

Preface

To derive rational and convincing solutions to practical decision making problems in complex and hierarchical human organizations, the decision making problems are formulated as relevant mathematical programming problems which are solved by developing optimization techniques so as to exploit characteristics or structural features of the formulated problems. In particular, for resolving conflict in decision making in hierarchical managerial or public organizations, the multi-level formulation of the mathematical programming problems has been often employed together with the solution concept of Stackelberg equilibrium.

However, we conceive that a pair of the conventional formulation and the solution concept is not always sufficient to cope with a large variety of decision making situations in actual hierarchical organizations. The following issues should be taken into consideration in expression and formulation of decision making problems.

In formulation of mathematical programming problems, it is tacitly supposed that decisions are made by a single person while game theory deals with economic behavior of multiple decision makers with fully rational judgment. Because two-level mathematical programming problems are interpreted as static Stackelberg games, multi-level mathematical programming is relevant to noncooperative game theory; in conventional multi-level mathematical programming models employing the solution concept of Stackelberg equilibrium, it is assumed that there is no communication among decision makers, or they do not make any binding agreement even if there exists such communication. However, for decision making problems in such as decentralized large firms with divisional independence, it is quite natural to suppose that there exists communication and some cooperative relationship among the decision makers.

Moreover, in the real-world problems, diversity of evaluation has taken on a growing importance, and it is natural to suppose that decision makers desire to attain several simultaneous goals. Namely, they have multiple objectives and evaluate alternatives, considering trade-offs among the objectives. For such situations, formulations of mathematical models including multiple objectives are appropriate, and the multi-level programming methods under multiobjective environments should be developed.

When we model actual situations of decision making in mathematical programming problems, there are some difficulties that decision makers may face and need to handle; we should take into account imprecise data gathered to formulate problems, inaccuracies of human judgments in decision making, bounded rationality of decision makers, and uncertainties of events related to the decision making. Moreover, the experts do not always understand the nature of parameters of the problems precisely in the problem-formulation process, and their understanding may be somewhat fuzzy. From vagueness of judgments of the decision makers, we suppose that the decision makers have a fuzzy goal with respect to each of the multiple objectives. In some sort of circumstances, formulations of mathematical models including stochastic events are required.

Real-world decision problems in hierarchical organizations can be often formulated as difficult classes of optimization problems such as combinatorial problems and nonconvex nonlinear problems. For such problems, it is difficult to obtain exact optimal solutions, and thus it is quite natural for decision makers to require approximate optimal solutions instead. To meet this demand, recently several metaheuristics have been developed and their effectiveness is demonstrated. Among them, genetic algorithms are known to be one of the most practical and proven methods. Genetic algorithms initially proposed by Holland in early 1970's have made a wide variety of contributions to optimization, adaptation, and learning. Especially, applications to optimization continue to extend across difficult classes of optimization problems.

In this book, after presenting basic concepts in multi-level mathematical programming problems, the authors intend to introduce the latest advances in the new field of multi-level mathematical programming problems under fuzzy, multiobjective, and/or uncertain environments. Because the relation among decision makers in real-world hierarchical organizations can be expressed by either a cooperative or a noncooperative framework, we provide cooperative and noncooperative formulations of multi-level programming problems. For computational aspects, exact solution methods based on linear programming techniques are given if possible, but for complex problems difficult to search optimal solutions, computational techniques using genetic algorithms are utilized.

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