ProCombo

Combinatorial Problems: Theory, Algorithms, and Applications

Final Report

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Theme: Theory of Computing

PROTEM-CC-II – CNPq

Abstract

The objective of this project was developing high level research in combinatorics, a subject of known importance in the area of theory of computing.

The main lines of research were three, characterized by the following problems:

Problem 1:	Investigate structural problems in combinatorics and graph algorithms;
Problem 2:	Study polyhedral methods and multi-algorithms for NP-hard problems;
Problem 3:	Investigate the application of probabilistic methods in combinatorics and in the theory of computing.

Our goal in this project was to develop, through cooperation within the participating institutions and with international research centers, research work to be published in international periodicals and high quality congress proceedings. We published over 40 papers in periodicals and over 20 in proceedings. We also had 4 books published (one of them by an international publishing company).

This project financed over 20 international research trips.

Keywords: combinatorics, graph theory, algorithms, complexity, probabilistic methods, polyhedral methods, approximation algorithm.

Contents

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1.4 Pontifícia Universidade Católica do Rio de Janeiro (PUC–Rio)

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[a] *Marcus Vinicius Soledade Poggi de Aragão* moved from UNICAMP to PUC–Rio in 1996.

2 Introduction

The activities of this project were started with the *I Oficina Nacional do ProComb* (First National ProComb Workshop), February 1995. The project lasted two years.

Our results and activities under this project may be summarized as follows:

- the organization of the *International Combinatorics Workshop* at UFRJ, and of 3 national workshops (2 at USP and 1 at UNICAMP);
- publication of 38 research papers, acceptance of 5 and submission of 16, all in international periodicals with refereeing process (total: 59 papers). Publication of 4 books and 25 papers in proceedings of national and international conferences;
- more than 50 presentations in national and international conferences;
- 10 short trips and 6 long trips abroad;
- 33 short trips in the country;
- 6 visits of leading researchers from abroad;
- purchase of equipment and books.

3 Events

3.1 First National ProComb Workshop

- IME-USP, 1–3 February 1995.
- Participants from the project:

  Celina M. H. de Figueiredo (UFRJ), Sulamita Klein (UFRJ), Marcia Rosana Cerioli (UFRJ), Jayme Luiz Szwarcfiter (UFRJ), Oscar Porto (PUC–Rio), Célia Picinin de Mello (UNICAMP), Cid Carvalho de Souza (UNICAMP), João Carlos Setubal (UNICAMP), João Meidanis (UNICAMP), Marcus Vinicius S. Poggi de Aragão (UNICAMP), Carlos Eduardo Ferreira (USP), José Augusto Ramos Soares (USP), Maria Angela Gurgel (USP), Paulo Feofiloff (USP), Yoshiharu Kohayakawa (USP), Yoshiko Wakabayashi (USP).
- Written versions of the talks were compiled into a technical report, produced at USP (RT-MAC-9515, 39 pages).
- Talks of the workshop:

- *Abordagem em grafos-E/OU para problemas de corte/empacotamento (AND/OR Graphs for Cutting and Packing Problems).*

  M. N. Arenales (ICMSC/USP) and R. Morábito (DEP/UFSCar).
- *Edge-Colouring, Indifference Graphs and Odd Maximum Degree Graphs.*

  C. M. H. de Figueiredo (UFRJ), J. Meidanis (UNICAMP) and C. P. de Mello (UNICAMP).
- *The Sampling Paradigm of Karger.*

  Y. Kohayakawa (USP).
- *An Algorithm to Compute Reduced Costs on a Spanning Tree.*

  A. Lucena (LNCC/RJ) and Y. M. Sharaiha (Imperial College, London).
- *A Lossy Data Compression Based on an Approximate Pattern Matching.*

  T. Łuczak (Polish Academy of Sciences and Adam Mickiewicz Univ.) and W. Szpankowski (Purdue University).
- *Sources, Sinks, Even and Odd Pairs in Comparability Graphs.*

  J. L. Szwarcfiter (UFRJ), C. P. de Mello (UNICAMP) and C. M. H. de Figueiredo (UFRJ).

3.2 Second National ProComb Workshop

- UNICAMP, 15–17 November 1995.
- Participants of the project:

  Sulamita Klein (UFRJ), Marcia Rosana Cerioli (UFRJ), Oscar Porto (PUC–Rio), Célia Picinin de Mello (UNICAMP), Cid Carvalho de Souza (UNICAMP), João Carlos Setubal (UNICAMP), João Meidanis (UNICAMP), Marcus Vinicius S. Poggi de Aragão (UNICAMP), Carlos Eduardo Ferreira (USP), José Augusto Ramos Soares (USP), José Coelho de Pina Jr. (USP), Maria Angela Gurgel (USP), Paulo Feofiloff (USP), Yoshiharu Kohayakawa (USP), Yoshiko Wakabayashi (USP).
- Written versions of the talks were compiled into a technical report, produced at UNICAMP (DCC-95-13, 58 pages).
- Talks of the workshop:
  - *A Pretty Class of Perfect Graphs*

    O. Porto (PUC–Rio), F. Maffray and M. Preissman (CRNS/IMAG, France).
  - *A Scalable Parallel Algorithm for List Ranking.*

    S. W. Song (USP) and F. Dehne (Carleton University).

- *The Homogeneous Set Sandwich Problem.*

  S. Klein (UFRJ), H. Everett (UQAM, Canada), C. M. H. de Figueiredo (UFRJ) and M. R. Cerioli (UFRJ).
- *Local Conditions for Edge-Coloring.*

  J. Meidanis (UNICAMP), C. P. de Mello (UNICAMP) and C. M. H. de Figueiredo (UFRJ).
- *A Parallel Version of Edmonds' Matching Algorithm.*

  J. C. Setubal (UNICAMP) and C. F. Bella Cruz (UNICAMP).
- *Upper Bounds for Minimum Covering Codes by Tabu-Search.*

  M. V. S. P. de Aragão, C. C. de Souza, W. A. Carnielli and E. L. do Monte Carmelo (UNICAMP).

3.3 Third National ProComb Workshop

- IME-USP, 29–30 April 1997
- Participants of the project:

  Celina M. H. de Figueiredo (UFRJ), Sulamita Klein (UFRJ), Marcia Rosana Cerioli (UFRJ), Jayme Luiz Szwarcfiter (UFRJ), Oscar Porto (PUC–Rio), Célia Picinin de Mello (UNICAMP), Cid Carvalho de Souza (UNICAMP), João Carlos Setubal (UNICAMP), João Meidanis (UNICAMP), Marcus Vinicius S. Poggi de Aragão (UNICAMP), Carlos Eduardo Ferreira (USP), José Augusto Ramos Soares (USP), Maria Angela Gurgel (USP), Paulo Feofiloff (USP), Yoshiharu Kohayakawa (USP), Yoshiko Wakabayashi (USP).
- Talks of the workshop:

  - *A Survey on Clique Graphs.*

    Jayme L. Szwarcfiter (UFRJ).
  - *Circuit Covers in Mixed Graphs.*

    Orlando Lee (USP) and Yoshiko Wakabayashi (USP).
  - *An Algebraic–Enumerative Algorithm for 0–1 Non-linear Programming.*

    Marcus V. Poggi (PUC–Rio).
  - *Edge Colouring Studies: Strategies that did not Work.*

    João Meidanis (UNICAMP), Celina M.H. Figueiredo (UFRJ) and Célia P. Mello (UNICAMP).

- *On Bull-Free Perfect Graphs: Transitivity, Perfect Orderings and Weakly Triangulated Graphs.*

  Celina M.H. de Figueiredo (UFRJ), Oscar Porto (PUC–Rio), Fréderic Maffray (Grenoble).
- *Asynchronous, Distributed and Parallel Maximum Flow Algorithm.*

  João C. Setubal (UNICAMP) and Edson N. Cáceres (UFMS).
- *On Factors and Packing of Graphs.*

  Estela M. Rodrigues (USP) and Maria Angela M.C. Gurgel (USP).

3.4 International Combinatorics Workshop

- UFRJ, 2–4 October 1996.
- Brazilian participants:

  All members of the project were present. Several other Brazilian researchers attended, among which we mention Cláudio Lucchesi (UNICAMP), Nelson Maculan (UFRJ), Cláudia Linhares (UFRJ), Kátia S. Guimarães (UFPE), Marcelo H. de Carvalho (UFMS), Nalvo Franco (UFMS) e L. Satoru Ochi (UFF). Several students attended.
- Foreign participants:

  A.M.H. Gerards (CWI–Amsterdam), B. Reed (Paris), Christos H. Papadimitriou (Berkeley), Frédéric Maffray (Grenoble), H.-J. Prömel (Berlin), J.A. Bondy (Lyon), Pierre Hansen (Montréal), U.S.R. Murty (Waterloo) e Marisa Gutierrez (Argentina).
- Workshop Programme (* indicates speaker):

October 2nd - Wednesday

08:00 - 08:50	Registration
08:50 - 09:00	Welcome
09:00 - 09:50	J. Adrian Bondy
	"Flows and Coverings of Graphs"
09:50 - 10:30	Yoshiharu Kohayakawa
	"The Coloured Tverberg Theorem and Related Results"
	Celina M. H. de Figueiredo, João Meidanis*, and Célia P. de Mello
	"Colouring Split Graphs"
10:30 - 11:00	Coffee Break
11:00 - 12:30	Mini-Courses

	Pierre Hansen – *"Recent Advances in Continuous Location Theory"*
	A.M.H. Gerards – *"The Matroids Representable over the 4-element Field"*
12:30 - 14:30	Lunch
14:30 - 15:20	Frédéric Maffray
	"Perfectly Contractile Graphs"
15:20 - 15:50	Rubem Mondaini* and Nelson Maculan*
	"Steiner and Baricentric Trees. The Possible Binders of Macromolecular Structure"
15:50 - 16:20	Coffee Break
16:20 - 16:30	Workshop Photo
16:30 - 17:20	H.-J. Prömel
	"Random Graphs, Evolution Processes, and Threshold Phenomena"
17:20 - 18:00	Marcus P. de Aragão and Eduardo Uchoa*
	"The γ-Connected Assignment Problem"
	João Meidanis* and Erasmo G. Munuera
	"A Theory for the Consecutive Ones Property"
18:00	Cocktail

October 3rd - Thursday

09:00 - 09:50	Christos H. Papadimitriou
	"Computational Approaches to Organization Theory"
09:50 - 10:30	Maurício G.C. Resende and Celso C. Ribeiro*
	"A GRASP for Graph Planarization"
	Marcus P. de Aragão
	"A Separation Procedure for the Flow Shop Scheduling Problem"
10:30 - 11:00	Coffee Break
11:00 - 11:30	Marcelo H. de Carvalho* and Cláudio L. Lucchesi
	"Edge Implication in Matching Covered Graphs"
11:30 - 13:00	Mini-Courses
	Pierre Hansen – *"Recent Advances in Continuous Location Theory"*
	A.M.H. Gerards – *"The Matroids Representable over the 4-element Field"*

October 4th - Friday

09:00 - 10:10	Christos H. Papadimitriou
	"A Survey on Approximation Algorithms for the TSP"
10:10 - 10:40	Luiz S. Ochi*, Lúcia M. A. Drummond and Rosa M. V. de Figueiredo
	"Design and Implementation of a Parallel Genetic Algorithm for a Job Sequencing Problem"
10:40 - 11:10	Coffee Break
11:10 - 12:40	Mini-Courses
	Pierre Hansen – *"Recent Advances in Continuous Location Theory"*
	A.M.H. Gerards – *"The Matroids Representable over the 4-element Field"*
12:40 - 14:40	Lunch
14:40 - 15:30	Bruce Reed
	"A Proof of the Gallai-Younger Conjecture"
15:30 - 16:00	Marisa Gutierrez
	"Tree-clique Graphs"
16:00 - 16:30	Coffee Break
16:30 - 17:10	Celina M. H. de Figueiredo* and Kristina Vušković
	"A Class of β-Perfect Graphs"
	Claudson F. Bornstein and Jayme L. Szwarcfiter*
	"Iterated Clique Graphs with Increasing Diameters"
17:10 - 18:00	Christos H. Papadimitriou
	"Complexity as Metaphor"

4 Publications

4.1 Papers in International Periodicals

(MR# indicates *Mathematical Reviews* numbers)

[1] R. Anderson and J.C. Setubal. A parallel implementation of the push-relabel algorithm for the maximum flow problem. *J. Parallel Distr. Com.*, 29(1):17–26, 1995.

[2] C.F. Bornstein and J.L. Szwarcfiter. On clique convergent graphs. *Graphs and Combinatorics*, 11(3):213–220, 1995. MR#96h:05105.

[3] B. Chandra, G. Das, G. Narasimhan, and J. Soares. New sparseness results on graph spanners. *Int. J. of Computational Geometry and Applications*, 5(1–2):125–144, 1995. MR#97a:05197.

[4] C.M.H. de Figueiredo, J. Gimbel, C.P. de Mello, and J.L. Szwarcfiter. Sources and sinks in comparability graphs. *Order*, 14(1):75–83, 1997. MR#1 468 958.

[5] C.M.H. de Figueiredo and S. Klein. The NP-completeness of multi-partite cutset testing. *Congressus Numerantium*, (119):217–222, 1996. MR#97i:05120.

[6] C.M.H. de Figueiredo, F. Maffray, and O. Porto. On the structure of bull-free perfect graphs. *Graphs and Combinatorics*, 13(1):31–55, 1997. MR#97m:05093.

[7] C.M.H. de Figueiredo, J. Meidanis, and C.P. de Mello. A greedy method for edge-colouring odd maximum degree chordal graphs. *Congressus Numerantium*, 111:170–176, 1995. MR#96h:05071.

[8] C.M.H. de Figueiredo, J. Meidanis, and C.P. de Mello. A linear time algorithm for proper interval graph recognition. *Information Processing Letters*, 56(3):179–184, 1995. MR#96g:05129.

[9] C.M.H. de Figueiredo, J. Meidanis, and C.P. de Mello. On edge-colouring indifference graphs. *Theoretical Computer Science*, 181(1):91–106, 1997. MR#1 463 531.

[10] C.C. de Souza and M. Laurent. Some new classes of facets for the equicut polytope. partitioning and decomposition in combinatorial optimization. *Discrete Appl. Math.*, 62(1–3):167–191, 1995. MR# 96j:52018.

[11] P. Erdős, A. Gyárfás, and Y. Kohayakawa. The size of the largest bipartite subgraphs. *Discrete Mathematics*, 177(1–3):267–271, 1997.

[12] H. Everett, C.M.H. de Figueiredo, F. Maffray, and B. Reed. Path parity and perfection. *Discrete Mathematics*, 165/166:233–252, 1997. MR#98a:05069.

[13] H. Everett, S. Klein, and B. Reed. An algorithm for finding homogeneous pairs. *Discrete Applied Mathematics*, (72):209–218, 1997. MR#97k:05183.

[14] Carlos E. Ferreira, A. Martin, and R. Weismantel. Solving multiple knapsack problems by cutting planes. *SIAM Journal on Optimization*, 6(3):858–877, 1996. MR#97e:90063.

[15] C.E. Ferreira, A. Martin, C.C. de Souza, R. Weismantel, and L. A. Wolsey. Formulations and valid inequalities for the node capacitated graph partitioning problems. *Mathematical Programming A*, 74(3):247–266, 1996. MR#97i:90101.

[16] J.Z. Gonçalves and A. Mandel. A commutativity theorem for division rings and an extension of a result of faith. *Results Math.*, 30(3–4):302–309, 1996. MR#1 419 945.

[17] M.A.M.C. Gurgel and Y. Wakabayashi. Adjacency of vertices of the complete

pre-order polytope. *Discrete Mathematics*, 175(1–3):163–172, 1997. MR#1 475 845.

[18] P.E. Haxell and Y. Kohayakawa. On an anti-Ramsey property of Ramanujan graphs. *Random Structures and Algorithms*, 6(4):417–431, 1995. MR#97c:05107.

[19] P.E. Haxell and Y. Kohayakawa. The size-Ramsey number of trees. *Israel Journal of Mathematics*, 89(1–3):261–274, 1995. MR#96c:05128.

[20] P.E. Haxell and Y. Kohayakawa. Partitioning by monochromatic trees. *Journal of Combinatorial Theory*, Series B, 68(2):218–222, 1996. MR#97h:05180.

[21] P.E. Haxell, Y. Kohayakawa, and T. Łuczak. The induced size-Ramsey number of cycles. *Combinatorics, Probability and Computing*, 4(3):217–239, 1995. MR#96h:05140.

[22] P.E. Haxell, Y. Kohayakawa, and T. Łuczak. Turán's extremal problem in random graphs: forbidding even cycles. *Journal of Combinatorial Theory*, Series B, 64:273–287, 1995. MR#96e:05151.

[23] P.E. Haxell, Y. Kohayakawa, and T. Łuczak. Turán's extremal problem in random graphs: forbidding odd cycles. *Combinatorica*, 16(1):107–122, 1996. MR#97k:05180.

[24] Y. Kohayakawa and B. Kreuter. Threshold functions for asymmetric Ramsey properties involving cycles. *Random Structures and Algorithms*, 11(3):245–276, 1997.

[25] Y. Kohayakawa and T. Łuczak. Sparse anti-Ramsey graphs. *Journal of Combinatorial Theory*, Series B, 63:146–152, 1995. MR#95m:05215.

[26] Y. Kohayakawa, T. Łuczak, and V. Rödl. Arithmetic progressions of length three in subsets of a random set. *Acta Arithmetica*, LXXV(2):133–163, 1996. MR#97b:11011.

[27] Y. Kohayakawa, T. Łuczak, and V. Rödl. Ramsey-type results for oriented trees. *Journal of Graph Theory*, 22(1):1–8, 1996. MR#97d:05211.

[28] Y. Kohayakawa, T. Łuczak, and V. Rödl. On K^4-free subgraphs of random graphs. *Combinatorica*, 17(2):173–213, 1997. MR#1 479 298.

[29] R.S. Lanzelotte, C.C. Ribeiro, and C.D. Ribeiro. Query optimization in distributed relational databases. *Journal of Heuristics*, 3:5–23, 1997.

[30] F. Maffray, O. Porto, and M. Preissmann. A generalization of simplicial elimination orderings. *J. Graph Theory*, 23(2):203–208, 1996. MR#1 408 348.

[31] S.L. Martins, C.C. Ribeiro, and N.R. Rodriguez. Ferramentas de programação paralela em ambientes de memória distribuída. *Investigación Operativa*, 5:67–98, 1996.

[32] F.K. Miyazawa and Y. Wakabayashi. An algorithm for the three-dimensional packing problem with asymptotic performance analysis. *Algorithmica*, 18(1):122–144, 1997. MR#1 432 033.

[33] S.C. Porto and C.C. Ribeiro. Parallel tabu search message-passing synchronous strategies for task scheduling under precedence constraints. *Journal of Heuristics*, 1:207–223, 1995.

[34] S.C. Porto and C.C. Ribeiro. A case study on parallel synchronous implementations of tabu search based on neighborhood decomposition. *Investigación Operativa*, 5:233–259, 1996.

[35] S.C.S. Porto and C.C. Ribeiro. A tabu search approach to task-scheduling on heterogeneous processors under precedence constraints. *Int. J. High Speed Com.*, 7(1):45–71, 1995.

[36] M.G.C. Resende and C.C. Ribeiro. A GRASP for graph planarization. *Networks*, 29(3):173–189, 1997.

[37] J.L. Szwarcfiter. On edge transitivity of directed graphs. *Discrete Math.*, 141(1–3):227–235, 1995. MR#96d:05053.

[38] J.L. Szwarcfiter. Recognizing clique-helly graphs. *Ars Combinatoria*, 45:29–32, 1997. MR#97m:05226.

4.2 Papers Accepted for Publication in International Periodicals

[1] R. Borndörfer, Carlos E. Ferreira, and A. Martin. Decomposing matrices into blocks. *SIAM Journal on Optimization*, 1997. To appear.

[2] C.E. Ferreira, A. Martin, C. C. de Souza, R. Weismantel, and L. A. Wolsey. The node capacitated graph partitioning problem: a computational study. *Mathematical Programming,* Series B, 1996. To appear.

[3] L.R.G. Fontes, M. Isopi, Y. Kohayakawa, and P. Picco. The spectral gap of the REM under the Metropolis dynamics. *Annals of Applied Probability*, 1997. To appear.

[4] P.E. Haxell and Y. Kohayakawa. Packing and covering triangles in tripartite graphs. *Graphs and Combinatorics*, 1996. To appear.

[5] N. Maculan, C.C. Ribeiro, and C.C. de Souza. A new formulation for scheduling unrelated processors under precedence constraints. *RAIRO Recherche Opérationnelle*, 1997. To appear.

4.3 Papers Submitted for Publication in International Periodicals

[1] J. Barrera, C.E. Ferreira, and R.F. Hashimoto. Finding optimal sequential decompositions of erosions and dilations. 1997. Submitted.

[2] C.M.H. de Figueiredo, M.R. Cerioli, H. Everett, and S. Klein. The homogeneous set sandwich problem. Submitted.

[3] C.M.H. de Figueiredo and L. Faria. On Eggleton and Guy conjectured upper bound for the crossing number of the n-cube. Submitted.

[4] C.M.H. de Figueiredo, J. Gimbel, C.P. Mello, and J.L. Szwarcfiter. Even and odd pairs in comparability and in P_4-comparability graphs. Submitted.

[5] C.M.H. de Figueiredo, J. Meidanis, and C.P. de Mello. A greedy method for edge-colouring odd maximum degree doubly chordal graphs. Submitted.

[6] C.M.H. de Figueiredo, J. Meidanis, and C.P. Mello. Local conditions for edge-coloring. Submitted.

[7] C.M.H. de Figueiredo, J. Meidanis, and C.P. Mello. Total chromatic number and chromatic index of dually chordal graphs. Submitted.

[8] C.M.H. de Figueiredo and K. Vuskovic. A class of *beta*-perfect graphs. Submitted.

[9] C.E. Ferreira, C.C. de Souza, and Y. Wakabayashi. Rearrangement of DNA fragments: a branch-and-cut algorithm. 1997. Submitted.

[10] C.E. Ferreira and M. Loparic. A branch-and-cut algorithm for a vehicle routing problem with capacity and time constraints. Submitted.

[11] M.A.M.C. Gurgel and Y. Wakabayashi. The complete pre-order polytope: facets and separation problem. Submitted.

[12] Y. Kohayakawa, B. Kreuter, and A. Steger. An extremal problem for random graphs and the number of graphs with large even-girth. Submitted.

[13] Y. Kohayakawa, H.-J. Prömel, and V. Rödl. Induced Ramsey numbers. Submitted.

[14] O. Lee and Y. Wakabayashi. Circuit covers in mixed graphs. 1997. Submitted.

[15] F.K. Miyazawa and Y. Wakabayashi. Approximation algorithms for the orthogonal z-oriented 3-D packing problem. Submitted.

[16] C. Ortiz, N. Maculan, and J.L. Szwarcfiter. Characterizing and edge-colouring split-indifference graphs. Submitted.

4.4 Books

[1] C.M.H. de Figueiredo, J. Meidanis, and C.P. Mello. *Coloração em Grafos.* Lecture notes published by *XVI Jornada de Atualização em Informática*, 1997.

[2] C.E. Ferreira and Y. Wakabayashi. *Combinatória Poliédrica e Planos-de-Corte Faciais.* Lecture Notes published by *X Escola de Computação*, UNICAMP, 1996.

[3] Y. Kohayakawa and J. Soares. *Demonstrações Transparentes e a Impossibilidade de Aproximações.* Lecture notes published by *20o. Colóquio Brasileiro de Matemática* – IMPA, Rio de Janeiro, 1995.

[4] J. Setubal and J. Meidanis. *Introduction to Computational Molecular Biology. PWS Publishing Company*, 1997.

4.5 Papers in Conference Proceedings

[1] A.A. Andreatta, S.E.R. Carvalho, and C.C. Ribeiro. A framework for the development of local search based heuristics for combinatorial problems. In *Proceedings of the 2nd International Conference on Metaheuristics – Sophia-Antipolis, França*, page 43, 1997.

[2] B. Bollobás and Y. Kohayakawa. A note on long-range percolation. In Y. Alavi and A.J. Schwenk, editors, *Graph Theory, Combinatorics, and Algorithms*, volume 1, pages 97–113, New York, 1995. Wiley. MR#97f:05177.

[3] R. Borndörfer, C.E. Ferreira, and A. Martin. Matrix decomposition: a branch and cut approach. In *Proceedings of the V SIAM Conference on Optimization*, volume 1, page 57, Canadá, 1996. abstract.

[4] C.F.B. Cruz and J.C. Setubal. Uma adaptação do algoritmo de emparelhamento de edmonds para execução em paralelo. In M.V.S. Poggi de Aragão and C. C. de Souza, editors, *Anais da II Oficina Nacional em Problemas Combinatórios: Teoria, Algoritmos e Aplicações*, pages 39–49. DCC-UNICAMP, novembro 1995.

[5] C.M H. de Figueiredo, J. Meidanis, and C.P. de Mello. Local conditions for edge-coloring. In *Anais da II Oficina de Problemas Combinatórios: Teoria, Algoritmos e Aplicações (Relatório Técnico DCC-95-17)*, 1995.

[6] C.M.H. de Figueiredo. Even pairs and bull-free perfect graphs. In Y. Alavi and A. Schwenk, editors, *Proceedings VII Quadriennial International Conference on the Theory and Applications of Graphs*, volume I, pages 391–401. Wiley Interscience, 1995.

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4.6 Conference Proceedings

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4.7 Theses

[1] J.C. de Pina Jr. *Applications of Shortest Path Methods.* PhD thesis, Universiteit van Amsterdam, 1995.

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[3] Y. Wakabayashi. *Contribuições a Teoria dos Grafos e Otimização Combinatória.* Instituto de Matemática e Estatística, USP, May 1995. Tese de Livre-Docência.

5 Trips

5.1 Trips abroad

5.1.1 Short trips

1. **Celina M. Herrera de Figueiredo** – UFRJ – 5–14 May 1995. *26th Southeastern International Conference on Combinatorics, Graph Theory and Computing* and University of Waterloo. Talks: *"A greedy method for the edge-colouring odd maximum degree doubly chordal graphs"*, *"Sources, sinks even and odd pairs in comparability graphs"*

2. **Yoshiharu Kohayakawa** – USP – 16–20 May 1995. *7th International Conference on Random Structures and Algorithms —Random Graphs '95*, Emory University, Atlanta GA. Talk: *"On a Turán Type Extremal Problem for Random Graphs."*

3. **Pedro Sérgio de Souza** – UNICAMP – 13–17 March 1995. *5th Workshop of the DGOR–Working Group, Multicriteria Optimization and Decision Theory*, Lambrecht, Germany, 13–17 March 1995. Talk: *"Asynchronous Teams: a Multi-Algorithm Approach for Solving Combinatorial Multi-Objective Function Optimization Problems."*

4. **Sulamita Klein** – UFRJ – 18–25 February 1996. *27th Southeastern International Conference on Combinatorics, Graph Theory and Computing.* Talk: *"The NP-completeness of multi-partite cutset testing"*.

5. **Carlos Eduardo Ferreira** – USP – 17–25 May 1996. *5th SIAM Conference on Optimization*, Victoria, British Columbia, Canada. Talk: *"Matrix Decomposition: a Branch and Cut Approach"*.

6. **Jayme L. Szwarcfiter** – UFRJ – 30 May to 10 June 1996. *Eighth Quadrennial International Conference on Graph Theory, Algorithms and Applications*, Kalamazoo, USA. Talk: *"Clique Graphs of RDV Path Graphs"*. Visited Carnegie Mellon and Columbia University.

7. **João Meidanis** – UNICAMP – 1–12 December 1996. Visited Waterloo and Wisconsin-Madison; attended the meeting *Combinatorial Pattern Matching '96.*

8. **Celso Carneiro Ribeiro** – PUC–Rio – 06–22 July 1996. *IFORS'96 - XVI World Conference on Operational Research, Vancouver.* Talk: *"A GRASP for Graph Planarization"*. Visited Information Sciences Research Center da AT&T Research.

9. **Jayme L. Szwarcfiter** – UFRJ – 1–12 March 1997. *28th Southeastern International Conference of Combinatorics, Graph Theory and Computing* em Boca Raton, Florida. Talk: *"A survey of Clique Graphs"*. Visited University of Central Florida.

10. **Celso Carneiro Ribeiro** – PUC–Rio – 06–26 March 1997. *III Conference on Operations Research*, Havana, Cuba. Tutorial: *"Metaheuristics and Applications"*. Talk: *"A GRASP for Graph Planarization"*. Visited Universidade de Havana, and *Instituto Superior Politécnico José Antonio Echeverria.*

5.1.2 Long trips

1. **Oscar Porto** – PUC–Rio – 17–30 June 1995.

   Visited Institute of Information Science, Academia Sinica (Taipei, Taiwan) and attended EURO XIV, Jerusalem, Israel. Talks: *"A New Class of Perfect Graphs"*, *"A Generalization of Simplicial Elimination Orderings"*.

2. **Cid Carvalho de Souza** – UNICAMP – 8–23 December 1995. Visited Center for Operations Research and Econometrics (CORE), Université Catholique de Louvain la Neuve, Belgium, and Université de Montréal – GERAD (Groupe d'Études et de Recherche en Analyse de Décisions). Talk: *"A Graph Model for Reconstruction of DNA Fragments Using k-contigs"*.

3. **Marcus V. S. Poggi de Aragão** – UNICAMP – 8–23 December 1995. Visited Center for Operations Research and Econometrics (CORE), Université Catholique de Louvain la Neuve, Belgium, and Université de Montréal – GERAD (Groupe d'Études et de Recherche en Analyse de Décisions). Talk: *"Asynchronous Teams for the Set Covering Problem"*.

4. **Celso Carneiro Ribeiro** – PUC–Rio – 9–30 July 1995. Visited AT&T Bell Laboratories, RUTCOR – Rutgers Center for Operations Research, and the Center for Applied Optimization – University of Florida. Attended *Metaheuristics International Conference – MIC '95*. Talks: *"Query Optimization in Distributed Relational Databases"* and *"Parallel Strategies for Task Scheduling Algorithms Using PVM"*.

5. **Sulamita Klein** – UFRJ – 2 January to 10 February 1997. Visited London School of Economics, London, and Laboratoire Leibniz, Institut IMAG, Grenoble. Talk: *"Perfect Graphs and Homogeneous Pairs"*.

6. **Célia P. de Mello** – UNICAMP – 10 January to 8 February 1996. Visited Waterloo, UQAM, McGill (Montréal), and Toronto.

5.2 Trips in the country

Project members made 33 short trips mainly to attend the 3 national and the international workshop organized under this project. Two of them were visits for joint research in other institutions.

5.3 Summary

- Trips abroad
  - short trips: 10
  - long trips: 6
- Trips in the country
  - short trips: 33

6 Foreign Visitors

- **Christos H. Papadimitriou** – University of California at Berkeley – 1–7 October 1996.

  Attended the *International Combinatorics Workshop*, UFRJ, Rio de Janeiro (2–4 October 1996). Visited UFRJ; short course: *"Computational Complexity."* Talks in the workshop: *"Computational Approaches to Organization Theory"*, *"A Survey on Approximation Algorithms for the TSP"*, and *Complexity as Metaphor."*

- **Pierre Hansen** – École des Hautes Études Commerciales - Montréal – 28 Septeber to 5 October 1996. Attended the *International Combinatorics Workshop*, UFRJ, Rio de Janeiro (2–4 October 1996). Visited PUC–Rio. Short course at the workshop: *"Recent Advances in Continuous Location Theory."*

- **Martin Loebl** – Charles University, Prague – 14 May to 23 June 1995. Visited USP (partially supported by FAPESP). Talks: *"Modularity of cycles in graphs and digraphs"* and *"Rapidly growing functions."*

- **J.A. Bondy** – Univ. Claude-Bernard, Lyon – 19 September to 6 October 1996. Visited UNICAMP. Talk at the *"Combinatorics Day"* (USP): *"Extremal theorems for weighted graphs."*. Attended the *International Combinatorics Workshop*; talk: *"Flows and Coverings of Graphs."*

- **A.M.H. Gerards** – CWI, Amsterdam — 27 September to 4 October 1996. Visited USP. Talk at the *"Combinatorics Day"* (USP): *"A new class of weakly bipartite graphs."* Attended the *International Combinatorics Workshop*; short course: *"The Matroids Representable over the 4-element Field."*

- **H.-J. Prömel** – Humboldt-Universität zu Berlin, Germany, 27 September to 7 October 1996. Visited USP (partially supported by DAAD/CAPES). Talk at the *"Combinatorics Day"* (USP): *"Approximation algorithms for the Steiner problem."* Attended the *International Combinatorics Workshop*; talk: *"Random Graphs, Evolution Processes, and Threshold Phenomena."*

6.1 Short Courses

- *João Carlos Setubal* gave a short course on computational biology in II Escola Latino-Americana de Pesquisa Operacional, Mendes, Rio de Janeiro, January 1995.
- *José Augusto Ramos Soares and Yoshiharu Kohayakawa* gave a short course on transparent proofs in the 20o. Colóquio Brasileiro de Matemática, IMPA - Rio de Janeiro, 24–28 July 1995.
- *Carlos Eduardo Ferreira and Yoshiko Wakabayashi* gave a short course on polyhedral combinatorics in the X Escola de Computação, UNICAMP - Campinas, São Paulo, 8–13 July 1996.

7 WWW Page

Further information may be obtained at

`http://www.ime.usp.br/dcc/procomb/`

8 Addresses of the Institutions

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05508–900 – São Paulo, SP
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UFRJ	IM	Instituto de Matemática Departamento de Ciência da Computação Caixa Postal 68530 21945–970 – Rio de Janeiro, RJ Tel: +55 (21) 290-8091 Fax: +55 (21) 290-1095 `http://www.lci.ufrj.br/dcc/depart/dcc.htm`
	NCE	Núcleo de Computação Eletrônica Caixa Postal 2324 20001–970 – Rio de Janeiro, RJ Tel: +55 (21) 598-3160 Fax: +55 (21) 598-3156 `http://www.nce.ufrj.br/`
PUC–Rio		Pontifícia Universidade Católica do Rio de Janeiro Rua Marquês de São Vicente, 225 22453–900 – Rio de Janeiro, RJ Tel: +55 (21) 529-9526 Fax: +55 (21) 511-5645 `http://www.inf.puc.rio.br/`