

*Foundations  
of Computing  
Series*

***Resource Allocation  
Problems***  
*Algorithmic Approaches*

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*Toshihide Ibaraki and  
Naoki Katoh*

*The MIT Press*

# Resource Allocation Problems Algorithmic Approaches

**Ming-Yang Kao, Xiang-Yang Li**



## **Resource Allocation Problems Algorithmic Approaches:**

**Resource Allocation Problems** Toshihide Ibaraki, Naoki Katoh, 1988 This book addresses a theoretical problem encountered in a variety of areas in operations research and management science including load distribution production planning computer scheduling portfolio selection and apportionment It is a timely and comprehensive summary of the past thirty years of research on algorithmic aspects of the resource allocation problem and its variants covering Lagrangean multiplier method dynamic programming greedy algorithms and their generalizations Modern data structures are used to analyze the computational complexity of each algorithm The resource allocation problem the authors take up is an optimization problem with a single simple constraint it determines the allocation of a fixed amount of resources to a given number of activities in order to achieve the most effective results It may be viewed as a special case of the nonlinear programming or nonlinear integer programming problem Contents Introduction Resource Allocation with Continuous Variables Resource Allocation with Integer Variables Minimizing a Convex Separable Function Minimax and Maximin Resource Allocation Problems Fair Resource Allocation Problem Apportionment Problem Fundamentals of Submodular Systems Resource Allocation Problems under Submodular Constraints Further Topics on Resource Allocation Problems Appendixes Algorithms and Complexity NP completeness and NP hardness Toshihide Ibaraki is Professor in the Department of Applied Mathematics and Physics at Kyoto University and Naoki Katoh is Associate Professor in the Department of Management Science at Kobe University of Commerce Resource Allocation Problems is included in the Foundations of Computing Series edited by Michael Garey and Albert Meyer     Equitable Resource Allocation Hanan Luss, 2012-09-11 A unique book that specifically addresses equitable resource allocation problems with applications in communication networks manufacturing emergency services and more Resource allocation problems focus on assigning limited resources in an economically beneficial way among competing activities Solutions to such problems affect people and everyday activities with significant impact on the private and public sectors and on society at large Using diverse application areas as examples Equitable Resource Allocation Models Algorithms and Applications provides readers with great insight into a topic that is not widely known in the field Starting with an overview of the topics covered the book presents a large variety of resource allocation models with special mathematical structures and provides elegant efficient algorithms that compute optimal solutions to these models Authored by one of the leading researchers in the field Equitable Resource Allocation Is the only book that provides a comprehensive exposition of equitable resource allocation problems Presents a collection of resource allocation models with applications in communication networks transportation content distribution manufacturing emergency services and more Exhibits practical algorithms for solving a variety of resource allocation models Uses real world applications and examples to explain important concepts Includes end of chapter exercises Bringing together much of the equitable resource allocation research from the past thirty years this book is a valuable reference for anyone interested in

solving diverse optimization problems      *Algorithmic aspects of resource allocation and multiwinner voting: theory and experiments* Kaczmarczyk, Andrzej, 2021-12-10 This thesis is concerned with investigating elements of computational social choice in the light of real world applications We contribute to a better understanding of the areas of fair allocation and multiwinner voting For both areas inspired by real world scenarios we propose several new notions and extensions of existing models Then we analyze the complexity of answering the computational questions raised by the introduced concepts To this end we look through the lens of parameterized complexity We identify different parameters which describe natural features specific to the computational problems we investigate Exploiting the parameters we successfully develop efficient algorithms for specific cases of the studied problems We complement our analysis by showing which parameters presumably cannot be utilized for seeking efficient algorithms Thereby we provide comprehensive pictures of the computational complexity of the studied problems Specifically we concentrate on four topics that we present below grouped by our two areas of interest For all but one topic we present experimental studies based on implementations of newly developed algorithms We first focus on fair allocation of indivisible resources In this setting we consider a collection of indivisible resources and a group of agents Each agent reports its utility evaluation of every resource and the task is to fairly allocate the resources such that each resource is allocated to at most one agent We concentrate on the two following issues regarding this scenario The social context in fair allocation of indivisible resources In many fair allocation settings it is unlikely that every agent knows all other agents For example consider a scenario where the agents represent employees of a large corporation It is highly unlikely that every employee knows every other employee Motivated by such settings we come up with a new model of graph envy freeness by adapting the classical envy freeness notion to account for social relations of agents modeled as social networks We show that if the given social network of agents is simple for example if it is a directed acyclic graph then indeed we can sometimes find fair allocations efficiently However we contrast tractability results with showing NP hardness for several cases including those in which the given social network has a constant degree Fair allocations among few agents with bounded rationality Bounded rationality is the idea that humans due to cognitive limitations tend to simplify problems that they face One of its emanations is that human agents usually tend to report simple utilities over the resources that they want to allocate for example agents may categorize the available resources only into two groups of desirable and undesirable ones Applying techniques for solving integer linear programs we show that exploiting bounded rationality leads to efficient algorithms for finding envy free and Pareto efficient allocations assuming a small number of agents Further we demonstrate that our result actually forms a framework that can be applied to a number of different fairness concepts like envy freeness up to one good or envy freeness up to any good This way we obtain efficient algorithms for a number of fair allocation problems assuming few agents with bounded rationality We also empirically show that our technique is applicable in practice Further we study multiwinner voting where we are given a collection of voters

and their preferences over a set of candidates The outcome of a multiwinner voting rule is a group or a set of groups in case of ties of candidates that reflect the voters preferences best according to some objective In this context we investigate the following themes The robustness of election outcomes We study how robust outcomes of multiwinner elections are against possible mistakes made by voters Assuming that each voter casts a ballot in a form of a ranking of candidates we represent a mistake by a swap of adjacent candidates in a ballot We find that for rules such as SNTV  $k$  Approval and  $k$  Borda it is computationally easy to find the minimum number of swaps resulting in a change of an outcome This task is however NP hard for STV and the Chamberlin Courant rule We conclude our study of robustness with experimentally studying the average number of random swaps leading to a change of an outcome for several rules Strategic voting in multiwinner elections We ask whether a given group of cooperating voters can manipulate an election outcome in a favorable way We focus on the  $k$  Approval voting rule and we show that the computational complexity of answering the posed question has a rich structure We spot several cases for which our problem is polynomial time solvable However we also identify NP hard cases For several of them we show how to circumvent the hardness by fixed parameter tractability We also present experimental studies indicating that our algorithms are applicable in practice

Diese Arbeit befasst sich mit der Untersuchung von Themen des Forschungsgebiets Computational Social Choice im Lichte realer Anwendungen Dabei trgt sie zu einem besseren Verstndnis der Bereiche der fairen Zuordnung und der Mehrgewinnerwahlen bei Fr beide Konzepte schlagen wir inspiriert von realen Anwendungen verschiedene neue Begriffe und Erweiterungen bestehender Modelle vor Anschließend analysieren wir die Komplexitt der Beantwortung von Berechnungsfragen die durch die eingefhrten Konzepte aufgeworfen werden Dabei fokussieren wir uns auf die parametrisierte Komplexitt Hierzu identifizieren wir verschiedene Parameter welche natrliche Merkmale der von uns untersuchten Berechnungsprobleme beschreiben Durch die Nutzung dieser Parameter entwickeln wir erfolgreich effiziente Algorithmen fr Spezialf lle der untersuchten Probleme Wir ergnzen unsere Analyse indem wir zeigen welche Parameter vermutlich nicht verwendet werden knnen um effiziente Algorithmen zu finden Dabei zeichnen wir ein umfassendes Bild der Berechnungskomplexitt der untersuchten Probleme Insbesondere konzentrieren wir uns auf vier Themen die wir gruppiert nach unseren beiden Schwerpunkten unten vorstellen Fr alle Themen bis auf eines prsentieren wir Experimente die auf Implementierungen der von uns neu entwickelten Algorithmen basieren Wir konzentrieren uns zunchst auf die faire Zuordnung unteilbarer Ressourcen Hier betrachten wir eine Menge unteilbarer Ressourcen und eine Gruppe von Agenten Jeder Agent gibt eine Bewertung des Nutzens jeder Ressource ab und die Aufgabe besteht darin eine faire Zuordnung der Ressourcen zu finden wobei jede Ressource hchstens einem Agenten zugeordnet werden kann Innerhalb dieses Bereiches konzentrieren wir uns auf die beiden folgenden Problemstellungen Der soziale Kontext bei der fairen Zuordnung unteilbarer Ressourcen In vielen Szenarien in denen Ressourcen zugeordnet werden sollen ist es unwahrscheinlich dass jeder Agent alle anderen kennt Vorstellbar ist beispielsweise ein Szenario in dem

die Agenten Mitarbeiter eines großen Unternehmens repräsentieren. Es ist höchst unwahrscheinlich, dass jeder Mitarbeiter jeden anderen Mitarbeiter kennt. Motiviert durch solche Szenarien entwickeln wir ein neues Modell der graphbasierten Neidfreiheit. Wir erweitern den klassischen Neidfreiheitsbegriff um die sozialen Beziehungen von Agenten, die durch soziale Netzwerke modelliert werden. Einerseits zeigen wir, dass wenn das soziale Netzwerk der Agenten einfach ist (zum Beispiel wenn es sich um einen gerichteten azyklischen Graph handelt), in manchen Fällen faire Zuordnungen effizient gefunden werden können. Andererseits stellen wir diesen algorithmisch positiven Ergebnissen mehrere NP-schweren Fällen entgegen. Ein Beispiel für einen solchen Fall sind soziale Netzwerke mit einem konstanten Knotengrad. Faire Zuteilung an wenige Agenten mit begrenzter Rationalität. Begrenzte Rationalität beschreibt die Idee, dass Menschen aufgrund kognitiver Grenzen dazu neigen, Probleme mit denen sie konfrontiert werden, zu vereinfachen. Eine mögliche Folge dieser Grenzen ist, dass menschliche Agenten in der Regel einfache Bewertungen der gewünschten Ressourcen abgeben, beispielsweise können Agenten die verfügbaren Ressourcen nur in zwei Gruppen (erwünschte und unerwünschte Ressourcen) kategorisieren. Durch Anwendung von Techniken zum Lösen von ganzzahligen linearen Programmen zeigen wir, dass unter der Annahme einer kleinen Anzahl von Agenten die Ausnutzung begrenzter Rationalität dabei hilft, effiziente Algorithmen zum Finden neidfreier und Pareto-effizienter Zuweisungen zu entwickeln. Weiterhin zeigen wir, dass unser Ergebnis ein allgemeines Verfahren liefert, welches auf eine Reihe verschiedener Fairnesskonzepte angewendet werden kann, wie zum Beispiel Neidfreiheit bis auf ein Gut oder Neidfreiheit bis auf irgendein Gut. Auf diese Weise gewinnen wir effiziente Algorithmen für eine Reihe fairer Zuordnungsprobleme, wenige Agenten mit begrenzter Rationalität vorausgesetzt. Darüber hinaus zeigen wir empirisch, dass unsere Technik in der Praxis anwendbar ist. Weiterhin untersuchen wir Mehrgewinnerwahlen, bei denen uns eine Menge von Wählern sowie ihre Präferenzen über eine Reihe von Kandidaten gegeben sind. Das Ergebnis eines Mehrgewinnerwahlverfahrens ist eine Gruppe oder eine Menge von Gruppen im Falle eines Unentschiedens von Kandidaten, welche die Präferenzen der Wähler am besten einem bestimmten Ziel folgend widerspiegeln. In diesem Kontext untersuchen wir die folgenden Themen: Die Robustheit von Wahlergebnissen. Wir untersuchen, wie robust die Ergebnisse von Mehrgewinnerwahlen gegen bestimmte Fehler der Wähler sind. Unter der Annahme, dass jeder Wähler eine Stimme in Form einer Rangliste von Kandidaten abgibt, modellieren wir einen Fehler als einen Tausch benachbarter Kandidaten in der Rangliste. Wir zeigen, dass für Wahlregeln wie SNTV, k-Approval und k-Borda die minimale Anzahl an Vertauschungen, welche zu einer Ergebnisänderung führt, einfach zu berechnen ist. Für STV und die Chamberlin-Courant-Regel ist diese Aufgabe allerdings NP-schwer. Wir schließen unsere Untersuchung der Robustheit unterschiedlicher Wahlregeln ab mit einer experimentellen Evaluierung der durchschnittlichen Anzahl zufälliger Vertauschungen, die zu einer Änderung des Ergebnisses führen. Strategische Abstimmung bei Wahlen mit mehreren Gewinnern. Wir fragen, ob eine bestimmte Gruppe von kooperierenden Wählern ein Wahlergebnis zu ihren Gunsten manipulieren kann. Dabei konzentrieren wir uns auf die k

Approval Wahlregel Wir zeigen dass die Berechnungskomplexit t der besagten Manipulation eine reiche Struktur besitzt Auf der einen Seite identifizieren wir mehrere F lle in denen das Problem in Polynomzeit l sbar ist Auf der anderen Seite identifizieren wir jedoch auch NP schwere F lle F r einige von ihnen zeigen wir wie die Berechnungsschwere durch parametrisierte Algorithmen umgangen werden kann Wir pr sentieren zudem experimentelle Untersuchungen welche darauf hindeuten dass unsere Algorithmen in der Praxis anwendbar sind

**Effective Resource Management in Manufacturing Systems** Massimiliano Caramia, Paolo Dell'Olmo, 2006-01-09 Manufacturing systems regardless of their size have to work with scarce resources in dynamic environments Effective Resource Management in Manufacturing Systems aims to provide methods for achieving effective resource allocation and to solve related problems that occur daily and often generate cost overruns This book will be bought by postgraduate students of business engineering and computer science as well as researchers in these fields It will also be of interest to practitioners in manufacturing systems and operations managers in industry

*Algorithmic Number Theory: Efficient algorithms* Eric Bach, Jeffrey Outlaw Shallit, 1996 Volume 1

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important fields The selected contributions in this book illustrate the broad diversity of ideas discussed at the meeting

**Approximation Algorithms for Combinatorial Optimization** Klaus Jansen, Samir Khuller, 2003-07-31 This book constitutes the refereed proceedings of the Third International Workshop on Approximation Algorithms for Combinatorial Optimization Problems APPROX 2000 held in Saarbrücken Germany in September 2000 The 22 revised full papers presented together with four invited contributions were carefully reviewed and selected from 68 submissions The topics dealt with include design and analysis of approximation algorithms inapproximability results on line problems randomization techniques average case analysis approximation classes scheduling problems routing and flow problems coloring and partitioning cuts and connectivity packing and covering geometric problems network design and various applications **Computing**

**Handbook, Third Edition** Teofilo Gonzalez, Jorge Diaz-Herrera, Allen Tucker, 2014-05-07 Computing Handbook Third Edition Computer Science and Software Engineering mirrors the modern taxonomy of computer science and software engineering as described by the Association for Computing Machinery ACM and the IEEE Computer Society IEEE CS Written by established leading experts and influential young researchers the first volume of this popular handbook examines the elements involved in designing and implementing software new areas in which computers are being used and ways to solve computing problems The book also explores our current understanding of software engineering and its effect on the practice of software development and the education of software professionals Like the second volume this first volume describes what occurs in research laboratories educational institutions and public and private organizations to advance the effective development and use of computers and computing in today's world Research level survey articles provide deep insights into the computing discipline enabling readers to understand the principles and practices that drive computing education research and development in the twenty first century **Computing Handbook** Allen Tucker, Teofilo Gonzalez, Heikki Topi, Jorge

Diaz-Herrera, 2022-05-29 This two volume set of the Computing Handbook Third Edition previously the Computer Science Handbook provides up to date information on a wide range of topics in computer science information systems IS information technology IT and software engineering The third edition of this popular handbook addresses not only the dramatic growth of computing as a discipline but also the relatively new delineation of computing as a family of separate disciplines as described by the Association for Computing Machinery ACM the IEEE Computer Society IEEE CS and the Association for Information Systems AIS Both volumes in the set describe what occurs in research laboratories educational institutions and public and private organizations to advance the effective development and use of computers and computing in today's world Research level survey articles provide deep insights into the computing discipline enabling readers to understand the principles and practices that drive computing education research and development in the twenty first century Chapters are organized with minimal interdependence so that they can be read in any order and each volume contains a table of contents and subject index offering easy access to specific topics The first volume of this popular handbook mirrors the modern taxonomy of



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**Clustering Challenges in Biological Networks** Sergiy Butenko,2009 This text offers introductory knowledge of a wide range of clustering and other quantitative techniques used to solve biological problems

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**Proportional Optimization and Fairness** Wieslaw Kubiak,2008-11-16 Proportional Optimization and Fairness is a long needed attempt to reconcile optimization with apportionment in just in time JIT sequences and find the common ground in solving problems ranging from sequencing mixed model just in time assembly lines through just in time batch production balancing workloads in event graphs to bandwidth allocation internet gateways and resource allocation in computer operating systems The book argues that apportionment theory and optimization based on deviation functions provide natural benchmarks for a process and then looks at the recent research and developments in the field Individual chapters look at the theory of apportionment and just in time sequences minimization of just in time sequence deviation optimality of cyclic sequences and the oneness bottleneck minimization competition free instances Fraenkel s Conjecture and optimal admission sequences response time variability applications to the Liu Layland Problem and pinwheel scheduling temporal capacity constraints and supply chain balancing fair queuing and stride scheduling and smoothing and batching     City Evacuations:

An Interdisciplinary Approach John Preston, Jane M Binner, Layla Branicki, Tobias Galla, Nick Jones, James King, Magdalini Kolokitha, Michalis Smyrnakis, 2014-08-01 Evacuating a city is a complex problem that involves issues of governance preparedness education warning information sharing population dynamics resilience and recovery As natural and anthropogenic threats to cities grow it is an increasingly pressing problem for policy makers and practitioners The book is the result of a unique interdisciplinary collaboration between researchers in the physical and social sciences to consider how an interdisciplinary approach can help plan for large scale evacuations It draws on perspectives from physics mathematics organisation theory economics sociology and education Importantly it goes beyond disciplinary boundaries and considers how interdisciplinary methods are necessary to approach a complex problem involving human actors and increasingly complex communications and transportation infrastructures Using real world case studies and modelling the book considers new approaches to evacuation dynamics It addresses questions of complexity not only in terms of theory but examining the latest challenges for cities and emergency responders Factors such as social media information quality and visualisation techniques are examined to consider the new dynamics of warning and informing evacuation and recovery

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In a fast-paced digital era where connections and knowledge intertwine, the enigmatic realm of language reveals its inherent magic. Its capacity to stir emotions, ignite contemplation, and catalyze profound transformations is nothing short of extraordinary. Within the captivating pages of **Resource Allocation Problems Algorithmic Approaches** a literary masterpiece penned by way of a renowned author, readers attempt a transformative journey, unlocking the secrets and untapped potential embedded within each word. In this evaluation, we shall explore the book's core themes, assess its distinct writing style, and delve into its lasting impact on the hearts and minds of those who partake in its reading experience.

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