0-1 GOAL PROGRAMMING APPROACH TO LECTURER-TIMESLOT ASSIGNMENT

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DECLARATION

I hereby declare that this dissertation is entirely my own work, except for quotations and summaries sources of which have been duly acknowledged.

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ABSTRACT

Lecturer-timeslot assignment plays an important role in constructing timetable for every educational institution. A feasible lecturer-timeslot assignment should be able to assign the particular lecturer to certain timeslot without overlap with other lecturer. The main objective in this study is to fulfill the department's offering goals, to satisfy the condition of policy and to satisfy the condition of limited resource. Data was collected from the website of Academic Department University Malaysia Sabah. The data involved those lecturers from programme Mathematics with Economics and Mathematics with Computer Graphics, school of Science and Technology at University Malaysia Sabah. 0-1 goal programming had been used in this study to construct a flexible time table. LINGO 8.0 was used throughout this study to get the result. Result showed that most of the objective function had been fully achieved.
PEGATURCARAAN 0-1 GOL DALAM PERJADUALAN PENSYARAH KEPADA
SELANG MASA

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=    equal to
Σ    summation
+    plus
-    minus
≥    greater than
CHAPTER 1

INTRODUCTION

1.1 Introduction

In an academic environment, almost all the administrative of academic department in educational institution need to find a feasible way in assigning the particular lecturer to the certain timeslot without overlap with other lecturer for every semester. Hence, there exists a relationship between lecturers with timeslots.

What is the best approach to measure the combination of lecturer with timeslot at the university level? In this paper, the application of goal programming model tends to measure the combination of lecturer with timeslot in this study.

1.2 Definition of Timetabling

According to Ismayilova et al. (2007), the problem of constructing timetable for every educational institution is a classical combinatorial problem that requires finding a schedule to determine which teachers will be teaching which courses in which classrooms during which timeslot. Below here is an educational timetabling problem which plays an important role in construct a timetable.
Refer to Figure 1.1, there is a difference between the timetabling problem in school level and university level. According to Valouxis & Housos (2003), the problem of constructing timetable at school level require each teacher to giving lesson in a certain timeslot with a fixed subset of class sections and all the class sections must be always in session without any empty periods in daily schedules.

In contract, the problem of constructing timetable at university level only involved allocation of courses to timeslots and classrooms to ensure those resources such as lecturers, students and classrooms are not used more than once per period and affect the efficiency of resource allocation and students may have many free timeslot in their daily schedules.

1.2.1 Definition of Lecturer-Timeslot Assignment

Lecturer-timeslot assignment is one of the general university timetabling problem which is also a schedule in matching peoples, places, and times. The main factor which influences the construction of lecturer-timeslot assignment will be the changes in student demand for course. The student demand in course which varies from time to time will directly affect the numbers of course required by the academic department administrators.
Nowadays, lecturer's responsibility is far different compared with the previous time. They need to run a research program which included writing scholarly article, participating in scholarly activities and travelling to conference to ensure the school stand at the top of the higher education list. Hence, the management of time for lecturers needs to arrange systematically. That is the reason why all the required courses offered by the administrators need to fulfill the lecturer's teaching load while schedule the lecturer-timeslot assignment. For example, some of the lecturers require giving lecture for 4 hours in one week while some of the lecturers require giving lecture for 6 hours in one week. The teaching load for each lecturer is not necessary will be the same.

Other than that, the limited resources such as the numbers of available classroom during the certain timeslot also influence the assignment problem. The administrators need to determine number of the limited resources to avoid problem of surplus or shortage. For example, if there are three lecturers require giving lecture in a same timeslot, but there are only two available classrooms only. Eventually, one of the lecturers needs to share the classroom with other lecturer although they are teaching different courses. It will bring a lot of inconvenient to the lecturers and students also.

There is one important consideration while assigning the lecturer-timeslot assignment problem. There should have some free timeslot for the particular lecturer when assigning them to the certain timeslot. For example, if a particular lecturer required to giving lecture at five different timeslots in a week. It is better to schedule an uncontinuous timeslot for the particular lecturer in order to let them have enough time to rest after giving one lecture. By considering all those factors that mentioned before this, lecturers will be able to perform themselves in class effectively. Eventually, this will affect the students' performance in class also. Hence, all those factors should not be ignored while assigning the timetable.
1.3 Study of Interest

The academic department administrators in every educational institution always need to find a feasible way in assigning the lecturer to a suitable timeslot. Why it seem like an important task to them? Over this few decades ago, higher education consider necessary and useful to every one of us. A degree holder in university becomes a basic requirement for most occupations in the modern country. This mean that it will be a larger population who seek for higher education compare with the previous time.

The increased size of students and the complexity of university grow directly bring to the difficulty in schedule the teaching program. Hence, a system is needed to allocate the teaching resources properly. Therefore, the existence of lecturer-timetabling assignment which considers the interest of lecturer and the requirement of the department administrators to those policy and limited resource are important.

1.4 Objective of Study

There are three objectives need to be achieved in this study:

a. To develop 0-1 goal programming model

b. To solve 0-1 goal programming by using LINGO

c. To develop a timetable for lecturer-timetable assignment problem

1.5 Scope of Study

The lecturer-timetable assignment problem commonly exists in all academic institution. This study gathers the data from the website of Academic Department University Malaysia Sabah. The data involved lecturers for odd number semester in year 2010-2011 from Mathematics with Economics and Mathematics with Computer Graphics programme, school of Science and Technology at University Malaysia Sabah. The data included eleven lecturers from Mathematics with Economics and Mathematics with Computer Graphics programme and five lecturers invited. Because there have
similar courses which contain in course structure of these two programmes, hence, the data was collected from both programme.

There are three different timeslots defined in the model. Those timeslots which included in this study are 0800-1000, 1000-1200, and 1400-1600. Those lecturers required giving lecture from Monday until Friday and they wouldn’t give any lecture on Saturday and Sunday. There will be a total of 15 timeslots available in one week. Since there are 2 classrooms which are BK2 and BK3 provided in this study, hence, there will be a total of 30 timeslots available in one week. The numbers of required timeslot for those lecturers that determined by the academic department administrators due to the changes of student demand in the particular semester will be 23.

An application of multi objective zero-one goal programming to demonstrate the problem in order to produce a model that able to satisfy departmental requirement with regard to department’s offering, condition of policy and limited resource is presented.
CHAPTER 2

LITERATURE REVIEW

2.1 Research in Academic Environment

Dimopoulou & Miliotis (2004) examined the design and implementation of a computer network based system to deal with the problem of construct a course timetable at university level. And the problem of constructing course timetable in academic institutions involved the allocation for a set of courses offering requirements in a particular classroom during an available time. The existence of this process is to prevent capacities of lecturers, students or rooms use more than once per period.

The system uses an integer programming model in assigning the courses to timeslots and classrooms in order to construct a suitable timetable for each department. An automated procedure is use to link the integer programming model and the data for each department to resolve the conflict produced by the distribution of processes. The whole distributed timetabling system is flexible and easily to construct by any user due to the increased capabilities of computer network (Dimopoulou & Miliotis, 2004).
2.2 Research on Lecturer-Course Assignment

Assign the lecturer to the course effectively is one of the most important element when the administrative department in every educational institution needs to construct a suitable time table for every semester. The best known model was introduced by Schniederjans & Kim (1987). They stated that assign full-time lecturer, part-time lecturer, instructors, or other teaching stuffs to a particular course will become a difficult task for the administrative department due to the charging of student's demand. Hence, they use a 0-1 goal programming model to optimize departmental preferences in course assignments.

In the model presented by Schniederjans & Kim (1987), the objective function contains three priorities. The first priority that needs to achieve is satisfy the requirements of the department’s course offering. While the second priority will be the set of lecturer teaching loads assignment goals and the third priority will be the preference of the lecturer to course. From the analysis of those objectives, they found that the goal achievement for first and second priority is fully achieved while the third priority is partial achieved.

Except from the model that mention before, several mathematical programming had been conducted to solve the problem of lecturer-course assignment. Andrew & Collins (1971) and Dyer & Mulvey (1976) proposed a linear programming to optimize the assignment of lecturer to course which related to numbers of course needed and lecturer teaching load. Brislaw (1976) also introduced an integer programming to solve the problem by adding other restrictions such as minimizing the number of preparations (Badri et al., 1998).

2.3 Research on Lecturer-Course-Timeslot Assignment

A feasible timetable not only included assigns the lecturer to particular course, but also assigns the lecturer to particular course during certain timeslot. Because of the limitation of the lecturer-course assignment model, therefore, many researches about the lecturer-course-timeslot assignment had been studied.
One of the famous models will be the two-stage multi objective zero-one course scheduling model introduced by Badri (1996). Since the models involved two stages with the first stage assigns the lecturer to particular course while the second stage assigns the lecturer-course assignment that obtain in first stage to an available time slot. From the analysis of those objectives, he found that only half of the priorities fully achieved the goal achievement. Therefore, a modification for the limitation of the model had been introduced and applied by Badri et al. (1998) by using one stage solution.

Besides that, Ozdemir & Gasimov (2004) developed three steps process which consist Analytic Hierarchy Process (AHP), scalarization and the subgradient method to deal with the lecturer-course-timeslot assignment. They compare between the satisfaction level for both lecturers and administrators in the current assignment and final assignment which obtain by using those three steps. They found that none of the parties come out very dissatisfied with the arrangement of the final assignment.

Ismayilova et al. (2007) introduced Conic scalarization, Analytic Hierarchy Process (AHP) and Analytic Network Process (ANP) to study the lecturer-course-timeslot assignment. This model considers paired lecturer-course and course-timeslot assignment for all the lecturers and administrators in a single stage. By using the AHP and ANP, they obtain the objective functions weights that they need for scalarization and they found out it is difficult to find a feasible solution to obtain a higher satisfaction level for all the lecturers.

Gunawan et al. (2006) suggested an integer programming model to combine both lecturer assignment and course scheduling problem simultaneously. They reported the computational results of solving the model of 50 and 100 lecturers. And they observed the changing of the average computation (CPU) time when the number of lecturers and number of courses increased. By using the computational result compare the data seizes of those parameters, they can solve the problem of timetabling in an institution.
2.4 Research on Apply Goal Programming in Academic Environment

Lawrence et al. (1983) stated that goal programming is often using to deal with multiple, often conflicting, objectives and their priorities. In the paper, they present a multiple objective model by considering the school system administrators and the teachers in the secondary school. One of the common areas for the disagreement between administrators and teachers is problem of assign the teacher to the classroom.

The objective functions in the model included maximize the course preferences of all teachers in a particular semester, maximize teacher rating by enhancing total performance of all teachers in a particular semester, maximize the number of highly qualified teachers to teach advance courses in a particular semester and maximize the number of highly qualified teachers to teach remedial course in a particular semester. This paper only presented the instructions which use the goal programming model to solve the problem (Lawrence et al., 1983).

Other than that, Caballero et al. (2001) also demonstrated goal programming model in the decision-making process at university level and carries out efficient resource allocation between units. The objective functions in the model included guarantee the real teaching needs of each functional unit are covered, satisfy the basic financing needs in each one of the functional units, increase the number of state-employed teaching doctors, decrease the number of pupils per teacher and per subject, and assign financial resources to those functional units which are under the mean real cost by credit taught at the University of Malaga. The arrangements from first priority until fifth priority are according to the objectives shown above here. From the result, they found that they had not obtained a satisfactory solution because only first priority fully achieved the goal achievement.
2.5 Research on Apply Goal Programming in Lecturer-Course-Timeslot Assignment

According to Badri et al. (1998), goal programming may be used to assure least possible deviation from goals in some decision processes. The conflicting objectives in the lecturer-course-timeslot assignment which assign the lecturer teaching particular course during certain timeslot represent an idea application of conflicting resolution characteristics in goal programming. The model of Harwood & Lawless (1975) and Schniederjans & Kim (1987) did use the goal programming to examine the conflicting goals in the lecturer-course-timeslot assignment.

The model of Harwood & Lawless (1975) may be very difficult to construct because they present a multitude of criteria that are strict requirements rather than goals. In the end, those criteria add unneeded complication and data collection requirements to the model. In order to overcome the implementation limitations of this model, Schniederjans & Kim (1987) presented a model which satisfies the number and type of course offering requirements, teaching loads requirements and preferences of lecturer particular course. But the only limitation of the model is it includes one dimension departmental course scheduling which is lecturer-course assignment.

To overcome the limitation for the model of Schniederjans & Kim (1987), Badri (1996) proposed a two-stage optimization procedure to solve the two dimension departmental course scheduling which is lecturer-course-timeslot assignment. In stage 1, this model modify model of Schniederjans & Kim (1987) by retain those three objectives and add in other constraints which will minimize the number of preparations per lecturer when several sections of the same course were offered. This model formed by a matrix, with rows indicating lecturers, columns indicating courses and elements indicating priorities for the preference of lecturer to particular course. The decision variable in this stage represent as $X_{ii}$. If the $i$th lecturer was assign to $l$th course, the $X_{ii}$ was equal to 1. In contrast, when the $i$th lecturer was not assign to $l$th course, the $X_{ii}$ was equal to 0. The outcomes of the analysis lead to the lecturer-course assignment.
Once they obtain the result from stage one, they use as the input for stage two to identify the course-timeslot assignment. The model in stage two follow the idea suggested by Schniederjans & Kim (1987) in assigning the lecturer (course) to certain time slot. This process intend to satisfy the departmental goal in number and type of course offering requirements, limited departmental resource such as the number of classroom that is available during certain timeslots, limited departmental preferences such as number of evening class that is available and last but not least, preference of lecturer to timeslot.

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<tr>
<td>• Satisfy departmental goals on types of courses</td>
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<tr>
<td>• Satisfy lecturer teaching load requirements</td>
<td></td>
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<tr>
<td>• Satisfy (maximize) preference lecturer to course</td>
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<tr>
<td>• Minimize number of lecturer course preparations</td>
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<td>• Schedule all courses assigned to faculty</td>
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<tr>
<td>• Satisfy departments limited resources (number of classes)</td>
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<tr>
<td>• Limit number of night courses</td>
<td></td>
</tr>
<tr>
<td>• Satisfy (maximize) preference lecturer to timeslot</td>
<td></td>
</tr>
<tr>
<td>• Other departmental preferences and priorities</td>
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</table>

**Figure 2.1** Description of the model stages and objectives (Source: Badri, 1996)

Although stage one and stage two apply the same procedure to obtain the result, but the matrix for the model in stage two is different from stage one. The rows in the matrix still remain as lecturer, but the columns change to time slots and the element change to priorities for the preference of lecturer to certain time slot. The objectives need to achieve in stage one and two are showed in Figure 2.1.
CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter is written to present the application of 0-1 goal programming in the model of this study. It will be more focused on constraints and objective functions used in the model.

3.2 Goal Programming

According to Lapin & Whisler (2002), the application of goal programming is not same like standard linear programming. Goal programming is flexible in solving multiple goals and allows a trade-off to be made between them while the standard linear programming involved single objective only. There are two types of constraints involved in goal programming. Those constraints included the hard constraint that usually found in linear programming and soft constraint which included nonnegative goal deviation variables inside.

Actually, goal programming consider as a special linear programming that combines all of the goals together through a set of goal deviation constraints, with one constraint from each goal. Goal programming uses to achieve certain targets for each goal and it may be impossible for decision maker to achieve all the goals.
Hence, the overall objective is to find the solution that collectively minimizes the deviation from these targets.

Taha (2007) stated that there are two methods to convert the multiple objectives into a single objective function. One of them is the weights method while another one is the preemptive method. The weights method forms a single objective function with the weighted sum of the functions representing the goals of the problem. The preemptive method prioritizes the goals according to the order of importance. The model is optimizing by using one goal at a time which means that the optimum value of a higher-priority goal is never degraded by a lower-priority goal.

3.3 Decision Variable and Notations

The data was referring to the prospectus University Malaysia Sabah 2008/2009 and find out the course that will be provided in semester I 2010/2011. I indicate the odd number semester which is first semester, third semester and fifth semester. From the code number provided in the prospectus, the number of lecturers and the number of timeslot that will be provided in semester I 2010/2011 will be obtained by referring to the website of Academic Department University Malaysia Sabah. There will be a total of sixteen lecturers and thirty timeslots that will be assigning in this study. The 0-1 goal programming used to examine the relationship between the lecturers and timeslots. The definition of the goal programming model’s decision variable and notations in this study are presented.

3.3.1 Decision Variable

\[ X_{i,j} = \begin{cases} 
1, & \text{if the } i\text{th lecturer giving lecture during the } j\text{th timeslot} \\
0, & \text{otherwise.} 
\end{cases} \]

3.3.2 Notations

\( l \) : total number of lecturers to assign ( \( l = 16 \) )
REFERENCES


