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Scheduling of Magister Program Courses at the Faculty of Mathematics and Natural Science of Syiah Kuala University Using Integer Linear Programming Method

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***ABSTRACT**--This study discusses modeling lecture scheduling with integer linear programming methods and building applications from the model. This research takes a case in the Masters Program at the Faculty of Mathematics and Natural Sciences, Syiah Kuala University. Variables used in modeling are days, time periods, courses, lecturers, and classrooms. To observe the results of the application used a quantity called conflict, namely the existence of courses that cannot be scheduled due to one or more obstacles that are not met. By repeating 1000 times, that the scheduling of lectures at the Master's Program at the Faculty of Mathematics and Natural Sciences, Syiah Kuala University can be done very well with success above 90%. Flexibility analysis according to each study program is also carried out with similar results.*

***Keywords—**schedulin ,magister, program, faculty mathematics, science, syiah kuala, university, integer, linear, programming method*

I. INTRODUCTION

For successful teaching and learning process in the Masters Program of Syiah Kuala University, it is necessary to set course schedules before classes begin. The lecture schedule is made by the academic office by paying attention to lecture days, time periods, courses, lecturers, and available lecture rooms. Information about course schedules for each study program can be seen by students in the Syiah Kuala University catalog when registering courses every semester.

Scheduling is a planning activity to determine when and where each operation is carried out as part of the overall work must be done on limited resources, as well as the allocation of resources at a certain time by taking into account the capacity of existing resources

Research on lecture scheduling has been actively carried out, among others, by [1] who formulated the problem of scheduling lectures at universities with integer programming. The variables used are courses, participants, instructors, days, time periods, and classrooms. [2] creates a schedule that combines lecture schedules and exam schedules. The problem is formulated by dividing the two basic concepts of different groupings, namely courses are called subject groups, and time periods are called time groups. This scheduling is applied at Athens University

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of Economics and Business. [3] examines the scheduling of post-enrollment system lectures and implements the binary integer linear programming method.

In this study, we are interested in researching the modeling of lecture scheduling using the integer linear programming method and building an application from that model. The case study was conducted at the Masters Program at the Faculty of Mathematics and Natural Sciences, Syiah Kuala University which involved four Masters study programs, namely Masters in Mathematics, Masters in Chemistry, Masters in Biology and Masters in Physics.

II. INTEGER LINEAR PROGRAMMING

Integer linear programing is a technique used for determining the maximum or minimum of a linear function of non-negative variables subject to constraints expressed as linear equalities [4]. In a general integer linear programming problem, we seek to maximize or minimize a linear cost function over all n-dimensional vectors x subject to a set of linear equality and inequality constraints restrictions on some or all of the variables in x.

Max/min $\boldsymbol{c^T x}$

s.t. $\mathbf{A}\boldsymbol{x} \leq \boldsymbol{b}$

$\boldsymbol{x} \geq \mathbf{0}$

$\boldsymbol{x} \in \mathbf{Z}^n$

where A is the $m \times n$ matrix, **c** is an n-dimension row vector, **b** is an m-dimension column vector, and x is an n-dimension column vector of a variable or unknown plus the restriction that certain variables must take integer values [5].

2.1 Formulation of the objective function

In this study the objective function of the course scheduling model is to minimize the number of courses that cannot be scheduled due to one or more obstacles that are not met. For this reason, a quantity of integer value, called conflict, is defined, namely the existence of courses that cannot be scheduled due to one or more constraints that are not met. So a course can be scheduled if it has zero conflict value, otherwise it cannot be scheduled.

It also defines the decision variable x, which is a binary integer value of 0 or 1. The variable x will be worth 0 if a course can be scheduled on certain days, time periods, lecture rooms and lecturers. Conversely, the variable x will be 1 if a course cannot be scheduled on certain days, time periods, lecture rooms and lecturers. So the objective function is defined as

$$\text{minimize } z = \sum_{i \in I} \sum_{j \in J} \sum_{k \in K} \sum_{l \in L} \sum_{m \in M} x_{i,j,k,l,m}$$

where

$$x_{i,j,k,l,m} = \begin{cases} 0, If\ it\ can\ scheduled\ on\ i \in I\ day, in\ the\ j \in J\ time\ period, \\ \quad the\ k\ \in K\ lecture\ room\ is\ scheduled, in\ the\ l \in L\ course, \\ \quad and\ the\ m \in M\ lecturer \\ 1, the\ others \end{cases}$$

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I = {1, 2, 3, ..., 5} is a set of day codes.

J = {1, 2, 3, ..., 14} is a set of time period codes.

K = {1, 2, 3, ..., 12} is a set of lecture room codes.

L = {1, 2, 3, ..., 47} is a set of course codes.

M = {1, 2, 3, ..., 55} is a set of lecturer codes.

2.2 Formulation of the constraints

In this study several obstacles have been established that need to be considered in formulating the model. These constraints are extracted from the rules that apply to the preparation of lecture scheduling in the Master Program at the Faculty of Mathematics and Natural Sciences. The following are the constraints used:

a) There are no lecturers who teach the same day and same time period.

b) Each room can only be used by one subject on the same day and time period.

c) Every lecture room must be scheduled according to the number of hours.

d) Laboratory rooms is used for practicum only.

e) Lecture rooms are used for lectures only.

f) Courses in the same semester, may not be scheduled at the same time and day but must be different rooms.

g) There are no lectures on Friday from 12:00 to 14:00.

h) In each study program may not use the lecture room of another study program.

III. RESULT AND DISCUSSION

Lecture scheduling model that has been obtained in this study was applied using Matlab programming. The application has successfully arranged a lecture schedule very well and has high flexibility. Flexibility here is defined as a form of accommodation to the existence of requests or booking schedules for certain subjects on certain days and time sessions.

Figure 1. shows the request for a course in the Mathematics Masters Study Program on Friday for first time period (session 1) in the Mathematical Modeling Laboratory Room.

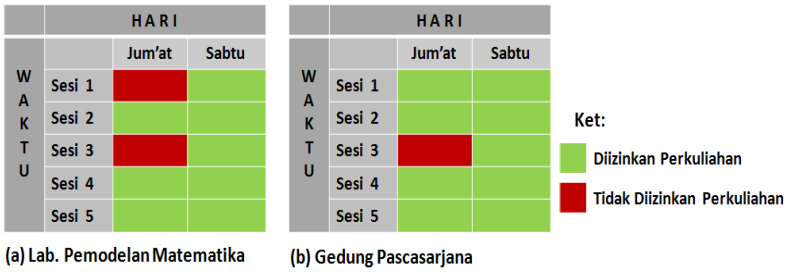

Figure 1: Example requests for class schedules in the Mathematics Masters Study Program.

Figure 2. shows the part of the application output, namely the lecture schedule on the Mathematics Masters Study Program on Friday, by paying attention to requests in the first time period (session 1).

Program Studi: Magister Matematika				
Hari	**Ruang**	**Pukul**	**Mata Kuliah**	**Dosen**
Jum'at	Lab. Pemodelan Matematika	08:15 - 09:55		
		10:00 - 11:30	Komputasi Matematika / 2	Prof. Dr. Marwan, M.Si
		12:00 - 13:30		
		14:30 - 16:00	Aljabar Linear Lanjut / 2	1. Dr. Rini Oktavia, M.Si 2. Prof. Dr. Marwan, M.Si
		16:30 - 18:10	Aljabar Linear Lanjut / 2	1. Dr. Rini Oktavia, M.Si 2. Prof. Dr. Marwan, M.Si
	Gedung Pascasarjana	08:15 - 09:55	Praktikum Model Kontrol Optimal / 2	Dr. Said Munzir, M.Eng.Sc
		10:00 - 11:30	Praktikum TPM / 4	Dr. Said Munzir, M.Eng.Sc
		12:00 - 13:30		
		14:30 - 16:00		
		16:30 - 18:10		

Figure 2: Example output of lecture schedules in the Mathematics Masters Study Program.

To check the flexibility of the aplication for the number of lecture schedule requests, the program runs as many as 1000 repetitions each with the selection of subjects ordered randomly for each repetition. Table 1. The following are the results of running applications for the number of requests 0, 10, 20 and 30.

Table 1: The results of running applications for the number of requests 0, 10, 20, and 30.

Sumat request	**Sumat confliks by scored = 0**	**Sumat confliks by scored ≥ 1**
0	946 (94.6 %)	54 (5.4 %)
10	930 (93.0 %)	70 (7.0 %)
20	921 (92.1 %)	79 (7.9 %)
30	910 (91.0 %)	90 (9.0 %)

Table 1. above shows that the greater the number of requests, the greater the conflict with a value greater than or equal to one. Based on the comparison between the number of conflicts valued at zero and the number of conflicts valued at one or more, it can be seen that the percentage of the number of conflicts that are worth zero is greater than 90% for each number of requests. This shows that the scheduling of lectures at the Masters Program at the Faculty of Mathematics and Natural Sciences, Syiah Kuala University can be done very well with success above 90%.

Flexibility analysis according to the study program is also carried out. An example can be seen in the Mathematics Masters study program. By applying the same method as in the flexibility analysis of all Masters study programs in the Faculty of Mathematics and Natural Sciences, the results obtained are shown in Table 2.

Table 2: The results of running applications for the number of requests 0, 1, 2, and 3 in the Master of Mathematics Study Program.

Sumat request	**Sumat confliks by scored = 0**	**Sumat confliks by scored ≥ 1**
0	957 (95.7 %)	43 (4.3 %)
1	948 (94.8 %)	52 (5.2 %)
2	935 (93.5 %)	65 (6.5 %)

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3	922 (92.2 %)	78 (7.8 %)

Table 2. shows the results that are similar to the results for all Masters study programs in the Faculty of Mathematics and Natural Sciences. The percentage of the number of conflicts with a value equal to zero greater than 90% means that scheduling lectures on the Mathematics Masters Study Program by using an application has a very good chance of success. Similar results were also obtained in other study programs.

IV. CONCLUSION

From the results of the result and discussion, the following conclusions are obtained:

1. The method of linear integer programming for lecture room scheduling models in the Master Program at the Faculty of Mathematics and Natural Sciences, Syiah Kuala University has been modeled well.

2. An application based on the results of the model has been built and implemented using Matlab programming.

3. The success of lecture room scheduling by using an application for various requests has been successfully carried out with a success rate of above 90%.

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