CWI

Workshop on
Advances in Algorithmic Game Theory

CWI Amsterdam, The Netherlands
September 2–3, 2010

Program: Thursday, September 2, 2010

9:50–10:00 **Opening**

INVITED TALK

10:00–11:00 **Tim Roughgarden (Stanford University, USA)**
Smoothness arguments and the price of anarchy

Abstract: The price of anarchy is a measure of the inefficiency of decentralized behavior that has been successfully analyzed in many systems. It is defined as the worst-case ratio between the welfare of an equilibrium and that of an optimal solution. Seemingly, a bound on the price of anarchy is meaningful only if players successfully reach an equilibrium. Our main result is that for most of the classes of games in which the price of anarchy has been studied, results are "intrinsically robust" in the following sense: a bound on the worst-case price of anarchy for equilibria *necessarily* implies the exact same worst-case bound for a much larger set of outcomes, such as the possible sequences generated by no-regret learners. We also describe recent applications to the analysis of Bayes-Nash equilibria in (non-truthful) mechanisms, and a "local" refinement of the framework that yields tight bounds on the price of anarchy in atomic splittable congestion games.

11:00–11:20 **Coffee break**

CONTRIBUTED TALKS

11:20–11:45 **Constantinos Daskalakis (MIT, USA)**
Geometrically embedded local search

Abstract: Recent work has shown that finding a mixed Nash equilibrium in normal form games is PPAD-complete, while the pure Nash equilibrium problem in congestion games is PLS-complete. Nevertheless, there are important classes of games, e.g. simple stochastic games, and fixed point problems, e.g. fixed points of contraction maps, that appear easier. For these problems the PPAD and PLS machinery seems inappropriate to provide an accurate complexity theoretic characterization; at the same time, polynomial time algorithms have been evading researchers for decades. We provide complexity theoretic machinery that could lead to completeness results at the interface of PPAD and PLS, in the form of geometrically embedded local search.

11:45–12:10 **Tobias Harks (Technical University Berlin, Germany)**
Pure Nash equilibria and potential functions in weighted congestion games

Abstract: It is well known that weighed congestion games need not possess pure Nash equilibria (PNE) even for simple two-player instances involving polynomial cost functions. Only for affine and exponential cost functions, the existence of PNE is guaranteed, because such games are potential games. In this talk, I will present recent work (with Max Klimm and Rolf H. Moehring) on structural characterizations of cost functions guaranteeing the existence of potential functions and PNE.

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12:10–12:35 **Martin Hoefer (RWTH Aachen University, Germany)**
Coalitions and dynamics in network routing games

Abstract: Congestion games are an elegant model to study the effects of resource usage and routing with strategic agents, but due to their simplicity they are inadequate to realistically model many features of traffic in computer and/or road networks. In my talk I survey our recent results on stability and convergence in extensions of congestion games towards more realistic modeling of network routing scenarios. Our results characterize the existence and computational complexity of exact and approximate pure-strategy Nash and strong equilibria. In addition, we study the more demanding goal of reaching equilibria using decentralized protocols and bound the duration of resulting improvement dynamics. More fundamentally, our treatment sheds light on the tractability of coordinated behavior of players in network routing.

12:35–13:00 **Evangelos Markakis (Athens University of Economics and Business, Greece)**
Coalition formation and price of anarchy in Cournot oligopolies

Abstract: We define a model of a coalition formation process that can be applied on top of a noncooperative game. Hence, agents can explore one extra dimension in the pursuit of their strategic goals, the possibility of forming coalitions with other agents. We analyze the implications of such considerations in oligopolistic markets where collusion arises in practice. In particular, we focus on the class of linear and symmetric Cournot oligopoly games, and we study the nature of stable coalition structures, i.e., partitions where no profitable deviation exists according to the rules of our coalition formation process. We prove that the ratio between the social welfare of the worst stable partition and the optimum social welfare is $\Theta(n^{2/5})$, where n is the number of firms that participate in the market. We denote this ratio as the price of anarchy of the dynamic Cournot coalition formation game and we note that this implies a significant improvement over the actual price of anarchy of Cournot oligopolies which is known to be $\Theta(n)$. Notably, we show that all results are robust even under weak (no-regret) behavioral assumptions.

13:00–14:00 **Lunch break**

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INVITED TALK

14:00–15:00 **Michal Feldman (Hebrew University of Jerusalem, Israel)**
Truth and justice: envy-freeness, truthfulness and the interplay between them

Abstract: The talk focuses on mechanisms for an allocation of objects among agents, where agents have no incentive to lie about their true values (incentive-compatible) and for which no agent will seek to exchange outcomes with another (envy-free). Mechanisms satisfying each requirement separately have been studied extensively, but there are few results on mechanisms achieving both. We give a general characterization of allocations that admit payments such that the resulting mechanism is simultaneously incentive-compatible and envy-free, and discuss the implications of the given characterization. In addition to general settings, we touch on special cases such as auctions with additive valuations and limited capacities. Here we show that for homogeneous capacities VCG is envy-free, incentive compatible and have no positive transfers. In contrast, for heterogeneous capacities, there is no mechanism meeting all requirements. Finally, we discuss envy-free mechanisms for assigning tasks to agents, where every task may take a different amount of time to perform by each agent, and the goal is to minimize the makespan.
The talk is based on several papers that are joint with Edith Cohen, Amos Fiat, Haim Kaplan and Svetlana Olonetzky.

15:00–15:20 **Coffee break**

CONTRIBUTED TALKS

15:20–15:45 **Ahuva Mu'alem (California Institute of Technology, USA)**
On scheduling mechanisms: theory, practice and pricing

Abstract: Markets of computing resources typically consist of computational jobs that request computing resources in exchange for payment. A mechanism in this context consists of a scheduling algorithm and a pricing policy. Intuitively, the mechanism needs to solve an optimization problem with game-theoretical binding constraint. (1) We start with a theoretical impossibility result showing the inapproximability of randomized dominant-strategy mechanisms for a natural scheduling problem on unrelated-machines (formulated as a mechanism design problem in the seminal paper of Nisan and Ronen). (2) We then briefly discuss individually-fair mechanisms. The challenge here is solving optimization problems with the binding constraint that *every* user gets a fair share of the resources with respect to her contribution or consumption. (3) We then briefly present a simulation-based results to explore the effects of: users' behavior on the (i) quality of service, (ii) the profit of the service provider and (iii) utility of the users. To study all this aspects simultaneously, we designed several simple one-shot games and showed that there are unique pure symmetric Nash equilibria in each of these restricted games.
Joint work with: Lior Amar, Amnon Barak, Michael Schapira and Sergei Shudler.

15:45–16:10 **Rob van Stee (MPI for Informatics, Germany)**
Truthful approximations for machine covering

Abstract: A classical fairness measure is the so-called max-min fairness. In terms of machine scheduling, we aim to maximize the minimum load over all the machines. In this talk, we discuss the problem of optimizing this fairness measure in the context of selfish related machines, where each machine has a private speed and is only interested in maximizing its own benefit.

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16:10–16:35 **Rene van den Brink (VU University Amsterdam, The Netherlands)**
Cooperative games with a permission structure: axiomatization and computation of solutions

Abstract: In a 'standard' cooperative TU-game it is assumed that every subset of the player set can form a feasible coalition and earn its worth. In the literature several appoaches to restrictions in coalition formation are studied. Here we focus on some approaches where these restrictions arise from some hierarchical structure on the player set. In a game with a permission structure the players are hierarchically ordered in the sense that there are players that need permission from other players before they are allowed to cooperate. The sets of feasible coalitions that arise are antimatroids. Besides finding axiomatizations of solutions for these classes of games, in order to apply these solutions it is also relevant to developed polynomial time algorithms to compute these solutions for (special classes of) these games.

16:35–17:00 **Piotr Krysta (University of Liverpool, UK)**
Combinatorial auctions with verification are tractable

Abstract: We study mechanism design for social welfare maximization in combinatorial auctions with general bidders given by demand oracles. It is a major open problem in this setting to design a deterministic truthful auction which would provide the best possible approximation guarantee in polynomial time, even if bidders are double-minded (i.e., they assign positive value to only two sets in their demand collection). On the other hand, there are known such randomized truthful auctions in this setting. In the general model of verification (i.e., some kind of overbidding can be detected) we design the first deterministic truthful auctions which indeed provide essentially the best possible approximation guarantees achievable by any polynomial-time algorithm. This shows that deterministic truthful auctions have the same power as randomized ones if the bidders withdraw from unrealistic lies.
This is joint work with Carmine Ventre.

19:30 **Workshop dinner (IJ-Kantine)**

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Program: Friday, September 3, 2010

INVITED TALK

10:00–11:00 **Jason Hartline (Nothwestern University, USA)**
Approximation in mechanism design

Abstract: This talk surveys three challenge areas for mechanism design and describes the role approximation plays in resolving them. Challenge 1: optimal mechanisms are parameterized by knowledge of the distribution of agent's private types. Challenge 2: optimal mechanisms require precise distributional information. Challenge 3: in multi-dimensional settings economic analysis has failed to characterize optimal mechanisms. The theory of approximation is well suited to address these challenges. While the optimal mechanism may be parameterized by the distribution of agent's private types, there may be a single mechanism that approximates the optimal mechanism for any distribution. While the optimal mechanism may require precise distributional assumptions, there may be approximately optimal mechanism that depends only on natural characteristics of the distribution. While the multi-dimensional optimal mechanism may resist precise economic characterization, there may be simple description of approximately optimal mechanisms. Finally, these approximately optimal mechanisms, because of their simplicity and tractability, may be much more likely to arise in practice, thus making the theory of approximately optimal mechanism more descriptive than that of (precisely) optimal mechanisms. The talk will cover positive resolutions to these challenges with emphasis on basic techniques, relevance to practice, and future research directions.

11:00–11:20 **Coffee break**

CONTRIBUTED TALKS

11:20–11:45 **Robert Kleinberg (Cornell University, USA)**
Bayesian algorithmic mechanism design in multi-dimensional settings

Abstract: We give a simple reduction that transforms any algorithm into a Bayesian incentive-compatible mechanism. The reduction preserves social welfare up to an additive loss that can be made arbitrarily small in polynomial time in the input size. Our reduction is applicable even in settings where the agents' types are multi-dimensional, provided that the type distributions are specified in one of the following ways: either the input specifies every type vector in the support of each agent's type distribution along with its associated probability, or we are provided with the ability to randomly sample from each agent's type distribution as well as the ability to evaluate the conditional expectation of any agent's utility given a fixed type vector in the support of its distribution.

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11:45–12:10 **Rudolf Müller (Maastricht University, The Netherlands)**
Path-monotonicity and incentive compatibility

Abstract: We study the role of monotonicity in the characterization of incentive compatible allocation rules when types are multi-dimensional, the mechanism designer may use monetary transfers, and agents have quasi-linear preferences over outcomes and transfers. It is well-known that monotonicity of the allocation rule is necessary for incentive compatibility. Furthermore, if valuations for outcomes are either convex or differentiable functions in types, revenue equivalence literature tells that path-integrals of particular vector fields are path-independent. For the special case of linear valuations it is known that monotonicity plus path-independence is sufficient for implementation. We show by example that this is not true for convex or differentiable valuations, and introduce a stronger version of monotonicity, called path-monotonicity. We show that path-monotonicity and path-independence characterize implementable allocation rules if (1) valuations are convex and type spaces are convex; (2) valuations are differentiable and type spaces are path-connected. Next we analyze conditions under which monotonicity is equivalent to path-monotonicity. We show that an increasing difference property of valuations ensures this equivalence. Next, we show that for simply connected type spaces incentive compatibility of the allocation rule is equivalent to path-monotonicity plus incentive compatibility in some neighborhood of each type. This result is used to show that on simply connected type spaces incentive compatible allocation rules with a finite range are completely characterized by path-monotonicity, and thus by monotonicity in cases where path-monotonicity and monotonicity are equivalent. This generalizes a theorem by Saks and Yu to a wide range of settings.

12:10–12:35 **Patrick Briest (University of Paderborn, Germany)**
Pricing lotteries

Abstract: Randomized mechanisms, which map a set of bids to a probability distribution over outcomes rather than a single outcome, are an important but ill-understood area of computational mechanism design. We investigate the role of randomized outcomes ("lotteries") in the context of a fundamental and archetypical multi-parameter mechanism design problem: selling heterogeneous items to unit-demand bidders. To what extent can a seller improve her revenue by pricing lotteries rather than items, and does this modification of the problem affect its computational tractability? We show that the answers to these questions hinge on the exact model of consumer behavior we deploy and present several tight bounds on the increase in revenue obtainable via randomization and the computational complexity of revenue maximization in these different models.
This is joint work with Shuchi Chawla, Bobby Kleinberg, and Matt Weinberg.

12:35–13:00 **Nicole Immorlica (Northwestern University, USA)**
Pricing information cascades

Abstract: We consider the problem of optimal pricing of a common-value product in the presence of social learning effects. A new product reaches the market and agents obtain private signals that partially inform them about the value of this product. Agents decide sequentially whether to purchase this product. Before making their own decisions, they also observe the purchasing decisions of agents who acted previously and learn from those actions in a Bayesian rational fashion. We address the problem of how a firm should price the product when taking social learning into account.
Our first result shows that firms do best asymptotically if the firm select prices that lead the customers to learn the true value of the product. We show how the firm can induce learning at a low cost by inducing a vanishing fraction of the agents to act according to their private signals. We also show a lower bound on the agents' regret of $T^{2/3}$ for a society of size T. We finally show a pricing policy that achieves this lower bound.
Joint work with Sham Kakade and Ilan Lobel.

13:00–14:00 **Lunch break**

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INVITED TALK

14:00–15:00 **Ioannis Caragiannis (University of Patras, Greece)**
Efficient coordination mechanisms for selfish scheduling

Abstract: In this talk, we present coordination mechanisms for scheduling selfish jobs on unrelated machines. A coordination mechanism aims to mitigate the impact of selfishness of jobs on the efficiency of schedules by defining a local scheduling policy on each machine. The scheduling policies induce a game among the jobs and each job prefers to be scheduled on a machine so that its completion time is minimum given the assignments of the other jobs. We consider the maximum completion time among all jobs as the measure of the efficiency of schedules. The approximation ratio of a coordination mechanism quantifies the efficiency of pure Nash equilibria (price of anarchy) of the induced game. The talk covers simple strongly local and non-preemptive coordination mechanisms as well as recent preemptive ones that achieve logarithmic or polylogarithmic (in terms of the number of the machines) approximation ratio. We also discuss several open problems.

15:00–15:20 **Coffee break**

CONTRIBUTED TALKS

15:20–15:45 **Giorgios Christodoulou (MPI for Informatics, Germany)**
Improving the price of anarchy for selfish routing via coordination mechanisms

Abstract: We reconsider the well-studied selfish routing game with affine latency functions. The price of anarchy for this class of games takes maximum value 4/3; this maximum is attained already for a simple network of two parallel links, known as Pigou's network. We improve upon the value 4/3 by means of coordination mechanisms.

15:45–16:10 **Orestis Telelis (INRIA Sophia-Antipolis, France)**
Discrete strategies in keyword auctions and their inefficiency for locally aware bidders

Abstract: We study formally two simple discrete bidding strategies in the context of iterative best response procedures, for the game induced by the Generalized Second Price keyword auction mechanism. These strategies have seen experimental evaluation in the recent literature as parts of best response procedures, which have been shown not to converge. Here we give a detailed definition of iterative best response under these strategies and, under appropriate discretization of the players' strategy spaces, we find that the best response state space contains socially optimal pure Nash equilibria of the original game (in continuous strategies). We cast the strategies under a new light, arguing that they constitute natural choices for conservative myopic bidders, that need to act based on local information only. For this case we provide bounds for the worst-case ratio of the social welfare of the reached locally stable states, relative to the socially optimum welfare. Finally, we make several interesting observations regarding convergence of the studied strategies, present related experimental evidence and discuss challenging open problems.
This is a joint work with Evangelos Markakis

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Stefano Leonardi (Sapienza University of Rome, Italy)
Combinatorial auctions with budgets

Abstract: We consider budget constrained combinatorial auctions where bidder i has a private value v_i for each of the items in some set S_i, agent i also has a budget constraint b_i. The value to agent i of a set of items R is $|R \cap S_i| \cdot v_i$. Such auctions capture adword auctions, where advertisers offer a bid for those adwords that (hopefully) reach their target audience, and advertisers also have budgets. It is known that even if all items are identical and all budgets are public it is not possible to be truthful and efficient. Our main result is a novel auction that runs in polynomial time, is incentive compatible, and ensures Pareto-optimality. The auction is incentive compatible with respect to the private valuations, v_i, whereas the budgets, b_i, and the sets of interest, S_i, are assumed to be public knowledge. This extends the result of Dobzinski et al. [FOCS 2008] for auctions of multiple identical items and public budgets to single-valued combinatorial auctions with public budgets.
Joint work with Amos Fiat, Jared Saia and Piotr Sankowski