

Lecture Notes in Computer Science

10504

Commenced Publication in 1973

Founding and Former Series Editors:

Gerhard Goos, Juris Hartmanis, and Jan van Leeuwen

Editorial Board

David Hutchison, UK

Takeo Kanade, USA

Josef Kittler, UK

Jon M. Kleinberg, USA

Friedemann Mattern, Switzerland

John C. Mitchell, USA

Moni Naor, Israel

C. Pandu Rangan, India

Bernhard Steffen, Germany

Demetri Terzopoulos, USA

Doug Tygar, USA

Gerhard Weikum, Germany

Advanced Research in Computing and Software Science

Subline of Lecture Notes in Computer Science

Subline Series Editors

Giorgio Ausiello, *University of Rome ‘La Sapienza’, Italy*

Vladimiro Sassone, *University of Southampton, UK*

Subline Advisory Board

Susanne Albers, *TU Munich, Germany*

Benjamin C. Pierce, *University of Pennsylvania, USA*

Bernhard Steffen, *University of Dortmund, Germany*

Deng Xiaotie, *City University of Hong Kong*

Jeannette M. Wing, *Microsoft Research, Redmond, WA, USA*

More information about this series at <http://www.springer.com/series/7409>

Vittorio Bilò · Michele Flammini (Eds.)

Algorithmic Game Theory

10th International Symposium, SAGT 2017
L’Aquila, Italy, September 12–14, 2017
Proceedings



Springer

Editors

Vittorio Bilò
University of Salento
Lecce
Italy

Michele Flammini
University of L'Aquila
L'Aquila
Italy

ISSN 0302-9743

ISSN 1611-3349 (electronic)

Lecture Notes in Computer Science

ISBN 978-3-319-66699-0

ISBN 978-3-319-66700-3 (eBook)

DOI 10.1007/978-3-319-66700-3

Library of Congress Control Number: 2017950086

LNCS Sublibrary: SL3 – Information Systems and Applications, incl. Internet/Web, and HCI

© Springer International Publishing AG 2017

This work is subject to copyright. All rights are reserved by the Publisher, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, reuse of illustrations, recitation, broadcasting, reproduction on microfilms or in any other physical way, and transmission or information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed.

The use of general descriptive names, registered names, trademarks, service marks, etc. in this publication does not imply, even in the absence of a specific statement, that such names are exempt from the relevant protective laws and regulations and therefore free for general use.

The publisher, the authors and the editors are safe to assume that the advice and information in this book are believed to be true and accurate at the date of publication. Neither the publisher nor the authors or the editors give a warranty, express or implied, with respect to the material contained herein or for any errors or omissions that may have been made. The publisher remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Printed on acid-free paper

This Springer imprint is published by Springer Nature

The registered company is Springer International Publishing AG

The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

Preface

This volume contains the papers presented at the 10th International Symposium on Algorithmic Game Theory (SAGT 2017), which was held on September 12–14, 2017, in L’Aquila, Italy.

This year, we received a record number of 66 submissions. Each submission was reviewed by at least three Program Committee members. After a careful reviewing process, the committee decided to accept 30 papers. The program also included three invited talks by distinguished researchers in Algorithmic Game Theory: Michal Feldman (Tel-Aviv University), Martin Hoefer (Goethe University), and Nicole Immorlica (Microsoft Research).

To accommodate the publishing traditions of different fields, the authors of accepted papers could request that only a one-page abstract of the paper appears in the proceedings. Among the 30 accepted papers, the authors of 4 papers opted to publish a one-page abstract. The accepted submissions cover various important aspects of algorithmic game theory, such as auctions, computational aspects of games, congestion games, network and opinion formation, mechanism design, incentives and regret minimization, and resource allocation. The best paper award, generously supported by Springer, has been shared between the papers *Tight Welfare Guarantees for Pure Nash Equilibria of the Uniform Price Auction* by Georgios Birmpas, Evangelos Markakis, Orestis Telelis and Artem Tsikiridis, and *Online Random Sampling for Budgeted Settings* by Alon Eden, Michal Feldman and Adi Vardi.

We would like to thank all authors who submitted their research work, the Program Committee members, and the external reviewers who assisted them, for their wonderful work. We are indebted to the Gran Sasso Science Institute of L’Aquila, Fondazione Cassa di Risparmio della Provincia dell’Aquila, the Department of Mathematics and Physics “Ennio De Giorgi” of the University of Salento, EATCS, and Springer for their generous support. We thank Anna Kramer and Alfred Hoffmann at Springer for helping with the proceedings. We are grateful for the use of the EasyChair paper management system.

July 2017

Vittorio Bilò
Michele Flammini

Organization

Program Committee

Elliot Anshelevich	Rensselaer Polytechnic Institute (RPI), USA
Vittorio Bilò (Co-chair)	University of Salento, Italy
Ioannis Caragiannis	University of Patras, Greece
George Christodoulou	University of Liverpool, UK
Xiaotie Deng	Shanghai Jiao Tong University, China
Angelo Fanelli	CNRS, France
Michele Flammini (Co-chair)	University of L'Aquila and Gran Sasso Science Institute (GSSI), Italy
Dimitris Fotakis	National Technical University of Athens, Greece
Martin Gairing	University of Liverpool, UK
Paul Goldberg	University of Oxford, UK
Tobias Harks	Augsburg University, Germany
Thomas Kesselheim	TU Dortmund, Germany
Elias Koutsoupias	University of Oxford, UK
Stefano Leonardi	University of Rome “La Sapienza”, Italy
Marios Mavronicolas	University of Cyprus, Cyprus
Gianpiero Monaco	University of L'Aquila, Italy
Luca Moscardelli	University of Chieti-Pescara, Italy
Giuseppe Persiano	University of Salerno, Italy
Guido Proietti	University of L'Aquila and Institute for Systems Analysis and Computer Science (IASI-CNR), Italy
Amin Saberi	Stanford University, USA
Rahul Savani	University of Liverpool, UK
Guido Schaefer	CWI Amsterdam, The Netherlands
Alexander Skopalik	Heinz Nixdorf Institute and Paderborn University, Germany
Nicolas Stier-Moses	Torcuato Di Tella University, Argentina
Chaitanya Swamy	University of Waterloo, Canada
Vasilis Syrgkanis	Microsoft Research, USA
Marc Uetz	University of Twente, The Netherlands
Adrian Vetta	McGill University, Canada

Steering Committee

Elias Koutsoupias	University of Oxford, UK
Marios Mavronicolas	University of Cyprus, Cyprus
Dov Monderer	Technion, Israel
Burkhard Monien	Paderborn University, Germany
Christos Papadimitriou	UC Berkeley, USA

Giuseppe Persiano University of Salerno, Italy
Paul Spirakis (Chair) University of Liverpool, UK

Organizing Committee

Vittorio Bilò (Co-chair)	University of Salento, Italy
Michele Flammini (Co-chair)	University of L'Aquila and Gran Sasso Science Institute (GSSI), Italy
Gianlorenzo D'Angelo	Gran Sasso Science Institute (GSSI), Italy
Mattia D'Emidio	Gran Sasso Science Institute (GSSI), Italy
Gianpiero Monaco	University of L'Aquila, Italy
Luca Moscardelli	University of Chieti-Pescara, Italy
Cosimo Vinci	Gran Sasso Science Institute (GSSI), Italy

Additional Reviewers

Amanatidis, Georgios	Fischer, Felix	Lykouris, Thodoris
Baumeister, Dorothea	Freeman, Rupert	Maillé, Patrick
Bhaskar, Umang	Giannakopoulos, Yiannis	Malladi, Suraj
Bilò, Davide	Greco, Gianluigi	Mandal, Debmalya
Birmpas, Georgios	Gualà, Luciano	Manlove, David
Biro, Peter	Gur, Yonatan	Markakis, Evangelos
Carosi, Raffaello	Hajiaghayi, Mohammadtaghi	Peters, Dominik
Colini Baldeschi, Riccardo	Hamada, Koki	Schroder, Marc
Cord-Landwehr, Andreas	Hoeksma, Ruben	Schwiegelshohn, Chris
Cseh, Ágnes	Igarashi, Ayumi	Sgouritsa, Alkmini
de Jong, Jasper	Jabbari, Shahin	Shameli, Ali
De Keijzer, Bart	Kern, Walter	Skochdopoloe, Nolan
Deligkas, Argyrios	Kliemann, Lasse	Tuffin, Bruno
Drees, Maximilian	Kodric, Bojana	Tönnis, Andreas
Duetting, Paul	Krimpas, George	Vegh, Laszlo
Eden, Alon	Krysta, Piotr	Ventre, Carmine
Epitropou, Markos	Kyropoulou, Maria	von Stengel, Bernhard
Fearnley, John	Lazos, Philip	Voudouris, Alexandros
Feldkord, Björn	Lenzner, Pascal	Xiao, Tao
Feldotto, Matthias	Leucci, Stefano	Yukun, Cheng
Ferraioli, Diodato	Lianeas, Thanasis	Zick, Yair
Filos-Ratsikas, Aris	Liu, Zhengyang	

Abstracts

Position Ranking and Auctions for Online Marketplaces

Leon Yang Chu, Hamid Nazerzadeh, and Heng Zhang

Data Sciences and Operations Department, University of Southern California,
Los Angeles, CA, USA, 90089

{leonyzhu, hamidnz, Heng.Zhang.2019}@marshall.usc.edu

Abstract. E-commerce platforms such as Amazon, Ebay, Taobao, and Google Shopping connect thousands of sellers and consumers everyday. When a consumer enters a search keyword related to a product of interest, the platform's search engine returns a list. Typically, the consumer looks for a desired item by searching downward in the list. With a large volume of returned results, consumers rarely consider all of the items because examining each option is costly. Therefore, the ranking of items is an important decision that determines the welfare of sellers, consumers and the platform. In this work, we study how such platforms should rank products displayed, and utilize the top and most salient slots. Building on the optimal sequential search theory, we present a model that considers consumers' search costs and the externalities sellers impose on each other. This model allows us to study a multi-objective optimization, whose objective includes consumer and seller surplus, as well as the sales revenue, and derive the optimal ranking decision. One of the challenges in obtaining a satisfactory solution in practice is information asymmetry. The platform may be unaware of sellers' private benefits of each consumer purchase, for example, profits, brand effects, and so on. We show that an uninformed decision, one in which sellers' private valuations are unknown to the platform, can lead to an arbitrary loss of average welfare. We propose selling the platform's top slots to extract private information, using the *surplus-ordered ranking* (SOR) mechanism. This mechanism is motivated in part by Amazon's sponsored search program. We study this mechanism in a mechanism design framework, and show that it is a near-optimal solution. In addition, when the platform sells all slots, we show that our mechanism can be implemented as a Nash equilibrium in a modified generalized second price (GSP) auction.

Asymptotic Existence of Fair Divisions for Groups

Pasin Manurangsi¹ and Warut Suksompong²

¹ Department of Computer Science, UC Berkeley
253 Cory Hall, Berkeley, CA 94720, USA
pasin@berkeley.edu

² Department of Computer Science, Stanford University, 353 Serra Mall,
Stanford, CA 94305, USA
warut@cs.stanford.edu

The problem of dividing resources fairly occurs in many practical situations and is therefore an important topic of study in economics. In this paper, we investigate envy-free divisions in the setting where there are multiple players in each party. While all players in a party share the same set of resources, each player has her own preferences. In this generalized setting, we consider a division to be envy-free if every player values the set of items assigned to her group at least as much as that assigned to any other group.

We show that under additive valuations drawn randomly from probability distributions, when all groups contain an equal number of players, an envy-free division is likely to exist if the number of goods exceeds the total number of players by a logarithmic factor, no matter whether the players are distributed into several groups of small size or few groups of large size. In particular, any allocation that maximizes social welfare is likely to be envy-free. A similar result holds when there are two groups with possibly unequal numbers of players and the distribution on the valuation of each item is symmetric.

To complement our existence results, we show on the other hand that we cannot get away with a much lower number of items and still have an envy-free division with high probability. In particular, if the number of items is less than the total number of players by a superconstant factor, or if the number of items is less than the total number of players and the number of groups is large, the probability that an envy-free division exists is low. This leaves the gap between asymptotic existence and non-existence of envy-free divisions at a mere logarithmic factor.

Finally, we tackle the issue of truthfulness and show that a simple truthful mechanism, namely the random assignment mechanism, is α -approximate envy-free with high probability for any constant $\alpha \in [0,1)$. Approximate envy-freeness means that even though a player may envy another player in the resulting division, the values of the

player for her own allocation and for the other player's allocation differ by no more than a multiplicative factor of α . Our result shows that it is possible to achieve truthfulness and approximate envy-freeness simultaneously in a wide range of random instances, and improves upon the previous result for the setting with one player per group in several ways.

Approximate Maximin Shares for Groups of Agents

Warut Suksompong

Department of Computer Science, Stanford University, 353 Serra Mall, Stanford,
CA 94305, USA
warut@cs.stanford.edu

We consider the problem of fairly allocating indivisible goods to interested agents. Several notions of fairness have been proposed, including envy-freeness and proportionality. However, the existence of allocations satisfying these notions, or even a multiplicative approximation of them, cannot be guaranteed. A notion that was designed to fix this problem and has been a subject of much interest in the last few years is the maximin share.

In this paper, we apply the concept of maximin share to a more general setting of fair division in which goods are allocated not to individual agents, but rather to groups of agents who can have varying preferences on the goods. Several practical situations involving fair division fit into this model. For instance, an outcome of a negotiation between countries may have to be approved by members of the cabinets of each country who have different opinions on the outcome. Another example is a large company or university that needs to divide its resources among competing groups of agents (e.g., departments in a university). The agents in each group have different and possibly misaligned interests; the professors who perform theoretical research may prefer more whiteboards and open space in the department building, while those who engage in experimental work are more likely to prefer laboratories.

We extend the maximin share to groups in a natural way by calculating the maximin share for each agent using the number of groups instead of the number of agents. When there are two groups, we completely characterize the cardinality of agents in the groups for which it is possible to approximate the maximin share within a constant factor regardless of the number of goods. In particular, an approximation is possible when one of the groups contain a single agent, when both groups contain two agents, or when the groups contain three and two agents respectively. In all other cases, no approximation is possible in a strong sense: There exists an instance with only four goods in which some agent with positive maximin share necessarily gets zero utility.

We then generalize to the setting with several groups of agents. On the positive side, we show that a constant factor approximation is possible if only one group contains more than a single agent. On the other hand, we show on the negative side that when all groups contain at least two agents and one group contains at least five agents, it is possible that some agent with positive maximin share will be forced to get zero utility, which means that there is no hope of obtaining an approximation in this case.

On Black-Box Transformations in Downward-Closed Environments

Warut Suksompong

Department of Computer Science, Stanford University, 353 Serra Mall, Stanford,
CA 94305, USA
warut@cs.stanford.edu

A major line of work in algorithmic mechanism design involves taking a setting where the optimization problem is computationally intractable, and designing computationally tractable mechanisms that yield a good global outcome and such that the agents have a truth-telling incentive. The widespread success of designing such mechanisms has raised the question of whether there exists a “black-box transformation” for transforming any computationally tractable algorithm into a computationally tractable mechanism without degrading the approximation guarantee. Chawla et al. showed that no fully general black-box transformation exists for single-parameter environments.

Despite this negative result, it is still conceivable that there are transformations that work for certain large subclasses of single-parameter environments. One important subclass is that of downward-closed environments, which occur in a wide variety of settings in mechanism design. In this paper, we consider such settings and assume, crucially, that the black-box transformation is aware that the feasible set is downward-closed. We investigate the potentials and limits of black-box transformations when they are endowed with this extra power.

We begin by showing the limits of black-box transformations in downward-closed environments. We prove that such transformations cannot preserve the full welfare at every input, even when the private valuations can take on only two arbitrary values. Preserving a constant fraction of the welfare pointwise is impossible if the ratio between the two values $l < h$ is sublinear, i.e., $h/l \in O(n^\alpha)$ for $\alpha \in [0,1)$, where n is the number of agents, while preserving the approximation ratio is also impossible if the values are within a constant factor of each other and the transformation is restricted to querying inputs of Hamming distance $o(n)$ away from its input.

Next, we show the powers of black-box transformations in downward-closed environments. We prove that when the private valuations can take on only a constant number of values, each pair of values separated by a ratio of $\Omega(n)$, it becomes possible for a transformation to preserve a constant fraction of the welfare pointwise, and therefore of the approximation ratio as well. The same is also true if the private valuations are all within a constant factor of each other. Combined with the negative results, this gives us a complete picture of constant-fraction welfare-preserving transformations for multiple input values. Not only are these results interesting in their own right, but they also demonstrate the borders of the negative results that we can hope to prove.

Contents

Auctions

Liquid Price of Anarchy.	3
<i>Yossi Azar, Michal Feldman, Nick Gravin, and Alan Roytman</i>	
Tight Welfare Guarantees for Pure Nash Equilibria of the Uniform Price Auction	16
<i>Georgios Birmpas, Evangelos Markakis, Orestis Telelis, and Artem Tsikiridis</i>	
Online Random Sampling for Budgeted Settings.	29
<i>Alon Eden, Michal Feldman, and Adi Vardi</i>	
Liquid Welfare Maximization in Auctions with Multiple Items	41
<i>Pinyan Lu and Tao Xiao</i>	

Computational Aspects of Games

On the Nucleolus of Shortest Path Games	55
<i>Mourad Baïou and Francisco Barahona</i>	
Earning Limits in Fisher Markets with Spending-Constraint Utilities	67
<i>Xiaohui Bei, Jugal Garg, Martin Hoefer, and Kurt Mehlhorn</i>	
Robustness Among Multiwinner Voting Rules	80
<i>Robert Bredereck, Piotr Faliszewski, Andrzej Kaczmarczyk, Rolf Niedermeier, Piotr Skowron, and Nimrod Talmon</i>	
Computing Constrained Approximate Equilibria in Polymatrix Games	93
<i>Argyrios Deligkas, John Fearnley, and Rahul Savani</i>	
Group Activity Selection on Graphs: Parameterized Analysis	106
<i>Sushmita Gupta, Sanjukta Roy, Saket Saurabh, and Meirav Zehavi</i>	
The Real Computational Complexity of Minmax Value and Equilibrium Refinements in Multi-player Games	119
<i>Kristoffer Arnsfelt Hansen</i>	
Conditional Value-at-Risk: Structure and Complexity of Equilibria	131
<i>Marios Mavronicolas and Burkhard Monien</i>	

Congestion Games, Network and Opinion Formation Games

Reconciling Selfish Routing with Social Good	147
<i>Soumya Basu, Ger Yang, Thanasis Lianeas, Evdokia Nikolova, and Yitao Chen</i>	
Selfish Network Creation with Non-uniform Edge Cost	160
<i>Ankit Chauhan, Pascal Lenzner, Anna Melnichenko, and Louise Molitor</i>	
Opinion Formation Games with Aggregation and Negative Influence.	173
<i>Markos Epitropou, Dimitris Fotakis, Martin Hoefer, and Stratis Skoulakis</i>	
The Efficiency of Best-Response Dynamics	186
<i>Michal Feldman, Yuval Snappir, and Tami Tamir</i>	
Efficient Best Response Computation for Strategic Network Formation Under Attack	199
<i>Tobias Friedrich, Sven Ihde, Christoph Keßler, Pascal Lenzner, Stefan Neubert, and David Schumann</i>	
Path Deviations Outperform Approximate Stability in Heterogeneous Congestion Games	212
<i>Pieter Kleer and Guido Schäfer</i>	

Mechanism Design, Incentives and Regret Minimization

Agent Incentives of Strategic Behavior in Resource Exchange	227
<i>Zhou Chen, Yukun Cheng, Xiaotie Deng, Qi Qi, and Xiang Yan</i>	
A 3-Player Protocol Preventing Persistence in Strategic Contention with Limited Feedback	240
<i>George Christodoulou, Martin Gairing, Sotiris Nikoletseas, Christoforos Raptopoulos, and Paul Spirakis</i>	
Hedging Under Uncertainty: Regret Minimization Meets Exponentially Fast Convergence	252
<i>Johanne Cohen, Amélie Héliou, and Panayotis Mertikopoulos</i>	

Resource Allocation

Tradeoffs Between Information and Ordinal Approximation for Bipartite Matching	267
<i>Elliot Anshelevich and Wennan Zhu</i>	
Group Strategyproof Pareto-Stable Marriage with Indifferences via the Generalized Assignment Game.	280
<i>Nevzat Onur Dumanç, Chi-Kit Lam, and C. Gregory Plaxton</i>	

The Spectrum of Equilibria for the Colonel Blotto and the Colonel Lotto Games.	292
<i>Marcin Dziubiński</i>	
On Proportional Allocation in Hedonic Games	307
<i>Martin Hoefer and Wanchote Jiamjitrak</i>	
Stable Marriage with Covering Constraints—A Complete Computational Trichotomy	320
<i>Matthias Mnich and Ildikó Schlotter</i>	
Fairly Allocating Contiguous Blocks of Indivisible Items	333
<i>Warut Suksompong</i>	
Author Index	345