ORSS Newsletter – Jun 2005

(for members only)

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Table of Contents

From the President's Desk

by Dr. Tan Kok Choon

This is the 30th year since our Society was founded on 21 November 1975. Founders of the Society, Honorary President Chew Kim Lin and others like Chow Peng Tien, William Liu, Tan Thiam Soon Chang Boon Chong, Chan Gin Hor, Louis Ta, Goh Thong Ngee, Yap Kim Yew, Ow Chin Cheow, and Micheal Liew, had framed the objective of the Society very appropriately then. Our objective, to promote Operational Research, Management and Decision Sciences in Singapore, is still very relevant today.

While some large organizations in Singapore are relatively knowledgeable of OR and had regularly applied OR in optimizing their operations and planning, there are still many in Singapore who are ignorant of what OR is and its capabilities. Major users of OR in Singapore are some government ministries, such as Ministry of Defense, Ministry of Health, and Ministry of Transport, and some government-linked corporations such as DSO National Laboratories, PSA Corporation and Singapore Airlines. There is always a strong need to promote OR/MS here.

This being our 30th anniversary year, the management committee plans to have a special commemorative publication at the end of this year. May I call upon you to come forward to serve as editors or to contribute articles that highlight the various applications of OR/MS. Please contact the Honorary Vice-President Mr Lai Kah Wah if you are keen to contribute in one way or other.

We should also have a party to celebrate the 30th Birthday of the Society. The MC will very much welcome ideas on how this special bash should be organized. Volunteers to organize the party are definitely needed. I sincerely urge you to come forward to help in the organization. Please get in touch with the Honorary Secretary Dr Ng Kien Ming.

Finally, I look forward to your active participation in the Society's activities and your effort to help to promote OR/MS.

Abstracts of Some Recent Technical Talks

A Practically Efficient Interior Point Method For Linear Programming

Abstract of Talk on 6 Apr 2005

by Prof. Katta Murty

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LP is the 20th century extension of the classical subject linear algebra to solve systems of linear inequalities. While algorithms for linear equations were developed over 2000 years ago, there was no computationally viable method to solve linear inequalities until the advent of LP with the development of the simplex method in mid-20th century by Dantzig. The simplex method is a 1-dimensional boundary method, and it quickly became the leading algorithm to solve LPs and related problems. Its computational success made LP a highly popular modeling tool to decision making problems with numerous applications in all areas of science, engineering, and business management.

Competing with the simplex method now are a variety of interior point methods for LP developed in the last 20 years, these follow a central path using a logarithmically defined centering strategy. All these methods need matrix inversions; their success for large scale problem solving requires taking careful advantage of sparsity in the data.

We discuss a new interior point method based on a new and much simpler centering strategy that can obtain approximate optima without matrix inversions, and hence can handle dense problems, and is also not affected by redundant constraints in the model.

Optimal Survivability Enhancement in Complex Vulnerable Systems

Abstract of Talk on 16 Dec 2004

by Dr. Gregory Levitin

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Complex vulnerable systems can have different states corresponding to different combinations of available elements composing the system. Each state is characterized by a system performance rate, which is the quantitative measure of a system's ability to perform its task. Both the impact of external factors (attack) and internal causes (failures) affect system survivability, which is determined as probability of meeting a given demand.

One of the ways to enhance the system survivability is to separate elements with the same functionality (parallel elements). Since system elements can have different performance rates and different availability, the way in which they are separated strongly affects system survivability. We formulate the problem of how to separate the elements of series-parallel system in order to achieve a maximal possible level of system survivability by the limited cost.

Another way to increase the system survivability is to protect its elements or groups of them. We present the algorithms for evaluating survivability of protected systems (including systems with multilevel protection in which protected subsystems are destroyed by external impacts only if all of the levels of their protection are destroyed), introduce the protection survivability importance index and formulate the optimal protection problem.

Finally we consider the case when the system with multilevel protection is exposed to multiple factor impacts.

Robust Optimization: A Tractable Approach to Optimization Uncertainty

Abstract of Talk on 1 Dec 2004

by Asst. Prof. Melvyn Sim

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A robust approach to solving linear optimization problems with uncertain data has been proposed in the early 1970s, and has recently been extensively studied and extended. Under this approach, we are willing to accept a suboptimal solution for the nominal values of the data, in order to ensure that the solution remains feasible and near optimal when the data changes. A concern with such an approach is that it might be too conservative. Hence, recent development focuses on limiting the containment of data uncertainties within ellipsoids, which has the flexibility of regulating the level of conservativeness. However, only a few classes of robust conic models are polynomial solvable. Furthermore, this method has reached a stalemate as many of the polynomial solvable discrete problems becomes NP-hard under the robust framework, which greatly penalizes the attractiveness of the model. We extend the framework of robust optimization so that the model remains tractable for wide varieties of mathematical programming problems, including linear, discrete, combinatorial, network and conic optimization models.

The main motivation for robust optimization is data uncertainty for structured mathematical programming problems. Under this perspective, we investigate different choices of uncertainty sets to model data uncertainty and characterize the structure of the resulting robust counterparts. We particularly focus on uncertainty sets for which the robust problem inherits the computational complexity of the underlying deterministic problem. Examples of concrete results in this direction include:

(a) Our new robust formulation of a linear optimization problem is also a linear optimization problem and hence, the method is computationally tractable both practically and theoretically. In particular, when both the cost coefficients and the data in the constraints of an integer-programming problem are subject to uncertainty, we propose a robust integer-programming problem of moderately larger size that allows controlling the degree of conservatism in terms of probabilistic bounds of constraint violations.

(b) We propose a generic approach for solving our robust model and demonstrate that the robust counterpart of a polynomial solvable 0-1 discrete optimization problem remains polynomial solvable. In particular, robust matching, spanning tree, shortest path, matroid intersection, etc. are polynomially solvable.

(c) Robust network flows can also be solved as a polynomial number of modified network flow problems.

(d) The robust counterpart of an NP-hard α-approximable 0-1 discrete optimization problem, remains α-approximable.

(e) Robust conic optimization problems retain their original structure. Specifically, robust second order cone problems (SOCPs) remain SCOPs and robust semidefinite optimization problems (SDPs) remain SDPs. Furthermore, we show the robust solution remains feasible with high probability when the underlying distribution stochastic.

A Study of Demand Functions of Mutually Substitutable Products and Pricing Models

Abstract of Talk on 28 Sep 2004

by Assoc. Prof. Zhao Gongyun

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The demand-price relationships (also called demand functions) of substitutable products are core ingredients in many decision models, such as product pricing, revenue management and supply chain. Though demand functions are frequently used in theoretical research and practical applications, and concrete and explicit models of demand functions are inevitably needed in practice, little attention has been paid to the issue of how to construct explicit demand functions. Even the simplest and widely used demand function, the (piecewise) linear demand function, has not been fully understood and completely constructed: we have not seen in the existing literature, a (piecewise) linear demand function which is defined on nonnegative prices.

Let us be more specific. A commonly used linear demand function has the form $d=b-Ap$, where d and p are the demand and price vectors respectively, b is a constant vector and A is a matrix of appropriate dimensions. An obstacle in defining a demand function is that the value of d_i will be negative for a large value of p_i because the demand d_i is decreasing in its own price p_i. Let Ω be the set of prices at which all components of $b-Ap$ are nonnegative. Now we have not found, in the existing literature, any definition of demand functions of multiple products which tells us how to evaluate the demand at any Ω. In some of the above papers, they do not actually explicitly state that demand is defined only for prices in Ω. Implicitly, however, prices must be restricted to Ω, because, if not, negative values of demand will be present and the analysis in these papers would not make sense. In others, the problem is evaded by defining demand functions only for prices in Ω. All p not in Ω are deemed infeasible in the pricing models in some of these papers.

But why must all feasible prices be confined to Ω? If we do not know the demand corresponding to p not in Ω, how can we say that all prices p not in Ω are infeasible or redundant? To understand the necessity of defining demand functions for all nonnegative prices, we will show in the next section that, in some applications, it is wrong to restrict p in Ω.

In this paper, we will construct piecewise linear demand functions that are defined on all nonnegative prices. If there is only a single product, it is natural and simple to consider a reverse demand function that has been used in Economics for centuries. That is, $d = b - ap$ if $p \leq b/a$, and $d = 0$ if $p > b/a$, where $a>0$ and $b>0$. However, if there are multiple products, it is no longer trivial to extend the definition of demand functions to all nonnegative prices. We will discuss the problems encountered and propose a definition that solves our problems by using a map defined by a linear complementarity problem (LCP). Further, under certain conditions, we will observe some theoretical properties of our demand model.

As competition intensifies, more products are offered in markets and their relationships become more complex. Thus good pricing models become core decision tools for corporations' revenue management. The next goal of our paper is thus to study a game-theoretic pricing model in which the above-mentioned demand functions are used. The best response problem facing each seller is then an LCP constrained optimization problem. We will show that, in some situations, the LCP constraints in this optimization problem can be eliminated to obtain a simplified model. This simplification essentially reduces the LCP constraints to

linear constraints; the reduction implicitly ensures that only p in Ω needs to be considered. The computations and analysis are thus tremendously simplified. As a by-product, this result provides a rigorous justification for the models used in Gallego and Van Ryzin (1997) and Maglaras and Meissner (2003) (in the case where the demand function is assumed linear and confined on Ω). However, there are also many other situations in which the aforementioned simplification cannot be realized. Indeed, the example given in Section 2 will show that the maximum possible revenue is achieved at some p outside Ω. Thus in these situations, the LCP constraints inherited from the demand functions will remain as a core structure in pricing models.

News Flash

- The 30th Annual General Meeting was held recently on Saturday, 12 March 2005 at the NUS Staff Club. The 30th ORSS Management Committee was elected.
- Assoc. Prof. Ong Hoon Liong stepped down as the Chief Editor of APJOR and was appointed as an Editorial Advisor of APJOR on 1st January 2005. The management committee extends its thanks to A/Prof. Ong for his dedicated past service as APJOR's Chief Editor.

Feature Profile

Dr. Zhao Gongyun
Chief Editor, Asia-Pacific Journal of Operational Research

Current Appointment:
Associate Professor
Department of Mathematics
National University of Singapore
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Research Areas:
Linear and nonlinear programming;
Stochastic programming;
Game theory

Teaching Areas:
Mathematical programming;
Network optimization;
Introduction to Operations Research;
Game theory and decision making; Inventory;
Queueing theory

Academic/Professional Qualifications:
B.Sc., Univ. of Xiamen, China, 1982
M.Sc., Univ. of Xiamen, China, 1985
Ph.D., Univ. of Wuerzburg, Germany, 1991

Career History:
University of Wuerzburg, Germany,
Research Assistant, 1991-1992

National University of Singapore,
Teaching Fellow, 1992-1995

National University of Singapore,
Lecturer, 1995-1998

National University of Singapore,
Senior Lecturer, 1998-2000

National University of Singapore,
Associate Professor, 2000-Present

Administrative Leadership:
Member of International Advisory Committee,
15th Mathematical Programming Symposium

Professional Activities:
Member of Mathematical Programming Society

Major Publications:
G. Zhao and J. Stoer, Applied Math. and Optimization 27 (1993) 86-103

J. Sun and G. Zhao, SIAM J. Optimization, 8 (1998) 123-139

G. Zhao, Math Programming, 90 (2001) 507-536