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Scheduling Final Exams

From 1964 to 1984, college enrollment in the United States more than doubled, growing from 5,280,000 to 12,241,000. In planning examination periods, which constitute roughly 10% of an academic schedule, colleges attempt to avoid conflicts, to use available class space efficiently, and to balance work loads and maximize other criteria associated with "good" schedules. The majority of colleges use some form of computerized scheduling, but most implementations concentrate on data processing and data manipulation and not on optimization. In "A Survey of Practical Applications of Examination Timetabling Algorithms," Michael W. Carter describes practical experience in applying a dozen different OR-based algorithms that provide fewer conflicts and more rapid scheduling. He also describes the relationship of these algorithms to the literature on graph-coloring heuristics and gives practical advice on choosing an examination scheduling algorithm depending upon its likely performance in a given problem setting.

Responding to Oil Spills

From 1974 to 1983, more than 192 million gallons of oil were lost in maritime spills in U.S. waters. A small number of large spills accounted for most of the loss. Consequently, deploying emergency oil-spill equipment effectively has become increasingly important in mitigating significant economic and environmental damages. In "Optimal Response to Oil Spills: The Strategic Decision Case," Harilaos N. Psaraftis, Geverghese G. Tharakan and Avishai Ceder propose a model for improving strategic decisions about where to locate emergency equipment. They illustrate the model's use on data from the New England region.

Applying for Government Land Leases

The federal government is the nation's largest landowner, with holdings exceeding 700 million acres. Every other month it holds simultaneous drawings in which citizens may acquire leases on parcels of public land. A multibillion-dollar industry of professional filing services assists investors in selecting parcels. Prior to each drawing, these filing services must determine which parcels each client should apply for in order to optimize aggregate performance measures. Awi Federgruen and Henry Groenevelt, in "Optimal Flows in Networks with Multiple Sources and Sinks, with Applications to Oil and Gas Lease Investment Programs," discuss a network flow model and its implementation for this problem. The proposed solution methods for this model, which have application to other resource allocation problems on capacitated networks with a concave objective, generalize well-known augmenting path techniques for the classical maximum flow problem.

Producing Style Goods

Clothing, electronics and other style goods are typically sold during short bursts of high demand: 95% of the demand for Sony Walkmen falls in June, September and the Christmas buying period; 85% of all scarves and gloves are sold in the pre-Christmas period. As a consequence, production planning of style goods poses distinctive production and inventory smoothing problems. In particular, producers must be able to balance the production of multiple products, some that are harder to forecast than others, and to revise their production plans as the buying season nears and revised forecasts become available. In "Production Planning of Style Goods with High Setup Costs and Forecast Revisions," Gabriel R. Bitran, Elizabeth A. Haas and Hirofumi Matsuo propose a hierarchical planning model for this problem and illustrate its use with data from a consumer electronics company.

Better Lot-Sizing in Material Requirements Planning

Material Requirements Planning (MRP) has become one of the most popular techniques used in industry to support purchasing and production decisions. The technique requires the manipulation of large data bases: it must explode bills of materials, net all material quantities against inventories, establish lot sizes for each item, and recommend dates for the release of procurement and production to account for lead time. Unfortunately, MRP systems do not meet the expectations of many users; at present, they provide little guidance on how to deal with uncertainties and capacity planning, or how to determine optimal lot sizes. Panayotis Afentakis and Bezalel Gavish, in "Optimal Lot-Sizing Algorithms for Complex Product Structures," develop an optimization methodology for

lot-sizing decisions with complex product structures. Their approach has been tested, with encouraging results, on problems with a single end-product requiring up to 40 production stages.

How Hard Are Linear Programs?

Recent results in linear programming have stimulated renewed interest in an important and elusive theoretical issue: is there an algorithm for linear programs that is guaranteed to require only a polynomial number of arithmetic computations in the *number* of defining equations and variables? Classical examples devised by Klee and Minty (*Inequalities*, 1972) show that the celebrated simplex method, despite its extraordinary efficiency in practice, can require an exponential number of computations. The highly cited methods of Khachiyan (*Soviet Mathematics. Doklady*, 1979) and Karmarkar (*Combinatorica* **4**, No. 4) not only provide interesting algorithmic alternatives to the simplex method, but also offer theoretical improvements: they are polynomial in the size of the problem data including costs, right-hand sides and constraint coefficients. In "A Strongly Polynomial Algorithm to Solve Combinatorial Linear Programs," Éva Tardos comes even closer to resolving the most general form of the theoretical question. She gives an algorithm that is polynomial in the number of defining equations and variables and in the size of the constraint matrix coefficients, but is independent of the size of the cost coefficient and right-hand side coefficients.

Improving Responses to Police Calls

Each U.S. city generates approximately one "911" emergency police call per citizen per year, fewer than 10% of which are high priority—that is, arise from life-threatening situations. Most present-day police dispatchers begin to queue calls for service only when all patrol cars in their jurisdiction are busy. This "taxicab" method dispatches police cars as calls arrive and ignores the possibility that cars might not then be available to respond to subsequent, more serious calls. Prior OR analysis has prompted the Justice Department ("Evaluation of the Differential Police Response Field Test," McEwen, Connors and Cohen, U.S. Department of Justice 1985) to "advocate a differential police response strategy," currently in use in many cities in the United States, that prioritizes incoming calls. In "An N-Server Cutoff Priority Queue," Christian Schaack and Richard C. Larson extend this work and develop a multiserver priority queueing model that incorporates a server management policy that deliberately saves available servers even in the presence of a lower priority queue. The model also applies to ambulance-dispatch and telecommunication systems.

When It Positively, Absolutely Has to Get There on Time

The well-known Federal Express slogan reflects the increasing importance that businesses and individuals place on reliable as well as fast delivery service. The management of such systems is dictated by some important trade-offs—the frequent dispatch of vehicles with small loads provides both fast and reliable service, but requires more drivers and more vehicles whose capacity utilization is poor; waiting for full loads has the opposite effect. Similar problems in bulk service queues arise in a variety of problem settings including communication systems, bus service, nonscheduled aircraft shuttle service and less-than-truckload freight distribution. A new approach for analyzing such systems, presented in "The Bulk Service Queue with a General Control Strategy: Theoretical Analysis and a New Computational Procedure" by Warren B. Powell and Pierre Humblet, leads to a fast and stable algorithm for deriving performance measures for bulk service queues, and raises the possibility of optimizing large networks of such queues. "Clearing Systems and (s, S) Inventory Systems with Nonlinear Costs and Positive Lead Times" by Shaler Stidham, Jr., extends previous results by showing how to characterize the optimal order-triggering and order-up-to points for bulk service queues with nonlinear (convex) holding and shortage costs.

Evaluating Computer Systems with Multiprogramming and Virtual Memory

The throughput of a computer system is determined, to a large extent, by two factors: the speed of its processor and the capacity of its memory. The concept of multiprogramming allows better utilization of the processor, while the technique of virtual memory permits large programs to be stored and processed. The IBM 360 Model 67 computer, introduced in the mid-1960s, and the subsequent IBM 370 series of computers popularized both these design innovations. Today, even inexpensive microprocessors support these two techniques for boosting overall performance. In "Cycle Times in Two-Stage Closed Queueing Networks: Applications to Multiprogrammed Computer Systems with Virtual Memory," Hans Daduna

studies a queueing model for such systems and shows how to determine the distribution time for jobs in these systems.

Reconciling Conflicting Analyses

Historically, decision analysis has focused on obtaining *the* correct answer to a decision problem, but recently decision analysts have come to recognize that any assessment is inevitably made with some error. For example, an important topic these days is the reconciliation of experts' judgments about probabilities. Dennis V. Lindley, in "The Reconciliation of Decision Analyses," tackles a broader question—how to reconcile the results of different analyses when they conflict. Lindley's approach assumes that both probabilities and utilities are measured with error, so that two formulations of a decision tree could lead to different answers. This model permits analysts to investigate in advance which of two decision tree analyses is more likely to give accurate results.

Choosing Best with Incomplete Information

When decision makers compare notes, they complain about never having enough information. Analysts face the same problem concerning the preferences of the decision maker they are supposed to help. In "Partial Information, Dominance, and Potential Optimality in Multiattribute Utility Theory," Gordon B. Hazen shows how we can tell whether the incomplete information we have about a decision maker's preferences is nevertheless sufficient to establish the best alternative for a given situation. Hazen illustrates his methodology on a previously published application to nuclear siting conducted by Ralph L. Keeney.

Controlling Inventories of Repairable Items

The U.S. Air Force maintains an inventory of repairable items that is valued in excess of ten billion dollars. The other branches of the armed forces have repairable inventories of similar magnitudes. The inventory systems that support these items are both multi-echelon and multi-indentured. These inventory systems are planned and managed by a system called METRIC (developed in 1968 by Craig C. Sherbrooke) and its subsequent refinements. METRIC and its successors are probably the most widely applied models from the literature of multi-echelon inventory theory. In "VARI-METRIC: Improved Approximations for Multi-Indenture, Multi-Echelon Availability Models," Sherbrooke presents an enhancement of the METRIC model that provides an improved approximation of inventory availability.

Technical Notes

In "A Note on Shot-Noise and Reliability Modeling," Austin J. Lemoine and Michael L. Wenocur study a reliability model in which susceptibility to breakdown depends on the "state of health" of the system, as measured by its residual system stress.

K. E. Trummel and J. R. Weisinger, in "The Complexity of the Optimal Searcher Path Problem," show, from the perspective of computational complexity theory, that two well-known search problems are inherently difficult.