Report from Dagstuhl Seminar 13461

Electronic Markets and Auctions

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Abstract

The main goal of this seminar was to study topics related to electronic markets and auctions both from the computational perspective and from a game-theoretic and economic one. From the computer science perspective, with the advent of the Internet, there has been a significant amount of work in Algorithmic Game Theory focusing on computational aspects of electronic markets and on algorithmic aspects of mechanism design. Economics have been traditionally interested in markets in general and designing efficient markets mechanisms (such as auctions) in particular. The recent emergence of electronic markets and auctions has only reemphasized the importance of this topic.

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1 Executive Summary

Yishai Mansour
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The relatively young field of Algorithmic Game Theory sets a goal of providing a computational understanding of game theory models. The research in the field has many focal points, including exploring the quality of equilibria, computation of equilibria, algorithmic mechanism design, as well as analyzing computer science related games and gaining an economics perspective for many important optimization problems.

While it is still too early for the evaluation the long term contribution of Algorithmic Game Theory to the field of Economics, in general, and to Game Theory in particular, we would like to highlight some successful contributions. The efficient computational aspects are a clear contribution, and this is also coupled with the understanding that sub-optimal solutions can have various degrees of sub-optimality. By using approximation algorithms approaches traditional in Theoretical Computer Science, the sub-optimality can be quantify in a very rigorous and clear way. The study of concrete convergence rates, rather than

convergence in the limit, has proved to be highly successful here, as well. Finally, the extensive study of discrete models, especially combinatorial auctions, has been an area where computer science has made significant contributions.

The economic field of Mechanism Design asks how to design mechanisms that will implement some desired social choice function under rational behavior of the participants. This field is at the forefront of economics research, and its goal is to gain a better understanding of designing mechanisms that considers the incentives of participant. This is in general viewed as part of market design, and micro-economics

One of the central areas of Algorithmic Game Theory is *Algorithmic Mechanism Design*. This field is relevant to designing distributed computer systems, suggested that mechanism design should also consider the algorithmic issues involved beyond the strategic ones commonly studied in economics. The seminar concentrated on Algorithmic Game Theory, with an emphasis on the sub-field of Algorithmic Mechanism Design.

The central application of Mechanism Design is the implementation of auctions and markets, and similarly the central application of algorithmic mechanism design is the implementation of complex computerized auctions and markets. As markets and auctions are increasingly implemented over computer networks, and as they are getting more sophisticated, much theoretical research has gone into the design of complex auctions and markets. Issues that need to be treated include computational ones, strategic ones, and communication ones. A central application is, so called, combinatorial auctions, which aim to concurrently sell many related items.

This seminar had researchers discussing basic research questions that lie behind the growing challenges in electronic markets and auctions. The seminar took a broad view of these challenges, focusing on foundational issues, taking a wide perspective, from the high-level issues of Algorithmic Game Theory through the Algorithmic Mechanism Design aspects, to basic challenges of electronic markets and auction.

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3 Overview of Talks

3.1 Single parameter mechanism for unrelated machine scheduling

Yossi Azar (Tel Aviv University, IL)

Joint work of Azar, Yossi; Maor, Idan

We show a randomized truthful mechanism for the restricted-related scheduling model with 3-approximation on the makespan.

3.2 On the Efficiency of the Walrasian Mechanism

Moshe Babaioff (Microsoft Research – Mountain View, US)

Joint work of Babaioff, Moshe; Lucier, Brendan; Nisan, Noam; Paes Leme, Renato
Main reference M. Babaioff, B. Lucier, N. Nisan, R. Paes Leme, "On the Efficiency of the Walrasian Mechanism," arXiv:1311.0924v1 [cs.GT], 2013.
URL http://arxiv.org/abs/1311.0924v1

Central results in economics guarantee the existence of efficient equilibria for various classes of markets. An underlying assumption in early work is that agents are price-takers, i.e., agents honestly report their true demand in response to prices. A line of research in economics, initiated by Hurwicz (1972), is devoted to understanding how such markets perform when agents are strategic about their demands. This is captured by the *Walrasian Mechanism* that proceeds by collecting reported demands, finding clearing prices in the *reported* market via an ascending price tâtonnement procedure, and returns the resulting allocation. Similar mechanisms are used, for example, in the daily opening of the New York Stock Exchange and the call market for copper and gold in London.

In practice, it is commonly observed that agents in such markets reduce their demand leading to behaviors resembling bargaining and to inefficient outcomes. We ask how inefficient the equilibria can be. Our main result is that the welfare of every pure Nash equilibrium of the Walrasian mechanism is at least one quarter of the optimal welfare, when players have gross substitute valuations and do not overbid. Previous analysis of the Walrasian mechanism have resorted to large market assumptions to show convergence to efficiency in the limit. Our result shows that approximate efficiency is guaranteed regardless of the size of the market.

We extend our results in several directions. First, our results extend to Bayes-Nash equilibria and outcomes of no regret learning via the smooth mechanism framework. We also extend our bounds to any mechanism that maximizes welfare with respect to the declared valuations and never charges agents more than their bids. Additionally, we consider other classes of valuations and bid spaces beyond those satisfying the gross substitutes conditions. Finally, we relax the no-overbidding assumption, and present bounds that are parameterized by the extent to which agents are willing to overbid.

3.3 The Tradeoff between Efficiency and Strategyproofness in Randomized Social Choice

Felix Brandt (TU München, DE)

Joint work of Brandt, Felix; Aziz, Haris; Brandl, Florian; Brill, Markus
Main reference H. Aziz, F. Brandt, M. Brill, "On the Tradeoff Between Economic Efficiency and Strategy Proofness in Randomized Social Choice," in Proc. of the 2013 Int'l Conf. on Autonomous Agents and Multi-agent Systems (AAMAS'13), pp. 455–462, IFAAMAS, 2013.
URL http://dl.acm.org/citation.cfm?id=2484993

Two fundamental notions in microeconomic theory are efficiency—no agent can be made better off without making another one worse off—and strategyproofness—no agent can obtain a more preferred outcome by misrepresenting his preferences. When social outcomes are probability distributions (or lotteries) over alternatives, there are varying degrees of these notions depending on how preferences over alternatives are extended to preference over lotteries. We show that efficiency and strategyproofness are incompatible to some extent when preferences are defined using stochastic dominance (SD) and therefore introduce a natural weakening of SD based on Savage's sure-thing principle (ST). While random serial dictatorship is SD-strategyproof, it only satisfies ST-efficiency. Our main result is that strict maximal lotteries—an appealing class of social decision schemes due to Kreweras and Fishburn—satisfy SD-efficiency and ST-strategyproofness.

3.4 Algorithms for Strategic Agents I: Revenue Maximization

Yang Cai (MIT, US)

Joint work of Cai, Yang; Daskalakis, Constantinos; Weinberg, S. Matthew
Main reference Y. Cai, C. Daskalakis, S. M. Weinberg, "Optimal Multi-Dimensional Mechanism Design: Reducing Revenue to Welfare Maximization," arXiv:1207.5518v1 [cs.GT], 2013.
URL http://arxiv.org/abs/1207.5518v1

In his seminal paper, Myerson [1981] provides a revenue-optimal auction for a seller who is looking to sell a single item to multiple bidders. Extending this auction to simultaneously selling multiple heterogeneous items has been one of the central problems in Mathematical Economics. We provide such an extension that is also computationally efficient. Our solution proposes a novel framework for mechanism design by reducing mechanism design problems (where one optimizes an objective function on "rational inputs") to algorithm design problems (where one optimizes an objective function on "honest inputs"). Our reduction is generic and provides a framework for many other mechanism design problems.

3.5 Economic Efficiency Requires Interaction

Shahar Dobzinski (Weizmann Institute – Rehovot, IL)

Joint work of Dobzinski, Shahar; Nisan, Noam; Oren, Sigal
Main reference S. Dobzinski, N. Nisan, S. Oren, "Economic Efficiency Requires Interaction," arXiv:1311.4721v1 [cs.GT], 2013.
URL http://arxiv.org/abs/1311.4721v1

We study the necessity of interaction between individuals for obtaining approximately efficient allocations. The role of interaction in markets has received significant attention in economic thinking, e.g. in Hayeks 1945 classic paper. We consider this problem in the framework of simultaneous communication complexity. We analyze the amount of simultaneous communication required for achieving an approximately efficient allocation. In particular, we consider two settings: combinatorial auctions with unit demand bidders (bipartite matching) and combinatorial auctions with subadditive bidders. For both settings we first show that non-interactive systems have enormous communication costs relative to interactive ones. On the other hand, we show that limited interaction enables us to find approximately efficient allocations.

3.6 Towards More Practical Linear Programming-based Techniques for Algorithmic Mechanism Design

Khaled Elbassioni (Masdar Institute – Abu Dhabi, AE)

Joint work of Elbassioni, Khaled; Ramezani, Fahimeh

Techniques based on linear programming, e.g., VCG-mechanism for fractional output sets and its extension to discrete output sets (Lavi and Swamy, 2005) for designing truthful(-in-expectation) mechanisms can be applied to many problems including combinatorial auctions. However, a direct implementation of these methods would be highly inefficient in practice, due to their reliance on general LP solvers, such as the Ellipsoid method. We investigate the possibility of using the much simpler and usually faster multiplicative weights update methods from convex optimization to speed-up these VCG- based techniques.

3.7 A unified approach to restricted complements

Michal Feldman (Tel Aviv University, IL)

Joint work of Feige, Uriel; Feldman, Michal; Immorlica, Nicole; Izsak, Rani; Lucier, Brendan; Syrgkanis, Vasilis

We study the efficiency of simultaneous single-item auctions when bidders have valuations that include restricted complementarities between items. We introduce and analyze a class of valuations that generalizes various notions of restricted complementarities, including supermodular degree recently introduced by Feige and Izsak (ECCC 2013), hypergraph valuations (Abraham et al. EC 2012), as well as monotone graphical valuations with positive

and negative weights (Acemoglu et al. 2012). For the introduced class of valuations, we show that the price of anarchy of simultaneous first-price item auctions is at most $2k$, where k describes the degree of complementarity. Our analysis proceeds via the smoothness framework, and therefore also applies to Bayesian equilibria and learning outcomes. Finally, we extend our results to the simultaneous composition of smooth mechanisms (e.g. simultaneous position auctions) under valuations that allow for restricted complements across mechanisms. One implication of this extension is that the price of anarchy of simultaneous second-price auctions is at most 2, for general bidder valuations, under a standard no- overbidding assumption.

3.8 Online price of anarchy for parking

Amos Fiat (Tel Aviv University, IL)

Joint work of Ardenboim, Alon; Cohen, Ilan; Colini-Baldeschi, Riccardo; Fiat, Amos

We show almost tight upper and lower bounds on the price of anarchy for parking in an unweighted line graph *sqrtn* and for arbitrary graphs.

3.9 Optimal Impartial Selection

Felix Fischer (University of Cambridge, GB)

Joint work of Fischer, Felix; Klimm, Max
Main reference F. Fischer, M. Klimm, "Optimal Impartial Selection," arXiv:1310.8631v1 [cs.GT], 2013.
URL http://arxiv.org/abs/1310.8631v1

We study the problem of selecting a member of a set of agents based on impartial nominations by agents from that set. The problem was studied previously by Alon et al. (TARK, 2011) and Holzman and Moulin (Econometrica, 2013) and has applications in situations where representatives are selected from within a group or where publishing or funding decisions are made based on a process of peer review. Our main result concerns a randomized mechanism that in expectation selects an agent with at least half the maximum number of nominations. Subject to impartiality, this is best possible.

3.10 Manipulation of Stable Matchings using Minimal Blacklists

Yannai A. Gonczarowski (The Hebrew Univ. of Jerusalem, IL)

Main reference Y. A. Gonczarowski, "Manipulation of Stable Matchings using Minimal Blacklists," arXiv:1307.7477v3 [cs.GT], 2013.
URL http://arxiv.org/abs/1307.7477v3

Gale and Sotomayor (1985) have shown that in the Gale-Shapley matching algorithm (1962), the proposed-to side W (referred to as women there) can strategically force the W-optimal stable matching as the M-optimal one by truncating their preference lists, each woman

possibly blacklisting all but one man. As Gusfield and Irving have already noted in 1989, no results are known regarding achieving this feat by means other than such preference- list truncation, i.e. by also permuting preference lists.

We answer Gusfield and Irving's open question by providing tight upper bounds on the amount of blacklists and their combined size, that are required by the women to force a given matching as the M-optimal stable matching, or, more generally, as the unique stable matching. Our results show that the coalition of all women can strategically force any matching as the unique stable matching, using preference lists in which at most half of the women have nonempty blacklists, and in which the average blacklist size is less than 1. This allows the women to manipulate the market in a manner that is far more inconspicuous, in a sense, than previously realized. When there are less women than men, we show that in the absence of blacklists for men, the women can force any matching as the unique stable matching without blacklisting anyone, while when there are more women than men, each to-be-unmatched woman may have to blacklist as many as all men. Together, these results shed light on the question of how much, if at all, do given preferences for one side a priori impose limitations on the set of stable matchings under various conditions. All of these results are constructive, providing efficient algorithms for calculating the desired strategies.

3.11 Optimal Competitive Auctions

Nick Gravin (Microsoft Research New England – Cambridge, US)

Joint work of Chen, Ning; Gravin, Nick; Lu, Pinyan
Main reference N. Chen, N. Gravin, P. Lu, "Optimal Competitive Auctions," arXiv:1401.0880v1 [cs.GT], 2013.
URL http://arxiv.org/abs/1401.0880v1

We study the design of truthful auctions for selling identical items in unlimited supply (e.g., digital goods) to n unit demand bidders. This classic problem stands out from profit-maximizing auction design literature as it requires no probabilistic assumptions on the buyers and employs the framework of competitive analysis. Our objective is to optimize the worst-case performance of an auction, measured by the ratio between a given benchmark and revenue generated by the auction.

We establish a sufficient and necessary condition that characterizes competitive ratios for all monotone benchmarks. The characterization identifies the worst-case distribution of instances and reveals intrinsic relations between competitive ratios and benchmarks in the competitive analysis. With the characterization at hand, we show optimal competitive auctions for two natural benchmarks.

The most well-studied benchmark measures the envy-free optimal revenue where at least two buyers win. Goldberg at el. (2004) have a sequence of lower bounds on the competitive ratio for each number of bidders n. They conjectured that all these bounds are tight. We show that optimal competitive auctions match these bounds. We confirm their conjecture and settle a central open problem in the design of digital goods auctions. As one more application we examine another economically meaningful benchmark, which measures the optimal revenue across all limited-supply Vickrey auctions. We identify optimal competitive ratios to be $(1 + 1/(n-1))^{(n-1)-1}$ for each number of buyers n, that is $e - 1$ as n goes to infinity.

3.12 Quantitative Comparative Statics for a Multimarket Paradox

Tobias Harks (Maastricht University, NL)

Joint work of Harks, Tobias; von Falkenhausen, Philipp
Main reference T. Harks, P. von Falkenhausen, "Quantitative Comparative Statics for a Multimarket Paradox," arXiv:1307.5617v3 [cs.GT] , 2013.
URL http://arxiv.org/abs/1307.5617v3

Comparative statics is a well established research field where one analyzes how changes in parameters of a strategic game affect the resulting equilibria. Examples of such parameter changes include tax or subsidy changes in oligopoly models or trade changes. While classic comparative statics is mainly concerned with qualitative approaches (e.g., deciding whether a parameter change improves or hurts equilibrium profits or welfare), we aim at quantifying this effect. We consider the famous multimarket oligopoly model introduced by Bulow, Geanakoplos and Klemperer. In this model, there are two firms competing on two markets with one firm having a monopoly on one market. Bulow et al. describe the counterintuitive example of a positive price shock in the firm's monopoly market resulting in a reduction of the firm's new equilibrium profit. We quantify for the first time the worst-case profit reduction for the case of two markets with affine price functions and firms with convex cost technologies. We show that the relative loss of the monopoly player is at most 25% no matter how many firms compete on the second market. In particular we show for the setting of Bulow et al. involving affine price functions and only one additional firm on the second market that the worst case loss in profit is bounded by 6.25%. We further investigate a dual effect: How much can a firm gain from a negative price shock in its monopoly market? Our results imply that this gain is at most 33%. We complement our bounds by concrete examples of markets where these bounds are attained.

3.13 Redesigning the Israeli Psychology Market

Avinatan Hassidim (Google Israel – Tel-Aviv, IL)

Joint work of Hassidim, Avinatan; Rom, Assaf

We present theoretical and practical issues that arose in the redesign process of the Israeli psychology market.

3.14 Designing Profit Shares in Coalition Formation Games

Martin Hoefer (Universität des Saarlandes, DE)

Joint work of Hoefer, Martin; Wagner, Lisa
Main reference M. Hoefer, L. Wagner, "Designing Profit Shares in Matching and Coalition Formation Games," in Proc. of the 9th Int'l Conf. on Web and Internet Economics (WINE'13), LNCS, Vol. 8289, pp. 249–262, Springer, 2013.
URL http://dx.doi.org/10.1007/978-3-642-45046-4_21

Matching and coalition formation are fundamental problems in many scenarios where agents join efforts to perform tasks, such as, e.g., in scientific publishing. To allocate credit or

profit stemming from a joint project, different communities use different crediting schemes in practice. A prominent approach is equal sharing, where every member receives the same credit for a joint work. It captures a natural egalitarian fairness condition when each member of a coalition is critical for success. Unfortunately, when coalitions are formed by rational agents, equal sharing can lead to high inefficiency of the resulting stable states. We study how to design profit shares to obtain good stable states in matching and coalition formation games. We relax equal sharing to sharing schemes where for each coalition each player is guaranteed to receive at least an α-share. Using such schemes we characterize the tension between efficiency and equal treatment, and provide polynomial-time algorithms for their computation.

3.15 Privacy-Preserving Auctions

Zhiyi Huang (Stanford University, US)

Joint work of Hsu, Justin; Huang, Zhiyi; Roth, Aaron; Roughgarden, Tim; Wu, Zhiwei Steven
Main reference J. Hsu, Z. Huang, A. Roth, T. Roughgarden, Z. S. Wu, "Private Matchings and Allocations," arXiv:1311.2828v1 [cs.GT], 2013.
URL http://arxiv.org/abs/1311.2828v1

We consider a private variant of the classical allocation problem: given m goods and n agents with individual, private valuation functions over bundles of goods, how can we partition the goods amongst the agents to maximize social welfare? Specifically, the valuation functions are sensitive information which the agents wish to keep private from arbitrary coalitions of other agents. An important special case is when each agent desires at most one good, and specifies her (private) value for each good: in this case, the problem is exactly the maximum-weight matching problem in a bipartite graph.

Private matching and allocation problems have not been considered in the differential privacy literature, and for good reason: they are plainly impossible to solve under the standard notion of differential privacy. Informally, the allocation must match agents to preferred goods in order to maximize social welfare, but this preference is exactly what agents wish to keep private! Therefore, we consider the problem under the recently introduced constraint of joint differential privacy: roughly, for any agent i, no coalition of agents excluding i should be able to learn about the valuation function of agent i. We first show that if there are a small number of identical copies of each good, then it is possible to efficiently and accurately solve the maximum weight matching problem while guaranteeing joint differential privacy. We then extend our techniques to the more general allocation problem, when bidder valuations satisfy the gross substitutes condition. Finally, we prove lower bounds demonstrating that the problem cannot be privately solved to non-trivial accuracy without requiring multiple copies of each type of good.

3.16 Duality and optimality of auctions for the uniform distribution

Elias Koutsoupias (University of Oxford, GB)

We derive exact optimal solutions for the problem of optimizing revenue in single-bidder multi-items auctions for i.i.d. uniform distribution valuations. We give optimal auctions of

up to 6 items; previous results were only known for two items. To do so, we develop a general duality framework for the problem of maximizing revenue in many-bidders multi-item additive Bayesian auctions. The framework extends linear programming duality and complementarity to constraints with partial derivatives. The dual system reveals the geometric nature of the problem and highlights its connection with the theory of bipartite graph matchings. It is used both for deriving the optimal auction, which happens to be deterministic, and for proving optimality.

3.17 Characterization of SMON mechanisms with additive valuations over the real domain

Annamaria Kovacs (Goethe-Universität Frankfurt am Main, DE)

Joint work of Christodoulou, Giorgos; Kovacs, Annamaria; Vidali, Angelina

We are interested in the limits of characterizability of mechanisms with multi-dimensional, additive player-valuations like unrelated scheduling or additive combinatorial auctions. We characterize decisive, strongly monotone mechanisms for two tasks or items as either task independent mechanisms or '(player-)grouping minimizer's, a generalization of affine minimizers. (Further assumptions are the continuity of the payment functions, and that the bids are arbitrary real values.) This is work in progress: we strongly conjecture that the results generalize to m tasks/items by inductive arguments. We present a general lemma implying the linearity of payment functions in regular cases.

3.18 Mechanisms for Multi-Unit Combinatorial Auctions with a Few Distinct Goods

Piotr Krysta (University of Liverpool, GB)

Joint work of Krysta, Piotr; Telelis, Orestis; Ventre, Carmine
Main reference P. Krysta, O. Telelis, C. Ventre, "Mechanisms for Multi-unit Combinatorial Auctions with a Few Distinct Goods," in Proc. of the 2013 Int'l Conf. on Autonomous Agents and Multi-Agent Systems (AAMAS'13), pp. 691–698, IFAAMAS, 2013.
URL http://dl.acm.org/citation.cfm?id=2485029

We design and analyze deterministic truthful approximation mechanisms for multi-unit combinatorial auctions with only a *constant* number of distinct goods, each in arbitrary limited supply. Prospective buyers (bidders) have preferences over *multisets* of items, i.e. for more than one unit per distinct good. Our objective is to determine allocations of multisets that maximize the Social Welfare. Despite the recent theoretical advances on the design of truthful combinatorial auctions (for several distinct goods) and multi-unit auctions (for a single good), results for the combined setting are much scarcer. Our main results are for *multi-minded* and *submodular* bidders. In the first setting each bidder has a positive value for being allocated one multiset from a prespecified *demand set* of alternatives. In the second setting each bidder is associated to a submodular valuation function that defines his value for the multiset he is allocated.

For multi-minded bidders we design a truthful FPTAS that *fully* optimizes the Social Welfare, while violating the supply constraints on goods within factor $(1+\epsilon)$ for any fixed $\epsilon > 0$ (i.e., the approximation applies to the constraints and not to the social welfare). This result is best possible, in that full optimization is impossible without violating the supply constraints. It also improves significantly upon a related result of Grandoni *et al.* [SODA 2010]. For submodular bidders we extend a general technique by Dobzinski and Nisan [JAIR, 2010] for multi-unit auctions, to the case of multiple distinct goods. We use this extension to obtain a PTAS that approximates the optimum social welfare within factor $(1+\epsilon)$ for any fixed $\epsilon > 0$, without violating the supply constraints. This result is best possible as well. Our allocation algorithms are *Maximum-in-Range* and yield truthful mechanisms when paired with Vickrey-Clarke-Groves payments.

3.19 Prior-free Auctions with Ordered Bidders

Stefano Leonardi (University of Rome "La Sapienza', IT)

Joint work of Bhattacharya, Sayan; Koutsoupias, Elias; Kulkarni, Janardhan; Leonardi, Stefano; Roughgarden, Tim; Xu, Xiaoming
Main reference S. Bhattacharya, E. Koutsoupias, J. Kulkarni, S. Leonardi, T. Roughgarden, X. Xu, "Near-optimal Multi-unit Auctions with Ordered Bidders," in Proc. of the 14th ACM Conf. on Electronic Commerce (EC'13), pp. 91–102, ACM, 2013.
URL http://doi.acm.org/10.1145/2482540.2482555

Auctions are traditionally evaluated in economics theory using average-case or Bayesian analysis, and expected auction performance is optimized with respect to a prior distribution over inputs. Worst-case guarantees are desirable when, for example, good prior information is expensive or impossible to acquire, and when a single auction is to be re-used several times, in settings with different or not-yet-known input distributions. In this talk, we present prior-free auctions with constant-factor approximation guarantees in both unlimited and limited supply that also apply to a relevant case of non identical bidders. These auctions are simultaneously near-optimal in a wide range of Bayesian multi-unit environments when compared against the performance of Myerson optimal bayesian auction.

3.20 Implementing the "Wisdom of the Crowd"

Yishay Mansour (Tel Aviv University, IL)

Joint work of Ilan, Kremer; Mansour, Yishay; Motty, Perry
Main reference I. Kremer, Y. Mansour, M. Perry, "Implementing the "Wisdom of the Crowd"," in Proc. of the 14th ACM Conf. on Electronic Commerce (EC'13), pp. 605–606, ACM, 2013.
URL http://doi.acm.org/10.1145/2482540.2482542

We study a novel mechanism design model in which agents each arrive sequentially and choose one action from a set of actions with unknown rewards. The information revealed by the principal affects the incentives of the agents to explore and generate new information. We characterize the optimal disclosure policy of a planner whose goal is to maximize social welfare. One interpretation of our result is the implementation of what is known as the "wisdom of the crowd". This topic has become increasingly relevant with the rapid spread of the Internet over the past decade.

3.21 Deferred Acceptance Auctions

Paul Milgrom (Stanford University, US)

Joint work of Milgrom, Paul; Segal, Ilya

We study auctions in which allocations are decided by an iterative process of rejecting the least attractive remaining bids. These *deferred-acceptance heuristic auctions* have distinctive properties that make them attractive for applications in computationally challenging environments. Deferred acceptance *threshold* auctions are group strategy-proof, can be implemented using clock auctions, and are outcome-equivalent in our complete-information model to paid-as-bid auctions based on the same heuristic. Paid-as-bid auctions based on such heuristics are dominance solvable, and every non-bossy dominance-solvable paid-as-bid auction is a deferred-acceptance heuristic auction. None of these properties are shared by auctions based on optimization or greedy-acceptance heuristics.

3.22 Plasticity, Monotonicity and Implementability

Rudolf Mueller (Maastricht University, NL)

Joint work of Carbajal, Juan Carlos; Mueller, Rudolf

Consider a setting in which agents have quasilinear utilities over money and social alternatives. The set of alternatives can be finite or infinite. A domain D of admissible valuation functions of an agent is called a 2-cycle (3-cycle) monotonicity domain if every 2-cycle (3-cycle) monotone allocation rule defined on D is truthfully implementable in dominant strategies. It is called a revenue equivalence domain if every truthfully implementable allocation rule defined on D satisfies the revenue equivalence property. We introduce the notions of weak and strong plasticity, and prove that (i) every weak plasticity domain is a 3-cycle monotonicity and revenue equivalence domain; and (ii) very strong plasticity domain is a 2-cycle monotonicity and revenue equivalence domain. Our proof is elementary and does not rely on strenuous additional machinery. We also show various economic environments, with countable or uncountable allocations, in which weak and strong plasticity are satisfied.

3.23 Revenue Maximization with Sampling

Noam Nisan (The Hebrew University of Jerusalem, IL)

Recent work in revenue-maximizing mechanism design has pursued, from an algorithmic perspective, multi-parameter extensions to Myerson's optimal single item auction. Much progress has been made, though much of it makes strong assumptions on the representation and/or structure of distributions from which players' values are drawn. We examine the single- buyer unit-demand mechanism design problem in its most general form, where the buyers' value distribution is presented as a "black box." We seek to understand the extent to

which revenue-maximizing mechanism design is possible in this general setting, and begin an exploration of the description complexity, sample complexity, and computational complexity of approximately revenue-maximizing auctions in the black-box model.

3.24 Dynamic Models of Reputation and Competition in Job-Market Matching

Sigal Oren (The Hebrew University of Jerusalem, IL)

Joint work of Kleinberg, Jon; Oren, Sigal

A fundamental decision faced by a firm hiring employees – and a familiar one to anyone who has dealt with the academic job market, for example – is deciding what caliber of candidates to pursue. Should the firm try to increase its reputation by making offers to higher-quality candidates, despite the risk that the candidates might reject the offers and leave the firm empty-handed? Or is it better to play it safe and go for weaker candidates who are more likely to accept the offer? The question acquires an added level of complexity once we take into account the effect one hiring cycle has on the next: hiring better employees in the current cycle increases the firm's reputation, which in turn increases its attractiveness for higher-quality candidates in the next hiring cycle. These considerations introduce an interesting temporal dynamic aspect to the rich line of research on matching models for job markets, in which long-range planning and evolving reputational effects enter into the strategic decisions made by competing firms.

We develop a model that captures these effects in a setting where two firms repeatedly compete for job candidates over multiple periods. Within this model, we attempt to estimate the effect that reasoning about future hiring cycles has on the efficiency of the job market: do people end up unnecessarily unemployed while the firms compete over the top candidates, or does the evolution of reputation over time eventually converge to a two-tiered system in which the firms each target different parts of the market?

3.25 Matchings, Vertex Cover und Network Bargaining Games

Britta Peis (RWTH Aachen, DE)

In an instance of the classical, cooperative *matching game* introduced by Shapley and Shubik [Int. J. Game Theory '71] we are given an undirected graph $G = (V, E)$, and we define the value $\nu(S)$ of each subset $S \subseteq V$ as the cardinality of a maximum matching in the subgraph $G[S]$ induced by S. The *core* of such a game contains all *fair* allocations of $\nu(V)$ among the players of V, and is well-known to be non-empty iff graph G is *stable*. G is stable if its inessential vertices (those that are exposed by at least one maximum matching) form a stable set.

In this paper we study the following natural edge-deletion question: given a graph $G = (V, E)$, can we find a minimum-cardinality *stabilizer*? I.e., can we find a set F of edges whose removal from G yields a stable graph?

We show that this problem is vertex-cover hard. We then prove that there is a minimum-cardinality stabilizer that avoids some maximum-matching of G. We employ this insight to give efficient approximation algorithms for sparse graphs, and for regular graphs.

3.26 Learning Equilibria of Games via Payoff Queries

Rahul Savani (University of Liverpool, GB)

Joint work of Fearnley, John; Gairing, Martin; Goldberg, Paul; Savani, Rahul
Main reference J. Fearnley, M. Gairing, P. Goldberg, R. Savani, "Learning Equilibria of Games via Payoff Queries," arXiv:1302.3116v3 [cs.GT], 2013.
URL http://arxiv.org/abs/1302.3116v3

We study a computational learning model for games in which an algorithm queries the payoffs of players at pure strategy profiles. The goal of the algorithm is to find an exact or approximate Nash equilibrium of the game with as few queries as possible. We give basic results on the payoff query complexity of bimatrix and graphical games. We then focus on symmetric network congestion games. For directed acyclic networks, we can learn the cost functions (and hence compute an equilibrium) while querying just a small fraction of pure-strategy profiles. For the special case of parallel links, we have the stronger result that an equilibrium can be identified while only learning a small fraction of the cost values.

3.27 Non Adaptive Methods for Adaptive Seeding

Yaron Singer (Harvard University, US)

Joint work of Badanidiyuru, Ashwin; Lattanzi, Silvio; Papadimidtriou, Christos; Rubinstein, Aviad; Seeman, Lior

Adaptive seeding is a two-stage stochastic optimization framework recently developed for information dissemination in social networks. The goal is to optimize a combinatorial function by making an initial decision that affects the realizations selected by nature. Beyond information dissemination in networks other interesting applications are in machine learning and operations research. In this talk we will discuss several optimization techniques for adaptive seeding as well as results in social network analysis that motivate this approach.

3.28 Cost-Recovering Bayesian Algorithmic Mechanism Design

Balasubramanian Sivan (Microsoft Research – Redmond, US)

Joint work of Fu, Hu; Lucier, Brendan; Sivan, Balasubramanian; Syrgkanis Vasilis
Main reference H. Fu, B. Lucier, B. Sivan, V. Syrgkanis, "Cost-Recovering Bayesian Algorithmic Mechanism Design," arXiv:1305.0598v1 [cs.GT], 2013.
URL http://arxiv.org/abs/1305.0598v1

Consider a group of participants competing to receive service from a mechanism that can provide such services at a cost. The mechanism aims to serve agents to maximize social

efficiency, without suffering an expected loss: the agent's payments should cover the service cost in expectation. We develop a general method for converting arbitrary approximation algorithms for the underlying optimization problem into Bayesian incentive compatible mechanisms that are cost-recovering in expectation.

3.29 Composable and Efficient Mechanisms

Éva Tardos (Cornell University, US)

Joint work of Syrgkanis,Vasilis; Tardos, Éva
Main reference V. Syrgkanis, É. Tardos, "Composable and Efficient Mechanisms," arXiv:1211.1325v1 [cs.GT], 2012.
URL http://arxiv.org/abs/1211.1325v1

In this talk, we consider auctions as games, and we discuss how to analyze such games providing robust guarantees for their performance even when players participate in multiple auctions, have valuations that are complex functions of multiple outcomes, and are using learning strategies to deal with an uncertain environment.

3.30 An Optimal Online Algorithm for Weighted Bipartite Matching and Extensions to Packing Linear Programs

Andreas Toennis (RWTH Aachen, DE)

Joint work of Thomas, Kesselheim; Klaus, Radke; Tönnis, Andreas; Berthold, Vöcking
Main reference T. Kesselheim, K. Radke, A. Tönnis, B. Vöcking, "An Optimal Online Algorithm for Weighted Bipartite Matching and Extensions to Combinatorial Auctions," in Proc. of the 21st Annual European Symp. on Algorithms (ESA'13), LNCS, Vol. 8125, pp. 589–600, Springer, 2013.
URL http://dx.doi.org/10.1007/978-3-642-40450-4_50

We present an e-competitive algorithm for online weighted bipartite matching in the random order model. In this model a bipartite edge-weighted graph is given by an adversary. The vertices on the right-hand side are given in advance, while the left-hand side vertices arrive online in a random order. Whenever a vertex arrives his adjacent edges with the corresponding weights are revealed and the online algorithm has to decide which of these edges should be included in the matching.

Furthermore we extend the approach to packing linear programs. Here the capacity vector is given in advance and columns, thus variables, arrive in a random order. With every variable, its contribution to the target function and its consumption of resources is revealed. In this setting we also provide an optimal algorithm that is $1 - O\big(\sqrt{(1+\log d)/\epsilon^2}\big)$-competitive where d is the maximal number of non-zero entries in a column. This algorithm can be turned into a truthful mechanism using VCG payments. Additionally the algorithm is not based on a primal-dual approach but solely depends on the primal solution and therefore it can be combined with any approximation algorithm.

3.31 Local computation mechanism design

Shai Vardi (Tel Aviv University, IL)

Joint work of Hassidim, Avinatan; Mansour, Yishay; Vardi, Shai
Main reference A. Hassidim, Y. Mansour, S. Vardi, "Local computation mechanism design," arXiv:1311.3939v1 [cs.GT], 2013.
URL http://arxiv.org/abs/1311.3939v1

We introduce the notion of Local Computation Mechanism Design – designing game theoretic mechanisms which run in polylogarithmic time and space. Local computation mechanisms reply to each query in polylogarithmic time and space, and the replies to different queries are consistent with the same global feasible solution. In addition, the computation of the payments is also done in polylogarithmic time and space. Furthermore, the mechanisms need to maintain incentive compatibility with respect to the allocation and payments.

We present local computation mechanisms for a variety of classical game- theoretical problems: (1) stable matching, (2) job scheduling, (3) combinatorial auctions for unit-demand and k-minded bidders, and (4) the housing allocation problem.

For stable matching, some of our techniques may have general implications. Specifically, we show that when the men's preference lists are bounded, we can achieve an arbitrarily good approximation to the stable matching within a fixed number of iterations of the Gale-Shapley algorithm.

3.32 Algorithms for Strategic Agents II

S. Matthew Weinberg (MIT, US)

Joint work of Cai, Yang; Daskalakis, Constantinos; Weinberg, S. Matthew
Main reference Y. Cai, C. Daskalakis, S. M. Weinberg, "Understanding Incentives: Mechanism Design becomes Algorithm Design," arXiv:1305.4002v1 [cs.GT], 2013.
URL http://arxiv.org/abs/1305.4002v1

We provide a computationally efficient black-box reduction from mechanism design to algorithm design. Specifically, we give an approximation-preserving reduction from truthfully optimizing any objective with arbitrary bidder types to algorithmically optimizing the same objective plus virtual welfare. Furthermore, we extend the reduction to accommodate a bi-criterion approximation algorithm that we call (α, β)-approximations. We apply our framework to obtain the following results:

1. This reduction is tight for revenue. That is, we also give an approximation-sensitive reduction from optimizing virtual welfare algorithmically to optimizing revenue truthfully.
2. As an application of 1), it is NP-hard to approximately maximize revenue for a single monotone submodular bidder within any poly(# items) factor.
3. A 10.5-approximate truthful mechanism for minimizing makespan on unrelated machines.

3.33 Utility-Target Auctions

Christopher A. Wilkens (Yahoo Labs – Sunnyvale, US)

Joint work of Hoy, Darrell; Jain, Kamal; Wilkens, Christopher A.
Main reference D. Hoy, K. Jain, C. A. Wilkens, "A Dynamic Axiomatic Approach to First-Price Auctions," arXiv:1304.7718v1 [cs.GT], 2013.
URL http://arxiv.org/abs/1304.7718v1

The first-price auction is popular in practice for its simplicity and transparency. Moreover, its potential virtues grow in complex settings where incentive compatible auctions may generate little or no revenue. Unfortunately, generalizing the first-price auction has proven fragile in theory and practice.

We show that the auctioneer's choice of bidding language is critical when generalizing beyond the single-item setting, and we propose a specific construction called the utility-target auction that performs well. The utility- target auction includes a bidder's final utility as an additional parameter, identifying the single dimension along which she wishes to compete. This auction is closely related to profit-target bidding in first-price and ascending proxy package auctions and gives strong performance guarantees for a variety of complex auction environments.

We also take a dynamic approach to studying pay-your-bid auctions: rather than basing performance guarantees solely on static equilibria, we study the repeated setting and show that robust performance guarantees may be derived from simple axioms of bidder behavior. For example, as long as a loser raises her bid quickly, a standard first-price auction will generate at least as much revenue as a second-price auction. We generalize such ideas to complex pay-your-bid auctions through the utility-target auction: as long as losers do not wait too long to raise bids, a first-price auction will reach an envy-free state that implies a strong lower-bound on revenue; as long as winners occasionally experiment by lowering their bids, the outcome will near the boundary of this envy-free set so bidders do not overpay; and when players with the largest payoffs are the least patient, bids converge to the egalitarian equilibrium. Significantly, bidders need only know whether they are winning or losing in order to implement such behavior.

3.34 A Unified Approach to Truthful Scheduling on Related Machines

Rob van Stee (University of Leicester, GB)

Joint work of Epstein, Leah; Levin, Asaf; van Stee, Rob
Main reference L. Epstein, A. Levin, R. van Stee, "A unified approach to truthful scheduling on related machines," arXiv:1207.3523v1 [cs.DS] , 2012.
URL http://arxiv.org/abs/1207.3523v1

We present a unified framework for designing deterministic monotone polynomial time approximation schemes (PTAS's) for a wide class of scheduling problems on uniformly related machines. This class includes (among others) minimizing the makespan, maximizing the minimum load, and minimizing the p-norm of the machine loads vector. Previously, this kind of result was only known for the makespan objective. Monotone algorithms have the property that an increase in the speed of a machine cannot decrease the amount of work assigned to it. The key idea of our novel method is to show that for goal functions that

are sufficiently well-behaved functions of the machine loads, it is possible to compute in polynomial time a highly structured nearly optimal schedule. An interesting aspect of our approach is that, in contrast to all known approximation schemes, we avoid rounding any job sizes or speeds throughout. We can therefore find the exact best structured schedule using dynamic programming. The state space encodes a sufficient amount of information such that no postprocessing is needed, allowing an elegant and relatively simple analysis without any special cases. The monotonicity is a consequence of the fact that we find the best schedule in a specific collection of schedules. Monotone approximation schemes have an important role in the emerging area of algorithmic mechanism design. In the game-theoretical setting of these scheduling problems there is a social goal, which is one of the objective functions that we study. Each machine is controlled by a selfish single-parameter agent, where its private information is its cost of processing a unit sized job, which is also the inverse of the speed of its machine. Each agent wishes to maximize its own profit, defined as the payment it receives from the mechanism minus its cost for processing all jobs assigned to it, and places a bid which corresponds to its private information. For each one of the problems, we show that we can calculate payments that guarantee truthfulness in an efficient manner. Thus, there exists a dominant strategy where agents report their true speeds, and we show the existence of a truthful mechanism which can be implemented in polynomial time, where the social goal is approximated within a factor of $1 + \epsilon$ for every $\epsilon > 0$.

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