05011 Abstracts Collection
Computing and Markets
— Dagstuhl Seminar —

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Abstract. From 03.01.05 to 07.01.05, the Dagstuhl Seminar 05011 "Computing and Markets" was held in the International Conference and Research Center (IBFI), Schloss Dagstuhl. During the seminar, several participants presented their current research, and ongoing work and open problems were discussed. Abstracts of the presentations given during the seminar as well as abstracts of seminar results and ideas are put together in this paper. The first section describes the seminar topics and goals in general. Links to extended abstracts or full papers are provided, if available.

Keywords. Algorithms, complexity, game theory, social choice, auctions, equilibrium

05011 Executive Summary – Computing and Markets

The seminar Computing and Markets facilitated a very fruitful interaction between economists and computer scientists, which intensified the understanding of the other disciplines' tool sets. The seminar helped to pave the way to a unified theory of markets that takes into account both the economic and the computational issues—and their deep interaction.

Keywords: Algorithms, complexity, game theory, social choice, auctions, equilibrium

Joint work of: Lehmann, Daniel; Müller, Rudolf; Sandholm, Tuomas

Full Paper: http://drops.dagstuhl.de/opus/volltexte/2005/224

The PageRank Axioms

Alon Altman (Technion - Haifa, IL)

This talk introduces the first graph-theoretic, ordinal representation theorem for the PageRank algorithm, bridging the gap between page ranking algorithms and the formal theory of social choice.

Keywords: Pagerank, social choice, ranking system

Full Paper: http://drops.dagstuhl.de/opus/volltexte/2005/197

The Value of Correlation in Strategic Form Games

Itai Ashlagi (Technion - Haifa, IL)

Every game in strategic form can be extended by adding a correlation device.

Any Equilibrium in such an extended game is called a correlated equilibrium (Aumann 1974).

Aumann showed that there exist games, where the agents' surplus in a correlated equilibrium is greater than their surplus in every equilibrium.

This suggests the study of two major measures for the value of correlation: 1. The ratio between the maximal surplus obtained in an correlated equilibrium to the maximal surplus obtained in equilibrium.

We refer to this ratio as the mediation value. 2. The ratio between the optimal surplus to the maximal surplus obtained in correlated equilibrium.

We refer to this ratio as the enforcement value.

In this work we initiate the study of the mediation value and of the enforcement value, providing several general results on the value of correlation as captured by these concepts.

We also present a set of results for the more specialized case of congestion games, a class of games that received a lot attention in the recent computer science and e-commerce communities.

Indeed, while much work in computer science has been devoted to the study of the ratio between the surplus in optimal strategies to the surplus in the worst Nash equilibrium (the so called "price of anarchy") for congestion games, our work presents and initiates the study of two other complementary measures.

Keywords: Correlation, mediation, enforcement, equilibrium, mediator

Full Paper: http://drops.dagstuhl.de/opus/volltexte/2005/231

Joint work of: Ashlagi, Itai; Monderer, Dov; Tenneholtz, Moshe

Single-Parameter Domains and Implementation in Undominated Strategies

Moshe Babaioff (The Hebrew University of Jerusalem, IL)

This paper studies Algorithmic Mechanism Design where the bidders are "single-parameter" (have the same private value for all desired outcomes), with a focus on Combinatorial Auctions (CA).

We study four variants of the CA model: where each player desires a single bundle ("single-minded") or he desires several bundles ("multi-minded"), and where the desired bundles are public information "known") or private information ("unknown").

We provide several mechanisms and examples in these settings.

Our first main result is a general technique to convert any *algorithm* to a truthful ascending *mechanism* for "known"domains (not only for CA).

For the "known" single-minded CA domain, it almost preserves the approximation ratio of the original algorithm.

Our second main result provides the first computationally efficient mechanism for the case of "unknown" single-parameter multi-minded bidders, with close to optimal welfare approximation.

This mechanism also works in general, non single-parameter, combinatorial auctions, with some additional approximation loss.

This mechanism is a *computationally feasible implementation in undominated strategies*, a notion that we define and justify, and which we believe is of independent interest.

Keywords: Mechanism Design; Combinatorial Auctions; Welfare Approximation; Implementation in Undominated Strategies

Joint work of: Babaioff, Moshe; Ron Lavi; Elan Pavlov

Substitutes valuations are M#-concave

Alejandro Bertelsen (The Hebrew University of Jerusalem, IL)

The (gross-) substitutes property plays a central role in the study of exchange economies of indivisible goods and matching between a set of agents and a set of goods. Kelso and Crawford (1982) introduced this property and showed that if all agents' valuations are substitutes, there exists a Walrasian equilibrium.

Fujishige and Yang (2003) characterized substitutes valuations as M-natural-concave functions: a characterization of substitutes valuations that does not involve prices and is convenient for algorithmic purposes. Their proof is based on the work of Murota and al. on convex discrete analysis. We present a stronger characterization of substitutes valuations whose proof is elementary. Apart from the novelty of the proof, a strengthening of the concavity condition is obtained,

enabling us to present a new algorithm for the maximization of M#-concave functions. Our algorithm, given a substitutes valuation and a price vector, finds a preferred set using only with k*n evaluations of the valuation function, where k is the minimal size of a preferred set and n the number of items. This algorithm can be used, for example, to implement efficiently the demand-set oracle in terms of the value oracle.

Keywords: Gross-substitutes, M-concave, demand oracle

On the Computational Power of Iterative Auctions: Ascending Auctions

Liad Blumrosen (The Hebrew University of Jerusalem, IL)

We embark on a systematic analysis of the power and limitations of iterative ascending-price combinatorial auctions. We prove a large number of results showing the boundaries of what can be achieved by different types of ascending auctions: item prices vs. bundle prices, anonymous prices vs. personalized prices, deterministic vs. non-deterministic, ascending vs. descending, preference elicitation vs. full elicitation, adaptive vs. non-adaptive, and single trajectory vs. multi trajectory.

Two of our main results show that neither ascending item-price auctions nor ascending anonymous bundle-price auctions can determine the optimal allocation among general valuations. This justifies the use of personalized bundle prices in iterative combinatorial auctions like the FCC spectrum auctions.

Keywords: Combinatorial auctions, iterative auctions, ascending auctions, communication

Joint work of: Blumrosen, Liad; Nisan, Noam

Near-Optimal Online Auctions

Avrim Blum (CMU - Pittsburgh, USA)

We consider the online auction problem proposed by Bar-Yossef, Hildrum, and Wu 2002 in which an auctioneer is selling identical items to bidders arriving one at a time. We give an auction that achieves a constant factor of the profit of the optimal fixed-price auction, minus an $O(h)$ additive loss term, where h is the value of the highest bid.

Furthermore, this auction does not require foreknowledge of the range of bidders' valuations. On both counts, this answers open questions from BHW-02 and BKRW-03. We achieve our results by adapting an algorithm of Kalai for the problem of "online learning from expert advice", that is especially well-suited to

the auction setting. We further improve on the results from BKRW-03 for the online posted-price problem (the seller proposes a price and only sees whether the buyer purchased or not, but does not get to see his bid value). Finally, we give a number of extensions: to competing against the optimal auction that may change prices a "few" times, and to attribute-auctions for 1-dimensional attributes.

Joint work of: Blum, Avrim; Hartline, Jason

Spiteful Bidding in Sealed-Bid Auctions

Felix Brandt (Stanford University, USA)

We study the bidding behavior of spiteful agents who, contrary to the common assumption of self-interest, maximize the weighted difference of their own profit and their competitors' profit. This assumption is motivated by inherent spitefulness, or, for example, by competitive scenarios such as in closed markets where the loss of a competitor will likely result in future gains for oneself. We derive symmetric Bayes Nash equilibria for spiteful agents in first-price and second-price sealed-bid auctions. In first-price auctions, bidders become "more truthful" the more spiteful they are. Surprisingly, the equilibrium strategy in second-price auctions does not depend on the number of bidders. Based on these equilibria, we compare revenue in both auction types. It turns out that expected revenue in second-price auctions is higher than expected revenue in first-price auctions whenever agents have the slightest interest in reducing others' profit as long as they still care for their own profit. In other words, revenue equivalence only holds for auctions in which all agents are either self-interested or completely malicious.

Keywords: Auctions, Externalities, Spite, Revenue

Joint work of: Brandt, Felix; Sandholm, Tuomas; Shoham, Yoav

Full Paper: http://drops.dagstuhl.de/opus/volltexte/2005/198

Expressive Negotiation over Donations to Charities

Vincent Conitzer (CMU - Pittsburgh, USA)

When donating money to a (say, charitable) cause, it is possible to use the contemplated donation as negotiating material to induce other parties interested in the charity to donate more. Such negotiation is usually done in terms of matching offers, where one party promises to pay a certain amount if others pay a certain amount. However, in their current form, matching offers allow for only limited negotiation. For one, it is not immediately clear how multiple parties can

make matching offers at the same time without creating circular dependencies. Also, it is not immediately clear how to make a donation conditional on other donations to multiple charities, when the donator has different levels of appreciation for the different charities. In both these cases, the limited expressiveness of matching offers causes economic loss: it may happen that an arrangement that would have made all parties (donators as well as charities) better off cannot be expressed in terms of matching offers and will therefore not occur.

In this paper, we introduce a bidding language for expressing very general types of matching offers over multiple charities. We formulate the corresponding clearing problem (deciding how much each bidder pays, and how much each charity receives), and show that it is NP-complete to approximate to any ratio even in very restricted settings. We give a mixed-integer program formulation of the clearing problem, and show that for concave bids, the program reduces to a linear program. We then show that the clearing problem for a subclass of concave bids is at least as hard as the decision variant of linear programming. Subsequently, we show that the clearing problem is much easier when bids are quasilinear—for surplus, the problem decomposes across charities, and for payment maximization, a greedy approach is optimal if the bids are concave (although this latter problem is weakly NP-complete when the bids are not concave). For the quasilinear setting, we study the mechanism design question. We show that an ex-post efficient mechanism is impossible even with only one charity and a very restricted class of bids. We also show that there may be benefits to linking the charities from a mechanism design standpoint.

Keywords: Expressive Negotiation, Charities, Public Goods, Externalities

Joint work of: Conitzer, Vincent; Sandholm, Tuomas

The Clock-Proxy Auction: A Practical Combinatorial Auction Design

Peter Cramton (University of Maryland, USA)

We propose the clock-proxy auction as a practical means for auctioning many related items. A clock auction phase is followed by a last-and-final proxy round. The approach combines the simple and transparent price discovery of the clock auction with the efficiency of the proxy auction. Linear pricing is maintained as long as possible, but then is abandoned in the proxy round to improve efficiency and enhance seller revenues. The approach has many advantages over the simultaneous ascending auction. In particular, the clock-proxy auction has no exposure problem, eliminates incentives for demand reduction, and prevents most collusive bidding strategies.

Keywords: Auction, clock auction, combinatorial auction, package auction, proxy auction

Joint work of: Cramton, Peter; Ausubel, Lawrence M.; Milgrom, Paul

Fair Payments for Efficient Allocations in Public Sector Combinatorial Auctions

Robert Day (Univ. of Connecticut, USA)

Motivated by the increasing use of auctions by government agencies, we consider the problem of fairly pricing public goods in a combinatorial auction. A well-known problem with the incentive-compatible Vickrey-Clarke-Groves (VCG) auction mechanism is that the resulting prices may not be in the core. Loosely speaking, this means the payments of the winners could be so low, that there are losing bidders who would have been willing to pay more than the payments of the winning bidders.

Clearly, this "unfair" outcome is unacceptable for a public-sector auction. Proxy-based combinatorial auctions, in which each bidder submits several package bids to a proxy, result in efficient outcomes and bidder-Pareto-optimal core-payments by winners, thus offering a viable practical alternative to address this problem.

This paper confronts two critical issues facing the proxy-auction. First, motivated to minimize a bidder's ability to benefit through strategic manipulation (through collusive agreement or unilateral action), we demonstrate the strength of a mechanism that minimizes total payments among all possible proxy auction outcomes, narrowing the previously broad solution concept. Secondly, we address the computational difficulties of achieving these outcomes with a constraint-generation approach, promising to broaden the range of applications for which the proxy-auction achieves a comfortably rapid solution.

Keywords: Auctions, core, bidder-Pareto-optimal, constraint generation, VCG payments, proxy auctions, combinatorial auctions

Joint work of: Day, Robert; Raghavan, S.

Full Paper: http://drops.dagstuhl.de/opus/volltexte/2005/183

Selfish Routing of Splittable Flow with Respect to Maximum Congestion

Rainer Feldmann (Universität Paderborn, D)

We study the problem of selfishly routing splittable traffic with respect to maximum congestion through a shared network.

Our model naturally combines features of the two best studied models in the context of selfish routing: The KP-model [KP99] and the Wardrop-model [War52].

We are given a network with source nodes s_i, sink nodes t_i, $1 \leq i \leq k$, m edges, and a latency function for each edge. Traffics of rate r_i are destined from s_i to t_i.

Traffics are splittable and each piece of traffic tries to route in such a way that it minimizes its private latency.

In the absence of a central regulation, Nash Equilibria represent stable states of such a system. In a Nash Equilibrium, no piece of traffic can decrease its private latency by unilaterally changing its route. The increased social cost due to the lack of central regulation is defined in terms of the coordination ratio, i.e. the worst possible ratio of the social cost of a traffic flow at Nash Equilibrium and the social cost of a global optimal traffic flow.

In this paper, we show that in the above model pure Nash Equilibria always exist.

Then, we analyze the coordination ratio of single-commodity networks with linear latency functions.

Our main result is a tight upper bound of $\frac{4}{3}m$, where m is the number of edges of the network, for the coordination ratio of single-commodity networks with linear latency functions.

On our way to our main result we analyze the coordination ratio of single-hop networks and show a tight upper bound of $m + \Theta(\sqrt{m})$. A more sophisticated analysis yields an upper bound of $\frac{4}{3}m$ for the coordination ratio of multi-hop networks, which is then used to derive the main result for arbitrary single-commodity linear networks.

Keywords: Selfish routing, coordination ratio

Extended Abstract: http://drops.dagstuhl.de/opus/volltexte/2005/199

The Price of Anarchy for Polynomial Social Cost

Martin Gairing (Universität Paderborn, D)

In this work, we consider an interesting variant of the well-studied KP model [KP99] for selfish routing that reflects some influence from the much older Wardrop [War52]. In the new model, user traffics are still unsplittable, while social cost is now the expectation of the sum, over all links, of a certain polynomial evaluated at the total latency incurred by all users choosing the link; we call it polynomial social cost. The polynomials that we consider have non-negative coefficients.

We are interested in evaluating Nash equilibria in this model, and we use the Price of Anarchy as our evaluation measure. We prove the Fully Mixed Nash Equilibrium Conjecture for identical users and two links, and establish an approximate version of the conjecture for arbitrary many links. Moreover, we give upper bounds on the Price of Anarchy.

Keywords: Selfish routing, KP-model, price of anarchy, fully mixed Nash Equilibrium

Joint work of: Gairing, Martin; Lücking, Thomas; Mavronicolas, Marios; Monien, Burkhard

Extended Abstract: http://drops.dagstuhl.de/opus/volltexte/2005/200

Sequences of Take-It-or-Leave-It Offers: Near-Optimal Auctions Without Full Valuation Revelation

Andrew Gilpin (CMU - Pittsburgh, USA)

We introduce take-it-or-leave-it auctions (TLAs) as an allocation mechanism that allows buyers to retain much of their private valuation information, yet generates close-to-optimal expected utility for the seller. We show that if each buyer receives at most one offer, each buyer's dominant strategy is to act truthfully. In more general TLAs, the buyers' optimal strategies are more intricate, and we derive the perfect Bayesian equilibrium for the game. We develop algorithms for finding the equilibrium and also for optimizing the offers so as to maximize the seller's expected utility. In several example settings we show that the seller's expected utility already is close to optimal for a small number of offers. As the number of buyers increases, the seller's expected utility increases, and becomes increasingly (but not monotonically) more competitive with Myerson's expected utility maximizing auction.

Keywords: Optimal auction design, mechanism design, perfect Bayesian equilibrium

Joint work of: Sandholm, Tuomas; Gilpin, Andrew

Full Paper: http://drops.dagstuhl.de/opus/volltexte/2005/207

Reference-Dependent Preferences in Multi-Issue Bargaining

Henner Gimpel (Universität Karlsruhe, D)

Game theoretic bargaining models usually assume parties to have exogenously given preferences from the beginning of a negotiation on. Preferences in these models do not depend on the history of offers made during a negotiation. This paper argues that preferences are based on issue-wise reference points changing during the bargaining process as result of the counterparty's offers.

Keywords: Negotiation Analysis, Bilateral Bargaining, Consumer Preferences, Behavioral Economics, Endowment Effect, Loss Aversion

Extended Abstract: http://drops.dagstuhl.de/opus/volltexte/2005/203

Online Homogeneous Markets

Rica Gonen (The Hebrew University of Jerusalem, IL)

We consider the problem of designing an online mechanism for homogeneous markets where bidders each bid to buy or sell one unit of a single commodity. As online mechanisms make their decisions on partial information they are not economically efficient. This important characteristic allows the online market mechanisms to achieve Incentive Compatibility, Individual Rationality and Budget Balance, attributes that can not simultaneously apply with optimal efficiency. We focus on an Incentive Compatible market that is IR and BB. This mechanism approximates the optimal trade k by $\frac{k-1}{2}$ and approximates the optimal gain from trade m by $\sqrt{m}$. We show that the trade's approximation bound is tight.

Joint work of: Gonen, Rica; Yair, Bartal

Derandomization of Auctions

Jason D. Hartline (Microsoft - Mountain View, USA)

We study the problem of designing seller optimal auctions. Prior to this work, the only previously known auctions that are approximately optimal in worst case employ randomization. Our main result is the existence of deterministic auctions that approximately match the performance gaurantees of these randomized auctions. We give a fairly general derandomization technique for turning any randomized mechanism into an asymmetric deterministic one with approximately the same properties. In doing so, we bypass an information theoretic impossibility result for symmetric deterministic auctions and show that asymmetry is nearly as powerful as randomization in optimal mechanism design problems. Our construction involves solving an exponential-sized flow problem and thus is not polynomial-time computable. We show that for an interesting problem related to auctions, the *2-color-guessing problem*, this derandomization can indeed be performed in polynomial time. We leave as an open question the existence of a polynomial-time computable deterministic auction that is approximately optimal.

Keywords: Auctions, randomization

Joint work of: Aggarwal, Gagan; Fiat, Amos; Goldberg, Andrew V.; Hartline, Jason D.; Immorlica, Nicole; Sudan, Madhu

Network structure and strong equilibrium in route selection games

Ron Holzman (Technion - Haifa, IL)

In a route selection game on a network, every player chooses a route from the origin to the destination, which are common to all players. Costs are assigned to road segments in the form of monotone nondecreasing functions of the number of players who use them. Each player incurs a total cost equal to the sum of the costs of the road segments in his route. It is known that such a game always has a Nash equilibrium in pure strategies. Here we obtain a structural characterization of those networks for which a strong equilibrium is guaranteed to exist regardless of the cost assignment. The route selection games based on networks in this class enjoy more stability as well as other desirable properties of equilibrium regarding uniqueness and efficiency.

Keywords: Congestion games, Networks, Route selection games, Strong equilibrium, Efficiency

Joint work of: Holzman, Ron; Law-yone(Lev-tov), Nissan

A Robust Open Ascending-price Multi-unit Auction Protocol against False-name Bids and an Experimental Examination

Atsushi Iwasaki (Kyushu University, J)

This research presents a ascending-price multi-unit auction protocol.

As far as the authors are aware, this is the first protocol that has an open format, and in which sincere bidding is an equilibrium strategy, even if the marginal utilities of each agent can increase and agents can submit false-name bids. As ever-increasing numbers of companies and consumers are trading on Internet auctions, a new type of cheating called "false-name bids" has been noticed. Specifically, there may be some agents with fictitious names such as multiple e-mail addresses. The VCG is not an open format, and truth-telling is no longer a dominant strategy if agents can submit false-name bids and the marginal utilities of each agent can increase. The Iterative Reducing (IR) protocol with a sealed-bid format is robust against false-name bids, although it requires the auctioneer to carefully pre-determine a reservation price for one unit. Open format protocols, such as the Ausubel auction, outperform sealed-bid format protocols in terms of the simplicity and privacy-preservation.

These two advantages are said to encourage more agents to bid sincerely and to provide the seller with higher revenue. We extend the Ausubel auction to our proposed protocol which can handle the cases where the marginal utilities of each agent can increase.

Moreover, it is robust against false-name bids and does not require the auctioneer to set a reservation price. Our simulation result indicates that our protocol herein obtains a social surplus close to Pareto efficient and that it outperforms the IR with respect to the social surplus and the seller's revenue. Furthermore, we evaluate the protocol employing subject experiments.

The experimental result suggests a segmentation which gives a seller a clue as to which protocol he should choose in his business. It also show that our protocol is more stable than a traditional and simple uniform-price auction in terms of individual bidding behavior and the seller's revenue.

Keywords: Auctions, Mechanism Design, Electronic Commerce, Experimental Economics

Joint work of: Iwasaki, Atsushi; Yokoo, Makoto

Approximate Utilitarian Mechanism Design via Primal-Dual Method

Piotr Krysta (Universität Dortmund, D)

This work deals with the design of efficiently computable incentive compatible, or truthful, mechanisms for combinatorial optimization problems with multi-parameter agents. Our focus lies on the design of approximation algorithms for NP-hard mechanism design problems. In order to ensure incentive compatibility, approximation algorithms need to satisfy certain monotonicity properties.

The most efficient way to solve packing integer programs (PIPs) is LP-based randomized rounding.

Unfortunately, this method is not monotone. We show that monotone primal-dual greedy algorithms are capable of achieving almost the same approximation ratios for PIPs as randomized rounding. We demonstrate this technique based on two intensively studied applications from mechanism design, namely combinatorial auctions and unsplittable flow (routing). In both cases, we can significantly improve on the previously known approximation ratios for incentive compatible mechanisms. For example, we obtain the first incentive compatible mechanism for routing in general networks that is capable of optimizing the network utilizations up to constant factors, if edge capacities are sufficiently large. The best previous mechanism only achieved approximation factors logarithmic in the size of the network.

Joint work of: Krysta, Piotr; Voecking, Berthold

Negotiating over Bundles and Prices Using Online Aggregate Knowledge

Han La Poutré (CWI - Amsterdam, NL)

We consider a form of multi-issue negotiation where a shop negotiates both the contents and the price of bundles of goods with his customers. We present some key insights about, as well as a procedure for, locating mutually beneficial alternatives to the bundle currently under negotiation. The essence of our approach lies in combining aggregate (anonymous) knowledge of customer preferences with current data about the ongoing negotiation process. The developed procedure either works with already obtained aggregate knowledge or, in the absence of such knowledge, learns the relevant information online. We conduct computer experiments with simulated customers that have nonlinear preferences. We show how, for various types of customers, with distinct negotiation heuristics, our procedure (with and without the necessary aggregate knowledge) increases the speed with which deals are reached, as well as the number and the Pareto efficiency of the deals reached compared to a benchmark.

Keywords: Negotiation, bundling, aggregate knowledge, non-linear preferences, online learning

Many-to-many matching: the subset agreement problem

Daniel Lehmann (The Hebrew University of Jerusalem, IL)

How can two parties agree on some subset of a set of possible contracts? A solution concept generalizing stable matchings is proposed.

Results concerning the existence of solutions and the structure of the set of solutions are presented, under conditions that are weak enough to apply to all previously known matching problems. Classical results about one-to-one and many-to-one matchings are generalized to many-to-many matchings. This work builds on recent work by Milgrom and by Alkan and Gale.

Keywords: Matching, Revealed Preferences, Choice Functions, Stable Matchings

Game-Theoretic Graphical Models for Congestion

Kevin Leyton-Brown (University of British Columbia - Vancouver, CDN)

Game-Theoretic Graphical Models for Congestion Leyton-Brown, Kevin; Tennenholtz, Moshe; Bhat, Navin A.R.

This talk will survey two graphical models which the authors have proposed for compactly representing single-shot, finite-action games in which a large number of agents contend for scarce resources.

The first model considered is Local-Effect Games (LEGs). These games often (but not always) have pure-strategy Nash equilibria. Finding a potential function is a good technique for finding such equilibria. We give a complete characterization of which LEGs have potential functions and provide the functions in each case; we also show a general case where pure-strategy equilibria exist in the absence of potential functions.

Action-graph games (AGGs) are a fully expressive game representation which can compactly express both strict and context-specific independence between players' utility functions, and which generalize LEGs. We present algorithms for computing both symmetric and arbitrary equilibria of AGGs, based on a continuation method proposed by Govindan and Wilson. We analyze the worst-case cost of computing the Jacobian of the payoff function, the exponential- time bottleneck step of this algorithm, and in all cases achieve exponential speedup. When the indegree of G is bounded by a constant and the game is symmetric, the Jacobian can be computed in polynomial time.

Keywords: Compact representation of games, congestion games, local-effect games, action-graph games

Joint work of: Leyton-Brown, Kevin; Tennenholtz, Moshe; Bhat, Navin A.R.

Full Paper: http://drops.dagstuhl.de/opus/volltexte/2005/219

Extended Abstract: http://drops.dagstuhl.de/opus/volltexte/2005/220

Self-Confirming Price Prediction for Bidding in Simultaneous Ascending Auctions

Jeffrey MacKie-Mason (University of Michigan, USA)

Simultaneous, separate ascending auctions are ubiquitous, even when agents have preferences over combinations of goods, from which arises the *exposure problem*. Little is known about strategies that perform well when the exposure problem is important. We present a new family of bidding strategies for this situation, in which agents form and utilize various amounts of information from predictions of the distribution of final prices.

The predictor strategies we define differ in their choice of method for generating the initial (pre-auction) prediction. We explore several methods, but focus on *self-confirming* predictions. An agent's prediction of characteristics of the distribution of closing prices is self-confirming if, when all agents follow the same predictor bidding strategy, the final price distributions that actually result are consistent with the utilized characteristics of the prediction.

We extensively analyze an auction environment with five goods, and five agents who each can choose from 53 different bidding strategies (resulting in over 4.2 million distinct strategy combinations). We find that the self-confirming distribution predictor is a highly stable, pure-strategy Nash equilibrium. We have been unable to find any other Nash strategies in this environment.

In limited experiments in other environments the self-confirming distribution predictor consistently performs well, but is not generally a pure-strategy Nash equilibrium.

Keywords: Computational markets; auctions; bidding strategies

Joint work of: Osepayshvili, Anna; Wellman, Michael; Reeves, Daniel; MacKie-Mason, Jeffrey

Full Paper: http://drops.dagstuhl.de/opus/volltexte/2005/202

Attribute Auctions

Yishay Mansour (Tel Aviv University, IL)

In an "attribute auction", a seller (auctioneer) is marketing some good of unlimited supply to n bidders, each of whom has a set of public attributes. The goal of the seller is to achieve a revenue competitive with the best pricing function in some given class of functions over the attributes. This setting was introduced in [BH-05], where the special case of 1-dimensional real-valued attributes was considered, and results were given for the comparison class of piecewise-constant functions with k pieces.

In this paper, we consider attribute auctions more generally, and show a natural strategy by which an auctioneer can perform nearly as well as the best pricing scheme in any given class, so long as the number of bidders is large enough as a function of an appropriate measure of the complexity of the class. We do this by making a natural connection to the notion of sample-complexity in machine learning, though from a learning perspective the auction setting presents certain unique challenges: in particular, the loss function is discontinuous and asymmetric, and the range of bid values may be large. We also consider a partial-information setting in which the auctioneer only gets information by making offers that are either accepted or rejected, and provide bounds for that case as well.

Joint work of: Balcan, Maria-Florina ; Blum, Avrim ; Hartline, Jason D.; Mansour, Yishay

Priority Auctions and Queue Disciplines that Depend on Processing Times

Benny Moldovanu (Universität Bonn, D)

We study a model where randomly arriving customers bid for places in a queue. The agents are privately informed about their own processing times. We derive steady-state bidding equilibria, and relate these equilibria to the "shortest (longest) processing time first" queue disciplines. A crucial role in our analyis is played by the convexity/concavity of the function measuring the cost of delay. For polynomial cost functions, Laplace-transform computations allow for for closed-form, explicit solutions.

Joint work of: Moldovanu, Benny; Kittsteiner, T.

Generalized Congestion Games

Dov Monderer (Technion - Haifa, IL)

The papers has three parts.
In **part 1** it is proved that every game in strategic form is isomorphic to an AS-congestion game – A congestion game with agent-specific payoffs. In this part I also give a classification of congestion models and characterization results. In particular we generalize the results of Rosenthal and of Monderer and Shapley regarding the equivalence of potential games and congestion games.
In **part 2** I discuss congestion models defined by solution concepts of cooperative game theory. I use it to characterize the Shapley value and indeed all semivalues.
In **part 3** the previous results are applied to combinatorial auctions with strategic goods.

On Decentralized Incentive Compatible Mechanisms for Partially Informed Environments

Ahuva Mu'alem (Hebrew University, IL)

Algorithmic Mechanism Design focuses on Dominant Strategy Implementations. The main positive results are the celebrated Vickrey-Clarke-Groves (VCG) mechanisms and computationally efficient mechanisms for severely restricted players ("single-parameter domains"). As it turns out, many natural social goals cannot be implemented using the dominant-strategy concept. This suggests that the standard requirements must be relaxed in order to construct general-purpose mechanisms.

We observe that in many common distributed environments computational entities can take advantage of the network structure to collect and distribute

information. We thus suggest a notion of partially informed environments. Even if the information is recorded with some probability, this enables us to implement a wider range of social goals, using the concept of iterative elimination of weakly dominated strategies. As a result, cooperation is achieved independent of agents' belief. As a case study, we apply our methods to derive Peer-to-Peer network mechanism for file sharing.

See also: On Decentralized Incentive Compatible Mechanisms for Partially Informed Environments, In EC-05

Fundamentals in Discrete Convex Analysis

Kazuo Murota (University of Tokyo, J)

This talk describes fundamental properties of M-convex and L-convex functions that play the central roles in discrete convex analysis. These concepts were originally introduced in combinatorial optimization, but turned out to be relevant in economics. Emphasis is put on discrete duality and conjugacy respect to the Legendre-Fenchel transformation.

Monograph information:
http://www.misojiro.t.u-tokyo.ac.jp/~murota/mybooks.html#DCAsiam2003

Keywords: Gross substitute, discrete convex functions, M-convex function, Fenchel-Legendre transformation

Joint work of: Murota, Kazuo

Extended Abstract: http://drops.dagstuhl.de/opus/volltexte/2005/216

Dominant Strategy Mechanisms with Multidimensional Types

Rudolf Müller (Maastricht University, NL)

This paper provides a characterization of dominant strategy mechanisms with quasi-linear utilities and multi-dimensional types for a variety of preference domains. These characterizations are in terms of a monotonicity property on the underlying allocation rule.

Keywords: Dominant Strategy, Farkas Lemma, Combinatorial Auctions

Joint work of: Hongwei Gui; Müller, Rudolf; Vohra, Rakesh V.

Full Paper: http://drops.dagstuhl.de/opus/volltexte/2005/210

Congestion games with failures

Maria Polukarov (Technion - Haifa, IL)

We introduce a new class of games, congestion games with failures (CGFs), which extends the class of congestion games to allow for facility failures. In a CGF agents share a common set of facilities (service providers), where each service provider (SP) may fail with some known probability. For reliability reasons, an agent may choose a subset of the SPs in order to try and perform his task. The cost of an agent for utilizing any SP is an agent-specific function of the total number of agents using this SP. A main feature of this setting is that the cost for an agent for successful completion of his task is the minimum of the costs of his successful attempts. We show that although congestion games with failures do not admit a potential function, and thus are not isomorphic to classic congestion games, they always possess a pure-strategy Nash equilibrium. Moreover, an efficient algorithm for the construction of pure-strategy Nash equilibrium profile is presented. We also show that the SPs' congestion experienced in different Nash equilibria is (almost) unique. For the subclass of symmetric CGFs we give a characterization of best and worst Nash equilibria, present algorithms for their construction, and compare the social disutilities of the agents at these points.

Keywords: Congestion games, Failures, Pure-strategy Nash equilibrium

Joint work of: Penn, Michal; Polukarov, Maria; Tennenholtz, Moshe

Full Paper: http://drops.dagstuhl.de/opus/volltexte/2005/209

Towards Generic Low Payment Mechanisms for Decentralized Task Allocation

Amir Ronen (Technion - Haifa, IL)

Situations in which a set of tasks is to be allocated among self-interested agents occur in many domains. Among the examples are electronic commerce applications, protocols for task allocation over the Internet, multi agent systems, etc. In this talk I will focus on the problem of procuring a cheap path in a disjoint path graph in which the edges belong to self interested agents (SDP). I will show that many decentralized task allocation problems can be reduced to SDPs. After that I will analyze two types of mechanisms (protocols) for the problem, incentive compatible and non incentive compatible, and describe the differences among their properties. (For the analysis of non incentive compatible mechanisms I will present an approach which is based on reinforcement learning.) Finally, I will describe how to combine the virtues of both types of mechanisms.

Keywords: Mechanism design, theory, computer science, economics

Joint work of: Ronen, Amir; Czumaj, Artur; Talisman, Rina

Equilibrium Prices in Markets Modeled with Mixed Integer Programs

Michael H. Rothkopf (Rutgers Univ. - Piscataway, USA)

Dual variables give useful prices in markets models with LPs. However, many markets have important economies of scale such as fixed or start up costs. These markets can be modeled using mixed integer programs (MIPs). Ever since Gomory and Baumol examined the dual of cutting planes in MIPs in 1960, we have "known" that there are no economically satisfactory prices for markets modeled with MIPs. In 1990 and 1994, Yale professor Herbert Scarf explained and lamented the problem in Operations Research and in the widely circulated Journal of Economic Perspectives.

We have found a simple way to get prices that support an economic equilibrium.

The key is pricing the discrete variables as well as the continuous ones. We do this in two stages. First we solve the MIP. Then, we add linear constraints that force the optimal solution and drop the integrality constraints. We show that the dual variables on the added constraints in the resulting LP effectively price the integer variables and that the dual prices support an economic equilibrium. In particular, we exhibit equilibrium- supporting prices for the example problem Scarf used to explain the problem to economists. In addition to their theoretical importance, our results have immediate practical relevance to electricity auctions where generators have start up costs and minimum run level constraints.

Joint work of: Richard P. O'Neill, Paul M. Sotkiewicz, Benjamin F. Hobbs, Rothkopf, Michael H., and William R. Stewart, Jr.

See also: Richard P. O'Neill, Paul M. Sotkiewicz, Benjamin F. Hobbs, Michael H. Rothkopf, and William R. Stewart, Jr., Efficient Market-Clearing Prices in Markets with Nonconvexities, William R. Stewart, Jr., Efficient Market-Clearing Prices in Markets with Nonconvexities, European Journal of Operations Research 164, pp 269-285, 2005.

Automated Mechanism Design

Tuomas Sandholm (CMU - Pittsburgh, USA)

Mechanisms design has traditionally been a manual endeavor. In 2002, Conitzer and Sandholm introduced the automated mechanism design (AMD) approach, where the mechanism is computationally created for the specific problem instance at hand. This has several advantages: 1) it can yield better mechanisms than the ones known to date, 2) it applies beyond the problem classes studied manually to date, 3) it can circumvent seminal economic impossibility results

that hold for classes of problems but not all instances, and 4) it shifts the burden of design from man to machine. In this talk I will overview our results on AMD to date. I will cover problem representations and the computational complexity of different variants of the design problem. Initial applications include revenue-maximizing combinatorial auctions and (combinatorial) public goods problems. Algorithms for AMD will be discussed. To reduce the computational complexity of designing optimal combinatorial auctions, I introduce an incentive compatible, individually rational subfamily called Virtual Valuations Combinatorial Auctions. The auction mechanism's revenue can be boosted (started, for example, from the VCG) by hill-climbing in this subspace. I will also present computational complexity and communication complexity results that motivate multi-stage and non-truth-promoting mechanisms. Finally, I present our first steps toward automatically designing multi-stage mechanisms.

Keywords: Automated mechanism design, mechanism design.

Joint work of: Sandholm, Tuomas; Conitzer, Vincent; Likhodedov, Anton; Boutilier, Craig

Overcoming Free Riding in Multi-Party Computations

Rann Smordinsky (Technion - Haifa, IL)

This paper addresses the question of multi party computation in a model with asymmetric information. Each agent has a private value (secret), but in contrast to standard models, the agent incurs a cost when retrieving the secret. There is a social choice function the agents would like to compute and implement. All agents would like to perform a joint computation, which input is their vector of secrets. However, agents would like to free-ride on others' contribution.

A mechanism which elicits players' secrets and performs the desired computation defines a game. A mechanism is 'appropriate' if it (weakly) implements the social choice function for all secret vectors. namely, if there exists an equilibrium in which it is able to elicit (sufficiently many) agents' secrets and perform the computation, for all possible secret vectors. We show that 'appropriate' mechanisms approach agents sequentially and that they have low communication complexity.

Keywords: Multi-party computation, equilibrium, mechanism-design

Joint work of: Smordinsky, Rann; Tennenholtz, Moshe

Full Paper: http://drops.dagstuhl.de/opus/volltexte/2005/206

A Contract and Balancing Mechanism for Sharing Capacity in a Communication Network

Richard Steinberg (Cambridge University, GB)

We propose a method for determining how much to charge users of a communication network when they share bandwidth. Our approach can be employed either when a network owner wishes to sell bandwidth for a specified period of time to a number of different users, or when users cooperate to build a network to be shared among themselves. We show how a Contract and Balancing Mechanism can be defined to mediate between rapidly fluctuating prices and the longer time scales over which bandwidth contracts might be traded. An important property of the process is that it avoids introducing perverse incentives for a capacity provider to increase congestion.

Keywords: Capacity Contracts; Congestion Pricing; Nash Equilibrium

Joint work of: Anderson, Edward; Kelly, Frank; Steinberg, Richard

Full Paper: http://drops.dagstuhl.de/opus/volltexte/2005/204

The Price of Stability for Network Design with Fair Cost Allocation

Eva Tardos (Cornell University, USA)

Given a collection of self-interested agents who want to form a network connecting certain endpoints, the set of stable solutions — the Nash equilibria — may look quite different from the centrally enforced optimum. We study the quality of the best Nash equilibrium, and refer to the ratio of its cost to the optimum network cost as the price of stability. The best Nash equilibrium solution has a natural meaning of stability in this context — it is the optimal solution that can be proposed from which no user will "defect".

We consider the price of stability for network design with respect to one of the most widely-studied protocols for network cost allocation, in which the cost of each edge is divided equally between users whose connections make use of it; this fair-division scheme can be derived from the Shapley value, and has a number of basic economic motivations. We show that the price of stability for network design with respect to this fair cost allocation is O(log k), where k is the number of users, and that a good Nash equilibrium can be achieved via best-response dynamics in which users iteratively defect from a starting solution. This establishes that the fair cost allocation protocol is in fact a useful mechanism for inducing strategic behavior to form near-optimal equilibria.

See also: E. Anshelevich, A. Dasgupta, J. Kleinberg, E. Tardos, T. Wexler and T. Roughgerden. The Price of Stability for Network Design with Fair Cost Allocation, Annual IEEE Symposium on Foundations of Computer Science (FOCS), 2004

Efficient Learning Equilibrium

Moshe Tennenholtz (Technion - Haifa, IL)

We introduce *efficient learning equilibrium* (ELE), a normative approach to learning in non-cooperative settings. In ELE, the learning algorithms themselves are required to be in equilibrium. In addition, the learning algorithms must arrive at a desired value after polynomial time, and a deviation from the prescribed ELE becomes irrational after polynomial time. We prove the existence of an ELE (where the desired value is the social surplus of an optimal Nash equilibrium) and of a Pareto-ELE (where the objective is the maximization of social surplus) in repeated games with full monitoring. We also show that an ELE does not always exist in the partial monitoring case; however, it does exist for symmetric games. Finally, we discuss the extension of these results to general-sum stochastic games.

Joint work of: Tennenholtz, Moshe; Brafman, Ronen

Agent-based Simulation in Electric Power- and CO2-Emission-Certificate Markets

Daniel Veit (Universität Karlsruhe, D)

The liberalization of international power markets unleashed great new chances but also risks for market participants. Industrial consumers are now able to cover their demand trading at power exchanges and do no longer have to necessarily negotiate long term agreements with power producers. On the other hand, producers of power are able to sell their capacities at exchanges and thereby use market mechanisms to determine prices of the electricity. Besides the liberalization of power markets, the introduction of CO2-Emission-Certificate markets, which regulate the amount of allowed emissions of CO2, influence the market structure in the electric power domain.

Due to rapidly grown internet availability, in recent years power exchanges based on electronic marketplaces for non storable goods have been established (such as the European Energy Exchange, EEX in Leipzig). The market share of these exchanges has strongly grown up to 20

Since this area is fairly new, the issue of our research is the identification of actually applied and possibly applicable market mechanisms for non storable goods. Using these mechanisms, market situations are simulated and possible

acting strategies upon these markets are determined. A key mean which can be applied for the derivation of recommendations for acting strategies upon such markets is simulation. One of the latest simulation methods is Agent-based Computational Economics (ACE). ACE is using software agents to represent market participants and makes them act on behalf of real market participants. Depending on the market mechanism and the strategy as well as the learning behavior of the agent a more or less successful participation in the market can be observed.

The aim of this research is to develop and contribute to the mechanisms in ACE, which are currently a lively research area. Additionally, the existing and developed methods in ACE are to be applied in the domains of power and GRID markets. ACE in power markets is the issue of the research project PowerACE (www.powerace.de) funded by the VolkswagenStiftung, in which I am currently involved.

Keywords: Agent-based Computational Economics, Agent-based Simulation, Electric Power Markets, CO2-Emission-Certificate Markets

The bisection auction is the fastest Vickrey auction

Dries Vermeulen (Maastricht University, NL)

In this paper we show that for the case where two bidders have private values for a single item the bisection auction is the stochastically dominant implementation of the Vickrey auction. Consequently the bisection auction is also optimal from a worst-case perspective and it has the lowest expected running time.

Keywords: Vickrey auction; binary search; stochastic dominance.

Joint work of: Grigorieva, Elena; Herings, P. Jean-Jacques; Vermeulen, Dries; Muller, Rudolf

Approximation Techniques for Utilitarian Mechanism Design

Berthold Vöcking (RWTH Aachen, D)

In order to ensure incentive compatibility, approximation algorithms need to satisfy certain monotonicity properties. Unfortunately, most of the known techniques for designing approximation algorithms do not fulfill these properties. We study alternative techniques that lead to monotone algorithms. For example, we present an alternative method transforming a pseudopolynomial algorithm into a monotone FPTAS. This method can be applied to various problems like, e.g., knapsack, constrained shortest path, or scheduling to minimize the weighted

number of tardy jobs. The monotone FPTAS for the knapsack problem is of particular interest as it gives a very efficient mechanism for multi-unit auctions. The best previous result for this kind of auctions was a 2-approximation. The transformation is based on an enumerative method that virtually enumerates over an infinite number of ways to round the coefficients of the objective function. We also show how to enhance another enumeration technique and derive a monotone PTAS for the generalized assignment problem with any bounded number of parameters per agent.

Furthermore, we also consider frugality aspects. In particular, we present upper bounds on the difference between the payment made by an approximate mechanism and the payment made by the exact VCG mechanism.

Combining these bounds, e.g., with our results for FPTASs, the overpayment for efficiently computable mechanisms can be made arbitrarily small. This shows that our FPTAS based mechanisms truly approximate the VCG mechanism both with respect to the social objective and payment.

Keywords: Mechanism design, approximation algorithms

Joint work of: Vöcking, Berthold; Krysta, Piotr; Briest, Patrick

Incentive-Compatible, Budget-Balanced, yet Highly Efficient Auctions for Supply Chain Formation

William Walsh (IBM TJ Watson Research Center - Hawthorne, USA)

We address the mechanism design problem of supply chain formation—the problem of negotiation mechanisms to coordinate the buying and selling of goods in multiple markets across a supply chain. Because effective negotiation strategies can be difficult to design for supply chains, we focus on incentive compatible auctions, in which the agents' dominant strategy is to simply report their private information truthfully. Unfortunately, with two-sided negotiation, characteristic of supply chains, it is impossible to simultaneously achieve perfect efficiency, budget balance, and individual rationality with incentive compatibility. To resolve this problem we introduce auctions that explicitly discard profitable trades, thus giving up perfect efficiency to maintain budget balance, incentive compatibility and individual rationality. We use a novel payment rule based on Vickrey-Clarke-Groves payments, but adapted to our allocation rule. The first auction we present is incentive compatible when each agent desires only a single bundle of goods, the auction correctly knows all agents' bundles of interest, but the monetary valuations are private to the agents. We introduce extensions to maintain incentive compatibility when the auction does not know the agents' bundles of interest. We establish a good worst case bound on efficiency when the bundles of interest are known, which also applies in some cases when the bundles are not known. Our auctions produce higher efficiency for a broader class of supply chains than any other incentive compatible, individually rational, and budget-balanced auction we are aware of.

Keywords: Auction, supply chain formation, mechanism design, combinatorial exchange, incentive compatible

Joint work of: Babaioff, Moshe; Walsh, William

Exploring Trading Strategy Spaces

Michael Wellman (University of Michigan, USA)

Given that the complexity of many market games precludes analytic characterization of equilibrium, we require alternative means of evaluating strategic alternatives. My group has been applying an empirical game-theoretic methodology to the study of several interesting market games, yielding insights into key strategic issues as well as evidence bearing on particular strategies. Examples include simultaneous auctions as well as two scenarios from the annual Trading Agent Competition: one in travel shopping and the other in supply chain management.

A Network Approach to Bayes-Nash Incentive Compatible Mechanisms

Sascha Wolf (Maastricht University, NL)

This paper provides a characterization of Bayes-Nash incentive compatible mechanisms in settings where agents have one-dimensional or multi-dimensional types, quasi-linear utility functions and interdependent valuations. The characterization is derived in terms of conditions for the underlying allocation function.

We do this by making a link to network theory and building complete directed graphs for agents' type spaces. We show that an allocation rule is Bayes-Nash incentive compatible if and only if these graphs have no negative, finite cycles.

In the case of one-dimensional types and given certain properties for agents' valuation functions, we show that this condition reduces to the absence of negative 2-cycles. In the case of multi-dimensional types and given a linearity requirement on the valuation functions, we show that this condition reduces to the absence of negative 2-cycles and an integratebility condition on the valuation functions.

Keywords: Implementation, Mechanism Design, Multi-Dimensional Types

Joint work of: Müller, Rudolf; Perea, Andres; Wolf, Sascha

Full Paper: http://drops.dagstuhl.de/opus/volltexte/2005/205

Inner Approximations for Cones of Outer Normal of Integer Programs with Application to Pricing in Combinatorial Auctions

Sven de Vries (TU München, D)

For sensitivity analysis of linear programs it is important to know the cone of outer normals of the linear program at an optimal solution. However, even when knowing an optimal solution of an integer program, there is no cone of outer normals readily available since the solution may not even be extremal for the underlying lp-relaxation. Even for binary integer programs, where the optimal ip-solution is extremal for the lp-relaxation, the cone of active constraints (that is available) usually does not contain the objective function.

One way to overcome this, is to use a Gomory-type cutting plane algorithm which generates enough hyperplanes to close the integrality-gap and makes the optimal solution extremal (even for non-binary IP's) with respect to the augmented formulation. This way was proposed by Gomory&Baumol (1960) and used by de Vries and Vohra (2003) as a mean to obtain prices and a price based mechanism for combinatorial auctions. However, as any practitioner of integer programming knows, a pure cutting plane algorithm is seldomly deemed the working horse of any actual solution algorithm for hard real world integer programs.

In the present study we describe how to use branch-and-bound-alike algorithms to obtain an inner approximation of the cone of outer normals at the optimal solution. This cone will turn out to contain the objective function in its interior in generic situations. This permits again to introduce linear prices in combinatorial auctions usually with less computational effort than is required to compute the shortfalls used sometimes to provide feedback in combinatorial auctions.

(This is joint work with Oliver Bastert of Dash Optimization.)

Keywords: Cone of outer normals, stability in integer programming, pricing in combinatorial auctions

Joint work of: de Vries, Sven; Bastert, Oliver