2nd German Day on Computational Game Theory

February 10-11, 2015, Department of Mathematics, TU Berlin

Schedule

February 10, 2015, MA 212.

16:00—17:00	**RECEPTION**
17:00—18:00	**OPEN PROBLEMS SESSION**

February 11, 2015, MA 144.

10:00—10:30	**WELCOME AND COFFEE**
10:30—11:15	Invited talk **MARTIN GAIRING (U LIVERPOOL)** **Quantifying the Efficiency of Congestion Games**
11:20—11:40	Contributed talk **GUILLAUME SAGNOL (ZIB BERLIN)** **Stackelberg Spot-Checking Games and Nash Approximation**
11:45—12:05	Contributed talk **SASCHA KURZ (U BAYREUTH)** **Dimension of the European Union Council according to the Lisbon Treaty**
12:05—13:15	**LUNCH BREAK — MA 212**
13:15—13:35	Contributed talk **NIMROD TALMON (TU BERLIN)** **Multi-Player Diffusion Games on Graph Classes**
13:40—14:00	Contributed talk **BALASZ SZIKLAI (HUNGARIAN ACADEMY OF SCIENCES)** **Universal Characterization Sets for the Nucleolus**
14:00—14:15	**BREAK**
14:15—14:35	Contributed talk **PIOTR FALISZEWSKI (AGH U OF SCIENCE AND TECHNOLOGY)** **The Complexity of Combinatorial Campaign Management Problems in Elections**
14:40—15:00	Contributed talk **MAXIMILIAN DREES (U PADERBORN)** **On alpha-approximated Nash equilibria in standard budget games**
15:00—15:30	**COFFEE BREAK**
15:30—16:15	Invited talk **MATUS MIHALAK (ETH ZÜRICH)** **Network Creation Games**
16:20—16:40	Contributed talk **FIDAA ABED (MPII SAARBRÜCKEN)** **Optimal Coordination Mechanisms for Multi-Job Scheduling Games**
16:45—17:05	Contributed talk **PASCAL LENZNER (U JENA)** **Network Creation Games: Think Global — Act Local**
17:05—17:20	**BREAK**
17:20—17:40	Contributed talk **JIEHUA CHEN (TU BERLIN)** **Why Most European Parliaments Should Go Anglo-American**
17:45—18:05	Contributed talk **THERESA THUNIG (TU BERLIN)** **Designing speed limits for good traffic equilibria**
18:05—18:15	**CLOSING** **ANNOUNCEMENT OF 3RD GERMAN DAY OF COMPUTATIONAL GAME THEORY**
19:00	**DINNER** Restaurant ship “Käpt'n Schillow”, Straße des 17. Juni 113, 10623 Berlin

Detailed Program

MARTIN GAIRING (U LIVERPOOL) **10:00—10:30**
Quantifying the Efficiency of Congestion Games **MA 144**

During the last decade, the quantification of the inefficiency of game-theoretic equilibria has been a popular and successful line of research. The two most widely adopted measures for this inefficiency are the Price of Anarchy (PoA) and the Price of Stability (PoS).
In this talk I will summarise recent results on the PoA and PoS. The main focus will be on congestion games. Such games provide us with a fairly general model for the non-cooperative sharing of resources.
Both concepts compare the social cost in a Nash equilibrium to the optimum social cost that could be achieved via central control. The PoA is pessimistic and considers the worst-case such Nash equilibrium, while the PoS is optimistic and considers the best-case Nash equilibrium. Therefore, the PoA can be used as an absolute worst-case guarantee in a scenario where we have no control over equilibrium selection. On the other hand, the PoS gives an estimate of what is the best we can hope for in a Nash equilibrium; for example, if a trusted mediator suggest this solution to them.

GUILLAUME SAGNOL (ZUSE INSTITUTE BERLIN) **11:20—11:40**
Stackelberg Spot-Checking Games and Nash Approximation **MA 144**

The problem of optimizing the tours of toll inspectors in a transportation network can be formulated as a Stackelberg game, which has been studied by several authors in the recent years. In this class of"spot-checking games", the leader chooses inspection levels of the network edges — that correspond to feasible control tours — and the follower (who represents the set of network users) choose a multi-commodity flow over the network.
While this problem is equivalent to a hard bilevel programming problem, a Nash equilibrium strategy of spot-checking games can be computed by linear programming, and it has been observed that this strategy is usually very good for real-world instances. In general however, the Nash strategy can become arbitrarily bad for the Stackelberg game. The only known positive result on the "price of spite", which measures how the payoff of the inspector degrades when committing to a Nash equilibrium, concerns games in which toll fares are proportional to the length, and in which all edges of the network are "controllable" (that is, users have no alternative to the toll-network).
In this talk, I will present an overview of these results, and present different kind of instances that have a large "price of spite". I will conclude by presenting a set of equalities that can be added to the linear programming formulation, and that have the potential to "close the gap" for many instances.

SASCHA KURZ (U BAYREUTH) **11:45—12:05**
Dimension of the European Union Council according to the Lisbon Treaty **MA 144**

In this talk we prove that the voting system of the European Union Council according to the Lisbon Treaty can not be represented as the intersection of five or fewer weighted games, i.e., its dimension is at least six, which makes it the current record holder within the class of real-world voting systems. Using (heuristic) discrete optimization techniques we compute a representation as the intersection of a few thousand weighted games. The exact determination of the dimension of the present EU voting system is introduced as a challenging computational problem. The Boolean dimension is determined to be exactly three.

NIMROD TALMON (TU BERLIN) — **13:15—13:35**, **MA 144**
Multi-Player Diffusion Games on Graph Classes

We study competitive diffusion games on graphs introduced by Alon et al. (IPL 2010) to model the spread of influence in social networks. Extending results of Roshanbin (AAIM 2014) for two players, we investigate the existence of pure Nash-equilibria for at least three players on different classes of graphs including paths, cycles and grid graphs. As a main result, we answer an open question proving that there is no Nash-equilibrium for three players on $m \times n$ grids for m and n at least 5.

BALAZS SZIKLAI (HUNGARIAN ACADEMY OF SCIENCES) — **13:40—14:00**, **MA 144**
Universal Characterization Sets for the Nucleolus

Computing the nucleolus is a notoriously hard problem even NP-hard for some classes of games. While NP-hardness was proven for minimum cost spanning tree games (Faigle, Kern, and Kuipers, 1998), voting games (Elkind, Goldberg, Goldberg, and Wooldridge, 2009) and flow and linear production games (Deng, Fang, and Sun, 2009), it is still unknown whether the corresponding decision problem — i.e. verifying whether an allocation is the nucleolus or not — belongs to NP or not. Faigle, Kern, and Kuipers (1998) conjecture the decision problem: "given $x \in \mathbb{R}^n$, is x the nucleolus?" to be NP-hard in general.
In recent years several polynomial time algorithms were proposed to find the nucleolus of important families of cooperative games, like standard tree, assignment, matching and bankruptcy games (Maschler, Potters, and Reijnierse, 2010; Solymosi and Raghavan, 1994; Kern and Paulusma, 2003; Aumann and Maschler, 1985). In addition Kuipers (1996) showed that there exists an efficient algorithm to compute the nucleolus for convex games.
The main breakthrough came from another direction. In their seminal paper Maschler, Peleg, and Shapley (1979) described the geometric properties of the nucleolus, which became the basis of many future works. They also devised a computational framework in the form of a sequential linear program. Although this LP consists of exponentially many inequalities it can be solved eciently if one knows which constrains are redundant. Huberman (1980); Granot, Granot, and Zhu (1998); Reijnierse and Potters (1998) provided methods to identify coalitions that correspond to non-redundant constraints. Granot, Granot, and Zhu (1998) provided the most fruitful approach. They introduced the concept of characterization set which is a collection of coalitions that determines the nucleolus by itself. Granot, Granot, and Zhu (1998) proved that if the size of the characterization set is polynomially bounded in the number of players, then the nucleolus of the game can be computed in strongly polynomial time. A collection that characterizes the nucleolus in one game need not characterize it in another one. Thus we are interested in characterization sets that are universal, i.e. that yield the nucleolus in every TU-game. Huberman (1980) was the first to show that such a collection exists. He introduced the concept of essential coalitions which are coalitions that have no weakly minorizing partition. Granot, Granot, and Zhu (1998) provided another collection that characterize the nucleolus in cost games with non-empty cores. Saturated coalitions contain all the players that can join the coalition without imposing extra cost.
We introduce two new characterization sets: dually essential and dually saturated coalitions. We show that each dually inessential coalition has a weakly minorizing overlapping decomposition which consists exclusively of dually essential coalitions. Thus dually essential coalitions determine the core, and if the core is non-empty they determine the nucleolus as well. If every player contributes to the value of a coalition then such coalition is called dually saturated. We show that dually saturated coalitions also determine the core and the nucleolus of a TU-game.
The larger a characterization set is the easier to uncover it in a particular game class. However with smaller characterization set it comes a faster LP. Hence there is a tradeoff between the difficulty in identifying the members of a characterization set and its efficiency. In order to exploit this technique we analyze the relationship of the four known universal characterization sets. We prove that essential

coalitions are a subset of dually saturated coalitions in monotonic profit games and that dually essential coalitions are a subset of saturated coalition in case of monotonic cost games. We show that in general essential and dually essential coalitions do not contain each other. In fact for additive games their intersection is trivial (consist of the grand coalition only). We prove that if the grand coalition is vital then the intersection of essential and dually essential coalitions forms a characterization set itself.

PIOTR FALISZEWSKI (AGH U OF SCIENCE AND TECHNOLOGY) **14:15—14:35**
The Complexity of Combinatorial Campaign Management Problems in Elections **MA 144**

There is a number of algorithmic problems that model means of affecting election results. For example, in control problems the goal is to ensure some candidate's victory by adding/deleting voters or candidates, and in the shift bribery problem we want to ensure the victory of a given candidate by shifting his position in the preference orders of the voters. In these problems we assume that each action that we perform is independent from the others. For example, we can delete any (small enough) set of candidates of our choice, or we can shift our candidate in any of the votes that we like. In practice, however, these actions are not independent. For example, if a university hiring committee decides to not consider a candidate that does not have a good enough publication record, it has to disregard all the candidates with weaker records. In this talk, I will present three recent papers (coauthored with Robert Bredereck, Jiehua Chen, Rolf Niedermeier, and Nimrod Talmon), where we discuss how complexity of election campaign management and control problems change when we take such effects into account.

MAXIMILIAN DREES (U PADERBORN) **14:40—15:00**
On alpha-approximated Nash equilibria in standard budget games **MA 144**

Standard budget games are related to weighted congestion games with player-specific utility functions. Instead of a fixed weight for each player, we assign an individual weight to every strategy-resource combination. Every resource has a limited budget and as long as the total weight on a resource does not exceed this budget, the utility functions of the corresponding players are constant. Otherwise, the budget is shared proportionally. The focus of the talk is on alpha-approximated Nash equilibria, in which no player can improve her utility by a factor of more than alpha through a unilateral strategy change. We give both upper and lower bounds for alpha based on the largest single weight in the game. Additionally, we show a tight bound for the Price of Anarchy for these equilibria.

MATUS MIHALAK (ETH ZÜRICH) **15:30—16:15**
Network Creation Games **MA 144**

Network creation games model the affect of self-interested agents during the process of creating communication networks such as the Internet. Introduced in the early period of Algorithmic Game Theory by Fabrikant, Luthra, Maneva, Papadimitriou, and Shenker, the original game and its plentiful variants are omni-present in the current research. Main research questions are the existence of pure Nash equilibria, their structural properties, and the price of anarchy/stability of such games. The new variants are all motivated to reflect better the reality, but, mathematically, they often rely upon techniques developed for the original network creation games. Despite all this active research in the area, the main questions are still left open for the original network creation game. In this talk I will focus on the original network creation game, survey some of the main results, talk about the main open questions, and report on the latest progress of the efforts trying to answer them.

FIDAA ABED (MPII SAARBRÜCKEN) **16:20—16:40**
Optimal Coordination Mechanisms for Multi-Job Scheduling Games **MA 144**

We consider the unrelated machine scheduling game in which players control subsets of jobs. Each player's objective is to minimize the weighted sum of completion time of her jobs, while the social cost is the sum of players' costs. The goal is to design simple processing policies in the machines with small coordination ratio, i.e., the implied equilibria are within a small factor of the optimal schedule. We work with a weaker equilibrium concept that includes that of Nash.
We first prove that if machines order jobs according to their processing time to weight ratio, a.k.a. Smith-rule, then the coordination ratio is at most 4, moreover this is best possible among nonpreemptive policies. Then we establish our main result. We design a preemptive policy, *externality*, that extends Smith-rule by adding extra delays on the jobs accounting for the negative externality they impose on other players. For this policy we prove that the coordination ratio is $1+\phi \approx 2.618$, and complement this result by proving that this ratio is best possible even if we allow for randomization or full information. Finally, we establish that this externality policy induces a potential game and that an ε-equilibrium can be found in polynomial time. An interesting consequence of our results is that an ε-local optima of $R \mid \mid \sum w_j C_j$ for the jump (a.k.a. move) neighborhood can be found in polynomial time and are within a factor of 2.618 of the optimal solution. The latter constitutes the first direct application of purely game-theoretic ideas to the analysis of a well studied local search heuristic.

PACAL LENZNER (U JENA) **16:45—17:05**
Network Creation Games: Think Global — Act Local **MA 144**

Network Creation Games model the construction of a communication network by selfish agents without any external coordination. Agents are nodes in a network, which can buy incident edges to connect to other nodes. Each agent tries to occupy a central position in the network at minimum cost for building edges. It is well-known that equilibrium networks of these games have desirable properties like a small diameter and low social costs. However, the original model assumes that any node may buy a link to any other node in the network, independently of the distance in the network. Especially, when modelling large communication networks or social networks, this is a very unrealistic assumption since no agent may have complete knowledge of the overall network structure.
To overcome this issue, in a recently considered game variant Bilò et al. analyzed the effects of restricted view ranges under certain worst-case assumptions. We take their approach one step further by weakening those assumptions and providing a more natural model for locality in Network Creation Games.
(This is joint work with Andreas Cord-Landwehr)

JIEHUA CHEN (TU BERLIN) **17:20—17:40**
Why Most European Parliaments Should Go Anglo-American **MA 144**

We study computational problems for two popular parliamentary voting procedures: the amendment procedure and the successive procedure. While finding successful manipulations or agenda controls is tractable for both procedures, our real-world experimental results indicate that most elections cannot be manipulated by adding ”few” voters and agenda control is typically impossible. In contrast, if the voter preferences are incomplete, then finding possible winners is NP-hard for both procedures. Whereas finding necessary winners is coNP-hard for the amendment procedure, it is polynomial-time solvable for the successive procedure.

THERESA THUNIG (TU BERLIN) **17:45—18:05**

Designing speed limits for good traffic equilibria **MA 144**

Introducing speed limits on the streets of a network is a way to influence selfish behavior and control traffic. To model this, we consider a directed graph in which the latency of an edge experienced by travelers is a non-negative, non-decreasing, and continuous function of its congestion. Users want to travel from a source vertex s to a destination vertex t and are assumed to selfishly and non-cooperatively choose their minimum latency path. We analyze the quality of such a routing, which is given by the sum of all travel times, also called the total latency. It is well known that selfishly routing users do not minimize the total latency. Therefore, our goal is to slightly change latency functions by introducing speed limits on the edges of the network, such that the total latency of selfish routing improves.

The problem of finding optimal speed limits is related to other kinds of network design problems as edge removals (Roughgarden 2006) or taxes (Cole et al. 2006). In this talk I am going to compare the three network design variants regarding their possible benefit and inapproximability.