UNIVERSITI PUTRA MALAYSIA

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By

NASRUDDIN BIN HASSAN

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DEDICATION

Dengan nama Allah yang Maha Pemurah lagi Maha Pengasihani

Penulis ingin merakamkan jutaan terima kasih di atas pengorbanan serta jasa kedua ayahanda dan bonda yang telah bersusah payah membesarkan penulis dengan penuh kesabaran selama ini. Semoga Allah mencucuri rahmat ke atas arwah ayahanda penulis yang telah kembali ke RahmatuLlah pada tahun 1999 sekembali dari Tanah Suci Makkah selepas mengerjakan ibadah haji bersama bonda dan moga Allah memelihara bonda dalam kesejahteraan tanpa ayahanda bersamanya lagi untuk berkongsi suka dan duka. Moga kedua-duanya beroleh haji yang mabrur dan kelak ditempatkan di kalangan orang-orang yang mukhlis dan soleh.

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Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Doctor of Philosophy

A TWO-STAGE MULTI-OBJECTIVE ALLOCATION MODEL FOR STUDENTS' ADMISSION INTO ACADEMIC DEPARTMENTS IN A MALAYSIAN PUBLIC UNIVERSITY

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NASRUDDIN BIN HASSAN

July 2007

Chairman : Associate Professor Mohd. Rizam Abu Bakar, PhD

Faculty : Science

We develop, formulate, verify and later validate a multiobjective model of student admission. Through a two-stage optimization procedure the model seeks to maximize student admission and student allocation into departments and academic programmes respectively. In the first stage, we seek to determine the optimal number of new student intake in all the departments of a given faculty by observing the departments' capacity limitations in terms of lecture rooms/halls availability, budget constraints, number of faculty members and affirmative action quota. The second stage concerns the application of the same procedure with the objective of determining the optimal allocation of students obtained in the first stage into the respective academic programmes within the same department with constraints unique to each academic programme. Every constraint has its own weightage besides its level of priority. We then describe the application of the model to the Faculty of Science & Technology of the Universiti Kebangsaan Malaysia with its five academic centres/departments and then to the Centre for

Mathematical Sciences with its three academic programmes. For both stages, we compare the results of the preemptive goal programming model with the non preemptive weighted goal programming model to analyse the adaptability of the models to real situations. Sensitivity analyses of the results are done to gauge the reliability of the model. We hope that the results of the application will demonstrate the model's capability to provide an optimal apportionment of student admission policy with regard to the number of student intake and allocation into the departmental academic programmes of a faculty, as well as recognizing the capacity limitations of each academic programme.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia
sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

MODEL AGIHAN PELBAGAI MATLAMAT DWI-PERINGKAT BAGI KEMASUKAN PELAJAR KE JABATAN AKADEMIK DI UNIVERSITI AWAM MALAYSIA

Oleh

NASRUDDIN BIN HASSAN

Julai 2007

Pengerusi : **Profesor Madya Mohd. Rizam Abu Bakar, PhD**

Fakulti : **Sains**

Satu model pelbagai matlamat bagi kemasukan pelajar baru dibentuk, diformulasikan sebagai rumusan matematik dan akhirnya disahkan. Model ini dibina untuk memaksimumkan kemasukan pelajar ke jabatan-jabatan di sesebuah fakulti. Pelajar kemudiannya diagihkan secara maksimum dari jabatan ke program-program akademik dalam jabatan tersebut melalui satu prosedur pengoptimuman dwi-peringkat. Pada peringkat pertama, bilangan optimum kemasukan pelajar ke setiap jabatan sesebuah fakulti harus ditentukan dengan mengambilkira had keupayaan jabatan bagi mematuhi batas-batas kapasiti ruang, kekangan peruntukan kewangan, bilangan tenaga pengajar dan kuota *affirmative action*. Pada peringkat kedua pula, bilangan optimum pengagihan pelajar ke program-program dalam sesebuah jabatan tersebut ditentukan dengan mengambilkira kekangan-kekangan khusus yang terdapat pada setiap program akademik itu dengan mengapplikasikan prosedur seperti pada peringkat pertama. Setiap kekangan mempunyai pemberatnya masing-masing di samping mempunyai aras keutamaan yang harus dipenuhi. Kemudian, model ini diaplikasikan di Fakulti Sains dan Teknologi, Universiti Kebangsaan

Malaysia yang mempunyai lima pusat pengajian dan seterusnya diaplikasikan pula di salah satu pusat pengajian fakulti berkenaan iaitu Pusat Pengajian Sains Matematik yang terdiri dari tiga program akademik. Keputusan yang diperoleh dari model premtif pengaturcaraan gol dibandingkan dengan model bukan premtif pengaturcaraan gol bagi kedua-dua peringkat untuk menganalisis keupayaan model berbanding dengan keadaan sebenar. Analisis kepekaan bagi hasil yang diperoleh juga dilakukan untuk menguji kesahan model-model tersebut. Hasil aplikasi dwi-tahap ini mempamerkan keupayaan model untuk menyediakan pengagihan optimum selaras dengan polisi pengambilan pelajar berdasarkan kekangan yang ada pada setiap jabatan sesebuah fakulti dan juga setiap program akademik dalam jabatan berkenaan.

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I certify that an Examination Committee has met on 10th of July 2007 to conduct the final examination of Nasruddin bin Hassan on his Doctor of Philosophy thesis entitled "A Two-Stage Multi-Objective Allocation Model for Student's Admission into Academic Departments in A Malaysian Public University" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the degree of Doctor of Philosophy.

Members of the Examination Committee were as follows:

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Date: 17 December 2007

This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Doctor of Philosophy. The members of the Supervisory Committee were as follows :

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Date: 22 January 2008

DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.

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NASRUDDIN HASSAN

Date: 8 November 2007

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CHAPTER 1

INTRODUCTION

1.0 Introduction

In this chapter, we discuss the problem background and problem statement in allocation of students to emphasize the research excellence in academia. The goals and constraints are stated and the research objective refined. The significance of research and the research methodology are also discussed in this chapter. The chapter is then concluded by the summary of thesis.

1.1 Problem Background

A number of important developments have taken place in the study of mathematical programming in academic scheduling and assignments. The priority of certain courses to emphasize the research excellence of an academic institution, the number of students' intake and the consequent fees collected are important administrative tasks that must be performed in academic departments each semester. In such an academic environment, there exist some organizational, as well as individual goals that influence the assignment problem. The goal of administrators are driven by changes in student demand for courses, and hence the desire of involved administrators to provide these necessary courses. In addition these courses have to reflect the thrust of research of the faculty in the departments. Other factors influencing the assignment problem might have to do with certain limited resources such as the limited number of faculty expertise in certain fields and the number of lecture halls and classroom availability. Other factors are related to policy, such as number of preparations (Tillet, 1975), and the racial quota system of entry into

public universities. Another consideration in the assignment process is the personal preferences of the faculty staff in specific course assignments (Schniederjans and Kim, 1987) due to their varied expertise.

1.2 Problem Statement

This study is done to develop a goal programming model which will optimize the departmental preferences in student allocation given the varied expertise of the faculty members subject to the availability of lecture halls and seminar rooms, students' entry policies, collection of tuition fees and the thrust of research excellence within the department. We regard the capacity requirements of first year students admission, capacity requirements of academic centers and academic programmes, affirmative action ratio, student-staff ratio and budget allocation to academic centers, as conflicting constraints. We then undertake to develop, verify and validate a multiobjective allocation model of students' admission into academic departments based on the given constraints and criteria.

1.3 Research Objective

Multicriteria assignment or allocation problem in academic institutions are often solved using various mathematical programming methods. However, many of those academic problems do not address the constraints such as student fees, subsidies, programmes offered and the main thrust of the departments. Literature reviews on research conducted are confined to simple models. The academic allocation and scheduling in high institutions is becoming more complex due to complexity of the academic advancement, social expectation and academic management. This research is an attempt to present a methodology for modeling student admission into

academic departments. The model may then be applied to solving real world problem.

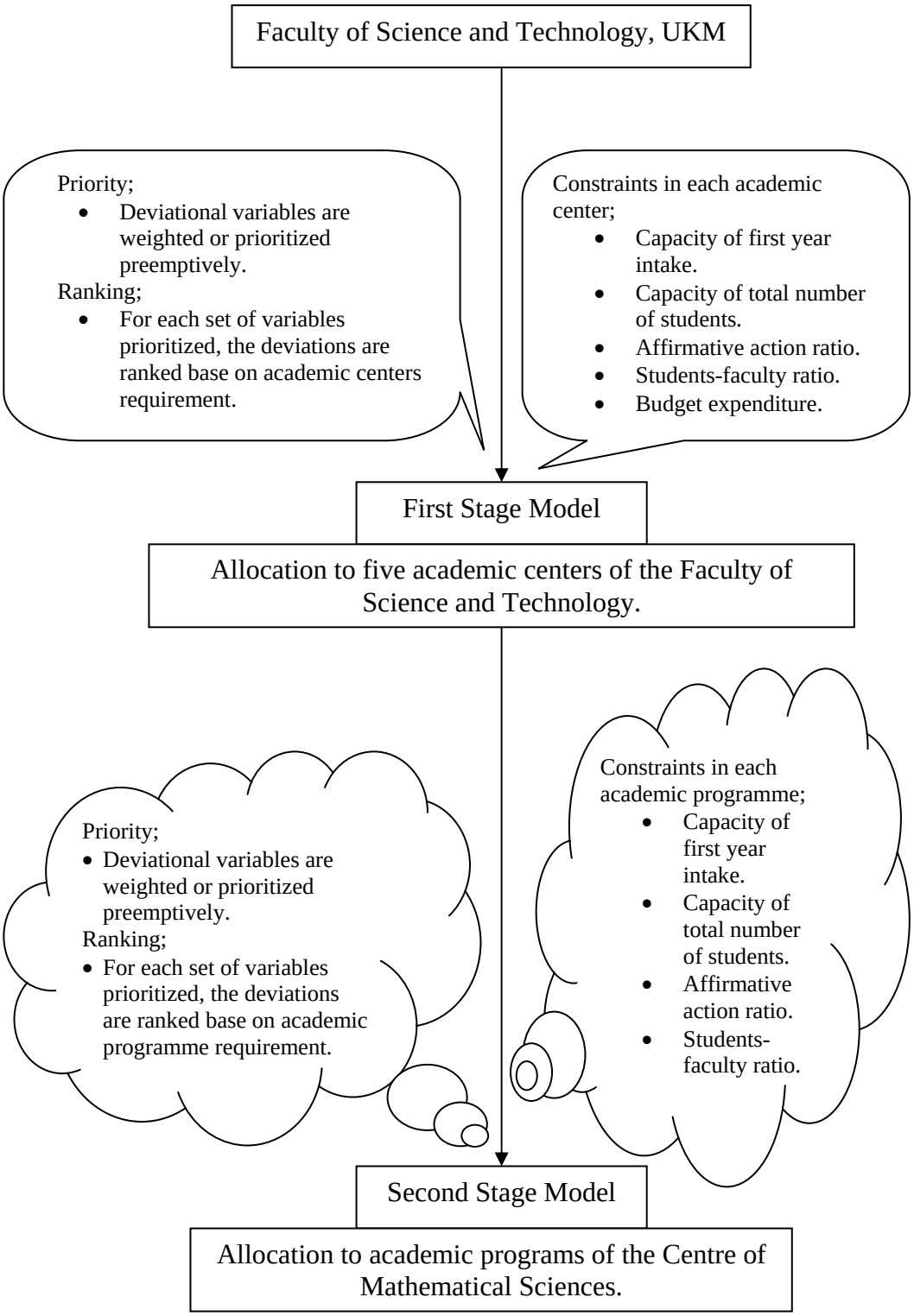

Figure 1.1 : A Diagrammatical Summary of the Problem

We further refine the objective as follows:

- To study current practices of student assignment and allocation at Universiti Kebangsaan Malaysia.
- To model and solve student assignment and allocation problem using goal programming method.
- To develop model with multi-criteria requirements and solving them using preemptive goal programming and non-preemptive weighted goal programming.

To obtain these objectives, the research framework of this study is designed as in Figure 1.1 above.

1.4 Significance of Research

The application of the multi-stage assignment problem will demonstrate the possibility of structuring the main problem into relatively small models not impossible to be solved. Else the problem will definitely involve too many constraints with too many conflicting objectives such that the solution to the problem will be elusive. This study will benefit academic institutions in coping with their budgeting problems under restrained government grants, establishing the correct racial balance of enrollment, reflecting the main thrusts of research excellence and provide a fair distribution of faculty assignment in terms of programme offering and student-faculty ratio. The scope of this study is the allocation of student admission into a faculty of a university with five academic centres, each with their own academic programmes.

Of course this study can be further extended in such a manner where the Ministry of Education can optimally allocate students into Malaysian public universities based on constraints unique to these universities and other constraints deemed necessary by the Ministry of Education, as illustrated in Figure 7.1. These universities will allocate students to their various faculties. The faculties will then allocate these students to their respective academic departments and programmes within those departments.

1.5 Methodology

The existing structure on goal programming for multi-objective function is used in developing and constructing the necessary goals and related constraints. A goal programming model involves an overwhelming number of decision variables and goal constraints. A study is conducted on one of the faculty and its academic departments and programmes in University Kebangsaan Malaysia. The study produced a goal programming model and was run on a personal Pentium IV computer using LINDO version 6.1 programming. This LINDO programming has the advantage of allowing weights to be attached to the positive and negative deviations of each goal to be optimized. The multistages structure will enable the model to capture the dynamic aspects of the problem. Moreover the number of decision variables and constraints will be drastically reduced. In the first stage, the core of the procedure is formed by a matrix of the coefficients of variables and weights. The output of the first stage is then utilized as inputs to the second stage. The process can be further repeated for the following stages.

1.6 Summary of Thesis

This research was done to optimize the allocation or assignment of students into the departments or academic centers of a university based on given system and goal constraints. Having found the optimal number of students allocated into the departments, these students were then channeled into the respective academic programmes within the particular department subject to further system and goal constraints unique to those programmes in the department, thus giving rise to a two-stage multicriteria goal programming problem. The introduction and background to this problem was explained in the beginning of Chapter 1, followed by the problem statement, objective, the significance of research, the methodology used in the research being undertaken and the synopsis of the thesis.

The literature review in Chapter 2 will enlighten the reader on developments and applications of goal programming in academic management and the two-stage procedure. This chapter is divided into two parts. The first part deals with the general literature while the second part explains in great detail those literatures related to the undertaking of this study.

The underlying concepts of mathematical programming are explained in Chapter 3. The linear programming and the goal programming are explained here. The formulation and methods of solution of these programming are also discussed in this chapter. The discussion of these programming will provide a prerequisite understanding of the formulation of the problem at hand to develop the objective function, goal and system constraints.

The problem is formulated in Chapter 4. The system and goal constraints are also formulated in this chapter. Each constraint is reasoned out. The weights attached as coefficients to the deviation variables, along with the priority factors in the objective function to be optimized are explained in this chapter.

The results are displayed in Chapter 5 followed by the discussion and the analysis of results. The positive and negative deviations of each constraints are discussed in order to give meaning to the results obtained. Sensitivity analysis is conducted to test the stability of the results obtained in the previous chapter.

The model is tested and verified in Chapter 5. Error analyses are conducted to determine the improvement of student allocation made possible by the implementation of the model. The model is then further validated in Chapter 6. The model is applied to fourteen trials of simulated data to compare its reasonableness of results. It is shown that this model can be reasonably applied to situations where changes in coefficients and constants of the constraints were made to suit its application to different environments.

The summary and conclusion of the research undertaken is elaborated in Chapter 7. The model expansion to several stages and extensions for further investigation are also suggested in this chapter.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

In this chapter we will discuss the general literature review regarding Operations Research, its origins and extended applications. We then proceed with the discussion on mathematical programming models developed for academic institutions which then brings goal programming in resource allocation into focus. Models developed by Elimam (1991), Bafail and Moreb (1993) and Badri (1996) are discussed in great detail. Thse discussions lead to our proposal in developing a two-stage allocation model for students' admission into academic departments.

2.1 General Literature Review

Operations Research or simply OR is a subject that use mathematical models, algorithms and statistics to aid in decision-making. It is often used to analyze complex real-world systems, typically with the goal of improving or optimizing performance. The terms operations research and management science are often used synonymously. When a distinction is drawn, management science generally implies a close relationship to the problems of business management and industrial engineering. Industrial engineering takes more of an engineering point of view, and industrial engineers typically consider OR techniques to be a major part of their toolset. Some of the primary tools used by operations researchers are statistics, optimization, stochastics, queueing theory, game theory, graph theory, and simulation. Because of the computational nature of these fields OR also has ties to