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IN THIS ISSUE

Supporting Managers in the Public Sector

There is a belief, evidently held by some in our community, that OR/MS does not—and cannot—help senior managers in large public enterprises. Contrary to this view, the OR Forum paper by Norman Waks offers two cases in which OR/MS thinking offered substantial help to large enterprises with beneficial results: the first case deals with establishing management arrangements for a very large defense program dominated by technology; the second describes some management science findings related to an ongoing, but troubled, army material program of major scale. The author uses these cases as the basis for urging OR/MS workers to accept the challenge of involvement in such programs.

Modeling National Emergencies

The National Board of Economic Defense is a Finnish government agency whose purpose is, among other things, to develop contingency plans for national emergencies. The agency developed an input-output model of the Finnish economy, which was solved using linear programming. They were not fully satisfied with their system, and were looking for a flexible decision aid. As a result, Visual Interactive Goal Programming (VIG), a flexible decision support system, was developed to analyze emergency management models. In "Multiple Objective Analysis of Input-Output Models for Emergency Management," I. Kananen, P. Korhonen, H. Wallenius and J. Wallenius describe the results of this study. The system has been applied successfully to emergency situations, including measuring the impact of an energy crisis, a crop failure, and a trade embargo on high technology products.

Repetitive Maneuvering Strategies

What's the most efficient way to move a collection of Chinese Checkers across a checkerboard when there is no opponent to worry about? The actual solution depends on the number of pieces to be moved, but it inevitably spends most of its time repeatedly translating just one or two efficient configurations. In "Graphs, Maneuvers and Turnpikes," Arthur Benjamin puts forth sufficient conditions for maneuvering problems to possess near-optimal movement strategies with repetitive structure.

Choosing an Appropriate Formulation

Over the past 30 years, an increasing number of problems in facility location, graph theory, and economics have been quantitatively modeled as mixed-integer, zero-one programming problems. The model chosen for a particular application is not unique and may influence the program solver's ability to obtain a solution. Realizing this, researchers have been concerned with the question of what constitutes a *good* model in the sense that it admits more efficient solution methodologies. In "Linearization Strategies for a Class of Zero–One Mixed Integer Programming Problems," Warren Adams and Hanif Sherali present general strategies for converting classes of nonlinear mixed-integer, zero–one polynomial programming problems into equivalent linear problems. They show that, when measured by the tightness of the associated continuous relaxation, their technique dominates other such methods.

Approximating Probabilities

The inclusion–exclusion formula and its generalization to compute the probabilities of the logical functions of events is frequently intractable because the number of arithmetic operations needed to compute the terms is enormous. On the other hand, inequalities that use a few terms do not provide satisfactorily good approximations. The same terms, supplied by linear programming multipliers, provide sharp lower and upper bounds for the probability. These bounds are frequently close to each other, even if only a few easily computable terms are used. In "Sharp Bounds on Probabilities Using Linear Programming," András Prékopa presents unified and simple probability approximation schemes that have been applied to approximate power and communication network reliability, and multivariate integrals.

Solving LPs Using KORBX®

In 1984, Narendra Karmarkar presented an interior point algorithm for solving linear programs, and in 1988, AT&T announced the KORBX® system, a product for solving linear programs based on this algorithm. The system consists of parallel processing hardware and software that implements four versions of the interior point algorithm: primal affine-scaling, dual affine-scaling, primal–dual and power series algorithms. Algorithm selection is user controlled. "An

Empirical Evaluation of the KORBX® Algorithms for Military Airlift Applications" (by William J. Carolan et al.) presents computational experience with all four KORBX® algorithms on test problems of 12 military airlift models. Primal affine-scaling was the default algorithm, but in tests on military airlift models the power-series algorithm was the most reliable. The power-series algorithm successfully solved a multicommodity network flow problem of 105,000 rows and 154,000 columns, a patient evacuation model of 33,000 rows and 105,000 columns, a channel routing model of 8,900 rows and 69,000 columns, and an operational airlift model of 10,000 rows and 230,000 columns.

Scheduling Naval Ships

The U.S. Navy schedules ships to large-scale exercises and deployments by attempting to meet the requirements for ship types and weapons systems as determined by the kind of exercise or deployment. Additionally, the workload placed on the various ships should be relatively even and allow the ships to individually meet Naval guidelines on time between deployments, time spent at sea, and time spent in home port. These guidelines are important for maintaining readiness and morale. Currently, scheduling takes place in quarterly conferences and employs essentially no automation. In "Annual Scheduling of Atlantic Fleet Naval Combatants," Jerry Brown, Clarke Goodman and Kevin Wood set up numerical criteria to judge candidate ship schedules and combine the selection of a schedule for each ship in the fleet into a large-scale, generalized set partitioning model. Solution of the model shows that significant improvements can be made in meeting guidelines without increasing violation of the ship-type and weapons system requirements imposed by the exercises.

Game of Strategy, or Intelligence?

Clausewitz said that to demonstrate the application of an idea "historical truth is not essential"; nevertheless, operations analysts prefer the real story. Hence, in one of the first demonstrations of an application of game theory to military decision (*Opns. Res.* **2,** 1954) O. G. Haywood, Jr. used an episode taken from the original WWII memoirs of General Omar Bradley. Twenty years later, following the uncovering of *the ultra secret*, that episode was attributed to deft intelligence rather than a game of strategy. Who knew what and when? All this is told in "Military Decision, Game Theory and Intelligence: An Anecdote," by Itzhak Ravid.

Predicting Nuclear Accidents

In "A Bayesian Escalation Model to Predict Nuclear Incidents and Risks," Tat-Chi Chow, Robert M. Oliver and G. Anthony Vignaux focus on predicting partial and complete nuclear core-melts leading to major releases of radioactivity. For major accidents, such as those in nuclear power plants, midair collisions, major explosions and fires, predictions may not be based on large amounts of historical data of like-severity accidents. By designing a model that describes how low severity incidents can escalate to high severity accidents and by combining engineering knowledge with operational experience, they could predict the time to the next incident of like severity and the probability of a severe future accident conditional on a record of low-severity incidents.

Retail Outlet Transshipments

While considerable effort has gone into determining good inventory control policies at a single location, less attention has been paid to the complex interactions in a multilocation environment. For example, customers may be willing to wait the short time it takes to transport an item from a nearby store when faced with a stockout. In "Optimal and Approximate Policies in Multiperiod Multilocation Inventory Models With Transshipment," Lawrence Robinson examines the consequences of allowing transshipments among locations as separate actions after demands are realized but before they must be satisfied. The savings in holding and shortage costs are weighed against the cost of transshipments. The best policy returns each outlet to some order-up-to inventory level each period. Since these levels can be computed exactly only for special cases (only two outlets or equal costs across the outlets), a heuristic solution employing Monte Carlo integration is developed for more general cases.

Longest-Queue Discipline

Information technology is one of the basic structural elements of production and distribution systems. This relationship has always been understood in a rather vague way, but recent developments in information technology have sharpened awareness of it—think of CAD/CAM and such low-tech innovations as kanbans. In particular, information about inventories has become cheaper to acquire, store and transmit, and the availability of such information opens opportunities for coordinating production, distribution and marketing. On the other hand, we do not understand very well how to use this information, nor how to

assess its value. "A Queueing Model to Analyze the Value of Centralized Inventory Information" offers a preliminary exploration of this issue, in a highly stylized mathematical setting. Using a simple model, Yu-Sheng Zheng and Paul Zipkin compare two approaches to information and its use in production control. They measure the benefits of improved information in terms of reduced inventories and backorders; they formulate and analyze a queueing system with a novel priority discipline, which they call the longest-queue discipline.

A Queue With Service Interruptions

In many manufacturing, computer and communications problems servers may be subject to random breakdowns. Also, while a server is broken down, the arrival rate and service requirements of customers may be different from those when the server is working. In "A Queue With Service Interruptions in an Alternating Random Environment," Bhaskar Sengupta analyzes such a problem in an M/G/1 setting. The work is a generalization of preemptive priority queues. The performance measures that are characterized are the distributions of the virtual and actual waiting times.

Spares Provisioning

Cars need batteries, so when a battery fails we need to replace it to operate the car. The battery price changes over time. Should we then buy spare batteries and keep them for future use? If so, when should we buy and how many? In "Optimal Spares Provisioning When Component Price Is Changing," David Assaf and J. George Shanthikumar consider a model for addressing these issues. They provide an optimal policy that determines the timing and quantity of these purchases.

Expediting Repairs of Manufacturing Systems

Manufacturing and merchandising companies in the United States annually incur inventory carrying costs that exceed $300 billion—more than 10¢ of every sales dollar. A major component of these costs is attributable to increased inventories from manufacturing interruptions caused by machine breakdowns. Such disruptions also make production lead times more variable, increase safety stocks and reduce flexibility in responding to orders. In "Optimal Maintenance Policies for Single-Server Queueing Systems Subject to Breakdowns," Awi Federgruen and Kut So analyze the problem of when to expedite normal repair procedures or how to choose between a number of increasingly expeditious and expensive repair modes in response to the workload or the number of customers. They show that an optimal repair strategy is characterized by a limited number of threshold levels that indicate when to switch from one repair mode to the next.

Modular Spares Provisioning

The rapid development of increasingly complex electronic and mechanical modular-type components can lead to the replacement of an entire module when a failure is detected or suspected somewhere within a system. Since these modules are expensive and critical to the functioning of a system, attention is focused on how long it would take to get the system up and running again. This issue is intimately related to the number of (expensive) spares retained and the nature of the repair process for the modules which returns them to an operable state. The model studied by M. Berg and M. Posner in "Customer Delay in M/M/∞ Repair Systems With Spares" yields information on the system down time, due to delays in obtaining a functioning spare, in simple explicit or algorithmic forms, thereby enabling the decision maker to examine the impact of system parameters on the delays.

Waiting for a Repaired Item

This paper arose from problems discussed at an annual meeting of the German OR Society. The problems dealt with determining the optimal number of spares in complex repair systems given delay time constraints. In these problems, customers exchange a failed item for any repaired one—not necessarily their own. This behavior is not feasible in most queueing networks for repair systems. This paper ("Exchangeable Items in Repair Systems: Delay Times") by Hans Daduna is a first step in the detailed investigation of this phenomenon. For a simple network, he studies the delay of a customer waiting outside the repair system for any returned repaired item.

Solving Nonlinear Equations

David Gale once wrote that those who know how to get solutions to a system of linear inequalities are those who know linear programming. A comparable statement about systems of nonlinear equations (or inequalities) and nonlinear programming does not seem to have been made. Daniel P. Heyman ("Another Way to Solve Complex Chemical Equilibria") shows that nonlinear programming can be used to solve the equations of chemical equilibria considered in a paper by Wall, Greening and Woolsey in this journal (**34,** 345–355).

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Unemployment Insurance and Job Searches

Unemployment insurance has two main objectives: to provide economic support to people who are temporarily out of work and searching for a new job; and to promote job search. The classical models of job search are based on the theory of sequential decisions. Under general conditions, the search policy of a job seeker has the reservation wage property. The search strategy is to accept the first available offer that exceeds a time dependent critical value—called reservation wages. Workers eligible for unemployment insurance will set higher reservation wages than those who are ineligible, leading to an increased duration of unemployment. Also, reservation wages usually decline as job search continues. Moshe Ben-Horim and Dror Zuckerman ("Stimulating Job Search Through the Unemployment Insurance System") formulate a theoretical game model and derive a socially optimal unemployment insurance policy.

Weighing Value Models

Decision makers are often faced with competing alternatives. The selection process usually starts with evaluating the alternatives based on some attribute, computing a score for each alternative, and ranking the choices. An agent wishing to promote an alternative might be interested in knowing how different the weights should be to make an alternative acceptable. The task of the agent is to derive some weights that closely approximate the decision maker's initial weights and rank the agent's alternatives. If this can be accomplished, the agent can assess the derived weights and justify their use. Such knowledge is useful in negotiating the relative importance of each attribute with the decision maker. It can also guide the agent to determine what kind of changes are necessary to make the alternative acceptable. In "Generalized Entropy-Based Weights for Multiattribute Value Models," Ehsan Soofi uses information theory to provide a methodology for developing weights that accomplish this task.

Sensitivity Analysis of Simulations

Sensitivity analysis of simulations is an important problem not only as a first step in the optimization and control of discrete event systems, but also as a tool in answering what-if questions. Infinitesimal Perturbation Analysis is a sensitivity analysis technique that provides gradient estimates from a single sample path, usually at negligible additional cost. In this technical note, Michael Zazanis investigates the statistical properties of these estimates for the M/M/1 queue.