

Chapter 10

NP-hard Problems and Approximation Algorithms

10.1 What is the class NP?

The class P consists of all polynomial-time solvable decision problems. What is the class NP? There are two misunderstandings:

(1) NP is the class of problems which cannot be solved in polynomial-time.

(2) A decision problem belongs to the class NP if its answer can be checked in polynomial-time.

The misunderstanding (1) comes from misexplanation of the brief name NP for "Not Polynomial-time solvable". Actually, it is polynomial-time solvable, but in a wide sense of computation, nondeterministic computation, that is, **NP is the class of all nondeterministic polynomial-time solvable decision problems**. Thus, NP is the brief name of "Nondeterministic Polynomial-time".

In nondeterministic computation, there may contain some guess steps. Let us look at an example. Consider the HAMILTONIAN CYCLE problem: *Given a graph $G = (V, E)$, does G contain a Hamiltonian cycle?* Here, a Hamiltonian cycle is a cycle passing through each vertex exactly once. The following is a nondeterministic algorithm for the HAMILTONIAN CYCLE problem.

input a graph $G = (V, E)$.

step 1 guess a permutation of all vertices.

step 2 check if guessed permutation gives a Hamiltonian cycle.

Approximation Algorithms For Np Hard Problems

Teofilo F. Gonzalez



Approximation Algorithms For Np Hard Problems:

Approximation Algorithms for NP-hard Problems Dorit S. Hochbaum, 1997 This is the first book to fully address the study of approximation algorithms as a tool for coping with intractable problems With chapters contributed by leading researchers in the field this book introduces unifying techniques in the analysis of approximation algorithms APPROXIMATION ALGORITHMS FOR NP HARD PROBLEMS is intended for computer scientists and operations researchers interested in specific algorithm implementations as well as design tools for algorithms Among the techniques discussed the use of linear programming primal dual techniques in worst case analysis semidefinite programming computational geometry techniques randomized algorithms average case analysis probabilistically checkable proofs and inapproximability and the Markov Chain Monte Carlo method The text includes a variety of pedagogical features definitions exercises open problems glossary of problems index and notes on how best to use the book *Approximation Algorithms* Vijay V. Vazirani, 2013-03-14 Most natural optimization problems including those arising in important application areas are NP hard Therefore under the widely believed conjecture that $P \neq NP$ their exact solution is prohibitively time consuming Charting the landscape of approximability of these problems via polynomial time algorithms therefore becomes a compelling subject of scientific inquiry in computer science and mathematics This book presents the theory of approximation algorithms This book is divided into three parts Part I covers combinatorial algorithms for a number of important problems using a wide variety of algorithm design techniques Part II presents linear programming based algorithms These are categorized under two fundamental techniques rounding and the primal dual schema Part III covers four important topics the first is the problem of finding a shortest vector in a lattice the second is the approximability of counting as opposed to optimization problems the third topic is centered around recent breakthrough results establishing hardness of approximation for many key problems and giving new legitimacy to approximation algorithms as a deep theory and the fourth topic consists of the numerous open problems of this young field This book is suitable for use in advanced undergraduate and graduate level courses on approximation algorithms An undergraduate course in algorithms and the theory of NP completeness should suffice as a prerequisite for most of the chapters This book can also be used as supplementary text in basic undergraduate and graduate algorithms courses

The Design of Approximation Algorithms David P. Williamson, David B. Shmoys, 2011-04-26 Discrete optimization problems are everywhere from traditional operations research planning scheduling facility location and network design to computer science databases to advertising issues in viral marketing Yet most such problems are NP hard unless $P = NP$ there are no efficient algorithms to find optimal solutions This book shows how to design approximation algorithms efficient algorithms that find provably near optimal solutions The book is organized around central algorithmic techniques for designing approximation algorithms including greedy and local search algorithms dynamic programming linear and semidefinite programming and randomization Each chapter in the first section is devoted to a single algorithmic technique

applied to several different problems with more sophisticated treatment in the second section The book also covers methods for proving that optimization problems are hard to approximate Designed as a textbook for graduate level algorithm courses it will also serve as a reference for researchers interested in the heuristic solution of discrete optimization problems

Approximation Algorithms for NP-hard Routing Problems Greg Norman Frederickson, 1977 **Approximation Algorithms for Combinatorial Optimization** Klaus Jansen, Stefano Leonardi, Vijay Vazirani, 2003-06-30 This book constitutes the refereed proceedings of the 5th International Workshop on Approximation Algorithms for Combinatorial Optimization Problems APPROX 2002 held in Rome Italy in September 2002 The 20 revised full papers presented were carefully reviewed and selected from 54 submissions Among the topics addressed are design and analysis of approximation algorithms inapproximability results online 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 applications to game theory and other fields Algorithm Designing Tools for Hard Problems Pasquale De Marco, 2025-07-19 In the realm of computer science where solving complex problems efficiently is paramount approximation algorithms have emerged as a beacon of hope These ingenious algorithms offer a practical approach to tackling computationally hard problems where finding an exact solution is often intractable By allowing for a controlled level of error approximation algorithms provide near optimal solutions in a reasonable amount of time This comprehensive book Algorithm Designing Tools for Hard Problems delves into the fascinating world of approximation algorithms making them accessible to a wide range of readers With clear explanations and engaging examples it guides readers through the fundamental concepts techniques and applications of approximation algorithms From the theoretical foundations of computational complexity theory to the practical implementation of specific algorithms this book covers a vast spectrum of topics It explores the inner workings of greedy algorithms dynamic programming local search algorithms and randomized algorithms providing readers with a deep understanding of how these algorithms achieve their remarkable results Furthermore the book showcases the diverse applications of approximation algorithms in various domains including computer science operations research economics biology and physics These applications highlight the versatility and impact of approximation algorithms in addressing real world challenges from scheduling tasks to optimizing networks and designing efficient algorithms This book is an invaluable resource for students seeking a thorough introduction to approximation algorithms researchers pushing the boundaries of this field and practitioners seeking practical solutions to complex problems With its comprehensive coverage clear explanations and insightful examples Algorithm Designing Tools for Hard Problems empowers readers to harness the power of approximation algorithms and unlock the potential of computing Join us on this intellectual journey as we explore the intricate world of approximation algorithms and discover the art of finding near optimal solutions to some of the most challenging problems in computer science and beyond If you like this book write a

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Algorithms and Theory of Computation Handbook - 2 Volume Set Mikhail J. Atallah, Marina Blanton, 2022-05-29 Algorithms and Theory of Computation Handbook Second Edition in a two volume set provides an up to date compendium of fundamental computer science topics and techniques It also illustrates how the topics and techniques come together to deliver efficient solutions to important practical problems New to the Second Edition Along with updating and revising many of the existing chapters this second edition contains more than 20 new chapters This edition now covers external memory parameterized self stabilizing and pricing algorithms as well as the theories of algorithmic coding privacy and anonymity databases computational games and communication networks It also discusses computational topology computational number theory natural language processing and grid computing and explores applications in intensity modulated radiation therapy voting DNA research systems biology and financial derivatives This best selling handbook continues to help computer professionals and engineers find significant information on various algorithmic topics The expert contributors clearly define the terminology present basic results and techniques and offer a number of current references to the in depth literature They also provide a glimpse of the major research issues concerning the relevant topics

Approximation Algorithms for NP-hard Routing Problems Greg N. Frederickson, 1979 Algorithms and Discrete Applied Mathematics Apurva Mudgal, C. R. Subramanian, 2021-01-28 This book constitutes the proceedings of the 7th International Conference on Algorithms and Discrete Applied Mathematics CALDAM 2021 which was held in Rupnagar India during February 11 13 2021 The 39 papers presented in this volume were carefully reviewed and selected from 82 submissions The papers were organized in topical sections named approximation algorithms parameterized algorithms computational geometry graph theory combinatorics and algorithms graph algorithms and computational complexity

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