07431 Abstracts Collection
Computational Issues in Social Choice
— Dagstuhl Seminar —

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Abstract. From the 21st to the 26th of October 2007, the Dagstuhl Seminar 07431 on "Computational Issues in Social Choice" was held at the International Conference and Research Center (IBFI), Schloss Dagstuhl. During the seminar, several participants presented their recent research, and ongoing work and open problems were discussed. The abstracts of the talks given during the seminar are collected in this paper. The first section summarises the seminar topics and goals in general. Links to full papers are provided where available.

Keywords. Computational social choice, voting theory, fair division, mechanism design, coalition formation, complexity theory, preference representation, algorithms

07431 Executive Summary – Computational Issues in Social Choice

Computational social choice is an interdisciplinary field of study at the interface of social choice theory and computer science, with knowledge flowing in either direction. On the one hand, computational social choice is concerned with importing concepts and procedures from social choice theory for solving questions that arise in computer science and AI application domains. This is typically the case for managing societies of autonomous agents, which calls for negotiation and voting procedures. On the other hand, computational social choice is concerned with importing notions and methods from computer science for solving questions originally stemming from social choice, for instance by providing new perspectives on the problem of manipulation and control in elections. This Dagstuhl Seminar has been devoted to the presentation of recent results and an exchange of ideas in this growing research field.

Dagstuhl Seminar Proceedings 07431
Computational Issues in Social Choice
http://drops.dagstuhl.de/opus/volltexte/2007/1273

Joint work of: Endriss, Ulle; Lang, Jérôme; Rossi, Francesca; Sandholm, Tuomas

Extended Abstract: http://drops.dagstuhl.de/opus/volltexte/2007/1274

Selection Games and Deterministic Lotteries

Alon Altman (Stanford University, USA)

The design of deterministic and fair mechanisms for selection among a set of self-motivated agents based solely on these agents' input is a major challenge for electronic commerce. These mechanisms are a special case of zero-sum games where the only possible outcomes are selections of a single agent among the set of agents. We assume the lack of an external coordinator, and therefore we focus on mechanisms which have a solution where the agents play weakly dominant strategies. Our first major result shows that dominated strategies could be added to any selection mechanism, so that the resulting mechanism becomes quasi-symmetric. For fairness, we require the mechanism to be non-imposing; that is, the mechanism should allow any agent to be selected in such a solution. We first show that such mechanisms do not exist when there are two or three agents in the system. However, surprisingly, we show that such mechanisms exist when there are four or more agents. Moreover, in our second major result, we show that there exist selection mechanisms that implement any distribution over the agents, when the agents play mixed dominant strategies.

These results also have significance for distributed computing, ranking systems, and social choice.

Keywords: Mutiagent lottery selection game

Joint work of: Altman, Alon; Tennenholtz, Moshe

Sequential Groves Mechanisms for Public Project Problems

Krzysztof Apt (CWI – Amsterdam, NL)

It is well-known that for several natural decision problems no budget balanced Groves mechanisms exist. This motivated recent research on designing variants of feasible Groves mechanisms (termed as 'redistribution of VCG (Vickrey-Clarke-Groves) payments') that generate reduced deficit.

We first show that for public project problems no feasible Groves mechanism can reduce the deficit inherently present in VCG mechanism.

This brings us to a study of sequential Groves mechanisms. We show that then other dominant strategies than truth-telling may exist and that in the case of public project problems they can be used to reduce deficit by simultaneously minimizing players' payments.

Keywords: Mechanism design, sequential implementation

Joint work of: Apt, Krzysztof; Estévez-Fernández, Arantza

Weighted Voting Games: Design and Link with Reliability Theory

Haris Aziz (University of Warwick, GB)

Weighted voting games are ubiquitous mathematical models which are used in economics, political science, neuroscience, threshold logic, reliability theory and distributed systems. They model situations where agents with variable voting weight vote in favour of or against a decision. A coalition of agents is winning if and only if the sum of weights of the coalition exceeds or equals a specified quota. The Banzhaf index is a measure of voting power of an agent in a weighted voting game. It depends on the number of coalitions in which the agent is the difference in the coalition winning or losing. We examine voting power theory and weighted voting games from a computational point of view. It is pointed out how weighted voting games and simple games provide a link between social choice theory and reliability theory. An efficient algorithm for designing weighted voting games is then presented.

Keywords: Weighted voting games, computational social choice, voting power, Banzhaf index, reliability theory, distributed systems and algorithms

Joint work of: Aziz, Haris; Paterson, Mike; Leech, Dennis

Parameterized Computational Complexity of Dodgson and Young Elections

Nadja Betzler (Universität Jena, D)

We show that, other than for standard complexity theory, the computational (in)tractability of the classic Dodgson and Young election systems behaves very differently from a parameterized complexity point of view. That is, on the one hand, we present an efficient fixed-parameter algorithm for determining a Condorcet winner in Dodgson elections by a minimum number of switches in the votes. On the other hand, we prove that the corresponding problem for Young elections, where one has to delete votes instead of performing switches, is W[2]-complete. In addition, we study Dodgson elections that allow ties between the candidates and give fixed-parameter tractability as well as W[2]-hardness results depending on the cost model for switching ties.

Keywords: Fixed-parameter tractability, W[2]-completeness, voting/election systems

Joint work of: Betzler, Nadja; Guo, Jiong; Niedermeier, Rolf

Efficiency and Envy-Freeness in Fair Division of Indivisible Goods: Logical Representation and Complexity

Sylvain Bouveret (ONERA – Toulouse, F)

We consider the problem of allocating fairly a set of indivisible goods among agents from the point of view of compact representation and computational complexity. We start by assuming that agents have dichotomous preferences expressed by propositional formulae. We express efficiency and envy-freeness in a logical setting, which reveals unexpected connections to nonmonotonic reasoning. Then we identify the complexity of determining whether there exists an efficient and envy-free allocation, for several notions of efficiency, when preferences are represented in a succinct way (as well as restrictions of this problem). We first study the problem under the assumption that preferences are dichotomous, and then in the general case.

Keywords: Fair division, complexity, envy-freeness, compact representation, preferences

Joint work of: Bouveret, Sylvain; Lang, Jérôme

Full Paper:
http://www.ijcai.org/papers/0656.pdf

Bibliography: Bouveret, Sylvain and Lang, Jérôme (2005). Efficiency and envy-freeness in fair division of indivisible good: logical representation and complexity. In *Proceedings of the 19th International Joint Conference on Artificial Intelligence (IJCAI'05).*

The Computational Complexity of Tournament Solutions

Felix Brandt (LMU München, D)

Various problems in the mathematical social sciences can be tackled by finding the "most desirable" elements of a set given some binary relation. Examples can be found in areas as diverse as social choice theory, game theory, and argumentation theory. We review the computational complexity of a number of solution concepts—so-called tournament solutions—ranging from von Neumann-Morgenstern stable sets to the Banks set. Some particularly attractive solution concepts are defined in terms of a *covering* relation—a transitive subrelation of the original relation. We consider three different types of covering (upward, downward, and bidirectional) and the corresponding solution concepts known as the *uncovered set* and the *minimal covering set*. We present the first polynomial-time algorithm for finding the minimal bidirectional covering set (an acknowledged open problem) and prove that deciding whether an alternative is in a minimal upward or downward covering set is NP-hard. Furthermore, we obtain

various set-theoretical inclusions, which reveal a strong connection between von Neumann-Morgenstern stable sets and upward covering on the one hand, and the Banks set and downward covering on the other hand. In particular, we show that every stable set is also a minimal upward covering set.

Keywords: Social choice theory, minimal covering set, dominance graphs, Condorcet

Joint work of: Brandt, Felix; Fischer, Felix

Bibliography: F. Brandt and F. Fischer. Computational aspects of covering in dominance graphs. In R.C. Holte and A. Howe (eds.), *Proc. 22nd Conference on Artificial Intelligence (AAAI'07)*, pp. 694–699. AAAI Press, 2007.

False-Name-Proofness in Social Choice, and Limited Verification of Identities

Vincent Conitzer (Duke University, USA)

A mechanism is false-name-proof if no agent can benefit from using multiple identifiers (*e.g.*, e-mail addresses). We show that the best false-name-proof voting rule satisfying participation is to draw two alternatives at random; if all votes prefer the same one, choose that one, otherwise flip a coin. To address this and other impossibility results, we show how to verify the identities of some agents so that the mechanism and the verification protocol together are false-name-proof.

Keywords: Voting, social choice, false-name-proofness, identity verification

The Use of Ultrafilters in Judgment Aggregation

Daniel Eckert (Universität Graz, A)

Although ultrafilters have long been used in the proof of Arrow's theorem, this proof technique has not been widely exploited in the recent literature on judgment aggregation. This is all the more astonishing as the formulation of the properties of judgment aggregation rules in terms of the collections of decisive sets of individuals almost directly translates into properties of collections which are known as simple games and which have been shown to be closely related to ultrafilters. We prove an important impossibility theorem of Nehring and Puppe by showing that any collection of decisive sets of individuals for a monotonic and independent judgment aggregation rule which satisfies universal domain, surjectivity and collective rationality for a strongly connected ("totally blocked") agenda of propositions is an ultrafilter, which, in the case of a finite number of individuals, is well known to be equivalent to a dictatorship.

Keywords: Judgment aggregation, ultrafilters, simple games

Computational Complexity of Weighted Voting Games

Edith Elkind (University of Southampton, GB)

Weighted voting games are coalitional games in which each player has a weight (intuitively corresponding to its voting power), and a coalition is successful if the sum of its weights exceeds a given threshold. Key questions in coalitional games include finding coalitions that are stable (in the sense that no member of the coalition has any rational incentive to leave it), and finding a division of payoffs to coalition members (an imputation) that is fair.

We investigate the computational complexity of such questions for weighted voting games. We study the *core*, the *least core*, and the *nucleolus*, distinguishing those problems that are polynomial-time computable from those that are NP-hard, and providing pseudopolynomial and approximation algorithms for the NP-hard problems.

Keywords: Weighted voting, core, least core, nucleolus

Joint work of: Elkind, Edith; Goldberg, Leslie Ann; Goldberg, Paul; Wooldridge, Michael

Full Paper:
http://www.csc.liv.ac.uk/∼mjw/pubs/aaai2007a.pdf

Bibliography: E. Elkind, L.A. Goldberg, P. Goldberg, and M. Wooldridge. Computational Complexity of Weighted Threshold Games. In *Twenty-Second Conference on Artificial Intelligence (AAAI-07), Vancouver, Canada, July 2007.*

Manipulation in Approval Voting

Ulle Endriss (University of Amsterdam, NL)

In approval voting each voter can approve of as many candidates as they wish. 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. We show that there are several interesting scenarios in approval voting in which no voter has an incentive to vote by means of an insincere ballot. This is possible (and does not contradict the Gibbard-Satterthwaite Theorem) because in approval voting there are multiple ways of voting sincerely for any given preference ordering. For instance, one of our results states that, if ties are broken using a uniform probability distribution and if voters are expected-utility maximisers, then they never have an incentive to manipulate the election by voting insincerely. The approach taken is, at least partly, computational in the sense that some of the results have been derived with the help of a computer. An early version of this paper has appeared in the proceedings of TARK-2007.

Keywords: Voting, manipulation

Full Paper:
http://www.illc.uva.nl/∼ulle/pubs/files/EndrissTARK2007.pdf

Bibliography: U. Endriss. Vote Manipulation in the Presence of Multiple Sincere Ballots. In D. Samet (ed.), *Proceedings of the 11th Conference on Theoretical Aspects of Rationality and Knowledge (TARK-2007)*, pp. 125–134, Presses Universitaires de Louvain, June 2007.

Distributed Algorithms for Social Choice

Boi Faltings (EPFL, CH)

We consider social choice problems consisting of interrelated sets of variables controlled by different agents.

Distributed algorithms are desirable for three reasons. First, agents can set their variables to reasonable values even if optimization is incomplete, thus improving the reliability of the process. Second, agents do not need to formalize their preferences for variables they control, thus avoiding potentially huge efforts of preference elicitation. Third, agents can maintain privacy of many aspects of their preferences.

I describe distributed optimization algorithms and how they can be extended to satisfy incentive compatibility and privacy requirements in social choice.

Keywords: Constraint optimization, constraint satisfaction

Dominance in Social Choice and Coalitional Game Theory

Paul Harrenstein (LMU München, D)

We consider dominance relations for social choice as based on the pairwise majority rule on the one hand and cooperative games with non-transferable utility (coalitional NTU games) on the other. As these dominance relations may fail to be transitive and even contain cycles, the notion of maximality becomes untenable as an analytical tool. Both in social choice theory and cooperative game theory, a number of concepts have been proposed to take over the role of maximality in the absence of transitivity. In 1953 McGarvey showed that any irreflexive and anti-symmetric relation can be obtained by the majority rule. In this paper, we address the analogous issue for finite NTU games. We find *any* irreflexive relation over a finite set can be obtained as the dominance relation of some ordinary, monotonic, and simple NTU coalitional game. We also show that any dominance relation can be induced by a *non-cooperative* game via beta-effectivity. Furthermore, we obtain a partial result for the case in which alpha-effectivity is used and consider the formal interrelationships between Smith sets, Schwartz sets, stable sets and the core in finite NTU games.

Keywords: Dominance solutions, coalitional game theory, NTU, social choice

Joint work of: Harrenstein, Paul; Brandt, Felix

Llull and Copeland Voting Broadly Resist Bribery and Control

Edith Hemaspaandra (Rochester Institute of Technology, USA)

Control of elections refers to attempts by an agent to, via such actions as addition/deletion/partition of candidates or voters, ensure that a given candidate wins. An election system in which such an agent's computational task is NP-hard is said to be resistant to the given type of control. Among election systems with polynomial-time winner determination problems, the only election systems known to be resistant to all the standard control types are highly artificial election systems created by hybridization. We prove that an election system developed by the 13th century mystic Ramon Llull, the well-studied Copeland election system, and generalizations of Copeland's system are all resistant to the standard types of (constructive) electoral control. This is the most comprehensive resistance to control yet achieved by any natural election system. In addition, we show that Llull, Copeland, and the Copeland generalizations are broadly resistant to bribery and manipulation attacks, and we integrate the potential irrationality of voter preferences into many of our results.

Keywords: Computational social choice, bribery, Copeland elections, control, voting, manipulation

Joint work of: Faliszewski, Piotr; Hemaspaandra, Edith; Hemaspaandra, Lane; Rothe, Jörg; Schnoor, Henning

Full Paper:
http://www.cs.rochester.edu/trs/theory-trs.html

Bibliography: P. Faliszewski, E. Hemaspaandra, L. Hemaspaandra, and J. Rothe. Llull and Copeland voting broadly resist bribery and control. *Proceedings of the 22nd AAAI Conference on Artificial Intelligence (AAAI 2007)*, AAAI Press, pp. 724–730, July 2007.

P. Faliszewski, E. Hemaspaandra, L. Hemaspaandra, and J. Rothe. Copeland voting fully resists constructive control. URCS TR 923, October 2007.

P. Faliszewski, E. Hemaspaandra, and H. Schnoor. Copeland voting: Ties matter. URCS TR 926, November 2007.

Sequential Voting in Multi-Issue Domains

Jérôme Lang (IRIT – Toulouse, F)

In many real-world group decision making problems, the set of alternatives is a Cartesian product of finite value domains for each of a given set of variables (or issues). Dealing with such domains leads to the following well-known dilemma: either ask the voters to vote separately on each issue, which may lead to so-called multiple election paradoxes as soon as voters' preferences are not separable; or allow voters to express their full preferences on the set of all combinations of values, which is practically impossible as soon as the number of issues and/or the size of the domains are more than a few units. We try to reconciliate both views and find a middle way, by relaxing the extremely demanding separability restriction into this much more reasonable one: there exists a linear order $\mathbf{x}_1 > \ldots > \mathbf{x}_p$ on the set of issues such that for each voter, every issue $\mathbf{x}_i$ is preferentially independent of $\mathbf{x}_{i+1}, \ldots, \mathbf{x}_p$ given $\mathbf{x}_1, \ldots, \mathbf{x}_{i-1}$. This leads us to define a family of sequential voting rules, defined as the sequential composition of local voting rules. These rules relate to the setting of conditional preference networks (CP-nets) recently developed in the Artificial Intelligence literature. Lastly, we study in detail how these sequential rules inherit, or do not inherit, the properties of their local components.

Keywords: Voting, combinatorial domains, multiple elections, preferential independence, CP-nets

Joint work of: Lang, Jérôme; Xia, Lirong

Representing Interval Orders by Weighted Bases: Some Complexity Results

Pierre Marquis (Université d'Artois – Lens, F)

This work is centered on the notion of interval order as a model for preferences. We introduce a family of representation languages for such orders, parameterized by a scale and an aggregation function. We show how interval orders can be represented by elements of those languages, called weighted bases. We identify the complexity of the main decision problems to be considered for exploiting such representations of interval orders (including the comparison problems and the non-dominance problem). We also show that the representation of interval orders based on weighted bases encompasses the penalty-based representation of complete preorders as a specific case.

Keywords: Compact representation of preferences, Preferences over combinatorial domains, Computational complexity

Joint work of: Marquis, Pierre; Öztürk, Meltem

Topological Issues in Multiagent Resource Allocation Problems

Nicolas Maudet (Université Paris-Dauphine, F)

Resource allocation is a typical social choice problem which consists in allocating (optimally) a set of resources to a number of agents. We present recent results and discuss issues pertaining to the topological structure of negotiation/communication graphs, when allocations are iteratively and locally negotiated by autonomous agents, in a truly distributed manner.

Joint work of: Chevaleyre, Yann; Endriss, Ulle; Maudet, Nicolas

Full Paper:
http://www.lamsade.dauphine.fr/~maudet/pubs/ChevaleyreEndrissMaudetAAAI2007.pdf

Bibliography: Yann Chevaleyre, Ulle Endriss, and Nicolas Maudet. Allocating Goods on a Graph to Eliminate Envy. In *Proceedings of the 22nd AAAI Conference on Artificial Intelligence (AAAI-2007)*, pp. 700–705, AAAI Press, July 2007.

Determining Winners in Weighted and Unweighted Sequential Majority Voting

Maria Silvia Pini (Università di Padova, I)

In weighted sequential majority voting, preferences are aggregated by a sequence of pairwise comparisons (also called an agenda) between candidates. The result of each comparison is determined by a weighted majority vote among the agents. In this paper we consider the situation where the agents may not have revealed all their preferences. This is common in many real-life settings, due to privacy issues or an ongoing elicitation process. We study the computational complexity of determining the winner(s), given that some preferences may not be revealed and/or the agenda is not decided. We show that it is easy to determine if a candidate wins whatever the agenda. On the other hand, it is hard to know whether a candidate wins in at least one agenda for at least one completion of the agents' preferences. This is also true if the agenda can be represented by a balanced tree. The computational complexity of determining if the candidates win in at least one (balanced) agenda, for every completion of the agents' preferences remains an open question. We also consider the case of fixed agendas, and we show that in this case it is easy to determine if a candidate wins in the fixed agenda for at least a completion, or for every completion of the agents' preferences.

Keywords: Sequential majority voting, multiagent systems, uncertainty

Joint work of: Pini, Maria Silvia; Rossi, Francesca; Venable, Kristen Brent; Walsh, Toby

Algorithms for the Coalitional Manipulation Problem

Ariel D. Procaccia (The Hebrew University of Jerusalem, IL)

We investigate the problem of coalitional manipulation in elections, which is known to be hard in a variety of voting rules. We put forward efficient algorithms for the problem in Scoring rules, Maximin and Plurality with runoff, and analyze their windows of error. Specifically, given an instance on which an algorithm fails, we bound the additional power the manipulators need in order to succeed. We finally discuss the implications of our results with respect to the popular approach of employing computational hardness to preclude manipulation.

Keywords: Voting, Coalitional manipulation, Complexity

Joint work of: Zuckerman, Michael; Procaccia, Ariel D.; Rosenschein, Jeffrey S.

Full Paper:
http://www.cs.huji.ac.il/~arielpro/papers/acmp.soda.pdf

Bibliography: Ofer Dekel, Felix A. Fischer, and Ariel D. Procaccia. Incentive Compatible Regression Learning. Proceedings of the Nineteenth ACM-SIAM Symposium on Discrete Algorithms (SODA-08), San Francisco, California, January 2008 (to appear).

Using Graphical Utility Models for Multi-Issue Bargaining and Preference Elicitation

Valentin Robu (CWI – Amsterdam, NL)

The first part of the talk will cover our work on using utility graphs for modeling bilateral negotiations between agents with k-additive utility functions. Multi-issue negotiation with non-linear utilities represents a considerably more challenging problem than the widely studied case of linearly additive utilities, since potentially complex complementarity/subtitutability dependencies between issues must be taken into account. We show, through algorithmic analysis and experimental evaluation, that our proposed graphical utility formalism enables agents to reach agreements that are close to Pareto-efficiency, with a limited number of negotiation steps.

We apply the proposed negotiation model to the e-commerce domain, in which agents bargain about the contents of bundles of items, where the utility functions of the buyers can be represented in k-additive form. In this setting, we complement our negotiation algorithm with a method to approximate the initial, starting structure of buyer utility graph, based on anonymous negotiation data. The construction of the maximal graph structure is based on techniques inspired from item-based collaborative filtering, used in online recommendation

algorithms. We show that this combined method enables electronic agents to achieve fast agreements in complex negotiations, by focusing the search on the most promising region of the high-dimensional utility space. (joint work with Koye Somefun, Han La Poutré)

The second part of the talk briefly covers the use of collaborative filtering techniques (initially developed by us in the above context of multi-issue negotiation) to construct tag correlation graphs using empirical data, in a collaborative tagging application (joint work with Harry Halpin, Edinburgh and Hana Shepherd, Princeton). Finally, we will discuss, very briefly, some ideas for ongoing work regarding the application of graphical utility models to preference elicitation in k-additive domains.

Keywords: Negotiation, bargaining, multi-issue negotiation, k-additive utilities, utility graphs, collaborative filtering, multi-agent systems, intelligent agents

Bibliography: V. Robu, D.J.A. Somefun, and J.A. La Poutré. Modeling complex multi-issue negotiations using utility graphs. In *Proc. of the 4th Int. Conf. on Autonomous Agents & Multi Agent Systems (AAMAS'05), Utrecht*, ACM Press, 2005.

V. Robu and J.A. La Poutré. Retrieving the structure of utility graphs used in multi-item negotiation through collaborative filtering of aggregate buyer preferences. In *2nd Int. Workshop on Rational, Robust and Secure Negotiations in Multi-Agent Systems. (RRS'06), Hakodate, Japan.* Studies in Computational Intelligence. Springer-Verlag, to appear, 2008.

H. Halpin, V. Robu, H. Shepherd. The Complex Dynamics of Collaborative Tagging. *Proceedings of the 16th Int. World Wide Web Conference (WWW'07), Banff, Canada*, ACM Press, 2007.

Approximating Optimal Weighted Lobbying

Jörg Rothe (Universität Düsseldorf, D)

We discuss issues regarding benign algorithms, frequency of hardness, and approximation of a voting-related problem.

Keywords: Optimal weighted lobbying; approximation; greedy algorithm

Joint work of: Erdélyi, Gábor; Hemaspaandra, Lane; Rothe, Jörg; Spakowski, Holger

Full Paper:
http://www.springerlink.com/content/k17158742477j513/

Bibliography: Gábor Erdélyi, Lane A. Hemaspaandra, Jörg Rothe, Holger Spakowski: On Approximating Optimal Weighted Lobbying, and Frequency of Correctness Versus Average-Case Polynomial Time. *FCT 2007*, pp. 300–311.

Clearing Algorithms for Barter Exchange Markets: Enabling Nationwide Kidney Exchanges

Tuomas Sandholm (CMU – Pittsburgh, USA)

In barter-exchange markets, agents seek to swap their items with one another, in order to improve their own utilities. These swaps consist of cycles of agents, with each agent receiving the item of the next agent in the cycle. We focus mainly on the upcoming national kidney-exchange market, where patients with kidney disease can obtain compatible donors by swapping their own willing but incompatible donors. With over 70,000 patients already waiting for a cadaver kidney in the US, this market is seen as the only ethical way to significantly reduce the 4,000 deaths per year attributed to kidney disease.

The clearing problem involves finding a social welfare maximizing exchange when the maximum length of a cycle is fixed. Long cycles are forbidden, since, for incentive reasons, all transplants in a cycle must be performed simultaneously. Also, in barter-exchanges generally, more agents are affected if one drops out of a longer cycle. We prove that the clearing problem with this cycle-length constraint is NP-hard. Solving it exactly is one of the main challenges in establishing a national kidney exchange.

We present the first algorithm capable of clearing these markets on a nationwide scale. The key is incremental problem formulation. We adapt two paradigms for the task: constraint generation and column generation. For each, we develop techniques that dramatically improve both runtime and memory usage. We conclude that column generation scales drastically better than constraint generation. Our algorithm also supports several generalizations, as demanded by real-world kidney exchanges.

Our algorithm replaced CPLEX as the clearing algorithm of the Alliance for Paired Donation, one of the leading kidney exchanges. The match runs are conducted every two weeks and transplants based on our optimizations have already been conducted.

Keywords: Matching market, exchange, clearing algorithm, winner determination, computational complexity

Joint work of: Abraham, David; Blum, Avrim; Sandholm, Tuomas

Full Paper:
http://www.cs.cmu.edu/∼sandholm/kidneyExchange.EC07.withGrantInfo.pdf

Bibliography: David J. Abraham, Avrim Blum, Tuomas Sandholm. Clearing algorithms for barter exchange markets: enabling nationwide kidney exchanges. In J. MacKie-Mason, D. Parkes, and P. Resnick (eds.), *Proceedings of the 8th ACM Conference on Electronic Commerce (EC-2007), San Diego, California, USA, June 11–15, 2007.*

Proportional Representation and Strategic Voters

Arkadii Slinko (University of Auckland, NZ)

The goal of this paper is to examine the incentives to vote insincerely, other than those created by rounding, faced by voters in the systems of proportional representation (PR). We rigorously investigate two models of voter behaviour. The first model assumes that a voter is primarily interested in the distribution of seats in the post-election parliament (seat maximiser) while the second considers a voter who is concerned with the distribution of power in it (power maximiser).

We show that under pure PR seat maximisers do not have any incentives to manipulate, which justifies the Bowler and Lanoue (1992) claim, and that such incentives for seat maximisers appear with the introduction of a threshold.

We show that, even in the absence of a threshold, there will always exist circumstances where a power maximiser would have an incentive to vote insincerely. We demonstrate that her incentives to make an insincere vote depend on her attitude toward uncertainty. The introduction of a threshold creates new and stronger opportunities for strategic voters regardless their attitude towards uncertainty. Finally we discuss the overshooting/undershooting phenomenon, when either too many or too few like-minded voters attempt to manipulate.

We use two models to explain voters' behaviour at the most recent (2005) New Zealand general election and demonstrate that rounding creates not only incentives but also disincentives for strategic voting.

Keywords: Parliament choosing rule, proportional representation, power index, strategic voting, manipulability, overshooting, undershooting

Joint work of: Slinko, Arkadii; White, Shaun

Full Paper:
http://www.cireq.umontreal.ca/publications/12-2006-cah.pdf

On the Link between Social Choice and Multiple Criteria Decision Analysis

Alexis Tsoukiàs (Université Paris-Dauphine, F)

In this talk I survey the several relations between Social Choice Theory and Multiple Criteria Decision Analysis. I first show the conceptual similarities between the two theories and how these have been developed in the past 30 years as an alternative to the mainstream multi-attribute value theory. I will also explore the critical differences between Social Choice and MCDA with particular emphasis to concepts such as weights, trade-offs, importance of coalitions and measures. The talk will also survey more recent results in the literature where the differences between preference aggregation procedures are revisited under conjoint measurement theory (work done by D. Bouyssou and M. Pirlot). Current research directions will conclude the presentation.

Keywords: Multiple Criteria Decision Analysis, Social Choice Theory

Full Paper:
http://www.springer.com/sgw/cda/frontpage/0,11855,7-40109-22-116132747-0,00.html

Bibliography: D. Bouyssou, Th. Marchant, M. Pirlot, A. Tsoukiàs, Ph. Vincke. *Evaluation and Decision Models: Stepping Stones for the Analyst*. Springer Verlag, Berlin, 2006.

A Family of Logic-Based Preference Representation Languages and an Application to Combinatorial Auctions

Joel Uckelman (University of Amsterdam, NL)

Logic-based preference representation langauges can be useful when agent preferences are over combinatorial domains—for example, possible committees in committee elections, or bundles of goods in combinatorial auctions—situations in which it can be challenging simply to convey agent preferences due to the large number of possible outcomes.

Logic-based languages have a number of appealing properties, among them that

1. natural syntactic constraints (*i.e.*, on the kinds of propositional formulas agents are allowed to use) are closely related to properties of utility functions, and so these languages can be tailored to express particular classes of utility functions, and
2. the structure of these languages is useful in answering queries about agent preferences.

In a paper presented at AiPref-2007, Ulle Endriss and I explore the expressive power, succinctness of representation, and complexity of finding maximal states for several logic-based languages. Recent work has involved comparing branch-and-bound heuristics for the Winner Determination Problem for combinatorial auctions where bidders use a logic-based language for bidding. Our heurisitcs attempt to exploit the structure of the language when solving the WDP.

Joint work of: Endriss, Ulle; Uckelman, Joel

Bibliography: J. Uckelman and U. Endriss. Preference Representation with Weighted Goals: Expressivity, Succinctness, Complexity. *Proc. AAAI Workshop on Preference Handling for Artificial Intelligence (AiPref-2007).*

Notions of Optimality in CP-nets, Strategic Games and Soft Constraints

Brent Venable (Università di Padova, I)

The notion of optimality naturally arises in many areas of applied mathematics and computer science concerned with decision making. Here we consider this notion in the context of three formalisms used for different purposes in reasoning about multi-agent systems: strategic games, CP-nets, and soft constraints. To relate the notions of optimality in these formalisms we introduce a natural qualitative modification of the notion of a strategic game.

We show then that the optimal outcomes of a CP-net are exactly the Nash equilibria of an appropriately defined strategic game. This allows us to use the techniques of game theory to search for optimal outcomes of CP-nets and vice-versa, to use techniques developed for CP-nets to search for Nash equilibria of the considered games. Then, we relate the notion of optimality used in the area of soft constraints to that used in strategic games, showing that, for a class of soft constraints that includes weighted constraints, every optimal solution is a Nash equilibrium. However, the notion that coincides in general with optimality for soft constraints is that of Pareto efficient joint strategy.

Keywords: Strategic games, pure Nash equilibria, preferences, CP-nets, soft constraints

Joint work of: Apt, Krzysztof R.; Rossi, Francesca; Venable, Brent

Some Complexity Issues in Preference Elicitation and Strategic Manipulation

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Complexity theory is a useful tool to study computational issues surrounding the elicitation of preferences, as well as the strategic manipulation of elections aggregating together preferences of multiple agents. We study here the complexity of determining when we can terminate eliciting preferences, and prove that the complexity depends on the elicitation strategy. We show, for instance, that it may be better from a computational perspective to elicit all preferences from one agent at a time than to elicit individual preferences from multiple agents. We also study the connection between the strategic manipulation of an election and preference elicitation. We show that what we can manipulate affects the computational complexity of manipulation. In particular, we prove that there are voting rules which are easy to manipulate if we can change all of an agent's vote, but computationally intractable if we can change only some of their preferences. This suggests that, as with preference elicitation, a fine-grained view of manipulation may be informative. Finally, we study the connection between predicting the winner of an election and preference elicitation.

Based on this connection, we identify a voting rule where it is computationally difficult to decide the probability of a candidate winning given a probability distribution over the votes.

Keywords: Preference elicitation, manipulation, computational complexity

Voting with Partial Orders

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Voters are not always able to to give a complete linear order of the alternatives, either because they are unable to compare certain alternatives, or because the set of alternatives is too large. Hence, we study the case where voters submit partial orders (possibly represented as a CP-net). We show several impossibility results regarding neutrality and Pareto efficiency for such voting rules/correspondences, and study the complexity of determining whether an alternative will win for some/any completion of the partial orders, given a standard voting rule.

Keywords: Seat-by-seat voting rule, decomposable voting rule, neutrality, Pareto efficiency, possible winner, necessary winner

Joint work of: Xia, Lirong; Conitzer, Vincent; Lang, Jérôme; Ying, Mingsheng

Voting with the Mean and with the (Spatial) Median: Decisiveness and Manipulability

William S. Zwicker (Union College – Schenectady, USA)

What do the following voting systems have in common?

- Approval voting
- Borda count
- Kemeny rule
- Typical grading systems that assign a letter grade for a course based on the average of several test scores.

Each is a mean proximity rule; each has a representation in which inputs (votes) are identified with points in Euclidean space, and the results of the election are determined by the "output point" closest (in the Euclidean metric) to the mean location q of the votes.

We show that the mean proximity rules coincide with the mean polygonal rules, and with a (highly) generalized class of scoring rules.

The mean affine rules represent a further generalization. We show that the rational mean affine rules are exactly the voting rules that are consistent and connected.

This is a sort of generalization of Smith's and Young's results characterizing scoring rules, but in a broader context, with no use of a neutrality axiom.

What happens when we substitute for the mean q, in these representations, the mediancentre (Fermat-Weber point) mc, a multidimensional version of the median? We obtain a new and rather strange class of voting rules with some interesting and different properties. For example, the "McBorda rule" is more resistant to manipulation than the Borda rule, and much more decisive (fewer ties).

The mediancentre presents us with some computational challenges, particularly when it is located on or near a segment boundary (the election is tied, or close to tied). I could use some advice on these algorithmic questions, especially in the case of median rules for many voters, or for more than three alternatives.

Keywords: Mean rule, generalized scoring rule, mean affine rule, Fermat-Weber point, mediancentre, decisiveness, manipulability

Social Software for Coalition Formation

Harrie de Swart (Tilburg University, NL)

This paper concerns an interdisciplinary approach to coalition formation. We apply the MacBeth software, relational algebra, the RelVieW tool, graph theory, bargaining theory, social choice theory, and consensus reaching to a model of coalition formation. A feasible government is a pair consisting of a coalition of parties and a policy supported by this coalition. A feasible government is stable if it is not dominated by any other feasible government. Each party evaluates each government with respect to certain criteria.

MacBeth helps to quantify the importance of the criteria and the attractiveness and repulsiveness of governments to parties with respect to the given criteria. Feasibility, dominance, and stability are formulated in relation-algebraic terms. The RelVieW tool is used to compute the dominance relation and the set of all stable governments. In case there is no stable government, *i.e.*, in case the dominance relation is cyclic, we apply graph-theoretical techniques for breaking the cycles. If the solution is not unique, we select the final government by applying bargaining or appropriate social choice rules. We describe how a coalition may form a government by reaching consensus about a policy.

Keywords: Coalition formation, stable government, MacBeth, relational algebra, RelVieW, graph theory

Joint work of: Rusinowska, Agnieszka; Berghammer, Rudolf; Eklund, Patrik; van der Rijt, Jan-Willem; Roubens, Marc; de Swart, Harrie

Full Paper:
http://www.springerlink.com/content/t6171205q434n006/

Bibliography: Harrie de Swart *et al.* Social Software for Coalition Formation. In de Swart *et al.*, *Theory and Applications of Relational Structures as Knowledge Instruments II.* Springer, LNAI 4342, pp. 1–30.

Reasoning about Coalitional Games

Wiebe van der Hoek (University of Liverpool, GB)

The area of Logic and Games roughly has two directions: Games for Logic, in which one for instance tries to give a game-theoretically inspired truth definition, or a notion of similarity of models, and Logic for Games, where one takes a representational, computational and proof-theoretic view on games. The talk will be an example of the latter branch. Until now, this branch is typically exploited by Modal Logicians, modeling phenomena in non-cooperative games. In this talk, we make a first step in formalising reasonnig in coalitional, or cooperative games. We present two logics that facilitate reasoning about such games: the first is expressively complete, whereas the second can deal with infinitely many outcomes of a coalitional game.

Keywords: Coalitional Games

Joint work of: Ågotnes, Thomas; van der Hoek, Wiebe; Wooldridge, Michael

Full Paper:
http://portal.acm.org/citation.cfm?id=1160659

Bibliography: Thomas Ågotnes, Wiebe van der Hoek, and Michael Wooldridge, On the Logic of Coalitional Games, In P. Stone and G. Weiss (eds.), *Proceedings of the Fifth International Joint Conference on Autonomous Agents and Multiagent Systems*, ACM Press, pp. 153–160, 2006.