Operations Research

Preface

Operations research is the application of scientific analysis to management problems; its aim is to provide decision makers with a sound quantitative basis for decision making in the face of complex relationships, uncertainty and risks, conflicts of interest and alternative courses of action.

The experimental method traditionally used in scientific research is not practical for the operations researcher because of the nature of the problems investigated. Like the astronomer, he resorts to a representation of reality which he calls a model. Models are typically used to gain insight, to observe and measure, to test, to discover significant variables and to determine a solution that is optimal or near optimal with respect to some measure of system performance. With the aid of computers, sophisticated mathematical models can be used to study man-machine systems and hence carry out experiments in a symbolic way.

Recent years have seen rapid growth in the number of specialized techniques that are used in constructing and optimizing models. The papers in this section of the *Journal* describe only part of such growth; they represent the scope and strategy of operations research, but are otherwise atypical in two (related) respects: (1) All of the papers are concerned with selection or arrangement of discrete elements in a finite system. This feature is an inherent consequence of the nature of the IBM Corporation as compared with, say, the petroleum industry. [The emergence of the discipline of finite or discrete mathematics from the shadow of continuous mathematics was noted in an earlier issue of the *Journal*: "Combinatorial Problems," *IBM J. Res. Develop.* **4**, 454 to 558 (1960).] (2) Networks and matrices dominate the mathematical structure of the problems discussed. These elements are the common ground for transferring experience from one problem situation to another.

Although the models dealing with a dispatching system (Evers and Thakur, p. 357) or a series production line (Abraham and Prasad, p. 343) have been motivated by specific situations, the applicability of each model to a class of situations is evident. The mathematical abstraction of a management decision model for fixed-price, variable-sales-force marketing (Savir, p. 366) as a nonzero sum, two-person game permits insight into the dynamics of sellers' competition. The paper on stochastic programming as the mathematical structure for dynamic inventory models (El Agizy, p. 351) demonstrates the unifying process in the strategy of operations research. The special structure of a stochastic problem is exploited to achieve more efficient computation by providing a link with the more widely investigated solution techniques for network-flow problems.

Many other problems, such as routing, communications and transportation, can also be formulated as network-flow models. In such situations it is essential to determine a minimal-cost maximal-flow path satisfying capacity constraints or a minimal-distance path between nodes of a network; the search for computationally faster algorithms to these ends is central to the strategy of operations research. Three papers (Arinal, p. 373; Hu and Torres, p. 387; and Raimond, p. 391) describe efforts in this direction.

Many network-flow problems can be formulated as linear programs, but alternative solutions often prove more economical in specific situations. A common problem is that of optimal assignment. Despite the existence of formulations of this problem in linear or integer programming, the need for computational feasibility in large assignment problems requires the exploration of near-optimal algorithms by alternative approaches or by the use of heuristics within the programming formulation. The suboptimal intermediate-speed algorithm (Donath, p. 380) is an approach in this spirit. Another important class of problems with a specific structure related to industrial and management applications, such as sequencing, is often referred to as the traveling-salesman problem. Relatively little is known about efficient methods for solving this problem and no method exists that is both economical and general. The description of a near-optimal algorithm for this problem (Raymond, p. 400) illustrates the heuristic approach to computationally large problems.

P. S. Wolfe at the IBM Thomas J. Watson Research Center, Yorktown Heights, New York stimulated our interest in assembling this group of papers and thereafter served in the voluntary but demanding capacity of consulting editor.