
Operations Research

Publication details, including instructions for authors and subscription information:
http://pubsonline.informs.org

# In This Issue

To cite this article:
(1987) In This Issue. Operations Research 35(1):3-5. https://doi.org/10.1287/opre.35.1.3

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### Improving Distribution in the Soft Drink Industry

Distribution activities in the soft drink industry involve complex, costly operations that, in 1985, amounted to approximately 70% of the value-added costs. Since many beverage distributors currently base their vehicle routing decisions on experience alone, computerized vehicle routing packages offer opportunities to reduce costs by allowing distributors to generate routes quickly and reduce the manpower required by the dispatching function. In "Computerized Vehicle Routing in the Soft Drink Industry," Bruce L. Golden and Edward A. Wasil focus on recent, successful implementations of these packages, citing 5 diverse case studies that highlight opportunities for enhancing productivity and control. They report that distributors' interest in computerized vehicle routing has increased dramatically in the past several years, and that the industry is on the verge of becoming a major consumer of this technology.

### Projecting Prison Populations

In recent years, both state and federal governments have moved sharply toward harsher prison sentencing. In April 1977, for example, the Congressionally appointed U.S. Sentencing Commission issued guidelines that would increase appreciably the length of the average federal prison term. With incarceration already costing U.S. taxpayers $11 billion per year, public officials have an enormous interest in predicting the effects of longer prison terms on the size of future inmate populations. Are there logical and defensible procedures for making such forecasts? "Prison Populations: A Projection Model" strives, in its author's, Arnold Barnett's, words, to be "a force for greater accuracy even if not great accuracy" in estimating future inmate numbers. The article warns that, while prison populations may stop growing around 1990, this seeming trend might represent merely a "technical correction" of no lasting significance.

### A Patient-Flow Model for Acute Health Care Facilities

Cost containment issues are becoming increasingly important in the health care sector as budget cuts deepen, new reimbursement methods take hold, and the cost of providing care continues to rise. A growing area of concern to hospital administrators—one that will continue to increase as the U.S. population ages—is the problem of "backup" patients: those who no longer require the acute care services of a hospital but must remain there while awaiting placement to an extended care facility. Such patients must pay for a level of care they do not require and that hospital personnel may not be trained to provide. In "Administrative Days in Acute Care Facilities: A Queueing-Analytic Approach," Elliot N. Weiss and John O. McClain present an effective methodology for analyzing the flow of patients in these facilities. Their model explicitly accounts for uncertainty effects by applying queueing theory methods, and is designed to be used by health planners and administrators to evaluate decisions concerning reimbursement, discharge planning and certification of extended care facilities.

### Reformulating and Solving Mixed Integer Programs

During the past few years, several innovations in the classical cutting plane methodology of integer programming have led to significant improvements in the mathematical programming community's ability to solve large-scale practical problems. For example, a contribution from this Journal ("Solving Large-Scale Zero-One Linear Programming Problems" by Harlan Crowder, Ellis L. Johnson and Manfred W. Padberg; Vol. 31, pp. 803–834), which shared ORSA's 1983 Lanchester Prize, showed how such methods could be used to solve pure 0-1 integer programs met in practice that contain up to 2,750 variables. Despite the prevalence of mixed integer programs in practice, much less has been done to improve our ability to solve these problems. Now Tony J. Van Roy and Laurence A. Wolsey ("Solving Mixed Integer Programming Problems Using Automatic Reformulation") describe a planning system that uses problem reformulation and cutting planes to solve a wide range of applications, including production planning, multilevel distribution system planning, drainage and heating system design and electrical generator scheduling.

### Managing Peak and Off-Peak Traffic Flow

During the daytime and early evening hours of any weekday, the number of vehicles in motion in midtown Manhattan varies between 3,000 and 7,500. Traffic on the prime arterial roads into and out of the city is regulated by 3,000 signals that normally operate via a clock mechanism. These signals can also respond to information received from underground sensors, and are therefore capable of responding to actual traffic conditions. Programming them to react effectively, however, requires insight concerning the logistics and control of dynamic network flows. In "Optimal Time-Varying Flows on Congested Networks," Malachy Carey develops an optimization model that can be used to describe dynamic traffic flows during peak and off-peak demand cycles. His approach, which combines dynamic attributes of multiperiod network models with modeling features that have become central to current static representations of urban traffic flow, is also useful in analyzing networks for communication and information flow, public utilities and services, computers, commodity and financial flows, and social and political interaction.

### Approximating the Solution Set to Multi-Objective, Shortest-Path Problems

The shortest-path problem is a core model of operations research that has generated a voluminous literature; it arises in numerous, diverse applications ranging in scope from production planning, finance, and vehicle fleet planning to the design of very-large-scale integrated circuits (VLSI). In many contexts the problem becomes more complex because several criteria—for example, cost vs. service—are relevant. A common approach in treating such situations is to compute the set of "efficient" or nondominated solutions. However, this strategy has one important limitation: the number of such solutions can grow exponentially in the problem's size, as measured, for example, by its number of nodes. To compensate for this feature, Arthur Warburton (in "Approximation of Pareto Optima in Multiple-Objective, Shortest-Path Problems") develops efficient methods for approximating, to any desired degree of accuracy, the set of nondominated solutions.

### Which Circle is Best?

The application of computational complexity principles to geometric problems has recently produced the important area of geometric complexity. A primary contribution of this field has been the rigorous algorithmic analysis of solution procedures for many operations research location problems. Though the major developments in geometric complexity have taken place over the past 15 years, many of the models it addresses are classical—for example, the problem, posed over a century ago by J. J. Sylvester, of finding a circle of minimum radius that encloses a family of given points in a plane (an application of this problem would be to determine the location of a fire station so that it is as close as possible to the set of residences it must serve). In "An Efficient Geometric Solution to the Minimum Spanning Circle Problem" B. John Oommen studies Sylvester's problem and proposes a new finite-time algorithm that encompasses important features of several existing procedures and that, experimentally, has a linear time complexity. His computational experience indicates that the new algorithm is extremely efficient.

### Analyzing Flexible Manufacturing Systems with Limited Buffer Capacity

Work-in-process (WIP) inventory is one of the major concerns of modern manufacturing. A flexible manufacturing system (FMS) can reduce such inventories by limiting buffer capacity—both in the system as a whole (by limiting entry) and before individual work stations. When the buffer at a station is full, arriving parts must either be rerouted to other stations or must remain in the material handling system (for example, on a conveyor) for later entry to the work station. However, the limited buffer capacity complicates the modeling and analysis of such systems. David D. Yao and J. A. Buzacott address a version of this problem in "Modeling a Class of Flexible Manufacturing Systems with Reversible Routing." They examine a "block-and-recirculate" mechanism in an FMS that uses a closed loop conveyor (or similar device) to handle part movements among stations, and show how to exploit the structure of such a system to adapt the well-studied "product form" models of networks of queues in order to derive various system performance measures. Their study indicates that these models are most appropriate for systems with small local buffers at the work stations.

### Minimizing Changeover Costs in Production Planning

Simple deterministic machine scheduling models often prove effective for analyzing production scheduling problems. In the November–December 1961 issue of this Journal (Vol. 9, pp. 841–848), T. C. Hu, one of the first researchers to successfully analyze such models, determined the minimum number of identical machines needed to complete a set of production steps to assemble a product by a known deadline. Now Professor Hu, with coauthors Y. S. Kuo and F. Ruskey ("Some Optimum Algorithms for Scheduling Problems with Changeover Costs"), again studies a version of this problem: how to produce a variety of products on a family of identical production lines (machines). The model is useful for determining a production schedule that meets demand deadlines while minimizing normal changeover costs that are incurred when any machine switches from manufacture of one product type to another. The authors specify circumstances when the optimal schedule can be determined efficiently.

### New Contracts Alter Employee Work Schedules

Over the past 10 years, workers in service and manufacturing industries such as utility companies, hospitals, health care facilities and prisons have successfully negotiated contracts designed to change their 7-day-week, multi-shift schedules to Monday-to-Friday dayshifts. In many instances, the maximum number of consecutive workdays has moved from 8 to 6, and is moving to 5 or fewer; in some hospitals, employees now work 2 out of 3 weekends, or even 1 out of 2, instead of the 5 out of 7 that was standard practice for many years. As these contracts continue to change and become more constraining, the task of determining minimum-cost work schedules becomes more formidable: for example, only a quarter of the total work force may be available for evening or night shifts, even though one-third may be needed. In "A Modular Approach to Optimal Multiple-Shift Manpower Scheduling," R. N. Burns and G. J. Koop describe methods they employed to develop microcomputer programs that determine the minimum-size staff that satisfies new contract provisions for scheduling nurses and prison guards. These programs are now in use in a number of Ontario hospitals and prisons.

### Seeking Uniform Performance in Computer Systems

Computer system design involves many criteria. A number of on-line systems, for example, require stable, preferably constant, response time. In the transmission of data to earth by a remote satellite, or monitoring of aircraft positions by radar, each batch of data transmitted must be processed before the next batch is received. If processing takes place sooner or later than expected, undesirable idle time, or erroneous results, may occur. Such systems must be designed for the most pessimistic case, allowing little variability in processing times. Vina Vani and M. Raghavachari ("Deterministic and Random Single Machine Sequencing with Variance Minimization") examine a similar situation in which excessive deviation on either side of the expected completion time can be costly. They study the scheduling of several jobs on a single machine so as to minimize the variance of the jobs' completion times. Their analysis permits them to obtain explicit optimal sequences for situations with a small number of jobs, and a new heuristic method for situations with a large number of jobs.

### The Control of Flows in a Production Line

In many manufacturing situations, service facilities are arranged as a tandem queue with a waiting room, or buffer, between subsequent stations. These systems, which are used in many areas of high-technology production—such as semiconductor and wafer fabrication—have the ability to change the rate of work done at each station on a station-by-station basis in a dynamic fashion. Katsuhisa Ohno and Kuniyoshi Ichiki, in "Computing Optimal Policies for Controlled Tandem Queueing Systems," use results from Markov decision processes to study systems that can be managed by altering the service rates of the stations.

### Making Statistical Inferences from Efficient Simulation Experiments

The outputs of Monte Carlo simulations are random quantities. Hence, to be meaningful, these results must be accompanied by statistical measures of their accuracy. Such simulations also consume huge computing resources; consequently, practitioners have a strong desire to conduct them efficiently. Addressing these issues in *The Journal of the American Statistical Society* (Vol. 73, pp. 504–525), L. W. Schruben and B. H. Margolin developed procedures for applying common random numbers and antithetic variates (two popular variance reduction techniques) to a broad class of experimental designs. Now Ardavan Nozari, Stephen F. Arnold and C. Dennis Pegden ("Statistical Analysis for Use with the Schruben and Margolin Correlation Induction Strategy") extend the work of these researchers by developing statistical techniques for drawing meaningful inferences from such studies.

### Technical Note

In "Recognizing Unbounded Integer Programs," R. H. Byrd, A. J. Goldman and Miriam Heller examine the relationship between a linear program and its companion integer program. If the linear programming problem is unbounded and all data are rational, the companion integer programming problem must be either infeasible or unbounded. The authors note that if irrational data are allowed, a third possibility arises, in which the integer programming problem may have only finitely many feasible solutions, but its feasible region is of lower dimension than that for the linear program.

### The Birth of Operations Research

Born in Britain on the eve of World War II out of the growing recognition of the possible uses of radar in national defense, operations research had, by 1938, acquired its name, and by 1941 had established itself, and the methods of inquiry it would employ throughout the war, in all of the principal branches of the British military. Its birth was assisted by some of the world's leading scientists, who came from such diverse fields as physiology, chemistry, biology and physics. This group included 7 Nobel Prize winners: E. A. Appleton, P. M. S. Blackett, J. Cockcroft, A. V. Hill, A. F. Huxley, J. C. Kendrew, C. H. Waddington. In OR FORUM, Joseph F. McCloskey ("The Beginnings of Operations Research: 1934–1941") offers an overview of these beginnings—from OR's scattered precursors in World War I, through the early experiments with radar off the British coast, to the contributions of the Royal Air Force OR group to British strategy in the Battle of France in 1940. The article is the first in a series of three by Professor McCloskey that will appear in OR FORUM during 1987.

### Former ORSA Presidents Speak

Our former presidents have, by virtue of their varied experiences, distinctive perspectives on the profession. As part of a special celebration of ORSA's (and this Journal's) 35th anniversary, OR FORUM will present, throughout the year, a series of articles in which a number of past presidents offer their views concerning our history, current status and future. In this issue, William P. Pierskalla ("Creating Growth in OR/MS") builds upon a view of history to project possible futures for the profession, and Robert E. Machol ("OR Elsewhere") offers a picture of operations research outside the United States.