Approximation Algorithms

Approx_Vertex_Cover is a 2-approximation algorithm.

```
Approx_Vertex_Cover(G) /* G = (V,E) */
1    C = ∅
2    E' = E
3    while E' ≠ ∅
4        let (u,v) be an arbitrary edge of E'
5        C = C ∪ {u,v}
6        remove from E' every edge joining either u or v
7    return C
```
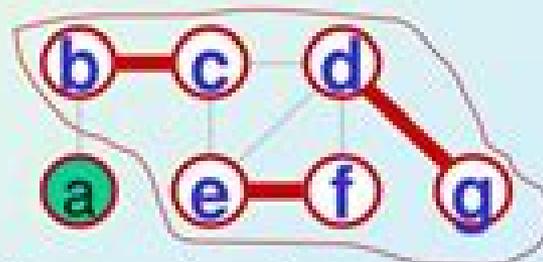
Proof:

Consider line 4. Suppose there are totally |A| edges considered in line 4.
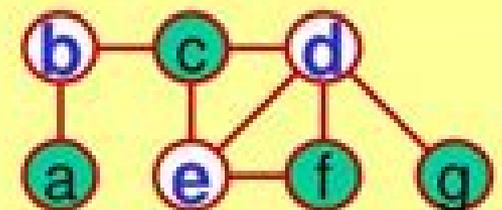
Then $|C^*| \geq |A|$

But $|C| = 2|A|$

Hence $|C| = 2|A| \leq 2|C^*|$

Near-optimal solution (C)

Optimal solution (C*)

Approximation Algorithms

Giorgio Ausiello,Pierluigi Crescenzi,Giorgio Gambosi,Viggo Kann,Alberto Marchetti-Spaccamela,Marco Protasi

Approximation Algorithms:

    Approximation Algorithms Vijay V. Vazirani,2002-12-05 Covering the basic techniques used in the latest research work the author consolidates progress made so far including some very recent and promising results and conveys the beauty and excitement of work in the field He gives clear lucid explanations of key results and ideas with intuitive proofs and provides critical examples and numerous illustrations to help elucidate the algorithms Many of the results presented have been simplified and new insights provided Of interest to theoretical computer scientists operations researchers and discrete mathematicians   *Geometric Approximation Algorithms* Sariel Har-Peled,2011 Exact algorithms for dealing with geometric objects are complicated hard to implement in practice and slow Over the last 20 years a theory of geometric approximation algorithms has emerged These algorithms tend to be simple fast and more robust than their exact counterparts This book is the first to cover geometric approximation algorithms in detail In addition more traditional computational geometry techniques that are widely used in developing such algorithms like sampling linear programming etc are also surveyed Other topics covered include approximate nearest neighbor search shape approximation coresets dimension reduction and embeddings The topics covered are relatively independent and are supplemented by exercises Close to 200 color figures are included in the text to illustrate proofs and ideas   *Handbook of Approximation Algorithms and Metaheuristics* Teofilo F. Gonzalez,2018-05-15 Handbook of Approximation Algorithms and Metaheuristics Second Edition reflects the tremendous growth in the field over the past two decades Through contributions from leading experts this handbook provides a comprehensive introduction to the underlying theory and methodologies as well as the various applications of approximation algorithms and metaheuristics Volume 1 of this two volume set deals primarily with methodologies and traditional applications It includes restriction relaxation local ratio approximation schemes randomization tabu search evolutionary computation local search neural networks and other metaheuristics It also explores multi objective optimization reoptimization sensitivity analysis and stability Traditional applications covered include bin packing multi dimensional packing Steiner trees traveling salesperson scheduling and related problems Volume 2 focuses on the contemporary and emerging applications of methodologies to problems in combinatorial optimization computational geometry and graphs problems as well as in large scale and emerging application areas It includes approximation algorithms and heuristics for clustering networks sensor and wireless communication bioinformatics search streams virtual communities and more About the Editor Teofilo F Gonzalez is a professor emeritus of computer science at the University of California Santa Barbara He completed his Ph D in 1975 from the University of Minnesota He taught at the University of Oklahoma the Pennsylvania State University and the University of Texas at Dallas before joining the UCSB computer science faculty in 1984 He spent sabbatical leaves at the Monterrey Institute of Technology and Higher Education and Utrecht University He is known for his highly cited pioneering research in the hardness of approximation for his sublinear and best possible approximation

algorithm for k tMM clustering for introducing the open shop scheduling problem as well as algorithms for its solution that have found applications in numerous research areas as well as for his research on problems in the areas of job scheduling graph algorithms computational geometry message communication wire routing etc <u>Design and Analysis of Approximation Algorithms</u> Ding-Zhu Du,Ker-I Ko,Xiaodong Hu,2011-11-18 This book is intended to be used as a textbook for graduate students studying theoretical computer science It can also be used as a reference book for researchers in the area of design and analysis of approximation algorithms Design and Analysis of Approximation Algorithms is a graduate course in theoretical computer science taught widely in the universities both in the United States and abroad There are however very few textbooks available for this course Among those available in the market most books follow a problem oriented format that is they collected many important combinatorial optimization problems and their approximation algorithms and organized them based on the types or applications of problems such as geometric type problems algebraic type problems etc Such arrangement of materials is perhaps convenient for a researcher to look for the problems and algorithms related to his her work but is difficult for a student to capture the ideas underlying the various algorithms In the new book proposed here we follow a more structured technique oriented presentation We organize approximation algorithms into different chapters based on the design techniques for the algorithms so that the reader can study approximation algorithms of the same nature together It helps the reader to better understand the design and analysis techniques for approximation algorithms and also helps the teacher to present the ideas and techniques of approximation algorithms in a more unified way **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 **Decision Sciences** Raghu Nandan Sengupta,Aparna Gupta,Joydeep Dutta,2016-11-30 This handbook is an endeavour to cover many current relevant and essential topics related to decision sciences in a scientific manner Using this handbook graduate students researchers as well as practitioners from engineering statistics sociology economics etc will find a new and refreshing paradigm shift as to how these topics can be put to use beneficially Starting from the basics to advanced concepts

authors hope to make the readers well aware of the different theoretical and practical ideas which are the focus of study in decision sciences nowadays It includes an excellent bibliography reference journal list information about a variety of datasets illustrated pseudo codes and discussion of future trends in research Covering topics ranging from optimization networks and games multi objective optimization inventory theory statistical methods artificial neural networks times series analysis simulation modeling decision support system data envelopment analysis queueing theory etc this reference book is an attempt to make this area more meaningful for varied readers Noteworthy features of this handbook are in depth coverage of different topics solved practical examples unique datasets for a variety of examples in the areas of decision sciences in depth analysis of problems through colored charts 3D diagrams and discussions about software *WALCOM: Algorithms and Computation* Ryuhei Uehara,Katsuhisa Yamanaka,Hsu-Chun Yen,2024-02-28 This book constitutes the refereed proceedings of the 18th International Conference and Workshops on Algorithms and Computation WALCOM 2024 held in Kanazawa Japan during March 18 20 2024 The 28 full papers presented in this book together with two extended abstracts of invited talks were carefully reviewed and selected from 80 submissions They cover diverse areas of algorithms and computation that is approximation algorithms algorithmic graph theory and combinatorics combinatorial algorithms combinatorial optimization computational biology combinatorial reconfiguration computational complexity computational geometry discrete geometry data structures experimental algorithm methodologies graph algorithms graph drawing parallel and distributed algorithms parameterized algorithms parameterized complexity network optimization online algorithms randomized algorithms and string algorithms **Key Concepts in Discrete Mathematics** Udayan Bhattacharya,2025-02-20 Key Concepts in Discrete Mathematics offers a comprehensive introduction to the fascinating realm of discrete mathematics covering a diverse array of topics essential for students and professionals in computer science mathematics engineering and related fields Through clear explanations illustrative examples and engaging exercises we provide readers with a solid foundation in discrete mathematics and its practical applications Our book covers a wide range of topics from fundamental concepts like sets relations and functions to advanced topics such as graph theory combinatorics and algorithm analysis We present complex concepts in a clear and accessible manner with detailed explanations and step by step examples guiding readers through each topic We emphasize practical applications and real world examples that demonstrate the relevance of discrete mathematics in various fields including computer science cryptography network theory and optimization Abundant exercises and problems ranging from basic to challenging allow readers to practice and reinforce their understanding of key concepts and techniques Additional online resources including solutions to selected exercises interactive quizzes and supplementary materials enhance the learning experience and provide opportunities for further exploration Whether used as a textbook in a classroom setting or as a self study guide Key Concepts in Discrete Mathematics serves as an invaluable resource for students seeking to deepen their understanding and for educators and professionals interested in exploring this essential

area of mathematics **Lectures on Proof Verification and Approximation Algorithms** Ernst W. Mayr,Hans Jürgen Prömel,Angelika Steger,1998-02-25 This is a self contained presentation of the enormous recent progress on the interplay between and applications of the theory of probabilistically checkable proofs and approximation algorithms 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 Saarbrcken 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 inapproximibility 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 *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 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 **Handbook of Approximation Algorithms and Metaheuristics** Teofilo F. Gonzalez,2018-05-15 Handbook of Approximation Algorithms and Metaheuristics Second Edition reflects the tremendous growth in the field over the past two decades Through contributions from leading experts this handbook provides a comprehensive introduction to the underlying theory and methodologies as well as the various applications of approximation algorithms and metaheuristics Volume 1 of this two volume set deals primarily with methodologies and traditional applications It includes restriction relaxation local

ratio approximation schemes randomization tabu search evolutionary computation local search neural networks and other metaheuristics It also explores multi objective optimization reoptimization sensitivity analysis and stability Traditional applications covered include bin packing multi dimensional packing Steiner trees traveling salesperson scheduling and related problems Volume 2 focuses on the contemporary and emerging applications of methodologies to problems in combinatorial optimization computational geometry and graphs problems as well as in large scale and emerging application areas It includes approximation algorithms and heuristics for clustering networks sensor and wireless communication bioinformatics search streams virtual communities and more About the Editor Teofilo F Gonzalez is a professor emeritus of computer science at the University of California Santa Barbara He completed his Ph D in 1975 from the University of Minnesota He taught at the University of Oklahoma the Pennsylvania State University and the University of Texas at Dallas before joining the UCSB computer science faculty in 1984 He spent sabbatical leaves at the Monterrey Institute of Technology and Higher Education and Utrecht University He is known for his highly cited pioneering research in the hardness of approximation for his sublinear and best possible approximation algorithm for k tMM clustering for introducing the open shop scheduling problem as well as algorithms for its solution that have found applications in numerous research areas as well as for his research on problems in the areas of job scheduling graph algorithms computational geometry message communication wire routing etc *Approximation Algorithms and Semidefinite Programming* Bernd Gärtner,Jiri Matousek,2012-01-10 Semidefinite programs constitute one of the largest classes of optimization problems that can be solved with reasonable efficiency both in theory and practice They play a key role in a variety of research areas such as combinatorial optimization approximation algorithms computational complexity graph theory geometry real algebraic geometry and quantum computing This book is an introduction to selected aspects of semidefinite programming and its use in approximation algorithms It covers the basics but also a significant amount of recent and more advanced material There are many computational problems such as MAXCUT for which one cannot reasonably expect to obtain an exact solution efficiently and in such case one has to settle for approximate solutions For MAXCUT and its relatives exciting recent results suggest that semidefinite programming is probably the ultimate tool Indeed assuming the Unique Games Conjecture a plausible but as yet unproven hypothesis it was shown that for these problems known algorithms based on semidefinite programming deliver the best possible approximation ratios among all polynomial time algorithms This book follows the semidefinite side of these developments presenting some of the main ideas behind approximation algorithms based on semidefinite programming It develops the basic theory of semidefinite programming presents one of the known efficient algorithms in detail and describes the principles of some others It also includes applications focusing on approximation algorithms Approximation, Randomization and Combinatorial Optimization. Algorithms and Techniques Klaus Jansen,Sanjeev Khanna,José D. P. Rolim,Dana Ron,2004-10-20 This book constitutes the joint refereed proceedings of the 7th

International Workshop on Approximation Algorithms for Combinatorial Optimization Problems APPROX 2004 and the 8th International Workshop on Randomization and Computation RANDOM 2004 held in Cambridge MA USA in August 2004 The 37 revised full papers presented were carefully reviewed and selected from 87 submissions Among the issues addressed are design and analysis of approximation algorithms inapproximability results approximation classes online problems graph algorithms cuts geometric computations network design and routing packing and covering scheduling game theory design and analysis of randomised algorithms randomized complexity theory pseudorandomness derandomization probabilistic proof systems error correcting codes and other applications of approximation and randomness   <u>Approximation, Randomization, and Combinatorial Optimization. Algorithms and Techniques</u> Josep Diaz,2006-08-11 This is the joint refereed proceedings of the 9th International Workshop on Approximation Algorithms for Combinatorial Optimization Problems APPROX 2006 and the 10th International Workshop on Randomization and Computation RANDOM 2006 The book presents 44 carefully reviewed and revised full papers Among the topics covered are design and analysis of approximation algorithms hardness of approximation problems small spaces and data streaming algorithms embeddings and metric space methods and more

Approximation Algorithms for Combinatorial Optimization Klaus Jansen,Jose Rolim,1998-07 Computer simulation has become a basic tool in many branches of physics such as statistical physics particle physics or materials science The application of efficient algorithms is at least as important as good hardware in large scale computation This volume contains didactic lectures on such techniques based on physical insight The emphasis is on Monte Carlo methods introduction cluster algorithms reweighting and multihistogram techniques umbrella sampling efficient data analysis and optimization methods but aspects of supercomputing the solution of stochastic differential equations and molecular dynamics are also discussed The book addresses graduate students and researchers in theoretical and computational physics   *Approximation, Randomization, and Combinatorial Optimization. Algorithms and Techniques* Sanjeev Arora,2003-08-13 This book constitutes the joint refereed proceedings of the 6th International Workshop on Approximation Algorithms for Optimization Problems APPROX 2003 and of the 7th International Workshop on Randomization and Approximation Techniques in Computer Science RANDOM 2003 held in Princeton NY USA in August 2003 The 33 revised full papers presented were carefully reviewed and selected from 74 submissions Among the issues addressed are design and analysis of randomized and approximation algorithms online algorithms complexity theory combinatorial structures error correcting codes pseudorandomness derandomization network algorithms random walks Markov chains probabilistic proof systems computational learning randomness in cryptography and various applications   *Complexity and Approximation* Giorgio Ausiello,Pierluigi Crescenzi,Giorgio Gambosi,Viggo Kann,Alberto Marchetti-Spaccamela,Marco Protasi,2012-12-06 N COMPUTER applications we are used to live with approximation Var I ious notions of approximation appear in fact in many circumstances One notable example is the type of approximation that arises in numer ical analysis or in computational geometry from the fact that we

cannot perform computations with arbitrary precision and we have to truncate the representation of real numbers In other cases we use to approximate com plex mathematical objects by simpler ones for example we sometimes represent non linear functions by means of piecewise linear ones The need to solve difficult optimization problems is another reason that forces us to deal with approximation In particular when a problem is computationally hard i e the only way we know to solve it is by making use of an algorithm that runs in exponential time it may be practically unfeasible to try to compute the exact solution because it might require months or years of machine time even with the help of powerful parallel computers In such cases we may decide to restrict ourselves to compute a solution that though not being an optimal one nevertheless is close to the optimum and may be determined in polynomial time We call this type of solution an approximate solution and the corresponding algorithm a polynomial time approximation algorithm Most combinatorial optimization problems of great practical relevance are indeed computationally intractable in the above sense In formal terms they are classified as Np hard optimization problems   *Algorithms and Computation* ,2005

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