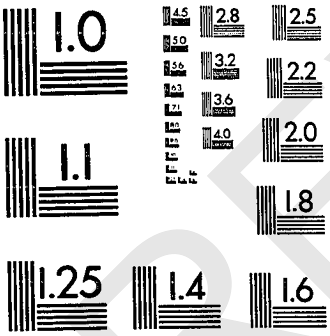

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A ZERO-ONE GOAL PROGRAMMING ALGORITHM

USING PARTITIONING

AND CONSTRAINT AGGREGATION

By

Richard L. Luebbe

A DISSERTATION

Presented to the Faculty of

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TITLE

A ZERO-ONE GOAL PROGRAMMING ALGORITHM USING PARTITIONING

AND CONSTRAINT AGGREGATION

BY

Richard L. Luebbe

APPROVED	DATE
Sang M. Lee	August 23, 1985
Kenneth E. Kendall	August 23, 1985
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A ZERO-ONE GOAL PROGRAMMING ALGORITHM USING PARTITIONING AND CONSTRAINT AGGREGATION

Richard L. Luebbe, Ph.D.

University of Nebraska, 1985

Adviser: Sang M. Lee

During the past decade, goal programming has proved to be a useful and flexible multiple objective quantitative technique that has been widely used to support management decision making. The most commonly used zero-one goal programming algorithm was developed by Lee and Morris (1977) and Morris (1976).

This research was conducted to develop an improved zero-one goal programming algorithm that would be computationally more efficient than the Lee and Morris algorithm. A subordinate goal was to develop a micro computer version of the algorithm.

The algorithm developed in this research is based upon an aggregation scheme presented by Babu and Balasurbramanian (1982). This scheme combines all constraints in one operation and also generates relatively small coefficients. The multipliers used are of the form ln p, where p denotes a distinct prime number.

The algorithm determines the upper and lower bounds for the number of nonzero variables required to satisfy each constraint and each priority level. These bounds are used to partition the constraints according to the priority structure, forming a subprogram. The subprogram consists of the first k priority levels in which all goals may be completely achieved. Invariant decision variables and

redundant contraints are also identified for the subprogram based upon the range for the number of nonzero variables. A set of necessary and sufficient conditions are derived which are used to provide an efficient procedure to generate the optimal solution.

The algorithm was coded in Pascal and tested on the IBM 3081D mainframe computer. Criteria established to compare the algorithm's performance with the Lee and Morris algorithm were: robustness, accuracy and reliability, sensitivity to parameters and data, and, computational effort.

The results of the test data indicated the algorithm was superior to the Lee and Morris Algorithm based upon the established criteria. The virtual CPU time for all of the test problems was less than ten percent of that required by the Lee and Morris Algorithm.

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I would also like to express my thanks to my family and in particular to my wife Karen. They have always been positive and encouraging and have willingly made sacrifices which permitted this research to be completed.

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I. An Introduction

Multiple Objective Decision Making

Profit maximization, which according to classic economic theory was regarded as the sole purpose of the business firm, is no longer recognized as the only objective of most organizations. Today many organizations seek a satisfactory level of profit while attempting to satisfy a variety of different objectives. These objectives may relate to such issues as the environment, labor relations, public relations and social responsibility. There is also considerably more emphasis being placed on long term goals which in many cases will conflict with short range profitability goals. In addition, not for profit organizations, of which there are more than six million, must deal with a variety of different social and service objectives, none of which are related to profit maximization.

Today, management is truly faced with a multiple objective decision making environment. Decision making in this type of environment is referred to as multiple objective decision making, multicriteria decision making or multiobjective decision making.

Multiple objective decision making deals with the process of how people make decisions in a complex environment involving multiple, often conflicting objectives. Our understanding of how decision makers act or should act in a multiple objective decision making environment is not well understood. The classic economic view of the decision maker who possesses omniscient rationality and is capable of measuring the utility of an outcome on a single utility scale is,

according to Simon (1979), no longer acceptable.

More recent views suggest that the decision maker must act on the basis of what Simon (1970, 1979) and March (1978) refer to as bounded rationality. This suggests the decision maker must make decisions with limited knowledge about the problem and the alternatives available as well as the implications of the decision.

In this type of decision making environment decision makers attempt to cope with a lack of information, the complexities of the problem and limited or bounded analytical abilities by accepting decisions that are satisfactory or acceptable. This satisficing behavior also leads to satisficing levels of attainment. Profit may be important to a given level of attainment, however other goals are perceived as more important once satisfactory levels of profit have been attained.

Although a lot is not known about the decision making process, the management science approach is that decision making can be improved by generating information relative to the problem through quantitative techniques. This view suggests that quantitative decision making techniques can support the decision making process through generating information, identifying alternatives available, and in general expanding the capabilities of the decision maker.

According to MacCrimmon (1973) there are four general categories of quantitative techniques related to multiple objective decision making. These categories are: weighting methods, sequential elimination methods, mathematical programming methods, and spatial proximity methods. These methods will be discussed in more depth in Chapter II.

Our primary area of interest here is mathematical programming techniques. The mathematical programming techniques identified by MacCrimmon are linear programming, goal programming and interactive multicriteria programming. Our focus will center primarily on goal programming.

In terms of multiple objective programming methods, goal programming has proved to be a very effective and flexible tool. In fact several studies have identified goal programming as the only multiple objective tool in use by practicioners (Petty and Bowlin, 1976; Green, Newsome and Jones, 1977). Schneiderjans (1984) identified more than 190 publications related to the use and development of goal programming. Techniques have been developed to solve goal programming problems that require the decision variables to be integers (Lee and Morris, 1977). Zero-one algorithms have also been developed by Lee and Morris (1977) and Morris (1976).

The Problem

A general characteristic of all zero-one problems is the extreme difficulty is generating solutions, especially for large scale problems. Researchers have struggled with this problem for the past quarter century, and yet there is no general zero-one programming algorithm that can successfully solve all types of zero-one problems.

In the area of zero-one goal programming, the most commonly used algorithm was developed by Lee and Morris (1977). Most of the research articles reported in the literature have used this algorithm. This algorithm has proved to be a useful tool in solving zero-one goal

programming problems.

The key difficulty with this algorithm is the time required to generate the optimal solution. Lee and Morris (1977) reported that for problems with more than 20 variables it was difficult to obtain the optimal solution in a reasonable amount of time. They cite an example of a problem involving 26 variables and 32 constraints in which a solution was not obtained after two hours of execution time.

The problem of generating an optimal solution to a zero-one programming problem is quite common. Woolsey (1974, P. 478) stated if one obtained the same solution for a given problem using two different commercial packages the probability that one has obtained the optimal solution is about 0.5.

Purpose of the Research

The purpose of this research is to continue the study of the zero-one problem. The major effort here will be to improve the computational speed required to solve zero-one goal programming problems. The results of this study will not however be limited to zero-one goal programming problems but may apply to the zero-one linear programming problem as well.

In addition, a micro computer version will also be developed. One of the factors that significantly limits the use of a mathematical programming technique is the availability of computer code. It is hoped this micro computer version will provide practicing managers a hands on tool that will solve most goal programming applications in a reasonable amount of time. With the recent advances made in micro computers such a program is now possible. Future advances will un-

doubtedly cut the computation time significantly.

The combination of recent advances and general availability of micro computers to almost all researchers and practitioners will make a program of this type a useful tool. It will also clearly further the cause of management science.

The algorithm developed in this research is based upon an aggregation scheme developed by Babu and Balasurbramanian (1982). This scheme allows all constraints to be combined in one operation and also generates relatively small coefficients. The multipliers used are of the form ln p, where p denotes a distinct prime number.

The algorithm determines the upper and lower bounds for the number of nonzero variables required to satisfy each constraint and each priority level. The algorithm then searches for the subprogram consisting of the first k priority levels that can be completely achieved.

Tests regarding constraint redundancy and variable invariance are applied to eliminate redundant constraints and fix variables that are determined to be either zero or one. Variables found to be invariant in effect create a new problem with a different number of variables and, if a variable is found to be equal to one, a new rhs value. The process continues until all invariant decision variables and all redundant constraints have been removed from the subprogram.

A set of necessary and sufficient conditions are derived which are used to determine the range of nonzero variables which may provide complete achievement for the subprogram and also to generate the