OPTIMA

MATHEMATICAL PROGRAMMING SOCIETY NEWSLETTER

JULY 1981

NUMBER 4

SOME ROADS HARDLY TAKEN

Robert G. Jeroslow
Georgia Institute of Technology

All OPTIMA readers are welcome to contribute to our Society's newsletter, and recently OPTIMA editor Don Hearn invited me to express my views on integer programming. Rather than organize a semi-scholarly piece when my "views" tend more toward broad speculations, I have chosen to get down a few ideas on some of the areas I think are very promising. I have largely neglected to seriously research these areas myself. The pink dogwoods are budding and as I begin to write, this city will be a park full of flowers in two weeks. I shall attribute any errors I make to spring fever.

Newcomers to the integer programming area may get the impression that researchers either do combinatorial optimization and get polynominal-time algorithms, or do group theory, cutting-planes, or computational complexity studies, or a few other erudite and advanced topics. In fact, there is a high concentration of work in relatively few subjects.

Actually, what I found refreshing, upon returning to operations research from the pure mathematics about ten years or so ago, was that this area was alive. It was motivated by problems that actually had to be solved, and it had users. The participants exhibited a wide variety of views as to what the most pressing questions were, and how to approach them. Proper discrimination was not an issue of a correct topic or approach, but primarily one of discerning those parts of research which went clearly beyond relatively pedestrian information into substantial results (in the case of theory) or a substantial development effort (in the case of empirical work). And with the natural tendency to further refine those narrow parts of our knowledge where an impetus had built up, there were a lot of "roads not taken" - or at least, hardly taken.

For one example, I believe that the "frontier" of empirical research on the

mixed-integer programming problem is at around 150 binary variables - i.e., it would be a real advance if we could fairly regularly expect to solve 200 binary variable problems with general MIP codes. Some years ago, it was reliably rumored that one of the major computer firms has sold 100 copies of a large-scale MIP/NLP code for around $80,000, so there is a market here. But what about developing an utterly dependable general MIP code for thirty or fewer binary variables, and not too large of an LP part, either? That could certainly be done.

We need a superb MIP code for total novices. The primary reason that no large organization is pushing MIP as a major market thrust is the need for experts to make adjustments when the code fails to converge. Currently any general MIP code for 100 variables would be a headache to service. The thrust in MIP industrial applications involves highly-paid technical consultants.

A general-purpose MIP computer code for novices certainly would not have the range of application of the more ambitious codes, but its market could well be adequate for itself and for stimulating further efforts. Its use would probably be best combined with heuristic, problem-based, and learning-theory based approaches to model formulation. In a complex situation with hundreds of variables, human conceptualizing may identify a much smaller number of major decisions, whose outcome will either set, or come close to setting, the values or relationships among these variables. If so, we should formulate and solve the much smaller problems in the key decisions. This will get us only an approximate solution to our actual problem, but that is usually better than no solution at all to the "accurate formulation."

One still needs "experts" to teach methods for compact formulation of integer programs. However, these skills are much closer to the users' abilities, interests, and personal knowledge. Minimally, we should get stimulating and realistic technical cases for master's students from these efforts!

So much for this point, let's move on. We will not make the case either for or against this "problem-free" code for a limited (but significant) set of MIP formulations, because good "attorneys" can argue it either way. The point is to find out, and I do not think that the investment involved is excessive.

Several researchers are working on interactive approaches to integer programming with embedded heuristics. These approaches differ from general MIP codes, in that extensive use is made of the particular kind of problem to get a good start and to guide the software part of the exploration.

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EXTRA JOURNALS

We are delighted to report that Dick Cottle, as Editor-In-Chief of the Society's publications, has concluded arrangements with North-Holland Publishing Company for printing three volumes (nine issues) of *Mathematical Programming* instead of the usual two volumes (six issues) in 1982. Members in good standing will receive all three volumes at no additional cost.

This increased publication schedule will reduce our backlog, thus enabling us to better serve the mathematical programming community through faster publication of accepted papers. Of course the same high standards will continue to apply.

—Michael Held

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In the relatively more technical business decisions, the user typically does develop good intuition from experience, and often starts close in value to the optimum. These interactive approaches are often supplemented by good visual displays of the solution under current consideration, and an ease of making changes in the solution. Very little has been published on interactive methods, and even technical reports are relatively few, although many IP papers do mention human intervention on an ad hoc basis for the solution of some programs.

Criticisms have been made of the work on interactive methods, to the effect that the quality of the solutions obtained is unknown. It is certainly true that few mathematical theorems can be proven about interactive procedures. However, mathematics is one of several sciences of value in the problems that occur in operations research.

I personally would view the recent development of some interactive codes and heuristic methods as "decision support systems." The criteria for such, is that the users are substantially aided by the algorithm, whether or not their final solution is "optimal." But if this is actually our approach, we need some empirical studies and protocols as to how humans will try to approach problems by use of programming techniques, in order to make suggestions or simply to discern the better approaches. This has not been done to my knowledge. The psychologists could provide clearer scientific standards by which to measure (and to promote) research of this type.

Let's move on.

Within the framework of exact algorithms, but still related to the previous points, is the issue of branching conditions in enumerative algorithms. Typically, the branching choice is x=0 versus x=1. But if it were felt that two projects are likely (but not certain) to be done together, or neither will be done, the branching choice should be x=y versus x=1-y (with the former branch x=y favored first to get a good "incumbent" solution)[1]. The branching choices can conform to other natural ways of grouping the logical alternatives, as long as all the alternatives are (implicitly) represented. An overlap of logical alternatives is not necessarily a bad thing, particularly if the overlap consists of unpromising alternatives. Also, there ought to be numerous ways of taking a large number of "unpromising" nodes in an enumerative search, and "coalescing" them into a "supernode" for further logical subdivision (so that similar node subdivisions do not occur repeatedly in the research)[2].

Despite a growing literature[3], not enough has been done in sensitivity analysis for integer programs. This is a crucial area for applications. Some good work was done earlier in an algorithmic setting, and Charlie Blair and I are now finding out that a lot of theoretical structure lies behind simple right-hand-side changes[4]. But much more remains undone. Perhaps this (admittedly inexact) question will help put one such open issue in focus: what is the mixed-integer analogue of the local sensitivity analysis of linear programming (i.e., the sensitivity analysis from a fixed basis), and in what essential ways is the analogous information for IP less encompassing than local LP sensitivity information?

The situation in multicriteria integer programming is akin to that for sensitivity analysis: the topic is of clear significance from the user's perspective, and so warrants more intensive exploration[5]. Let me ask a straightforward question: with only two criteria to trade-off against each other, what should a master's student know about how the integer programming efficiency frontier is different from that for a linear program?

Surely, the "answers" to both prompting questions must involve the limitations of local information, which occur in integer but not linear programming. If we can phrase fairly complete answers in accessible language, it will indicate that we understand the phenomena reasonably well.

The computational complexity of a large number of problems in discrete optimization has been extensively studied[6], with several surprising results regarding outwardly similar problems which (appear to) have different complexity. What happens when we study the complexity of questions that begin, "For every value of this parameter, does. . .?" Such questions arise in sensitivity analysis[7]. What new complexity heirarchies do they lead to and how often are these heirarchies actually needed?

In the mid-60's through the early 70's, a small number of integer programmers worked on both sampling and probabilistic approaches to integer programs[8]. By randomly generating attempts at solution and sampling the outcome, techniques were developed for estimating the optimal value, etc. Attempts were made to determine if the current incumbent was optimal with a certain probability, etc. Possibly not all these attempts were properly modelled. There are a lot of variations possible on these ideas, and they are not (conceptually or mathematically) equivalent.

Rumors have it, that these sampling/probabilistic methods lost interest when the state of the art for exact solutions went beyond what these methods were then capable of for linear integer programs (as opposed to nonlinear ones). I, for one, am unconvinced that enough of the alternatives in this approach were considered. For one thing, these methods were never adopted to specially-structured problems. In recent years, some interesting probabilistic results have been established which utilize structure.

I think it likely that the Shapley-Folkman-Starr Theorem[9] has a certain relevance to integer programming. This result has been interpreted as saying that the sum of a large number of (possibly nonconvex) sets is "more convex" than the sets, in the sense that the size of the "holes" is less, relative to the total size of the set. An immediate application is to any integer programming constraint set, where the individual sets are doubletons consisting of zero and a column of the constraints, but there are less obvious applications.

Now Cassel's proof[9] reveals even more, for he shows implicitly that a sampling technique can be used to get approximate solutions to any point in the convex span of the sum set. Is this about as close as a discrete problem has approximate solutions for its linear relaxation? For which special structures, and for which conditions, are approximations of this type satisfactory?

I would be only guessing if I were to project future trends in integer programming research. My sole expectation is that it will prosper, as will operations research generally.

What directions would I, personally, like to see? I would like to see an enlargement of the focus of research interests that is more in line with the diversity of users' needs. Our field, as a collective entity, could support a broader range of serious

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research efforts than it now does. Such efforts would, for the most part, represent substantial concentration on issues that are already of interest.

NOTES

1. Several years ago I made a very modest start in this direction. See *"Cross-branching in Bivalent Programming,"* MSRR no. 331, GSIA, Carnegie-Mellon University, March 1974.

2. Some of the types of phenomenae which occur in this setting were noted in *"Treeless Searches,"* by C.E. Blair and the author, MSRR no. 396, GSIA, Carnegie-Mellon University, October 1976.

3. A few representative papers are: C. Piper and A.A. Zoltners, *"Some Easy Postoptimality Analysis for Zero-one Programming,"* Management Science 22 (1976), pp. 759-765; A.M. Geoffrion and R. Nauss, *"Parametric and Postoptimality Analysis in Integer Linear Programming,"* Management Science 23 (1977), pp. 453-466; and L.A. Wolsey, *"Integer Programming Duality: Price Functions and Sensitivity Analysis,"* Mathematical Programming 20 (1981), pp. 173-195.

4. See our paper, *"The Value Function of an Integer Program,"* to appear in Mathematical Programming. Wolsey's article referenced in footnote 3 also has an emphasis on conceptual structure.

5. See, for example, the paper by S. Zionts, *"Integer Linear Programming with Multiple Objectives,"* July 1975, State University of New York, Buffalo, N.Y.

6. The "bible" for this area is the book by M.R. Garey and D.S. Johnson, *"Computers and Intractibility: A Guide to the Theory of NP-Completeness,"* W.H. Freeman and Company, San Francisco, 1979 (paperback). The P versus NP classifications are very significant for conceptual analysis, although they do not seem to conform to our intuitive concepts of "tractible" and "intractible" problems. The Simplex Method, the mainstay of mathematical programming, has no polynominal bounds. Khachian's recent polynominal algorithm appears to be much worse than the Simplex. While the classification of P versus NP (versus all other heirarchies as well!) is one of the problem and not a specific algorithm for it, the view which equates nonpolynomial (worst-case) bounds to intractibility is clearly tied to the assertion that a nonpolynomial algorithm is bad (or, in any case, worse than a polynomial one). That assertion is false and based on an a priori analysis that is far removed from actual experience.

7. In my paper, *"Bracketing Discrete Problems by Two Problems of Linear Optimization,"* (Operations Research Verfahren, XXV, 1977, pp. 205-216, Anton Hain publisher), I showed that a natural question of linear programming sensitivity analysis could be NP-hard. The NP sets are usually associated with integer programming. More recently, in an AMS abstract with Charlie Blair, *"Computational Complexity of Parametric Programming,"* we will announce several more results, including parametric linear problems which are polynominal, parametric linear problems which are exactly as hard as their integer counterparts, and parametric integer problems which do not leave NP. Moreover, the classification of a parametric problem can depend on how it is presented. There are also parametric problems that require exponential space. These are initial results in a problem area which, I believe, merits a systematic development.

8. A paper from that period is *"Discrete Optimizing Solution Procedures for Linear and Nonlinear Integer Programming Problems,"* by S. Reiter and D.B. Rice, Management Science 12 (1966), pp. 829-850. A use of this approach for purposes of conceputal analysis occurs in *"Allocating Indivisible Resources Affording External Economics or Diseconomices,"* by S. Reiter and G.R. Sherman, International Economic Review 3 (1962), pp. 108-134; and there are more recent related economics papers as well (see e.g., 1976 Econometrica).

9. *"Measures of the Nonconvexity of Sets and the Shapley-Folkman-Starr Theorem,"* Mathematical Proceedings of the Cambridge Philosophical Society 78 (1975), pp. 443-436. The "implicit" sampling technique is simply to generate points in accordance with the probabilistic processes studied by Cassel, since random points will realize the expected values or do better. Incidentally, Cassel's proof is also the most economical one available in terms of exposition and contains some sharpening of the original result as well.

MATHEMATICAL PROGRAMMING SOCIETY INCORPORATION

The Council of the Mathematical Programming Society has unanimously decided that it will be desirable for the Society to obtain the benefits that are uniquely available to professional societies organized as tax-exempt not-for-profit corporations. Some of these are: (1) The ability to solicit institutional memberships from Universities and Corporations throughout the world, and the ability to carry on other fund raising activities; (2) Limitation of the Society's legal liability to the assets of Society, rather than being unlimited as is now the case; (3) Better organization of the Society's internal operating procedures.

(Most international scientific societies comparable to ours are incorporated entities, for these reasons.)

Consequently, under the Council's direction the Mathematical Programming Society, Inc. has been organized under the laws of the state of Delaware in the U.S.A. It is anticipated that the final steps of this re-organization will take place in the Fall of 1981.

This re-organization will in no way affect the Society's professional activities nor its Constitution. It is, however, required by law that the Constitution be supplemented by a set of By-Laws which spell out internal operating procedures, primarily with regard to disbursements by the Society.

Members of the Society who wish to comment on this re-organization or obtain a copy of the Articles of Incorporation and By-Laws may do so by writing, prior to August 31, 1981 to the Chairman of the Society, Professor Jean Abadie at 29, Boulevard Edgar-Quinet, Paris 14 FRANCE.

This public document was promulgated at a cost of $426.15 or $0.61 per copy to inform researchers in mathematical programming of recent research results.

OPTIMA

Newsletter of the Mathematical Programming Society

Donald W. Hearn, Editor

Achim Bachem, Associate Editor

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POST CONFERENCE NOTES

CONFOLANT
Puy-de-Dôme, France

Seventy-two participants, mainly from France and West Germany but also from nine other countries, attended the Conference, *"Optimization: Theory and Algorithms"* held in CONFOLANT, March 16-20.

The Scientific organization was directed by **J.-B. Hiriart-Urruty** (Clermont-Ferrand II), **W. Oettli** (Mannheim) and **J. Stoer** (Wurzburg).

Thirty-five papers on theoretical and applied topics were presented in eight half-day sessions. A proceedings will be published in an international series which is, as yet, not definitely fixed.

—J.-B. Hiriart-Urruty

WASHINGTON

Approximately sixty participants representing nine countries attended the Third Symposium on Mathematical Programming with Data Perturbations held in Washington, D.C. in May. The meeting was directed by A.V. Fiacco, George Washtington University.

Topics covered included parametric programming, stability and sensitivity analysis in mathematical programming and related problems. Contributions to the theory were complimented by papers on applications in business and economics. The conference was technically rewarding and socially pleasant. There will be a conference proceedings of refereed papers edited by A.V. Fiacco. A similar meeting is planned in 1982 in Washington, D.C.

Direct inquiries to A.V. Fiacco, Operations Research Dept., The George Washington University, Washington, D.C. 20037.

—S. Schaible

MÁTRAFÜRED

The Sixth Mathematical Programming conference organized at Mátrafüred (Hungary) took place between January 18-22, 1981. The Conference was organized and sponsored by the Computer and Automation Institute of the Hungarian Academy of Sciences (Chairman: A. Prékopa, Secretary: Mrs. P. Turchányi) and its site was the Summer House of the Academy. The five former meetings in this series took place in 1973, 1974, 1975, 1977, 1979. Many well-known mathematical programmers have participated and given talks at these conferences and everybody enjoys the good atmosphere that one can experience both from the scientific and the social point of view. This time there were 80 participants, of which 60 were from Hungary, and 20 from other countries. The scientific program consisted of 27 lectures; and one round table discussion on the problems of theory and practice. Many participants expressed their views with great devotion and enthusiasm.

—A. Prekopa

RESULT CITED IN SCIENCE

A recent report, "Integer Programming with a Fixed Number of Variables" by H.W. Lenstra, Jr., University of Amsterdam (see Technical Report Section for full address) has been cited in the April 3, 1981 issue of **Science**.

According to the article by Gina Kolata, Lenstra's result represents a possible major advance in integer programming. Kolata quotes both Herbert Seart (Yale) and Richard Karp (Berkeley) as being favorably impressed by the result.

In response to an inquiry, Professor Lenstra has provided OPTIMA with the following abstract of his paper:

"It is shown in the paper that for any fixed natural number n there is a polynominal algorithm for the integer linear programming problem with n variables. The degree of the polynominal that bounds the running time is an exponential function of n. It appears that the practical value of the result is limited to small values of n. The basic ingredient of the method is a reduction process for lattices in n-dimensional space."

ZOR
Zeitschrift für Operations Research

ZOR is a journal of Operations Research consisting of Series A: Theory, and Series B: Applications.

ZOR Theory publishes quality papers in operations research and related optimization theory, including works on mathematical programming, dynamic programming and optimal control, stochastic programming, discrete programming, graphs and network problems, game theory, stochastic decision processes, inventory, queueing, and reliability. ZOR Theory also welcomes theoretical papers in economics and computer science that are relevant to operations research. ZOR Theory is published in English. All papers in the journal are refereed to ensure high quality. The waiting list for accepted papers is much shorter than in most other operations research journals; most accepted papers are published within twelve months of their submission dates.

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THE MATHEMATICAL PROGRAMMING SOCIETY
ENROLLMENT 1981

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The Mathematical Programming Society
The International Statistical Institute
428 Prinses Beatrixlaan
2270 AZ Voorburg, Netherlands

MPS CALENDAR

This Calendar lists meetings specializing in mathematical programming or one of its subfields in the general area of optimization and applications, whether or not the Society is involved in the meeting. (These meetings are not necessarily "open".) Any one knowing of a forthcoming meeting not listed here is urged to inform the Vice Chairman of the Society, Dr. Philip Wolfe, IBM Research 33-221, POB 218, Yorktown Heights, NY 10598, U.S.A; Telephone 914-945-1642, Telex 137456. *

1981

July 6-17: " Deterministic & Stochastic Scheduling: A study institute", Durham, England. Contact: Prof. A. H. G. Rinnooy Kan, Econometric Institute, Erasmus University, P.O. Box 1738, 3000 DR Rotterdam, The Netherlands.

July 13-24: "NATO Advanced Research Institute on Nonlinear Optimization", Cambridge, England. Contact: Professor M.J.D. Powell, Department of Applied Mathematics and Theoretical Physics, University of Cambridge, Silver Street, Cambridge CB3 9EW, England. Sponsored by the MPS.

July 20-24: "Eighth British Combinatorial Conference", Swansea, England. Contact: A.D. Keedwell, Department of Mathematics, University of Surrey, Guildford, Surrey GU2 5XH, U.K.

August 24-28: "CO81: Conference on Combinatorial Optimization", Stirling, Scotland. Contact: Professor L. Wilson (CO81), Department of Computing, Stirling University, Scotland, U.K.

August 24-28: "International Colloquium on Stochastic Programming", Koszeg, Hungary. Contact: Bolyai János Mathematical Society, Budapest VI, Anker köv 1-3, H-1061, Hungary.

August 31-September 4: "Tenth IFIP Conference on System Modeling and Optimization", New York City, U.S.A. Deadline for submission of abstracts, 15 February. Contact: 10th IFIP Conference, Polytechnic Institute of New York, 333 Jay Street, Brooklyn, NY 11201, U.S.A.; telephone 212-643-2305.

September 8-10: "International Symposium on Semi-infinite programming and Applications", Austin, Texas, U.S.A. Contact: K.O. Kortanek, Department of Mathematics, Carnegie-Mellon University, Pittsburgh, PA 15213, U.S.A.

October 19-20: Second Mathematical Programming Symposium Japan, Kyoto, Japan. Contact: Professor Toshihide Ibaraki, Department of Applied Mathematics and Physics, Faculty of Engineering, Kyoto University, Sakyo-ku, Kyoto, Japan 606.

October 19-22: "International Symposium on Optimum Structural Design" (Eleventh Naval Structural Mechanics Symposium), Tucson, Arizona, U.S.A. Contact: Dr. Erdal Atrek, Dept. of Civil Engineering, Building 72, University of Arizona, Tucson, AZ 85721, U.S.A.

1982

August 23-28: Eleventh International Symposium on Mathematical Programming in Bonn, Federal Republic of Germany. Contact: Institut für Ökonometrie und Operations Research Universität Bonn, Nassestraße 2, 5300 Bonn 1, Federal Republic of Germany; Telex 886657 unibo b, Telephone (02221) 739285. Official triennial meeting of the MPS. (Note: The International Congress of Mathematicians will be held August 11-19 in Warsaw, Poland.)

* Substantial portions of regular meetings of other societies such as SIAM, TIMS, and the many national OR societies are devoted to mathematical programming, and their schedules should be consulted.

Technical Reports & Working Papers

UNIVERSITY OF MARYLAND

College of Business and Management
University of Maryland
College Park, Maryland 20742

Assau and Golden, *"A Categorized Bibliography of Survey Articles in Management Science and Operations Research,"* 81-001.

Provan and Ball, *"The Complexity of Counting Cuts and of Computing the Probability that a Graph is Connected,"* 81-002.

Golden, Assad, Bodin, Ball and Dahl, *"Listings and Documentation for Selected Network Optimization Computer Codes,"* 81-003.

Gass and Joel, *"Concepts of Model Confidence,"* 81-005.

Ball, Bodin, Golden, Assad and Stathes, *"A Stratgic Truck Fleet Sizing Problem Analyzed By a Routing Heuristic,"* 81-006.

Ball, Bodin and Dial, *"A Matching Based Heuristic for Scheduling Mass Transit Crews and Vehicles,"* 81-007.

Gass, *"Validation and Assessment Issues of Energy Models,"* 81-008.

Stewart, *"New Algorithms for Deterministic and Stochastic Vehicle Routing Problems,"* 81-009.

Golden and Wasil, *"A Curve-Fitting Experiment in Estimating Optimal Solution Values to Traveling Salesman Problems,"* 81-011.

Ball and Provan, *"Calculating Bounds on Reachability and Connectedness in Stochastic Networks,"* 81-012.

Ball and Provan, *"Bounds on the Reliability Polynominal for Shellable Independence Systems,"* 81-013.

Ball, Bodin and Golden, *"Large Scale Network Algorithms and Applications,"* 81-015.

Golden and Keating, *"Network Techniques for Solving Asset Diversification Problems in Finance,"* 81-017.

Golden and Keating, *"On Simplifying a Network Model for Cash Flow Management,"* 81-019.

Assad and Golden, *"PERT,"* 81-021.

UNIVERSITY OF AMSTERDAM

Department of Mathematics
Mathematisch Institut
Roetersstraat 15
1018 WB Amsterdam

H.W. Lenstra, Jr., *"Integer Programming with a Fixed Number of Variables,"* Report 81-03.

UNIVERSITY OF COLOGNE

Department of Mathematics
D-5000 Cologne, West Germany

H.Hamacher, *"On a Class of Easily Solvable Optimal Co-Circuit Problems in Regular Matroids,"* 80-15.

R. Euler, *"Augmenting Paths and a Class of Independence Systems,"* 80-16.

B. Neng, *"Zur Erstellung von Optimalen Triebfahrzeuglaufplanen,"* 80-17.

R. Burkard and U. Fincke, *"On Random Quadratic Bottleneck Assignment Problems,"* 81-2.

R. Burkard and U. Fincke, *"Probabilistic Asymptotic Properties of Quadratic Assignment Problems,"* 81-3.

R. Burkard, H. Hamacher and J. Tind, *"An Abstract Duality Theory in Mathematical Programming,"* 81-4.

UNIVERSITY OF WISCONSIN-MADISON

Mathematics Research Center
610 Walnut Street
Madison, WI 53706

Roland Zielke, *"Elementary Proofs of an Inequality for Symmetric Functions for $n \leqslant 5$,"* No. 2113.

C. Conley, *"The Behavior of Spherically Symmetric Equilibria Near Infinity,"* No. 2117.

Emmanuele DiBenedetto, *"Continuity of Weak Solutions to Certain Singular Parabolic Equations,"* No. 2124.

George Miel, *"An Updated Version of the Kantorovich Theorem for Newton's Method,"* No. 2125.

Nira Dyn and Warren Ferguson, *"Numerical Construction of Smooth Surfaces From Aggregated Data,"* No. 2129.

Ronald J. DiPerna, *"Finite Difference Schemes for Conservation Laws,"* No. 2139.

S. -P. Han, *"Least-Squares Solution of Linear Inequalities,"* No. 2141.

Dan Amir and Zvi Ziegler, *"Relative Chebyshev Centers in Normed Linear Spaces, Part II,"* No. 2143.

Peter A. Markowich, *"A Theory for the Approximation of Solutions of Boundary Value Problems on Infinite Intervals,"* No. 2146.

O.L. Mangasarian, *"Least-Norm Linear Programming Solution as an Unconstrained Minimization Problem,"* No. 2147.

Guang-Chang Dong, *"Data Smoothing,"* No. 2151.

Peter A. Markowich, *"Eigenvalue Problems on Infinite Intervals,"* No. 2157.

Carl de Boor, S. Friedland and A. Pinkus, *"Inverses of Infinite Sign Regular Matrices,"* No. 2159.

Carl de Boor and Allen Pinkus, *"A Factorization of Totally Positive Band Matrices,"* No. 2163.

Okitsugu Fujiwara, *"Morse Programs: A Topological Approach to Smooth Constrained Optimization,"* No. 2169.

C.W. Cryer, P.M. Flanders, D.J. Hunt, S.F. Reddaway and J. Stansbury, *"The Solution of Linear Complementarity Problems on an Array Processor,"* No. 2170.

Cu Duong Ha, *"A Decomposition Method and its Application to Block Angular Linear Programs,"* No. 2174.

Okitsugu Fujiwara, *"Morse Programs: A Topological Approach to Smooth Constrained Optimization II,"* No. 2176.

Shih-Ping Han, *"Solving Quadratic Programs by an Exact Penalty Function,"* No. 2180.

UNIVERSITY OF WATERLOO

Faculty of Mathematics
Department of Combinatorics and Optimization
Waterloo, Ontario, Canada N2L 3G1

Mustafa Akgül, *"Ellipsoidal Algorithm: Khachiyan's Proof."*

Mustafa Akgül, *"Solving Convex-Concave Games via Ellipsoidal Algorithm,"* CORR 81-16.

Mustafa Akgül, *"On Convex Programming via Ellipsoidal Algorithms,"* CORR 81-17.

Mustafa Akgül, *"On the Work of Judin-Nemirovskii on the Ellipsoidal Algorithm and a Proof of Khachiyan's Result,"* CORR 81-8.

Mustafa Akgül, *"On the Shor-Khachiyan Algorithm,"* CORR 80-50, Rev. 12/80.

Mustafa Akgül, *"An Ellipsoidal Algorithm Solves Some Well-known Hard LP and LCP Problems Almost Instantly,"* CORR 80-51.

TECHNICAL REPORTS & WORKING PAPERS. . . .

UNIVERSITY OF BONN
Department of Operations Research
D-5300 Bonn, West Germany

J. Araoz and E.L. Johnson, *"Polyhedra of Additive System Problems,"* WP 80160-OR.

L. Butz, *"Connectivity in General Designs with two Blocking Factors,"* (extended abstract) WP 80162-OR.

E.L. Johnson, *"Characterization of Facets for Multiple Right-hand Choice Linear Programs,"* WP 80162-OR.

B. Körte and R. Schrader, *"On the Existence of Fast Approximation Schemes,"* WP 80163-OR.

W.R. Pulleyblank, *"The Matching Rank of Halin Graphs,"* WP 80165-OR.

A. Bachem and M. Grötschel, *"Homogenization of Polyhedra,"* WP 80166-OR.

E.L. Johnson and M.W. Padberg, *"Degree-two Inequalities, Clique Facets, and Biperfect Graphs,"* WP 80167-OR.

A. Bachem and B. Körte, *"Primal and Dual Methods for Updating Input-Output Matrices,"* WP 80168-OR.

D.A. Holton and M.D. Plummer, *"Cycles Through Prescribed and Forbidden Point Sets,"* WP 80170-OR.

D. Naddef and W.R. Pulleyblank, *"Ear Decompositions of Elementary Graphs and $G(F_2)$-rank of Perfect Matchings,"* WP 80171-OR.

G. Cornuejols and W.R. Pulleyblank, *"The Travelling Salesman Polytope and $[0,2]$-Matchings,"* WP 80172-OR.

Institut für Ökonometrie und Operations Research: *"Annual Report 1980"* WP 81173-OR.

R. Schrader, *"Ellipsoid Methods,"* WP 81174-OR.

L. Lovász, *"Bounding the Independence Number of a Graph,"* WP 81175-OR.

M. Grötschel, L. Lovász and A. Schrijver, *"Polynomial Algorithms for Perfect Graphs,"* WP 81176-OR.

B. Körte and R. Schrader, *"Can the Ellipsoid Method be Efficient?"* WP 81177-OR.

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Gallimaufry

Bill Cunningham (Carleton University) will spend the year 1981-82 at the Institute for Operations Research, University of Bonn. . .**Siegfried Schaible** was awarded a McCalla Research Professorship by the University of Alberta for 1981-82. . .**Henri Theil**, formerly of the University of Chicago, will become McKethan-Matherly Professor of Econometrics and Decision Sciences at the University of Florida starting Fall 1981. . .**Horst W. Hammacher**, formerly of Cologne, and **Suleyman Tufekci** formerly of Syracuse, have joined the Industrial and Systems Engineering Department, University of Florida. . .The June, 1981 issue of *Scientific American* contains a feature article, *The Allocation of Resources by Linear Programming,"* by **Robert G. Bland** (Cornell). This amply illustrated article covers both applications and computational aspects of LP, including the ellipsoid algorithm, at an introductory level. . .From Madison, Wisconsin, we have the following items: **S.-P. Han** (Illinois) will spend a second year at MRC, **Steve Robinson** will be Chairman of Industrial Engineering, and **Bob Meyer** will be Chairman of Computer Science. Academic Press has indicated that *Nonlinear Programming 4*, consisting of papers presented at the July, 1980 NLP 4 Symposium, will be published by July 29, 1981. . .**A.C. Williams** (Mobil) is the new MPS liaison representative to ORSA. . .**Mike Todd** (Cornell) has been awarded one of twenty Sloan Research Fellowships in Mathematics for 1981. The award is for two years. Deadline for the next OPTIMA is October 15, 1981. ●

CALL FOR NOMINATIONS 1982

In accordance with the Constitution of the Society, the triennial elections of officers will be held in March, 1982. All offices will be on the ballot: Chairman, Treasurer, and four Council members-at-large. The Nominating Committee (Jean Abadie, Chairman) welcomes suggestions for consideration from the membership. Naturally, before anyone is proposed it should be determined, if possible, that the potential candidate is a member in good standing of the Society and is willing to run. It is perfectly appropriate for a member to propose himself as a candidate.

The Nominating Committee will circulate the proposed names among the Council of the Society, which will choose the candidates. In addition, any person nominated in writing by at least six members of the Society, and who agrees to stand, will be placed on the ballot.

Suggestions should be sent to the Chairman of the Society (Professor Jean Abadie, 29 Boulevard Edger-Quinet, Paris 14, France) or to the Chairman of the Executive Committee (Dr. A.C. Williams, Mobil Oil Corpoaration , 150 East 42nd Street, New York, N.Y. 10017) by January 31, 1982. ○

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