a high priority in providing support to students to participant in the workshops. Below are some indications of the outcomes of this support.

"I'm a PhD student at the Institute for Logic, Language, and Computation at the University of Amsterdam, and am working on preference representation languages. One of the talks at the Paris workshop last October suggested to me that I look into using the preference representation languages I've been working on as a way of extending the expressivity of voting methods. This has been a very fruitful avenue of research for me so far, and has resulted in a talk at the LCD'07 workshop in Lille in last month. I doubt that I would have made this connection between my work and voting theory without having attended the LAMSADE/DIMACS workshop, so I can say that for me the workship was highly worthwhile."
Joel Uckelman, Institute for Logic, Language, and Computation, University of Amsterdam

"On October 25-28, 2006 I attended the DIMACS/LAMSADE Workshop on Voting Theory and Preference Modeling. Thanks to DIMACS' funding to travel to LAMSADE in Paris I was exposed to this exciting interdisciplinary field.

"I found great interest in many of the talks at the workshop. The presentations that affected me the most were "Computer Science and Decision Making" by Dr. Fred Roberts and "A Minimax Procedure for Electing Committees" by Remzi Sanver presenting his work with by Steve Brams and Marc Kilgour. The first presentation acquainted me to sequential decision making problems through the example of container inspection in sea ports. I recently started to study a related problem of least cost diagnosis of points of a Boolean discriminant (/classification) function.

"The second presentation introduced a minmax procedure in order to select a committee by approval voting where the set of candidates approved are represented by a Boolean vector, and preferences are ordered according to Hamming distances. The minmax procedure, while having some desirable properties, is shown to be subject to manipulation by voters. At the conference I spoke to Prof. Steve Brams about the possibility of min-2^{nd}-max (2^{nd} or other ranks) as an alternative to minmax that might prevent or reduce manipulability. Although min-2^{nd}-max does not turn out to completely prevent manipulability it might still be an interesting possibility for research."
Noam Goldberg, RUTCOR, Rutgers University

Another major part of this project was support visits by graduate students between DIMACS and LAMSADE.

Bruno Escoffier and Meltem Öztürk visited DIMACS in November 2004, December 2004 and January 2005. Bruno Escoffier is a PhD student at Lamsade, Université Paris Dauphine. His research deals with complexity theory, combinatorial optimization and, more specifically, polynomial approximation of optimization problems. Meltem Öztürk is also a PhD student at Université Paris Dauphine. Her research is on the use of non-classical logics in preference modelling. They returned for follow up visits in 2006.

Rutgers graduate students Tiberius Bonates and Marcin Kaminski visited LAMSADE in May and June 2005. Marcin Kaminski's research interests are combinatorics, graph theory and their

algorithmic applications. He has worked on exact graph coloring algorithms and related problems (maximal independent sets, maximal bipartite subgraphs). His other interests are in poset theory, probabilistic algorithms, and combinatorial optimization. Tiberius Bonates works on optimization and combinatorial methods applied to machine learning, mainly on boolean problems arising in the context of the classification method called Logical Analysis of Data. He has developed algorithms to solve such problems using integer linear programming and heuristics.

Rutgers students, Milanic Martin, Nilay Nogan, and Gabor Rudolf visited LAMSADE in 2006.

The impact of the DIMACS visit on the graduate students from LAMSADE can best be expressed in their own words.

"During my stay at DIMACS, I met new people, had new contacts with different researchers in different fields (mathematicians from DIMACS, computer scientists from RUTCOR, industrial engineers from industrial department). These contacts were very interesting in the sense that I learned new things, dicovered new domains, had new ideas, etc. I met postdocs, graduate students, senior researchers. My contact with postdocs and graduate students helped me to better understand the university system of the United State, how the research is doing here etc. I had different contact with senior researchers. In Dimacs, I found different articles on my research domain (for example, I am working on non-classical logics, especially on four-valued logic and I found interesting works on this subject thanks to Ilya Muhnick) and heard about new ideas that are different from the ones used in Europe (for example, I discovered different use of lattices). Some talks with another visitor Vadim Mottl helped me to learn more about data mining. My meetings with Doctor Hammer were very fruitful for me also. His papers on country risk rating are really related to my domain and the subject is very interesting. I reserved a section on this subject on a paper that I am writing with my advisor for a special issue of International Journal of Intelligent Systems. I met also some researchers of industrial engineering department, especially Doctor Altiok since I am industrial engineer also. I hope that I can continue to have some contact with this department for future research.

The topic of my PhD thesis is on preference modelling where we use non-classical logics for our models. During my visit I learned some other approaches like the use of graphs etc., which I want to introduce in my models. I would like to continue to work on country risk rating with Doctor Hammer. As a result of our discussion, we realized that there are a variety of new things to do on the subject. I would be ready and glad to do some joint work with DIMACS and Rutcor as a visiting researcher or postdoc during a much longer time (6 months, one year). Thanks to my visit I discovered new approaches for preference modelling. My PhD topic is very theoretical and I had the opportunity to see some applications in classification problems of some models that are similar to mine. My discussions with researchers were much more related to my field of specialization. But I realized that some methods that we use for preference modelling could be also used in different fields, such as data mining."
Meltem Öztürk, LAMSADE

"My stay at DIMACS has been a great opportunity to meet people and to start collaborations with them. These collaborations will continue, they represent new directions in my work (see

below). The research done here constitutes a great step in the progress of my PhD thesis. This stay was also very fruitful as it was my first stay in a foreign research lab. I could see how research is organized, how people work, what are the differences and similarities with the situation in France. I made some contacts with several people, mainly at DIMACS and at RUTCOR. I especially met two PhD candidates, Tiberius Bonates and Marcin Kaminski, who will come to my laboratory in France in spring, as part of the same DIMACS/LAMSADE partnership. I also worked with senior researchers, James Abello from DIMACS and Peter Hammer from RUTCOR. In both cases, these works were productive, and are still on going, hence these collaborations should continue. As a matter of fact, another stay is about to be planned; I may come back to RUTGERS (for a week) in spring. I also hope to work with the two PhD. candidates who will visit my lab, since their research areas are strongly related to mine.

My visit was part of a partnership between LAMSADE (my lab in France), and DIMACS. This partnership is focused on connections between computer science and decision theory. The research area in my PhD concerns computer science, and thanks to this partnership (more especially my visit here, but also a workshop scheduled in Paris in October 2004) I learnt a lot about social choice and decision theory, and began to work on these topics. There are a lot of interesting connections, and this must constitute an interesting future direction in my work. Of course, the first step is to continue the collaborations started here during my stay.

My collaboration with James Abello is related to but is not directly in my research area. More precisely, this gave me the opportunity to work on social choice theory, and the relations between my area (complexity theory) and social theory must be a very fertile research direction. Moreover, the work with Peter Hammer was especially interesting to me as it is a direct application of my research field to a concrete problem (Logical Analysis of Data).

I also went to a lot of seminaries, on many different topics, mainly at DIMACS but also at Institute for Advanced Studies (Princeton), which is always a very rich and interesting experience."
Bruno Escoffier, LAMSADE

The LAMSADE visit had similar impact on the graduate students from Rutgers.

"The LAMSADE visit gave me the opportunity to establish contact with researchers working on topics closely related to my research interests at the time, e.g. combinatorial optimization, mathematical programming, and also with researchers that work in somewhat unrelated areas, such as approximation algorithms and online algorithms.

Alexis Tsoukiàs is professor at LAMSADE who works on applications of rough sets theory to machine learning, and demonstrated strong interest in combining the ideas of rough sets with those present in Logical Analysis of Data, which has been the main focus of my research for at least one year. We are discussing such an idea with Jose Figueira, an associate researcher at LAMSADE. Alexis' visit to DIMACS in October, 2005 will be very helpful for advancing in this direction.

Vangelis Paschos is another professor at LAMSADE, who introduced me to the topic of online algorithms for combinatorial optimization problems such as vertex covering and weighted set covering. We discussed some research directions that can lead to new algorithms and new online models for such problems.

I also worked with Dominique Quadri, who is currently a doctoral student at LAMSADE. She works under the supervision of Pierre Tolla and Eric Soutif and we started a study on the solution of a separable integer quadratic problem with knapsack constraints. Although this is a topic on which I had a previous interest, I had never actually worked on it and I am extremely interested about the possible outcome of this research.

The LAMSADE visit was remarkably beneficial to me, as it opened my view to different topics of study, broadening the horizons of my research, and as it introduced me to competent researchers with whom I plan to continue collaborating in the future."
Tiberius Bonates, RUTCOR

"I find my visit to LAMSADE very successful. Working with researchers at LAMSADE, I was introduced to algorithmic problems that I had not studied before and together we were able to design new, fast algorithms. There is a lot of room for improvement and I am planning to continue working with them in that field.

At LAMSADE I worked with Vangelis Paschos and Federico Della Croce on algorithmic aspects of the maximum cut problem. We studied exact algorithms for this problem and developed a technique that seems to be a new approach. Visiting LAMSADE was a great opportunity for me and I am sure I will also benefit from the visit in future. I am planning to continue the work with Prof. Paschos and Prof. Della Croce."
Marcin Kaminski, RUTCOR

V. Outreach Activities

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

VI. Papers/Books/Internet

Books

B. Escoffier and M. Öztürk (eds.), *Annales du LAMSADE No 3*, Universite Paris Dauphine, October, 2004.

F. Roberts and A. Tsoukiàs (eds.), *Annals of Operations Research Special Issue on Decision Theory and Computer Science*, in preparation.

F. Roberts and A. Tsoukiàs (eds.), *Mathematical Social Science Special Issue on Voting and Preference Theory*, in preparation.

Many modern computer science problems involve issues that decision theorists have addressed for years, in particular issues involving preferences, consensus and associated order relations. Applications of methods of decision theory to problems of computer science place great strain on these methods due to the sheer size of the problems addressed, limitations on information possessed, and sequential nature of repeated applications. Hence, there is great need to develop a new generation of methods to satisfy these requirements of CS applications. In turn, the new methods will provide powerful tools of use in problems of the social sciences (economics, political science, etc.) to which methods of decision theory have traditionally been applied as well as to newer areas of application of decision theory such as in policy-making concerning emerging diseases or bio-terrorism. The first special issue aims to explore the connections between computer science and decision theory, present the state of the art in this fascinating and dynamic area and attract papers at the boundary between the two communities.

The interface between their disciplines is becoming increasingly relevant for both decision theorists and computer scientists. However, there is as yet in the literature no systematic presentation of these issues. We expect this special issue of the Annals of OR to become a reference publication for this increasingly important field.

We are collecting original contributions in areas such as:
- preference elicitation and learning of preferences;
- qualitative decision theory;
- logical representations of preferences;
- AI planning, action and causality;
- preference modeling and aggregation;
- data-base querying and repair;
- data mining and knowledge extraction;
- social choice theory;
- fusion of information;
- computational intractability of consensus functions;
- applications of decision theory in computer science;
- algorithmic decision theory;
- collaborative filtering;
- meta-search.

There have been 18 submissions and we expect to publish a volume of about 250 pages. We expect to be able to deliver the issue to the editor by June 2007.

The second special issue is devoted to the interface between computer science and voting/preference. We have so far three submissions and expect to conclude the issue by the end of 2008.

Papers

R. Bisdorff, “Preference aggregation with multiple criteria of ordinal significance,” in D. Bouyssou, M. Janowitz, F. Roberts, and A. Tsouki´s (eds.), *Annales du LAMSADE*, Université Paris-Dauphine, **3** (2004), 25-44.

R. Bisdorff, “Preference aggregation with multiple criteria of ordinal significance,” *4OR, Quaterly Journal of the Belgian, French and Italian Operations Research Societies*, submitted.

R. Bisdorff, “Concordant outranking with multiple criteria of ordinal significance,” *4OR, Quaterly Journal of the Belgian, French and Italian Operations Research Societies*, Springer-Verlag, **2** (2004), 293 - 308.

R. Bisdorff, “On enumerating the kernels in a bipolar-valued digraph,” *Annales du Lamsade*, Université Paris-Dauphine, **6** (2006), 1 – 38, submitted.

T. Bonates and A. Tsoukiàs, “Logical Analysis of Data and rough sets theory,” in preparation.

S.J. Brams, D.M. Kilgour, and M.R. Sanver, “A minimax procedure for electing committees,” *Public Choice*, to appear.

S.J. Brams and M.R. Sanver, “Voting systems that combine approval and preference,” in S.J. Brams, W.V. Gehrlein, and F.S. Roberts (eds.), *The Mathematics of Preference, Choice, and Order: Essays in Honor of Peter C. Fishburn*, Springer, Heidelberg, Germany, to appear.

S.J. Brams, M.A. Jones, and C. Klamler, “Better ways to cut a cake,” *Notices of the AMS*, **35** (2006), 1314-1321.

S.J. Brams, M.A. Jones, and C. Klamler, “Divide-and-conquer: A proportional, minimal-envy cake-cutting algorithm,” in preparation.

Y. Chevaleyre, U. Endriss, and J. Lang, “Expressive power of weighted propositional formulas for cardinal preference modeling,” in P. Doherty, J. Mylopoulos, and C. Welty (eds.), *Proceedings of the 10th International Conference on Principles of Knowledge Representation and Reasoning (KR-2006)*, AAAI Press, 2006, 145-152.

Y. Chevaleyre, U. Endriss, S. Estivie, and N. Maudet, “Multiagent resource allocation in *k*-additive domains: Preference representation and complexity,” *Annals of Operations Research*, to appear.

F.D. Croce, M. Kaminski, and V. Paschos, “An exact algorithm for MAX-CUT in sparse graphs,” DIMACS Technical Report 2006-03, 2006.

F.D. Croce, M. Kaminski, and V. Paschos, “An exact algorithm for MAX-CUT in sparse graphs,” *Operations Research Letters*, to appear.

U. Endriss, "Vote manipulation in the presence of multiple sincere ballots," in *Proceedings of the 11th Conference on Theoretical Aspects of Rationality and Knowledge (TARK-2007)*, to appear.

B. Escoffier and J. Abello, "Consistent sets of permutations and voting procedures," in preparation.

B. Escoffier and P.L. Hammer, "Polynomial approximation of the quadratic set covering problem," *Journal of Discrete Optimization*, submitted.

B. Escoffier and P.L. Hammer, "Approximation of the quadratic set covering problem," DIMACS Technical Report 2005-09, 2005.

B. Escoffier, M. Milanic, and V. Paschos, "Simple and fast reoptimizations for the Steiner tree problem," DIMACS Techncial Report 2007-01, 2007.

B. Escoffier, M. Milanic, and V. Paschos, "Simple and fast reoptimizations for the Steiner tree problem," *INFORMS J. Compuing,* submitted.

M. Milanic and J. Monnot, "On the complexity of the exact weighted independent set problem," *Discrete Math,* submitted.

M. Milanic and J. Monnot, "On the complexity of the exact weighted independent set problem," in *30th Anniversary of the Lamsade. Combinatorial Optimization Theoretical Computer Science: Interfaces and Perspectives*, V. Paschos (ed.), Hermes, 2007.

M. Milanic and J. Monnot, "On the complexity of the exact weighted independent set problem for various graph classes," DIMACS Technical Report 2006-17, 2006.

B. Grimm, S. Pickl, and A. Reed, "Management and optimization of environmental data within emission trading markets - Veregister and Tempi," in *Emissions Trading and Business*, R.Antes, B. Hansjürgens, P.Letmathe (Eds), Physica Verlag, 165-176, 2006.

D. Lozovanu and S. Pickl, "Nash equilibria conditions for cyclic games with p players," *Electronic Notes in Discrete Mathematics*, Elsevier, **25** (2006), 123-129.

D. Lozovanu and S. Pickl, "Algorithms for solving multiobjective discrete control problems on dynamic c-games on networks," *International Journal for Discrete Applied Mathematics*, to appear.

D. Lozovanu and S. Pickl, "Algorithms and the calculation of Nash equilibria for multi-objective control of time - Discrete systems and polynomial - Time algorithms for dynamic c-games on networks," *European Journal for Operations Research*, to appear.

M. Öztürk and A. Tsoukias, "Modelling uncertain positive and negative reasons in decision making," *Decision Support Systems*, submitted.

M. Öztürk and A. Tsoukiàs, "Modelling continuous positive and negative reasons in decision aiding," *Special Issue of Decision Support System Journal*, submitted.

M. Öztürk and A. Tsoukiàs, "Bipolar preference modelling in decision: Billatice approach," *Special Issue of International Journal of Intelligent Systems*, submitted.

M. Öztürk and A. Tsoukiàs, "Modelling continuous positive and negative reasons in decision aiding," DIMACS Technical Report 2005-03, 2005.

F.S. Roberts, "Computer science and decision theory," *Annals of Operations Research*, to appear.

D.G. Saari, "Condorcet domains: A geometric perspective," in *The Mathematics of Preference, Choice, and Order: Essays in Honor of Peter C. Fishburn*, S.J. Brams, W.V. Gehrlein, and F.S. Roberts (eds.), Springer, Heidelberg, Germany, to appear.

D.G. Saari, "Can cycles and other voting peculiarities be statistically dismissed?" in preparation.

Talks

T. Bonates, "Optimization problems in the logical analysis of data," LAMSADE, May 24, 2005.

U. Endriss, "Vote manipulation in the presence of multiple sincere ballots. In *Proceedings of the 11th Conference on Theoretical Aspects of Rationality and Knowledge (TARK-2007)*, June 2007.

B. Escoffier, "Polynomial approximation of NP-hard problems: the differential ratio," DIMACS Theoretical Computer Science seminar, December 13, 2004.

B. Escoffier and P.L. Hammer, "Polynomial approximation of the quadratic set covering problem," extended abstract submitted to LATIN 2006.

B. Escoffier, "Roptimisation de problmes d'optimisation: le cas de l'arbre de Steiner," Confrence scientifique conjointe en Recherche Oprationnelle et Aide la Dcision, Grenoble, France, February 20-23, 2007.

B. Escoffier, M. Milanic, and V. Paschos, "Reoptimizations for the Steiner tree problem," 33rd International Workshop on Graph-Theoretic Concepts in Computer Science, Dornburg, Germany, June 21 - 23, 2007, waiting for acceptance.

M. Kaminski, "3-colorability in the class of claw-free graphs," LAMSADE, May 24, 2005.

M. Kaminski, "An exact algorithm for MAX-CUT in sparse graphs, iET, (an affiliated workshop of ICAPL), Venice, Italy, 2006.

M. Milanic, “Finding independent sets of given weight: hard and easy cases,” Canadian Discrete and Algorithmic Mathematics Conference 2007, Banff, Alberta, Canada, May 28-31, 2007.

M. Milanic, “On the complexity of the exact weighted independent set problem,” 16th International Symposium on Fundamentals of Computation Theory, Budapest, Hungary, August 27-30, 2007, waiting for acceptance.

M. Öztürk, “Comparing intervals for decision aiding,” DIMACS Computation and the Socio-Economic Sciences Special Seminar, November 29, 2004.

M. Öztürk, A. Tsoukias, “Preferences on intervals: A general framework,” IJCAI-05 Multidisciplinary Workshop on Advances in Preference Handling, July 31 - August 1, 2005 Edinburgh, Scotland in conjunction with IJCAI-05.

M. Öztürk, “Positive and negative reasons for interval comparison,” Seminar on the Preference modeling and multiple criteria decision aid, Universite Paris Dauphine, March 15, 2005.

M. Öztürk, “Mathematical and logical structures for interval comparison,” Seminar on Decision Aiding, Universite Libre de Bruxelles, November 10, 2005.

S.W. Pickl, “Design and optimization of emission trading markets and sustainable bargaining systems,” Invited Semi-Plenary Talk, 21st European Conference on Operational Research, Reykjavik, Iceland July 2-5, 2006.
F.S. Roberts, “Social choice and computer science,” Invited Semi-Plenary Talk, 21st European Conference on Operational Research, Reykjavik, Iceland July 2-5, 2006.

J. Uckelman, “Modeling player preferences with weighted formulas,” LCD'07: Workshop on Logics and Collective Decision Making, Erasmus International Institute MSH Nord-Pas-de-Calais, Lille, France, March 13-14, 2007.

Web site

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://l1.lamsade.dauphine.fr/dimacs/index.html

The main web sites for the workshop DIMACS/LAMSADE Workshop on Voting Theory and Preference Modelling

http://dimacs.rutgers.edu/Workshops/DecisionTheory2/
http://l1.lamsade.dauphine.fr/dimacs/

VIII. Contributions within Discipline

Probably the most important contribution of this project is the example it set for international collaborations among the senior and junior researchers of the United States and France in such an interdisciplinary area. The work of this project has led and will continue to lead to many of these collaborations. Here are some of the comments we received abut the international collaborations.

"The LAMSADE/DIMACS initiative established for us a lasting connection between the Social Theory and Decision Aiding Theory cummunities. This is well illustrated in our ongoing collaboration with Michel Regenwetter (University of Illinois at Urbana-Champaign).

"The DIMACS/LAMSADE workshops have provided us numerous opportunities for idea exchange and intellectual stimulation. Their impact is clearly noticeable in our scientific production. The active collaboration with US scientists, as shown in the forthcoming EMPG2007 event, is very fruitful and promising. No doubt that we are most grateful to all supporting institutions like DIMACS, LAMSADE and NSF for offering such opportunities."
Raymond Bisdorff, Applied Mathematics Unit, University of Luxembourg

"I found the DIMACS-LAMSADE workshops extremely useful (I've attended both in 2004 and in 2006). (I have) three papers that have, in one way or another, been influenced by these meetings and by the people I've met there"
Ulle Endriss, Institute for Logic, Language & Computation (ILLC), University of Amsterdam

"A couple of very positive consequences.

1. My research network was significantly expanded. I met, and learned about the research projects of several people from Europe and even the US that I did not know about. These collaborations are bearing fruit; e.g., in strong part because of the Paris conference, there will be another one in the states in May where I am giving a plenary talk. I did not know these people before the conference.

2. I am in the process of writing a paper that was directly inspired by talks given at the Paris conference. Earlier this year, in January, I wrote another paper where the ideas and motivation completely came from a talk given at the conference. So, as of right now, two papers of mine will be directly linked to this meeting, and I expect more to be forthcoming.

Donald G. Saari, Distinguished Professor: Mathematics and Economics, Director: Institute for Mathematical Behavioral Sciences, University of California, Irvine,

IX. Contributions -- other Disciplines

This was an inherently interdisciplinary project. We expect that the connections between computer science, mathematics, statistics, decision theory, economics, psychology, etc. will continue to be brought to light due to the influence of this project. Here are some of the responses to these themes from participants.

"Although our collaboration (Christian Klamler, M. Remzi Sanver and Steven J. Brams) began before the workshop, it was certainly facilitated by the workshop, which stimulated new research that all of us have undertaken. In particular, Jones (who was also at the workshop),Klamler, and I completed a new paper, "Divide-and-Conquer: A Proportional, Minimal-Envy Cake-Cutting Algorithm," and Kilgour, Sanver, and I have continued our discussions of new voting procedures that could be used in a variety of situations. … My colleagues and I have clearly benefited from the LAMSADE/DIMACS partnership."
Steven J. Brams, Dept. of Politics, New York University

"Following our active participation in both Paris LAMSADE/DIMACS workshops, we are hosting this year the forthcoming 38th meeting of the European Mathematical Psychology Group (see http://sma.uni.lu/empg38)."
Raymond Bisdorff, Applied Mathematics Unit, University of Luxembourg

One of the major themes coming out of this project was "algorithmic decision theory." A major new initiative in this area was developed by the participants from Lamsade and DIMACS and submitted to the European Community, which has agreed to support the European side of this activity.

X. Contributions -- Human Resource Development

This project provided support for an interchange of graduate students. This interchange is having a major impact on the research and careers of these students. The interactions that they have with other students in the institutions they visit impact the students of the hosting institution. This is documented in more detail in the section on Project Training/Development. Here are additional examples of the impact of the project. As a result of Meltem Öztürk's visit to DIMACS, Fred Roberts, PI, Rutgers, agreed to be on her thesis committee. Öztürk defended her thesis in December 2005. Peter Hammer, Rutgers, served on Bruno Escoffier's committee. Escoffier defended in November 2005. Escoffier was invited by Hammer for a return visit to Rutgers to continue their collaboration. Alexis Tsoukiàs, Co-PI, LAMSADE, will serve on Tiberius Bonates' committee.

XI. Contributions to Resources for Research and Education

The research that has resulted from this project is being disseminated to faculty across disciplines.

"On the teaching and training side, I will be teaching a 4-hour short course on the subject … at the next annual meeting of the American Political Science Association, Chicago, Aug. 30 - Sept. 2, 2007. I previously taught minicourses at the Joint Mathematics Meetings and MathFest on these topics."

Steven J. Brams, Dept. of Politics, New York University

XII. Contributions Beyond Science and Engineering

Steven J. Brams, Michael A. Jones, and Christian Klamler published the article "Better Ways to Cut a Cake," in the Notices of the AMS in December 2006. After it was published, about 40 popular articles describing their results appeared in magazines and newspapers around the world, including Scientific American (February 2007) and Science News (December 14, 2006). Two video reports were also done; one by the Discovery Channel can still be found on its website.