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Thornthwaite's Classic Paper Revisited

In 1953 in the second issue of this journal, then named the *Journal of the Operations Research Society of America*, the lead article was a paper by C. W. Thornthwaite titled "Operations Research in Agriculture." Against the dominant background of military OR at that time, it was viewed as a significant contribution to the peacetime application of OR. Indeed, virtually unchanged in over 40 years, the method it described for managing vegetable crop planting and harvesting is still in active use at the large farm where the original work was done. Yet a close review of the paper reveals some hiatuses and discrepancies, as well as a terseness of description that misleads by making the analysis appear overly simple. In his *OR Forum* paper Howard W. Kreiner has examined Thornthwaite's other publications to discover the much broader and deeper research and analysis that supported the method described in the 1953 paper. The full case history exemplifies the kind of close observation and careful synthesis that is needed for successful operations research practice.

Modeling the Effects of Acid Rain

When Congress started to consider proposals to reduce acid rain, staff at the U.S. Bureau of Mines wanted to know how various proposals would affect aluminum smelting and other mineral processing activities for which electricity is a large share of production costs. In this *OR Practice* paper, Edward Hillsman, Donald Alvic and John Bennett describe how they answered this question and, in the process, developed a modeling system that attracted interest within the agency and elsewhere. One reason for their success is that they recognized the need to develop methods that could be adapted easily as new legislation was introduced. In addition, they were able to anticipate some of the questions that might be asked once legislation was enacted and to include the flexibility to answer these questions.

Models Help in Forest Planning

Important decisions in forest planning involve the geographic arrangement and timing of management activities, and the design of transportation networks to provide efficient access with acceptable effects on forest amenity values. These potentially complex planning problems have been successfully modeled as mixed integer linear programs. These models are difficult to solve with commercial software due to the relatively large number of binary variables. In an *OR Practice* paper, Weintraub and others present a heuristic approach that has solved these problems well. The heuristic rules and a linear programming package interact within a closed system requiring no special user intervention. Several applications of this system have been made in real planning situations in the USDA Forest Service with good results in terms of solution quality and with moderate computational effort.

A Unified Framework for Total Tardiness

Total tardiness is an important criterion in deterministic machine scheduling, as is evident from the bulk of literature on the subject. C. Koulamas provides a unified framework for the total tardiness problem by surveying the related literature in the single machine, parallel machine, flow shop, and jobshop settings. The heuristics available for the single and the parallel machine problems are evaluated both experimentally and analytically. A decomposition heuristic for the single machine problem and a new heuristic for the parallel machine problem are proposed. The favorable performance of the new heuristics and the close examination of existing solution methods provide insights to the surveyed problems, which can lead to further research in this area.

A Key to Successful Branch and Bound

Branch-and-bound algorithms are well known and widely used methods to solve difficult optimization problems. The emergence of parallel computation raises the expectation that realistically large-size instances of many such complex problems may be solved. Bernard Gendron and Teodor Crainic survey over 150 papers on parallel branch and bound and present a comprehensive synthesis of the challenges and strategies associated with adapting branch-and-bound methods to parallel architectures. Given the steady rate of increase in parallel computer utilization, both in academia and industry, this paper is a

timely and useful guide to efficient design and implementation of branch-and-bound algorithms for today's problems.

Joint Replenishment Problems

Most production or distribution planning systems are driven by a time series of forecasts for the demands of each final product and end item. The planning problems for the different items are often interdependent. Traditional planning approaches typically ignore or deemphasize these interdependencies. Exact solution methods for planning models which incorporate the interdependencies have been incapable of handling typical problems. A variety of heuristics have been proposed, but their performance is not well understood and they cannot be tailored to the needs of the specific application. A. Federgruen and M. Tzur address the general class of joint replenishment problems (JRP), in which interdependencies between the items arise due to common setup costs. They derive a heuristic based on time partitioning. The method has low polynomial complexity, can be designed to guarantee an arbitrarily small optimality gap, and is asymptotically optimal. An extensive numerical study shows that the method performs exceptionally well, even on moderate size problems.

Switching is Expensive

Suppose that an oil company has K locations in which to explore for oil. It has prior information concerning how likely is a search of the locations to be successful and on the costs/rewards involved. If the company's resource allocation problem is described by multi-armed bandit-type models, then the resulting policies would likely involve an unacceptable amount of switching of the available resource between locations. This is, in part, because those models take no explicit account of the cost of such switching. Lakdere Benkerhouf, Keven Glazebrook, and Wyn Owen discuss ways of modifying conventional analyses to tackle this problem, including the development of a new class of single visit policies. Not surprisingly, such policies allow for only one visit of the resource to each location; one needs to specify in which order the locations should be visited and how long the resource should stay in each one.

Alternatives to Increase Bargaining Power

In the academic market, one of the most effective ways to bargain for a promotion is to find a better alternative somewhere else. In buying a commodity, one way to convince the seller of a lower offer is to show alternative offers received from other places. In many real-life situations, the "alternative option" appears to be a crucial factor in determining the bargaining outcome. However, searching for alternatives often involves cost. How would then the search cost affect the bargainers' decisions and their respective payoffs in a bilateral bargaining situation? Ching Chyi Lee describes a model that resembles the two scenarios sketched above. The results are intriguing because they run counter to several of the standard results of bargaining theory.

A New Application for an Old Law of Physics

The motivation for this article is to improve the way in which decision makers communicate with computer systems for solving multiple criteria problems. In many such systems, the user must repeatedly indicate the desired direction of improvement from the *status quo.* Spreadsheet modeling may be regarded as a multiple criteria decision problem, so the practical application of this work is to enhance spreadsheet software. Spreadsheet users may employ interactive multicriteria optimization to manipulate the model. Marvin Troutt improves the accuracy of the user's direction of improvement. For each criterion, the user provides a number using a constant-sum scale. When these numbers are interpreted as forces applied to the status quo solution, Newton's Second Law of Motion can be applied to obtain the direction of improvement. The importance to theory is that a more accurate direction finding method is available for interactive methods.

New Paradigm for Transportation Modeling

Friesz and others address the difficult problem of modeling the day-to-day dynamic flow patterns of network travelers who have experienced some disequilibrating event. Theirs is the first dynamic disequilibrium model for a general network topology with asymmetric demand and cost functions. Their model offers a new, computationally tractable, behavior-based paradigm for traffic network analyses which may significantly alter the transportation planning process. That paradigm is made possible by an original representation of the travelers' adjustments of flows and cost perceptions as a projective dynamic system in which virtually any type of constraint involving flows and costs may be embedded. As such, their model will easily accommodate a variety of constraints, including the social, technological, legal and regulatory constraints that are expected to influence the adoption of various forms of intelligent infrastructure and vehicles.

Passage Time, Volume, Permanent and Monte Carlo

Several recent papers have used a product estimator with Monte Carlo sampling to estimate problem parameters. These include the first passage time distribution in a positive recurrent Markov chain, the volume of an m-dimensional convex body, and the permanent of an $m \times m$ matrix. The permanent includes the number of perfect matchings in a bipartite graph as a special case. These multiple usages of the product estimator suggest its practical value in Monte Carlo experiments and encourage a deeper understanding of its properties. George Fishman studies these properties when the data come from a Markov chain that starts in an arbitrarily selected initial state. The account emphasizes the relationships among the number of factors in the product, the lengths of the warm-up intervals, and the number of independent replications to be performed to achieve a specified relative accuracy. The paper formulates and solves for the least-cost sampling design in terms of the number of steps in each warm-up interval and the number of independent replications for each factor.

Process Scheduling in Real-Time Systems

Real-time computer systems like process control systems and multimedia video systems often have to guarantee timing requirements which are expressed in terms of deadlines. A flexible way of finding a tradeoff between deadline enforcement and the additional costs induced by context switches is the use of semi-preemptive scheduling strategies. M. Paterok and M. Ettl establish a homogeneous, efficient and extendable framework for the analysis of a broad class of semi-preemptive priority systems. The solutions generalize the well-known results for the $M/G/1$ preemptive and nonpreemptive priority queues and cover a variety of systems operating under different priority regimes. The paper is motivated by a joint industrial-university project on flexible manufacturing systems. An example taken from the scheduling of real-time process control systems illustrates the approach and demonstrates the modeling power of preemption-distance priorities.

Release Control for Queueing Systems

A fundamental problem in manufacturing systems is when to release a new job to the shop floor. This problem has recently attracted a lot of attention, especially in semiconductor manufacturing. Izak Duenyas proposes a simple release policy for systems that produce multiple products on the same line. This policy outperforms more complicated dynamic release and sequencing rules when used in conjunction with static sequencing rules. This work is part of a larger project to develop simple, yet effective control mechanisms for manufacturing systems.

Parallel Machine Scheduling

Many practical scheduling problems in manufacturing involve dividing the jobs into batches and then determining the processing order for the batches with setup times between consecutive batches. The computational complexity of the parallel-machine scheduling problem with an arbitrary number of batches and batch setup times to minimize the total completion time of the jobs has remained open for some time. T. C. E. Cheng and Z. L. Chen present a formal proof that the problem is NP-hard even with independent setup times and equal processing time.