Intratabilidade e Otimização

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encontro de teoria da computação
congresso da sbc · porto alegre · 2016

David Johnson

1945–2016

Bio – AT&T Labs

- Americano, matemático, pesquisador
  área de Ciência da Computação, Algoritmos e Otimização

- Mestrado (1968) e Doutorado (1973) no MIT
  "Near-Optimal Bin Packing Algorithms"

- 1973–2013: AT&T Bell Labs / AT&T Labs Research:
  - 1988: chefe do depto de Fundamentos Matemáticos de Computação
  - 1996: chefe do depto de Algoritmos e Otimização
  - 2013: membro honorário

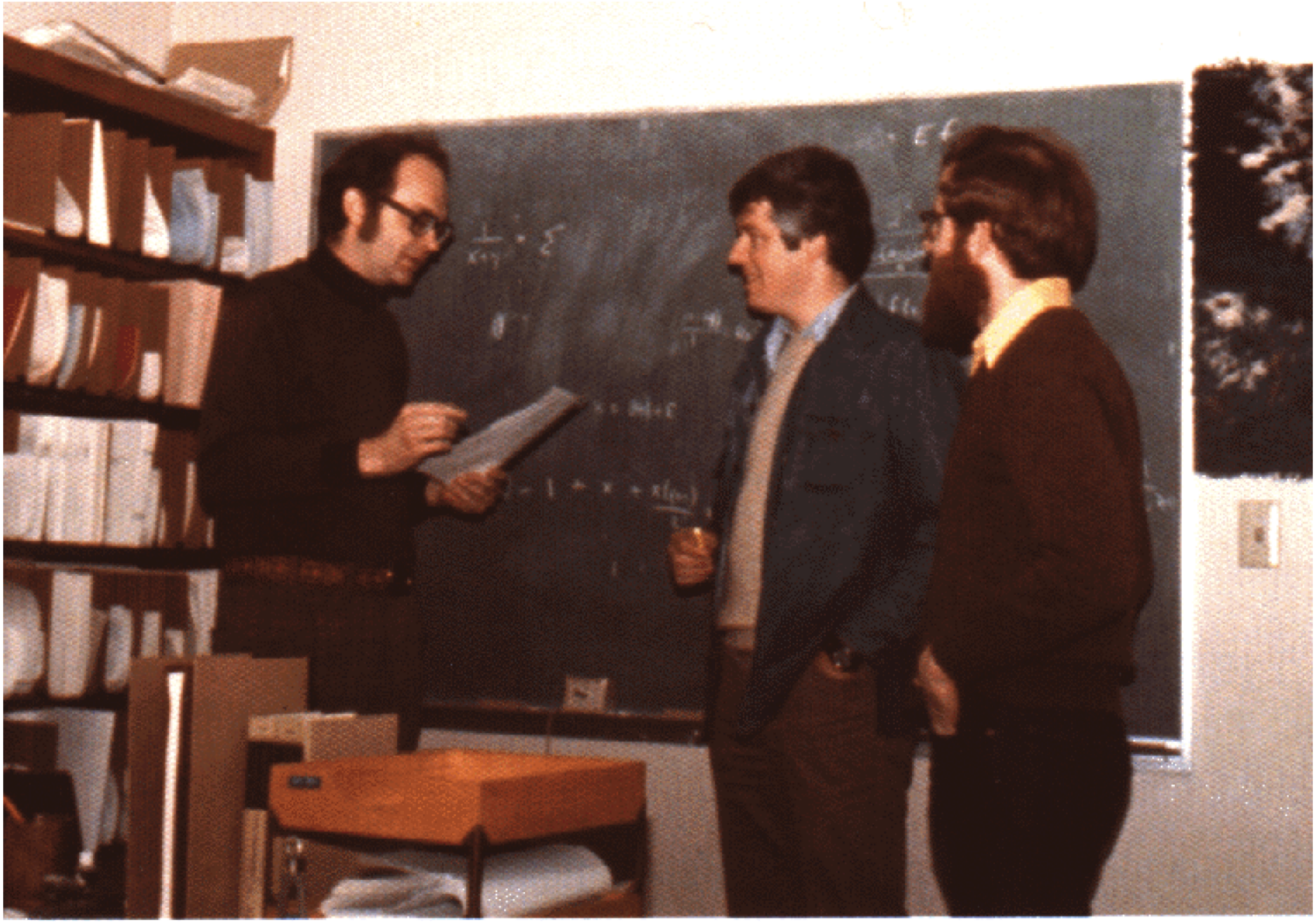
- 2014–2016: Columbia University

Bio – AT&T Labs – Down the Hall

- M.R. Garey, R. L. Graham, D.S. Johnson, and D.E. Knuth
  Complexity results for bandwidth minimization
  SIAM J. Appl. Math. 34 (1978), 477–495

- M.R. Garey, D.S. Johnson, and R.E. Tarjan
  The planar Hamiltonian circuit problem is NP-complete
  SIAM J. Computing 5 (1976), 704–714

Knuth – Garey – Johnson



Tarjan – Garey – Johnson

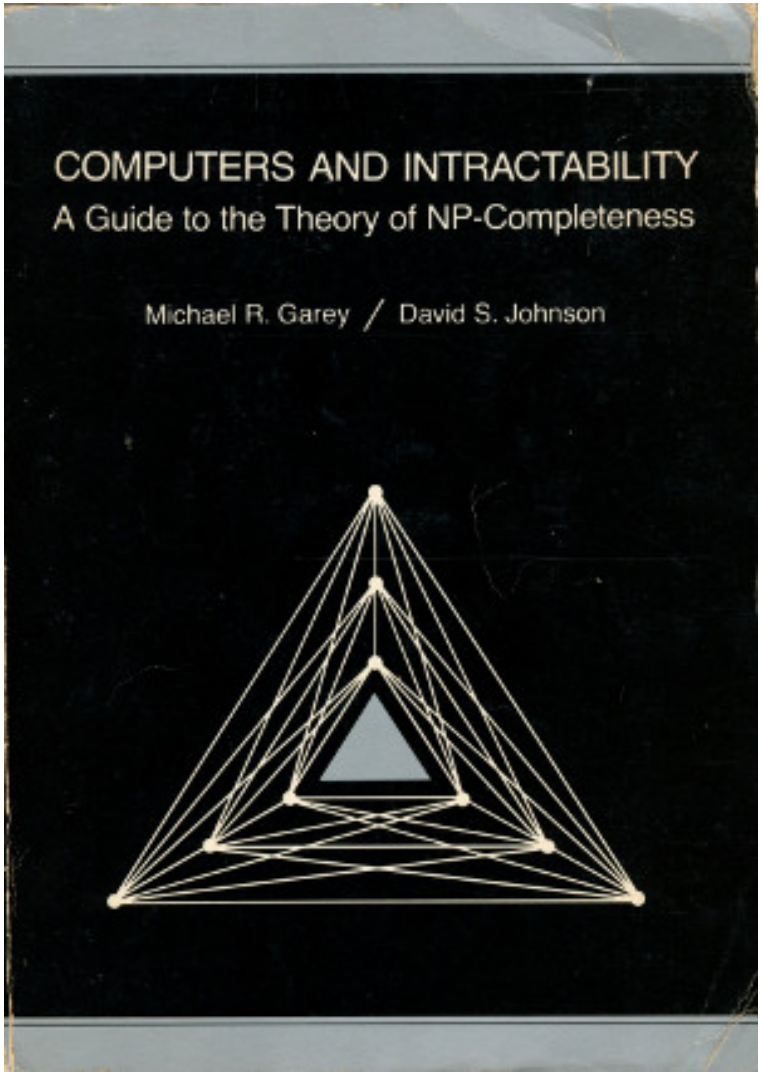
Bio – Service: Book, Editor, Chair

- 1979: "Computers and Intractability: A Guide to the Theory of NP-Completeness" (livro com Michael Garey)
- 1982: An Ongoing Guide on NP-completeness
  Journal of Algorithms / ACM Transactions on Algorithms
- 1990: fundou o ACM-SIAM Symposium on Discrete Algorithms (SODA), foi committee chair 25 anos
- 1987–1991: chair do ACM Special Interest Group on Algorithms and Computation Theory (SIGACT)
- 1983–1987: editor do Journal of the ACM
- 2004–2016: associate editor of ACM Transactions on Algorithms (TALG)

Bio – Prizes

- 1995 ACM Fellow
  contribuições fundamentais para as teorias de algoritmos aproximativos e de complexidade computacional, e para ACM
- 1997 SIGACT Distinguished Service Prize
  dedicação generosa e iniciativa pessoal para Teoria da Computação
- 2010 Knuth Prize, ACM SIGACT
  contribuições para teoria e análise de algoritmos, algoritmos para problemas de otimização, para encontrar a melhor solução dentre as soluções viáveis, para a teoria dos problemas NP-completos, para identificar os problemas difíceis de resolver eficientemente, para técnicas de aproximação e a definição de soluções quase ótimas, contribuições para a análise teórica e experimental de algoritmos
- 2016 Member of National Academy of Engineering

The Guide – Computers and Intractability



"Despite that 23 years have passed since its publication, I consider Garey and Johnson the single most important book on my office bookshelf. Every computer scientist should have this book on their shelves as well. NP-completeness is the single most important concept to come out of theoretical computer science and no book covers it as well as Garey and Johnson."

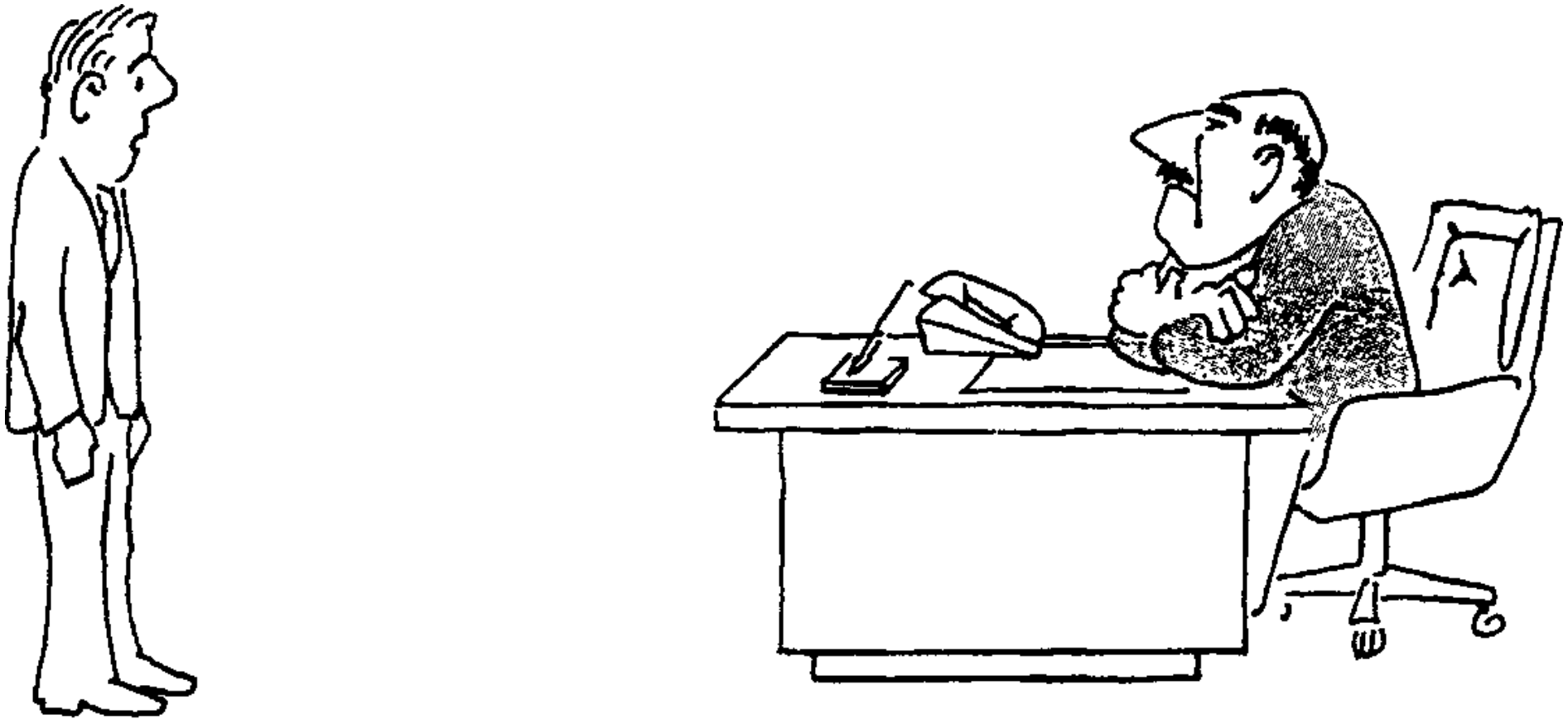
Lance Fortnow, "Great Books: Computers and Intractability: A Guide to the Theory of NP-Completeness"

NP-completo: simboliza o abismo da intratabilidade inerente para resolver problemas maiores e mais complexos

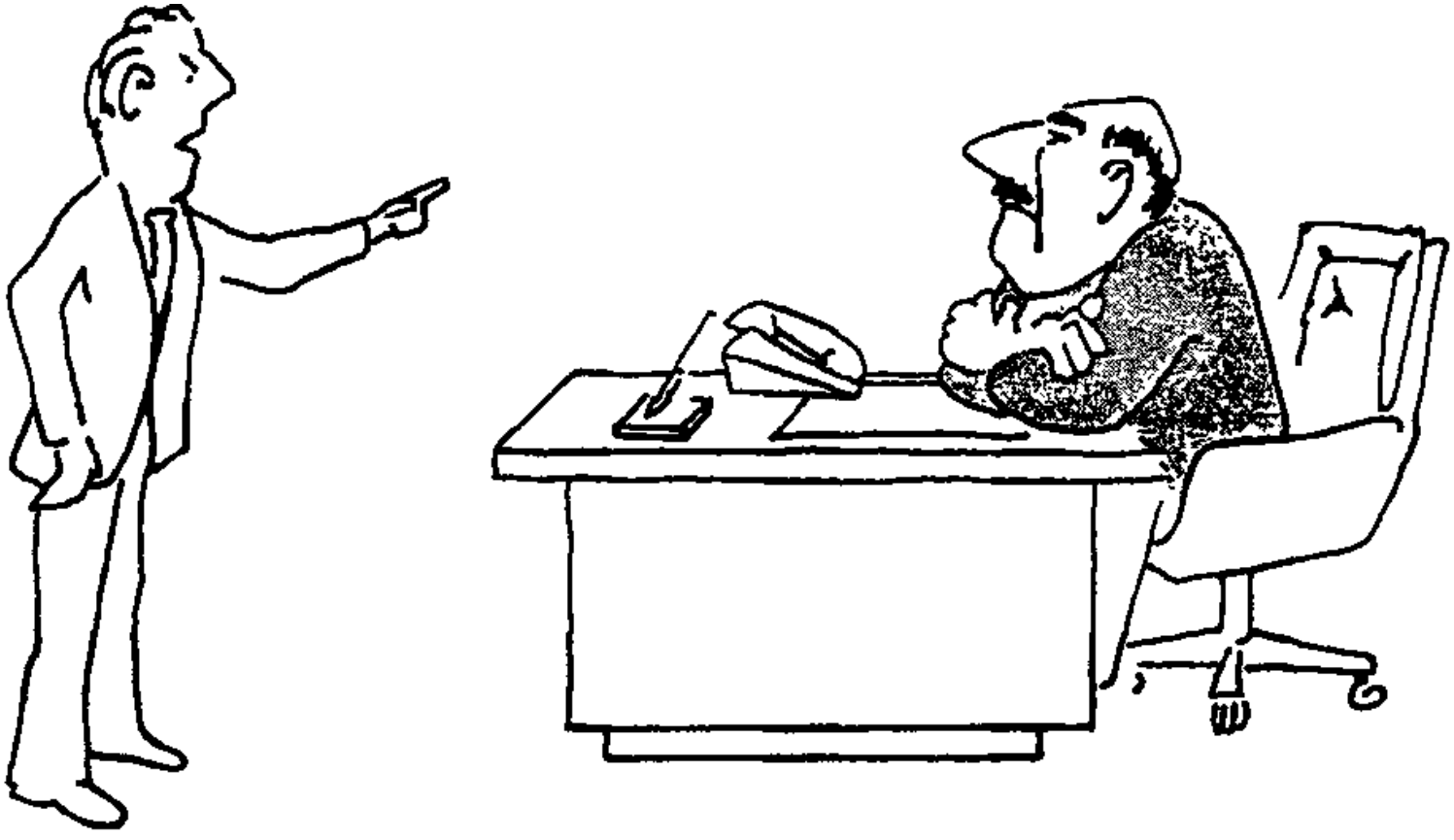
Variedade ampla de problemas frequentes: matemática, computação, pesquisa operacional

- Capítulos 1–5: teoria básica
- Capítulos 6–7: aproximação, hierarquia de classes de complexidade
- Apêndice: metade do livro! Lista bem organizada de problemas

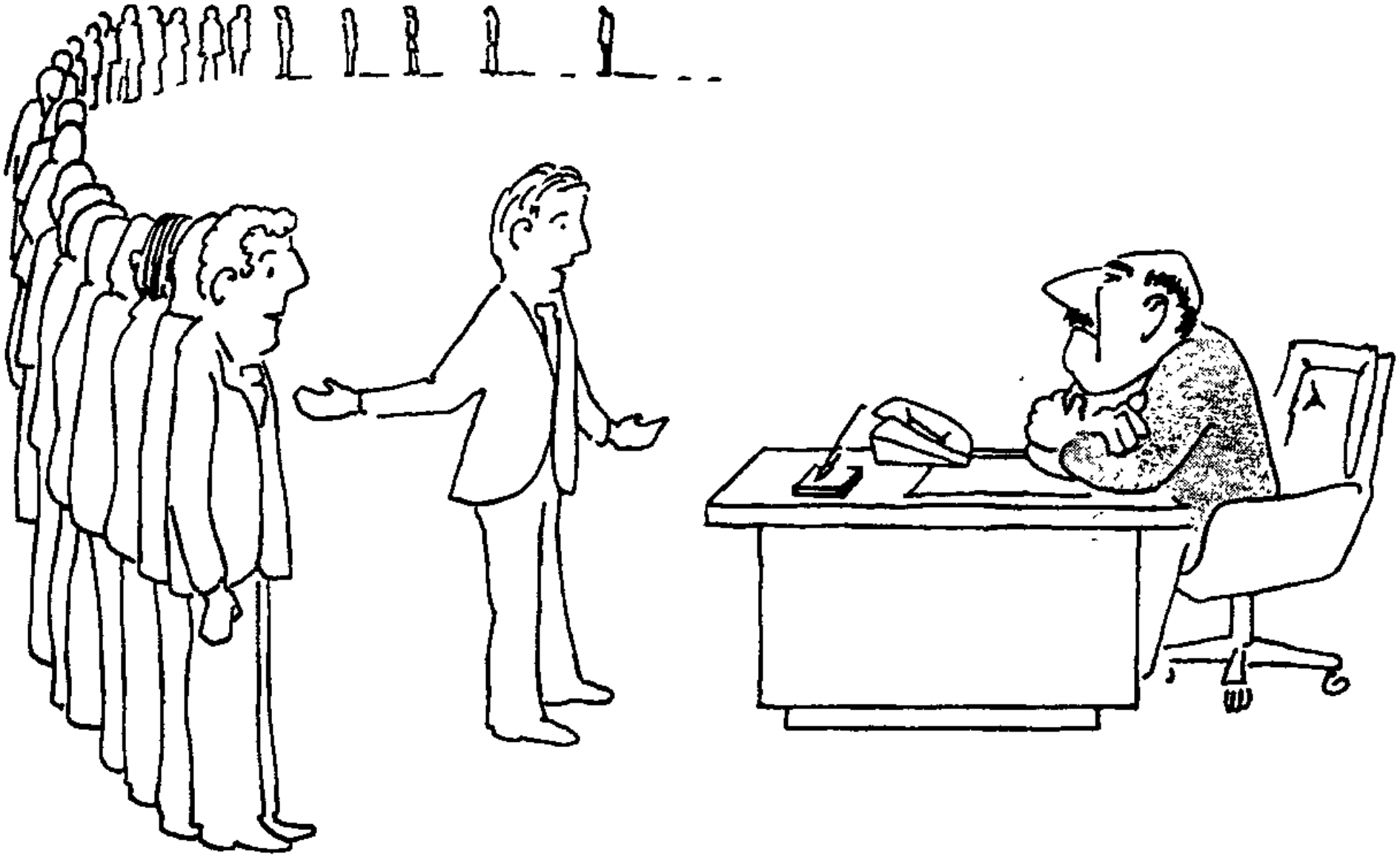
"Bandersnatches are the subject of a difficult algorithm design project for an apparently NP-complete problem."



"I can't find an efficient algorithm, I guess I'm just too dumb."



"I can't find an efficient algorithm, because no such algorithm is possible!"



"I can't find an efficient algorithm, but neither can all these famous people."

The Lost Cartoon

The Guide 12 problemas em aberto em 1979

- Graph isomorphism
- Subgraph homeomorphism (for a fixed graph H)
- Graph genus
- Chordal graph completion
- Chromatic index
- Spanning tree parity problem
- Partial order dimension
- Precedence constrained 3-processor scheduling
- Linear programming
- Total unimodularity
- Composite number
- Minimum length triangulation

Ongoing Guide – Os 12 problemas atualizados em 2005

Problem Name	Source	Status	Covered in
GRAPH ISOMORPHISM	[G&J]	Open	–
SUBGRAPH HOMEOMORPHISM (FOR A FIXED GRAPH H)	[G&J]	P	[Col 19, 1987]
GRAPH GENUS	[G&J]	NPC	[Col 21, 1988]
CHORDAL GRAPH COMPLETION	[G&J]	NPC	[Col 1, 1981]
CHROMATIC INDEX	[G&J]	NPC	[Col 1, 1981]
PARTIAL ORDER DIMENSION	[G&J]	NPC	[Col 1, 1981]
PRECEDENCE CONSTRAINED 3-PROCESSOR SCHEDULING	[G&J]	Open	–
LINEAR PROGRAMMING	[G&J]	P	[Col 1, 1981]
TOTAL UNIMODULARITY	[G&J]	P	[Col 1, 1981]
SPANNING TREE PARITY PROBLEM	[G&J]	P	[Col 1, 1981]
COMPOSITE NUMBER	[G&J]	P	This Column
MINIMUM LENGTH TRIANGULATION	[G&J]	Open	–
IMPERFECT GRAPH	[Col 1, 1981]	P	This Column
GRAPH THICKNESS	[Col 2, 1982]	NPC	[Col 5, 1982]
EVEN COVER (MINIMUM WEIGHT CODEWORD)	[Col 3, 1982]	NPC	This Column
"UNRESTRICTED" TWO-LAYER CHANNEL ROUTING	[Col 5, 1982]	Open	–
GRACEFUL GRAPH	[Col 6, 1983]	Open	–
ANDREEV'S PROBLEM	[Col 17, 1986]	Open	–
SHORTEST VECTOR IN A LATTICE	[Col 18, 1986]	"NPC"	This Column

Ongoing Guide – Graph Restrictions and Their Effect

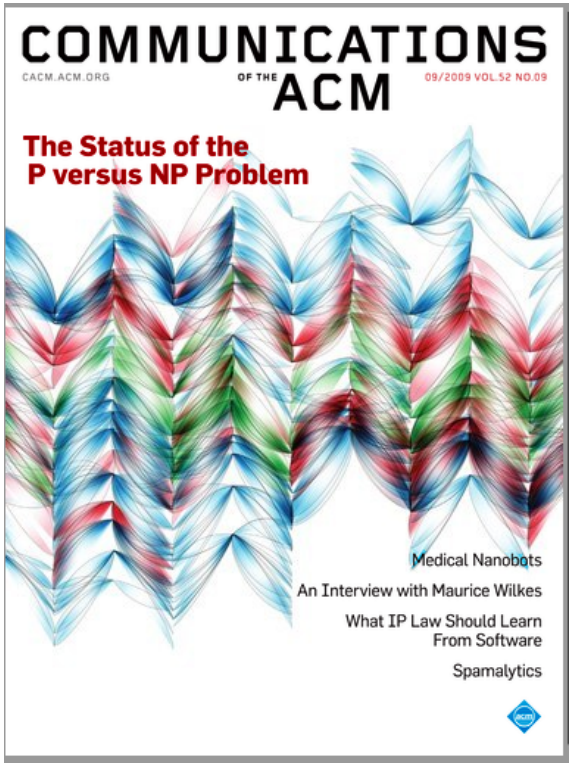
Graph Class	Member		IndSet		Clique		CliPar		ChrNum	
Trees/Forests	P	[T]	P	[GJ]	P	[T]	P	[GJ]	P	[T]
Almost Trees (k)	P		P	[24]	P	[T]	P?		P?	
Partial k-Trees	P	[2]	P	[1]	P	[T]	P?		P	[1]
Bandwidth-k	P	[68]	P	[64]	P	[T]	P?		P	[64]
Degree-k	P	[T]	N	[GJ]	P	[T]	N	[GJ]	N	[GJ]
Planar	P	[GJ]	N	[GJ]	P	[T]	N	[10]	N	[GJ]
Series Parallel	P	[79]	P	[75]	P	[T]	P?		P	[74]
Outerplanar	P		P	[6]	P	[T]	P	[6]	P	[67]
Halin	P		P	[6]	P	[T]	P	[6]	P	[74]
k-Outerplanar	P		P	[6]	P	[T]	P	[6]	P	[6]
Grid	P		P	[GJ]	P	[T]	P	[GJ]	P	[T]
$K_{3,3}$-Free	P	[4]	N	[GJ]	P	[T]	N	[10]	N	[GJ]
Thickness-k	N	[60]	N	[GJ]	P	[T]	N	[10]	N	[GJ]
Genus-k	P	[34]	N	[GJ]	P	[T]	N	[10]	N	[GJ]
Perfect	O!		P	[42]	P	[42]	P	[42]	P	[42]
Chordal	P	[76]	P	[40]	P	[40]	P	[40]	P	[40]
Split	P	[40]	P	[40]	P	[40]	P	[40]	P	[40]
Strongly Chordal	P	[31]	P	[40]	P	[40]	P	[40]	P	[40]
Comparability	P	[40]	P	[40]	P	[40]	P	[40]	P	[40]
Bipartite	P	[T]	P	[GJ]	P	[T]	P	[GJ]	P	[T]
Permutation	P	[40]	P	[40]	P	[40]	P	[40]	P	[40]
Cographs	P	[T]	P	[40]	P	[40]	P	[40]	P	[40]
Undirected Path	P	[39]	P	[40]	P	[40]	P	[40]	P	[40]
Directed Path	P	[38]	P	[40]	P	[40]	P	[40]	P	[40]
Interval	P	[17]	P	[44]	P	[44]	P	[44]	P	[44]
Circular Arc	P	[78]	P	[44]	P	[50]	P	[44]	N	[36]
Circle	P	[71]	P	[GJ]	P	[50]	O?		N	[36]
Proper Circ. Arc	P	[77]	P	[44]	P	[50]	P	[44]	P	[66]
Edge (or Line)	P	[47]	P	[GJ]	P	[T]	N	[GJ]	N	[49]
Claw-Free	P	[T]	P	[63]	O?		N	[GJ]	N	[49]

ChrInd		HamCir		DomSet		MaxCut		StTree		GraIso	
P	[GJ]	P	[T]	P	[GJ]	P	[GJ]	P	[T]	P	[GJ]
P?		P?		P	[45]	P?		P?		P?	
O?		P	[3]	P	[3]	P?		P?		O?	
P?		P?		P	[64]	P	[64]	P?		P	[58]
N	[49]	N	[GJ]	N	[GJ]	N	[GJ]	N	[GJ]	P	[58]
O		N	[GJ]	N	[GJ]	P	[GJ]	N	[35]	P	[GJ]
P	[74]	P	[74]	P	[54]	P	[GJ]	P	[82]	P	[GJ]
P	[67]	P	[T]	P	[6]	P	[GJ]	P	[81]	P	[GJ]
P	[74]	P	[T]	P	[6]	P	[GJ]	P?		P	[GJ]
O?		P	[6]	P	[6]	P	[GJ]	P?		P	[GJ]
P	[GJ]	N	[51]	N	[55]	P	[T]	N	[35]	P	[GJ]
O?		N	[GJ]	N	[GJ]	P	[5]	N	[GJ]	O?	
N	[49]	N	[GJ]	N	[GJ]	N	[7]	N	[GJ]	O?	
O?		N	[GJ]	N	[GJ]	O?		N	[GJ]	P	[61]
O?		N	[1]	N	[14]	O?		N	[GJ]	I	[GJ]
O?		N	[22]	N	[14]	O?		N	[83]	I	[GJ]
O?		N	[22]	N	[19]	O?		N	[83]	I	[15]
O?		O?		P	[32]	O?		P	[83]	O?	
O?		N	[1]	N	[28]	O?		N	[GJ]	I	[GJ]
P	[GJ]	N	[1]	N	[28]	P	[T]	N	[GJ]	I	[GJ]
O?		O		P	[33]	O?		P	[23]	P	[21]
O?		P	[25]	P	[33]	O?		P	[23]	P	[25]
O?		O?		N	[16]	O?		O?		I	[GJ]
O?		O?		P	[16]	O?		P	[83]	O?	
O?		P	[53]	P	[16]	O?		P	[83]	P	[57]
O?		O?		P	[13]	O?		P	[83]	O?	
O?		P	[12]	O?		O?		P	[70]	O?	
O?		P	[12]	P	[13]	O?		P	[83]	O?	
O?		N	[11]	N	[GJ]	O?		N	[70]	I	[15]
O?		N	[11]	N	[GJ]	O?		N	[70]	I	[15]

Perspectivas – O Problema do Milênio

Problema central em Teoria da Computação: P versus NP

Existe pergunta cuja resposta pode ser verificada rapidamente, mas cuja resposta requer muito tempo para ser encontrada?



setembro 2009

- Real world instances were not as worst-case or asymptotic as our theory is.
- Champion algorithms from the theory world could be outclassed by ad hoc algorithms with much worse (or unknown) worst-case behavior.
- Some algorithms and ideas from the theory world have been successfully applied, often to purposes for which they were not originally designed.
- Algorithms from the Operations Research and Metaheuristic communities have perhaps had more real-world impact on coping with NP-hardness than those from TCS.