Apoio à Decisão em Programação Linear Multiobjectivo. Um Modelo para o Planeamento Estratégico de Redes de Telecomunicações

Decision Support in Multiobjective Linear Programming. A Model for Strategic Planning of Telecommunication Networks

Extended Abstract

The complexity of the problems arising in modern technological societies is characterized by the existence of multiple, conflicting, and incommensurate criteria. Mathematical models, as well as the perception of the problems by decision makers, become more realistic if the different aspects of reality are explicitly considered, and not just encompassed in a sole objective function (generally, a global economic indicator). The interactive approach, which combines technical means to compute nondominated solutions and information about the decision maker's preference structure in the solution search process, is nowadays accepted as the most adequate way to tackle these decision problems. Interactive methods consist of alternate phases of computation and dialogue, and they reflect a diversity of strategies for carrying out the search for nondominated solutions. These methods enable the learning and preference evolution as more information is gathered throughout the decision process, which in turn is used to guide the search, and minimize both the computational effort and the cognitive burden on the decision maker.

In this context, the research and development work underlying this dissertation has been carried out according to four main directions: - Interactive methods use distinct of strategies for carrying out the search for nondominated solutions and differ in the type of information required from and presented to the decision maker. The experience acquired with computer implementations and applications of multiple objective linear programming interactive methods, as well as the evaluation of their conceptual characteristics, led to the development of a new integrated computer package: a method base which enables to take advantage of the combination of different methods. The TOMMIX method base includes at present five multiple objective linear programming interactive methods, which are representative of different strategies for reducing the scope of the search, use distinct scalarization functions to obtain nondominated solutions in each computation phase, and differ in the information required from and presented to the decision maker. Besides providing the standard operation of each method, TOMMIX offers the possibility of method switching at any interaction with the decision maker. This enables a better use of the potentialities of each method in

different stages of the decision process, as well as the evaluation of the effectiveness of each method in a particular decision problem. The underlying principle is to support interactively the decision maker in the progressive narrowing of the scope of the search, using the knowledge accummulated in the previous interactions. The method base aims at creating a flexible computational decision aid tool respecting the conceptual characteristics of the methods, the main concern being the possibilities of combining them while guaranteeing the transfer of usable information.

- The interactive process plays a significant role to the enhancement of the knowledge acquisition process, by improving skills to gain new insights into the problems. The possibility of performing some kind of stability or sensitivity analyses concerning compromise solutions is thus a very important component of computational decision aid tools, in order to construct more realistic representations of the decision makerÕs preferences, aimed at capturing the lack of surety and/or preference changes that may arise as the interactive decision process proceeds. On the one hand, it enables the decision maker to consider modifications of the original data, concerning uncertainty, inaccuracy and changes associated with the input data, as well as the imprecisions stemming from the modelling phase. On the other hand, it enables the decision maker to exploit changes of his/her preference structure. Interactive techniques for sensitivity analyses in multiple objective linear programming problems have been proposed and implemented. Linear parametrizations of the objective function matrix and the right-hand side of the constraints have been considered, as well as the introduction of new constraints and new decision variables. The analysis is based on the weight space in the framework of the TRIMAP package, which enables to present graphical information to the decision maker in a way which promotes rapid comprehension. Special attention has been paid to the computational simplicity and graphical interactivity, in order to visualize dynamically the behaviour of the nondominated solutions according to changes in perturbation parameters, by displaying the indifference regions on the weight space and the projection of the objective space.

- Telecommunications networks have been subject to continuing technical innovations and to constantly evolving multifaceted modes of communication, and major changes in equipment technologies and service offerings are currently underway. It becomes then increasingly attractive for the telecommunication operating companies or administrations to offer a broad range of new services to the customers. This trend raises new problems and challenges concerning the strategic modernization planning of telecommunications networks, namely regarding the evolution towards new supporting technologies and service offerings. A multiple objective linear programming model has been developed, aimed at capturing the main aspects which need to be weighted by decision makers in planning the modernization of telecommunication networks concerning the introduction of new supporting technologies and service offerings. The model is based on a state transition diagram, the nodes of which characterize a subscriber line in terms of service offerings and supporting technologies. The model considers both the transition of lines to a more advanced state as well as the installation of new lines directly in any state. Three objective functions have been considered which quantify the net present value of the expansion of subscriber lines, the foreign dependence cost and the degree of modernization associated with the desirability of new services. These objective function are optimized subject to market, budget, technical and social constraints.

- The integration of different strategies for carrying out the search for nondominated solutions creates the need of other type of support to decision makers. Some fundamental issues that arise are: - how to use the knowledge acquired throughout the interactive decision process to aid the decision maker in the choice of procedures or sequence of procedures to be applied to a given kind of problem; - how to make the most of the transference of information among the procedures to improve the cognitive representation of the problem; - how to provide the decision maker with tools aimed at facilitating the interpretation of the results. These issues provided the motivation for the development of a decision support system (now in its prototype version), which integrates interactive multiple objective linear programming procedures and expert system techniques aimed at aiding the decision maker in some of those tasks. A conceptual framework has been discussed, aimed at establishing some guidelines for the development of interactive decision support systems which integrate multiple objective linear programming procedures and expert systems techniques. The methods are decomposed in basic processes which can be aggregated in a dynamic and flexible manner in the study of a particular problem in the form of procedures consisting of a stream of different types of basic processes. The ultimate goal is to develop decision support systems capable of suggesting problem-solving strategies based on the characteristics of the problem (descriptive knowledge), the decision makerÕs preferences (preferential knowledge), the characteristics of the available procedures (procedural knowledge), the general knowledge about the domain (expert knowledge) and the learning of the problem (acquired knowledge). These strategies consist in making the most of the procedures, ways of preference elicitation, and means of interaction to guide the interactive decision process to regions of the nondominated solution set where satisfactory compromise solutions which most correspond to the decision makerÕs (evolving) preferences are located.