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A Bi-Criteria DSS Dedicated to Location Problems

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INTRODUCTION

In *location problems* we want to determine the best way to serve a set of clients, or communities, whose location and demand are known.

This implies to decide the number and location of the facilities, the size or capacity of each facility, and the allocation of the demand points to the open facilities in order to optimize some objective function.

The type of optimality criterion depends on the nature of the activities or of the equipment to be installed.

Most location models deal with desirable facilities, such as warehouses, service and transportation centers, emergency services, and so forth, which interacts with the customers and where usually travel is involved. The typical criteria for such decisions include minimizing some function of the distances between facilities and/or clients.

However, during the last two or three decades, those responsible for the areas overall development, where the new equipment is going to be located (i.e., central government, local authorities) as well as those living there, are showing an increasing interest in preserving the area's quality of life.

The traditionally optimality criterion of "closeness" (to locate the facility as close as possible to the customers) is replaced by the opposite criterion (how far away from the customers can the facility be placed ensuring accessibility to the demand points).

The environmental issues on the approaches to undesirable facility location have generally been formulated as constraints or addressed by a surrogate criterion (distance) on a single objective structure.

Single objective models cannot be expected to accurately represent problems of this type (Erkut & Neuman, 1989). The modeling of environmental issues as objectives, as opposed to constraints, would generate more information regarding the cost and other implications of environmental considerations (Current, Min, & Schilling, 1990). It is an established fact that a number of different criteria are important in making locational decisions regarding public facilities (Ross & Soland, 1980).

Quite surprisingly the multi-objective decision tools have been scarcely used in undesirable facility location problems. Of the available literature in location models only a small percentage is on multi-objective optimization models in facility location.

Generally, the different criteria are formulated as constraints imposing some minimum or maximum value, or are addressed by a surrogate criterion (like distance) on a single objective structure.

To deal with this type of models we can choose one of the following approaches:

- Calculation of the whole efficient set of solutions (generating methods);
- A priori articulation of preferences of the decision-maker (utility function methods); or
- Progressive articulation of the decision-maker preferences (interactive methods) searching for a "compromise" efficient solution.

For this type of problem the number of efficient solutions can be very large. To present to the decision maker (DM) all the solutions and to expect him/her to be able to choose a good one is not realistic.

In general we do not believe that the DM has a process of defining an a priori utility function to be maximized.

We believe that interactive methods are the best choice, especially if they are thought of as learning procedures (improving the knowledge about the problem) and not as procedures seeking some "optimal" solution. They should also be designed so as to be useful in a group decision and negotiation environment.

The consideration of several criteria enables the stable part of the DM's preference structure to be fixed (Bouyssou, 1989). The use of a bi-criteria model will allow the DM to consider the model as the core of a learning-oriented decision support tool, enabling a reflection on the different non-dominated solutions and allowing negotiation with all the actors of the decision process while tolerating hesitations and ambiguities (dealing with the uncertainties associated with the aggregation of the preferences expressed by each criterion). The interactive process looks for a progressive and selective learning of the non-dominated solutions set, clarifying the criteria values aggregation meaning and consequences. Although in some situations it is possible to opt for one alternative, in many others the interactive process just enables the elimination of a greater part of the feasible solutions reducing the final choice to a small part of the non-dominated ones. In this case, if necessary, these alternatives can be scrutinized using another multi-criteria analysis tool dedicated to discrete problems, where the alternatives are known explicitly and in small number. Of course, this stage looks for a more detailed analysis of this subset of the non-dominated alternatives. However, it does not enable the combinatorial nature of feasible solutions to be explored. So, it just should be used for a deeper study of alternatives filtered by the phase one of the process.

In this article we propose the use of a bi-criteria decision support tool dedicated to the above referred to first phase of the process.

BACKGROUND

In Malczewski and Ogryczak (1990) the location of hospitals (a real application in Warsaw) is formulated as a multi-objective optimization problem and an interactive approach DINAS (Ogryczak, Studzinski, & Zorychta, 1989) based on the so-called reference point approach (Wierzbicki, 1982) is presented.

Erkut and Neuman (1992) propose a multi-objective mixed-integer program, assuming that the DM has selected a number of candidate sites for the location of several undesirable facilities, with different sizes, to meet regional demand for some service concentrated at population centers, in order to find a solution that has a low cost, is equitable, and results in acceptable levels of opposition.

Caruso, Colorni, and Paruccini (1993) present a model for planning an Urban Solid Waste Management System considering the last three phases of a well-known scheme structured into four phases: collection, transportation, processing, and disposal.

Wyman and Kuby (1993, 1995) present a Multi-objective Mixed Integer Programming Model for the location of hazardous material facilities (including the technology choice variables) with three objective functions (cost, risk, and equity).

Melachrinoudis, Min, and Wu (1995) propose a dynamic (multi-period) multi-objective capacitated mixed integer programming model for the location of sanitary landfills.

Fonseca and Captivo (1996, 2006) study the location of semi-obnoxious facilities as a discrete location problem on a network. Several bi-criteria models are presented considering two conflicting objectives, the minimization of the obnoxious effect, and the maximization of the accessibility of the communities to the closest open facility. Each of these objectives is considered in two different ways, trying to optimize its average value over all the communities or trying to optimize its worst value.

Ferreira, Santos, Captivo, Clímaco, & Silva (1996) present a bi-criteria mixed integer linear model for central facilities where the objectives are the minimization of total cost and the minimization of environmental pollution at facility sites. The interactive approach of Ferreira, Clímaco, and Paixão (1994) is used to obtain and analyze non-dominated solutions.

Ferreira (1997) also presents a bi-criteria mixed integer linear model for the location of semi-obnoxious facilities incorporating the routing phase, considering as objectives the minimization of total cost and the minimization of the obnoxious effect of the open facility and the risk associated with the transport phase.

Giannikos (1998) presents a multi-objective discrete model for the location of disposal or treatment facilities