

Contents

Foreword by Matthew O. Jackson and Yoav Shoham	v
Preface by the Editor	vi
Contributors	xiii
1 Playing, Voting, and Dividing	1
J. Rothe	
1.1 Playing	3
1.1.1 Noncooperative Game Theory	3
1.1.2 Cooperative Game Theory	4
1.2 Voting	5
1.2.1 Preference Aggregation by Voting	5
1.2.2 Manipulative Actions in Single-Peaked Societies	8
1.2.3 Judgment Aggregation	8
1.3 Dividing	9
1.3.1 Cake-cutting: Fair Division of Divisible Goods	9
1.3.2 Fair Division of Indivisible Goods	10
1.3.3 A Brief Digression to Single-Item Auctions	11
1.4 Some Literature Pointers	16
1.5 A Brief Digression to Computational Complexity	17
1.5.1 Some Foundations of Complexity Theory	17
1.5.2 The Satisfiability Problem of Propositional Logic	23
1.5.3 A Brief Compendium of Complexity Classes	33

Part I Playing Successfully

2 Noncooperative Game Theory	41
P. Faliszewski, I. Rothe, and J. Rothe	
2.1 Foundations	42
2.1.1 Normal Form, Dominant Strategies, and Equilibria	43
2.1.2 Further Two-Player Games	50
2.2 Nash Equilibria in Mixed Strategies	60
2.2.1 Definition and Application to Two-Player Games	60

2.2.2	Existence of Nash Equilibria in Mixed Strategies	69
2.3	Checkmate: Trees for Games with Perfect Information	81
2.3.1	Sequential Two-Player Games	81
2.3.2	Equilibria in Game Trees	94
2.4	Full House: Games with Incomplete Information	100
2.4.1	The Monty Hall Problem	101
2.4.2	Analysis of a Simple Poker Variant	107
2.5	How Hard Is It to Find a Nash Equilibrium?	119
2.5.1	Nash Equilibria in Zero-Sum Games	119
2.5.2	Nash Equilibria in General Normal Form Games	122
3	Cooperative Game Theory	135
	E. Elkind and J. Rothe	
3.1	Foundations	136
3.1.1	Cooperative Games with Transferable Utility	137
3.1.2	Stability Concepts for Cooperative Games	140
3.1.3	Convex Games	149
3.2	Simple Games	151
3.2.1	The Core of a Simple Game	152
3.2.2	Counting and Representing Simple Games	152
3.2.3	Weighted Voting Games	153
3.2.4	Dimensionality	157
3.2.5	Power Indices	159
3.2.6	The Shapley–Shubik Index and the Shapley Value	160
3.2.7	The Banzhaf Indices	166
3.3	Complexity of Problems for Succinctly Representable Games	168
3.3.1	Games on Graphs	169
3.3.2	Weighted Voting Games	175
3.3.3	Hedonic Games	183

Part II Voting and Judging

4	Preference Aggregation by Voting	197
	D. Baumeister and J. Rothe	
4.1	Some Basic Voting Systems	198
4.1.1	Scoring Protocols	199
4.1.2	Voting Systems Based on Pairwise Comparisons	202
4.1.3	Approval Voting and Range Voting	213
4.1.4	Voting Systems Proceeding in Stages	215
4.1.5	Hybrid Voting Systems	221
4.1.6	Overview of Some Fundamental Voting Systems	227
4.2	Properties of Voting Systems and Impossibility Theorems	228
4.2.1	The Condorcet and the Majority Criterion	229
4.2.2	Nondictatorship, Pareto Consistency, and Consistency	231
4.2.3	Independence of Irrelevant Alternatives	235
4.2.4	Resoluteness and Citizens' Sovereignty	237

4.2.5	Strategy-Proofness and Independence of Clones	238
4.2.6	Anonymity, Neutrality, and Monotonicity	240
4.2.7	Homogeneity, Participation, and Twins Welcome	244
4.2.8	Overview of Properties of Voting Systems	249
4.3	Complexity of Voting Problems	251
4.3.1	Winner Determination	253
4.3.2	Possible and Necessary Winners	260
4.3.3	Manipulation	269
4.3.4	Control	291
4.3.5	Bribery	317
5	The Complexity of Manipulative Actions in Single-Peaked Societies	327
	E. Hemaspaandra, L.A. Hemaspaandra, and J. Rothe	
5.1	Single-Peaked Electorates	331
5.2	Control of Single-Peaked Electorates	334
5.3	Manipulation of Single-Peaked Electorates	344
5.4	Bribery of Single-Peaked Electorates	351
5.5	Do Nearly Single-Peaked Electorates Restore Intractability?	353
5.5.1	K -Maverick-Single-Peakedness	355
5.5.2	Swoon-Single-Peakedness	356
6	Judgment Aggregation	361
	D. Baumeister, G. Erdélyi, and J. Rothe	
6.1	Foundations	365
6.2	Judgment Aggregation Procedures and Their Properties	367
6.2.1	Some Specific Judgment Aggregation Procedures	368
6.2.2	Properties, Impossibility Results, and Characterizations	371
6.3	Complexity of Judgment Aggregation Problems	374
6.3.1	Winner Determination in Judgment Aggregation	375
6.3.2	Safety of the Agenda	376
6.3.3	Manipulation in Judgment Aggregation	376
6.3.4	Bribery in Judgment Aggregation	383
6.3.5	Control in Judgment Aggregation	387
6.4	Concluding Remarks	391
	Part III Fair Division	
7	Cake-Cutting: Fair Division of Divisible Goods	395
	C. Lindner and J. Rothe	
7.1	How to Have a Great Party with only a Single Cake	395
7.2	Basics	396
7.3	Valuation Criteria	401
7.3.1	Fairness	401
7.3.2	Efficiency	410

7.3.3	Manipulability	411
7.3.4	Runtime	415
7.4	Cake-Cutting Protocols	416
7.4.1	Two Envy-Free Protocols for Two Players	417
7.4.2	Proportional Protocols for n Players	423
7.4.3	Super-Proportional Protocols for n Players	445
7.4.4	A Royal Wedding: Dividing into Unequal Shares	450
7.4.5	Envy-Free Protocols for Three and Four Players	452
7.4.6	Oversalted Cream Cake: Dirty-Work Protocols	461
7.4.7	Avoiding Crumbs: Minimizing the Number of Cuts	466
7.4.8	Degree of Guaranteed Envy-Freeness	485
7.4.9	Overview of Some Cake-Cutting Protocols	489
8	Fair Division of Indivisible Goods	493
	J. Lang and J. Rothe	
8.1	Introduction	493
8.2	Definition and Classification of Allocation Problems	495
8.2.1	Allocation Problems	495
8.2.2	Classification of Allocation Problems	496
8.3	Preference Elicitation and Compact Representation	500
8.3.1	Ordinal Preference Languages	502
8.3.2	Cardinal Preference Languages	504
8.4	Criteria for Allocations	508
8.4.1	Ordinal Criteria	509
8.4.2	Cardinal Criteria	511
8.5	Computing Allocations: Centralized Mechanisms	518
8.5.1	Centralized Fair Division with Ordinal Preferences	519
8.5.2	Centralized Fair Division with Cardinal Preferences without Money	522
8.5.3	Centralized Fair Division with Cardinal Preferences and Money	532
8.6	Decentralized Allocation Protocols	538
8.6.1	The Descending Demand Protocols	539
8.6.2	The Picking Sequences Protocols	541
8.6.3	Contested Pile-Based Protocols: Undercut	543
8.6.4	Protocols Based on Local Exchanges	546
8.7	Further Issues	547
8.7.1	Strategy-Proofness	547
8.7.2	Matching	548
8.7.3	Private Endowments	549
8.7.4	Randomized Fair Division	549
	References	551
	List of Figures	581
	List of Tables	585
	Index	587