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# Implementation of Back Tracking Algorithm in The Scheduling of Mathematics Study Program Faculty of MIPA Unsoed

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**Abstract**

The complicated case of scheduling courses at the Mathematics and Natural Sciences Faculty of Mathematics Study Program, Universitas Jenderal Soedirman, is a topic that is quite interesting to discuss and find a solution to using a mathematical method. In fact, manual course scheduling without a method is prone to scheduling errors such as class schedule clashes, clashes in the use of lecture rooms and so on, so a more efficient method of scheduling courses is needed. Scheduling lectures with the backtracking algorithm is a systematic and efficient method of scheduling lectures with influencing factors such as the number of courses, number of sessions, number of rooms, and lecture time. Algorithm backtracking is an algorithm based on Depth First Search to find solutions to problems more efficiently. The back tracking algorithm performs a systematic search for solutions to all possible solutions at each node based on recursive Depth First Search. Depth First Search is a search method that is carried out at one node in each level from the far left. If a solution has not been found, then the search continues on the right hand node. And so on until a solution is found or if you find a dead end it will backtrack to the previous position. If a solution is found, the search will stop even if there are nodes that have not been traced. The implementation of the backtracking algorithm pays close attention to the factors that become obstacles in scheduling courses. The course schedule function with the backtracking algorithm can meet every influencing factor such as the number of courses, rooms, classes, and lecture time so that scheduling lectures with this method is very helpful because the method used is more efficient and can avoid errors in scheduling.

*Keywords*: Backtracking, depth first search, node

## 1. Introduction

Scheduling courses is a very important activity for the implementation of a good teaching and learning activity for a department at a university or college (Bringle & Hatcher, 1996; Kenney, & Newcombe, 2011). A good schedule is a schedule that can be carried out by all parties involved in teaching and learning activities, not only for lecturers who teach, but also for students taking the course. Many obstacles are faced when compiling a good schedule. Scheduling courses at a university is a difficult problem to solve (Ernst, et al., 2004). This scheduling problem is found in many universities around the world. Many obstacles are encountered when scheduling courses (Bingimlas, 2009; LaValle, & Kuffner Jr, 2001). There are some limitations in the course scheduling if they are not taken into account properly will make it difficult to do a systematic and efficient scheduling. Scheduling problems that occur in the mathematics study program can be minimized with proper scheduling calculations. In addition, it also considers all aspects related to teaching and learning activities in the mathematics study program. With the problem of scheduling courses in the mathematics study program, it will be discussed how to solve the problems that exist in scheduling with an algorithm method, namely the Backtracking Algorithm (Sakkout, & Wallace, 2000; Congram,et al., 2002; Lu, et al., 2017; Ramamritham, et al.,1990). The backtracking algorithm is efficient enough to be used in scheduling courses at a university.

Backtracking algorithm is one way to solve a fairly large problem with a fairly efficient solution even though the problem requires a long execution time when done manually (Van-Beek, 2006; Schmidt, & Druffel, 1976; Civicioglu, 2013).

## 2. Research Methodology

### 2.1. Research Time and Place

The research was conducted from June 2020 to July 2020. Data were taken from the Department of Mathematics, Faculty of Mathematics and Natural Sciences, Universitas Jenderal Sudirman.

### 2.2. Data Analysis

The method used is descriptive analysis. Descriptive analysis method is a method for analyzing data by describing or describing the data that has been collected as it is in order to find a solution and implement the backtracking algorithm as an efficient solution for scheduling study programs to draw conclusions from this (Song, et al., 2015).

The research steps, as follows:

1. Observing problems in the scheduling of mathematics study programs;
2. Collecting data and factors that affect the scheduling of mathematics study programs;
3. Analyzing the data and the factors obtained to find solutions and conclusions;
4. Implement the backtracking algorithm from the results of the literacy study in the problem of scheduling lectures for the mathematics study program;
5. The results of systematic and efficient mathematics study program scheduling are obtained;
6. Facilitate the process of teaching and learning activities at the university.

## 3. Results and Discussions

### 3.1. Result

In this subchapter will display the results of research such as data, lecture scheduling, components of class schedule formation, backtracking algorithm lecture scheduling tree graph, and the results of lecture scheduling of the Mathematics Study Program, Faculty of Mathematics and Natural Sciences, Universitas Jenderal Soedirman.

#### 3.1.1. Data

The data used is the Lecture Schedule for the Mathematics Study Program, Faculty of Mathematics and Natural Sciences, Universitas Jenderal Sudirman in the 2020/2021 odd semester. The mathematics study program lecture schedule is as Table 1, Table 2, Table 3 and Table 4.

**Tabel 1:** Semester 1 Compulsory Courses

| **Semester 1** | |
|---|---|
| **Course** | **credits** |
| Calculus I | 4 |
| Introduction to Mathematical Logic and Sets (PLMH) | 3 |
| Statistical Method I (MetStat I) | 3 |
| Analytical Geometry (GA) | 4 |
| Introduction to Information Technology (PTI) | 2 |
| Unsoed Identity (JDU) | 2 |

**Tabel 2:** Semester 3 Compulsory Courses

| **Semester 3** | |
|---|---|
| **Course** | **credits** |
| Multiple Variable Calculus (LCM) | 4 |
| Linear Algebra (Aline) | 3 |
| Ordinary Differential Equation (GDP) | 4 |
| Inventory Management and Control (MPP) | 2 |
| English (B. English) | 2 |
| Pancasila | 2 |
| Indonesian (B. Indonesian) | 2 |

**Tabel 3:** Semester 5 Compulsory Courses

| **Semester 5** | |
|---|---|
| **Course** | **credits** |
| Algebraic Structure II (SA II) | 2 |
| Real Analysis I (Anriil I) | 4 |
| Introduction to Mathematical Statistics (PSM) | 4 |
| Numerical Method (MetNum) | 3 |
| Optimization I (OP 1) | 4 |

**Tabel 4:** Odd Semester Elective Courses

| **Course** | **credits** |
|---|---|
| Number Theory (TeoBil) | 3 |
| Axiomatic Geometry | 3 |
| Capita Selecta Algebra I (Kapsel Al I) | 2 |
| Capita Selecta Analysis I (Kapsel An I) | 2 |
| Sample Survey Method (MSS) | 2 |
| Non-parametric Statistics (SNP) | 2 |
| Applied Regression Analysis (ART) | 2 |
| Introduction to Stochastic Processes (PPS) | 3 |
| Introduction to Actuarial | 3 |
| Capita Selecta Statistics I (KapSel Stat I) | 2 |
| Survival Analysis | 2 |
| Financial Mathematics II (MatKeu II) | 2 |
| Graph Theory (TheoGraphic) | 3 |
| Applied Linear Algebra (ALT) | 2 |
| Dynamic System (SisDin) | 2 |
| Capita Selecta Applied Mathematics I (Kapsel Ter I) | 2 |
| Capita Selecta Applied Mathematics II (KapSel Ter II) | 2 |
| Math Computing | 2 |
| Data Structure | 2 |
| Object Oriented Programming | 2 |
| Capita Selecta Computing I (KapSel Kom I) | 2 |

### 3.1.2. Lecture Scheduling

Lecture scheduling consists of lecture time, number of classes, and rooms. With the following explanation:

1. College time

Class time is Monday to Friday, each day is divided into 5 sessions. Each lecture session must be divided into session 1 for 2 credits, session 2 for 2 credits, session 3 for 3 credits, session 4 for 2 credits, and session 5 for 2 credits. For each credit duration 50 minutes with lecture hours at 07.00-17.00 WIB. Especially for Fridays at 11.35-12.25WIB it is used for Friday prayer breaks.

2. Number of classes

There are 8 class choices, namely 1A, 1B, 3A, 3B, 5A, 5B, optional, and mandatory1. Where what is meant by 1A are compulsory subjects for semester 1 of class A, 1B for compulsory subjects for semester 1 of class B, 3A for compulsory subjects for semester 3 of class A, 3B for compulsory subjects for semester 3 of class B, 5A for compulsory semester subjects 5 classes A, 5B for compulsory subjects for semester 5 for class B, elective courses for electives, and compulsory1 for compulsory subjects for a combination of classes A and B. In the manual, compulsory courses are only taught until semester 5 students. So that the class division in the semester odd, compulsory courses are for semester 1, 3, and 5 students. Elective courses can be taken if they have passed the course prerequisites listed in the guidebook.

3. Room

There are 3 rooms available, namely B1.1, B1.2, and B1.3. Each room has its own number/capacity. Room B1.1 can accommodate 50 students, room B1.2 can accommodate 50 students, and room B1.3 can accommodate 100 students. For room B1.3, it is usually reserved for compulsory class1 or optional class.

### 3.1.3. Components of the formation of a lecture schedule

The components of the formation of the lecture schedule consist of:

1. Variable
   a) Days, that is Monday-Friday
   b) Number of sessions, which is 5 sessions
   c) Class groups, namely 1A, 1B, 3A, 3B, 5A, 5B, optional, and mandatory1

Scheduling is done every day with the number of variables needed is as many as 20 variables obtained from: number of days (1) × number of sessions (5) × number of class groups (4). Variables are represented by X1, X2, …, X20

2. Domain
   a) The courses, seen in Table 1, Table 2, Table 3, Table 4
   b) The room, namely room B1.1, B1.2, and B1.3
   c) Credits, the number of credits in the mathematics study program is 2, 3, and 4 credits.
3. Limits
   a) Number of credits in one week
   b) Number of rooms
   c) The number of room loads, namely B1.1 as much as 50, B1.2 as much as 50, and B1.3 as much as 100.

Class placement is based on class groups and courses taught.

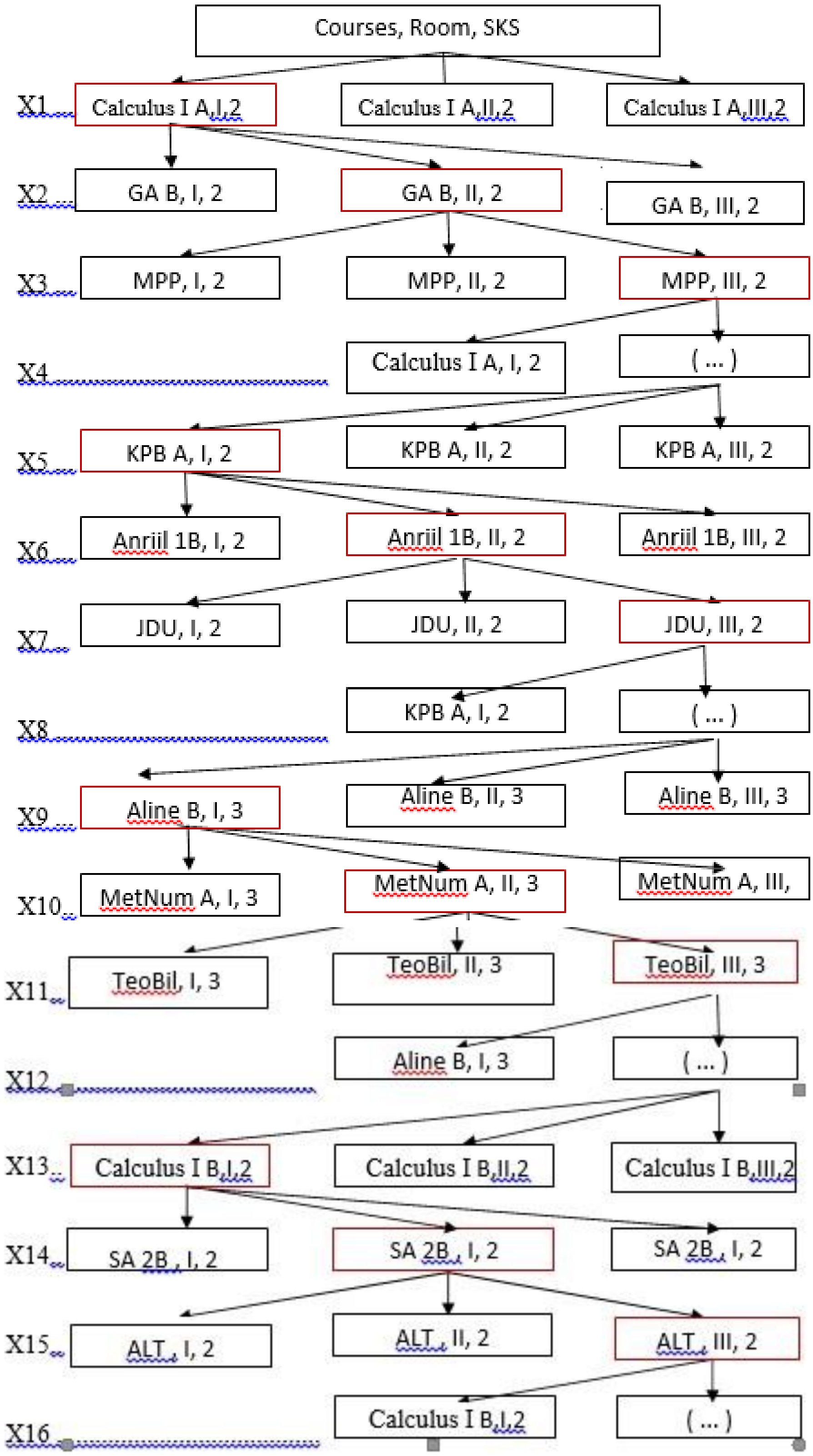
### 3.1.4. Tree Graph Scheduling Lecture Backtracking Algorithm

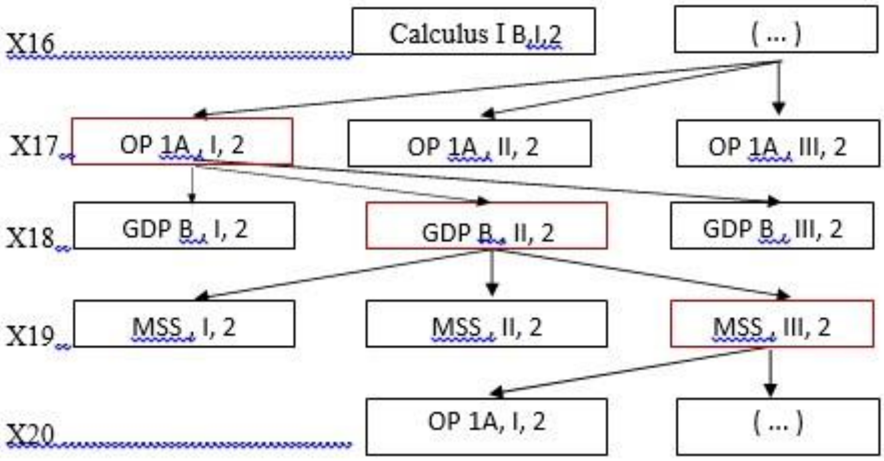
It is assumed th at no one repeats compulsory courses or elective courses. Back tracking algorithm solution tree on scheduling. The lecture is formed from the components of the lecture schedule with the point on the graph stating the course.room.SKS (example: calculus1A. I. 2) and the side connecting the two points state the trajectory to be traced according to the specified criteria. How to create a backtracking algorithm lecture scheduling tree graph is as follows:

1. Create a main chart that contains parameters for the creation of a lecture schedule, namely courses, rooms, credits.
2. Create sub charts according to parameters that have been determined by the main chart. The trajectory starts from the leftmost node to the right node according to the parameters.
3. If you have a solution, then the trajectory will stop and will find other solutions started again from the leftmost node.
4. If the track does not find a solution according to the parameters that have been determined, then the track will stop and move back to the beginning by repeating the trajectory that has been passed and looking for other solutions.
5. Nodes that meet the parameters are marked in red which is the solution of the backtracking algorithmic tree.

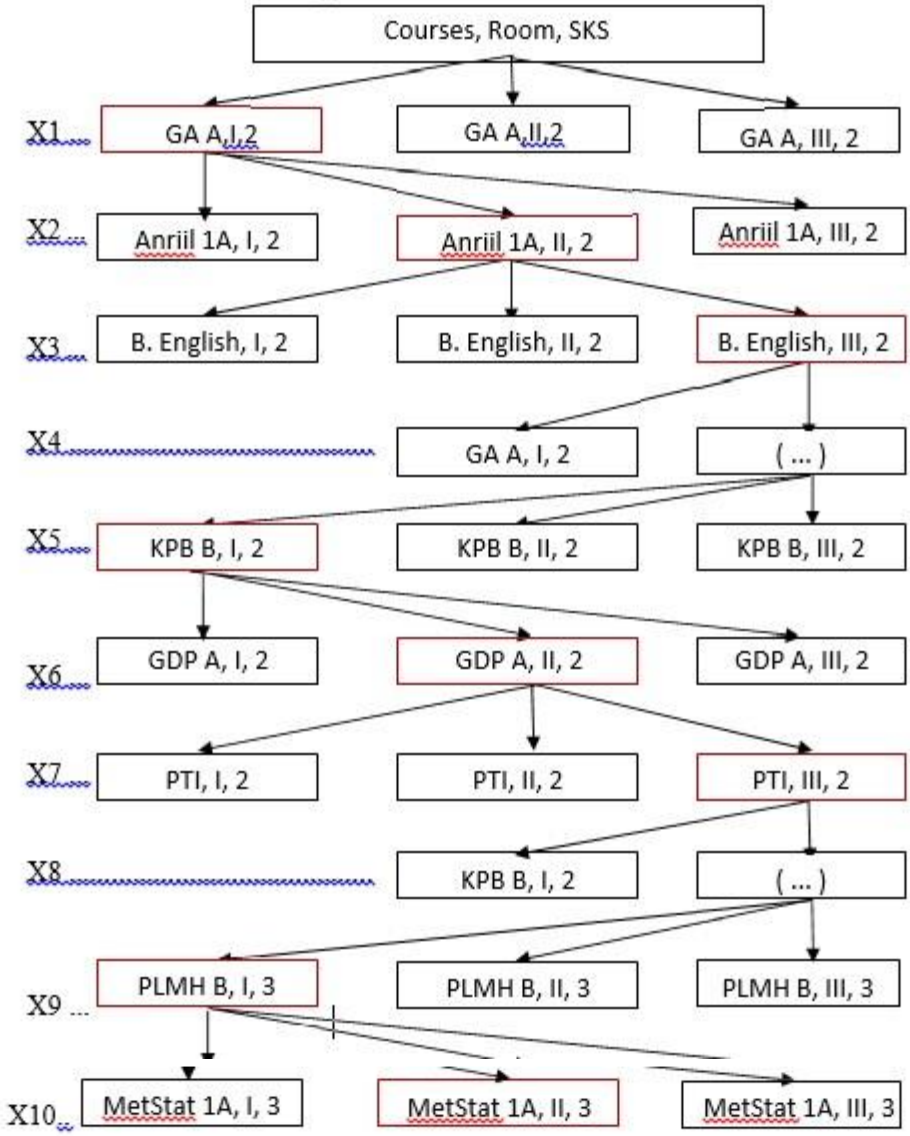
From the steps above can be formed a backtracking algorithm solution tree on the scheduling of mathematics study program, Faculty of Mathematics and Natural Sciences, University Jenderal Sudirman.

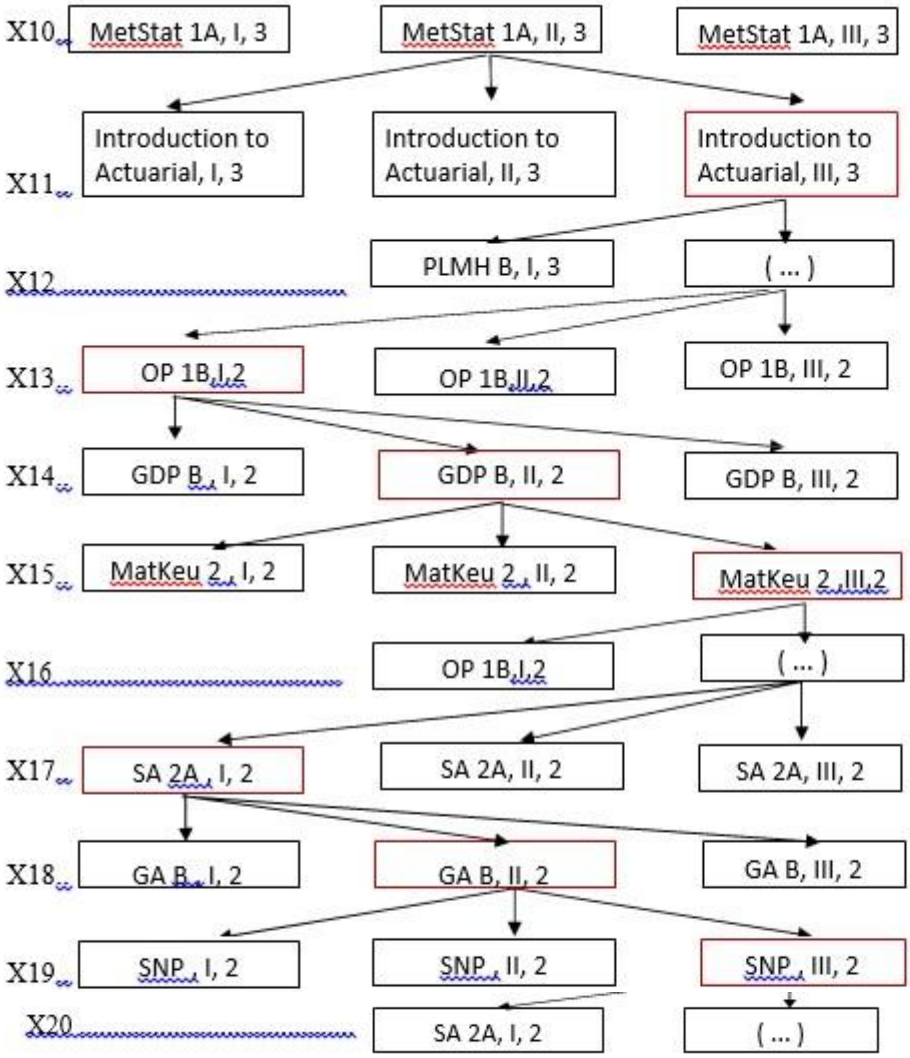
The solution tree of Monday scheduling is as follows:


Courses, Room, SKS
X1
Calculus I A,I,2
Calculus I A,II,2
Calculus I A,III,2
X2
GA B, I, 2
GA B, II, 2
GA B, III, 2
X3
MPP, I, 2
MPP, II, 2
MPP, III, 2
X4
Calculus I A, I, 2
( ... )
X5
KPB A, I, 2
KPB A, II, 2
KPB A, III, 2
X6
Anriil 1B, I, 2
Anriil 1B, II, 2
Anriil 1B, III, 2
X7
JDU, I, 2
JDU, II, 2
JDU, III, 2
X8
KPB A, I, 2
( ... )
X9
Aline B, I, 3
Aline B, II, 3
Aline B, III, 3
X10
MetNum A, I, 3
MetNum A, II, 3
MetNum A, III,
X11
TeoBil, I, 3
TeoBil, II, 3
TeoBil, III, 3
X12
Aline B, I, 3
( ... )
X13
Calculus I B,I,2
Calculus I B,II,2
Calculus I B,III,2
X14
SA 2B , I, 2
SA 2B , I, 2
SA 2B , I, 2
X15
ALT , I, 2
ALT , II, 2
ALT , III, 2
X16
Calculus I B,I,2
( ... )

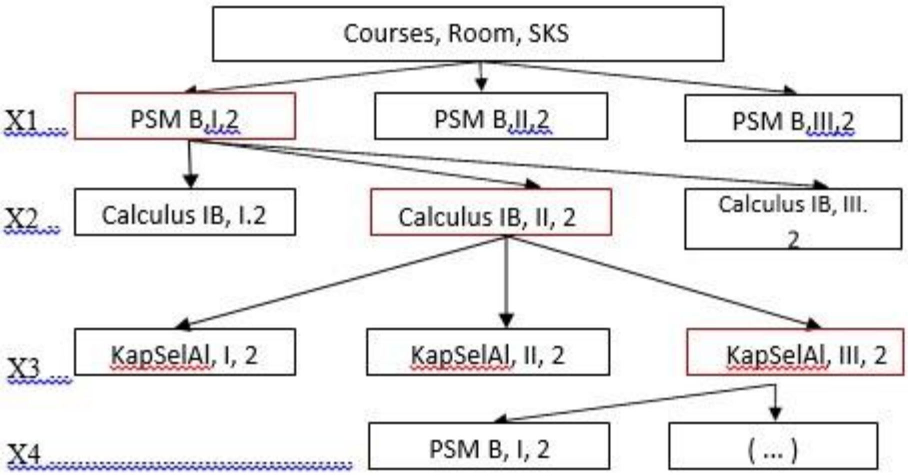


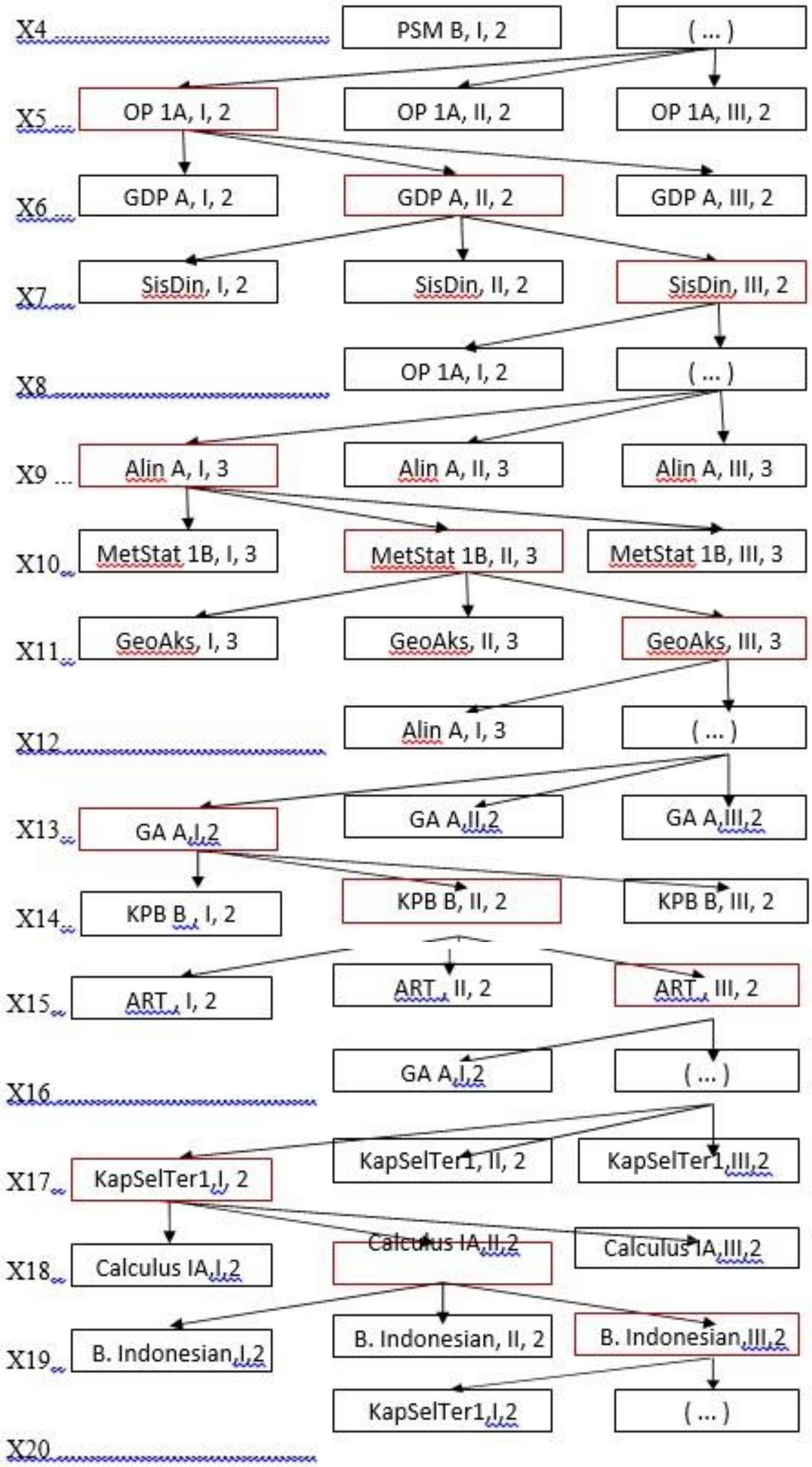

Tuesday's scheduling



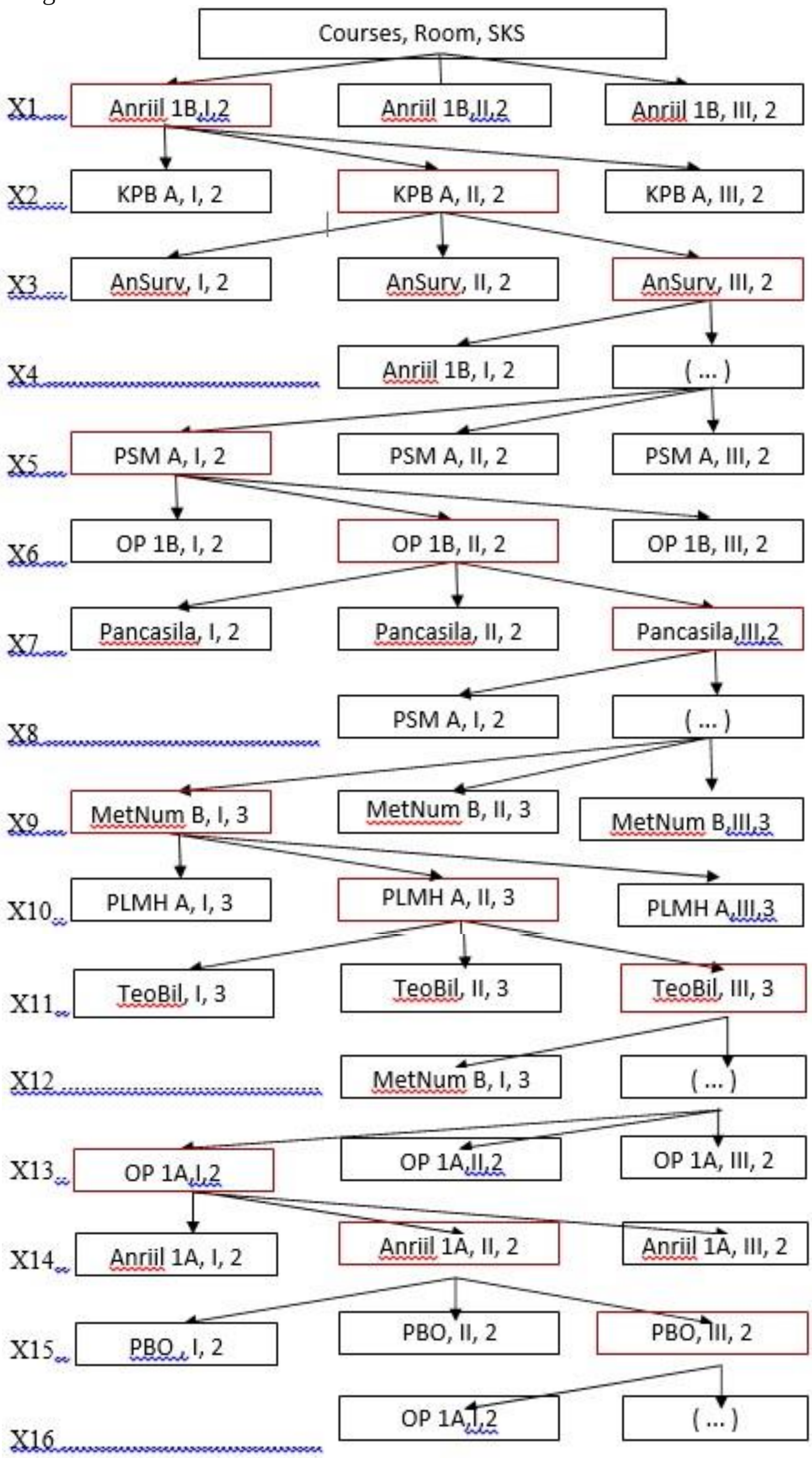


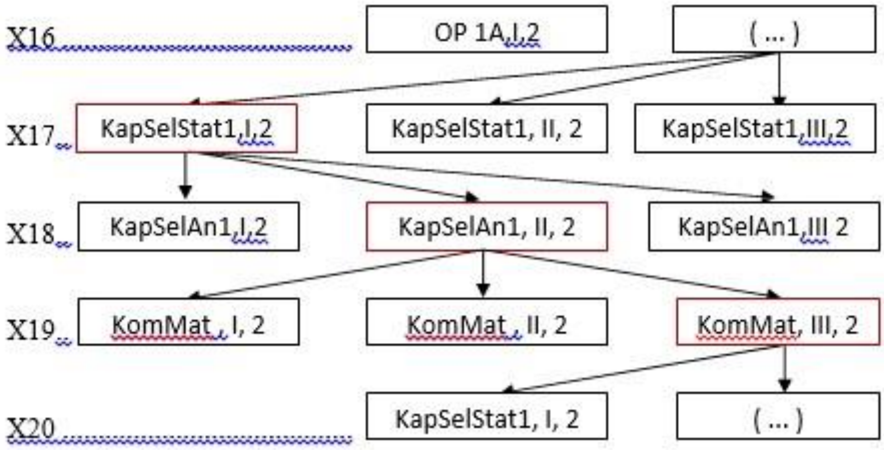

Wednesday's scheduling



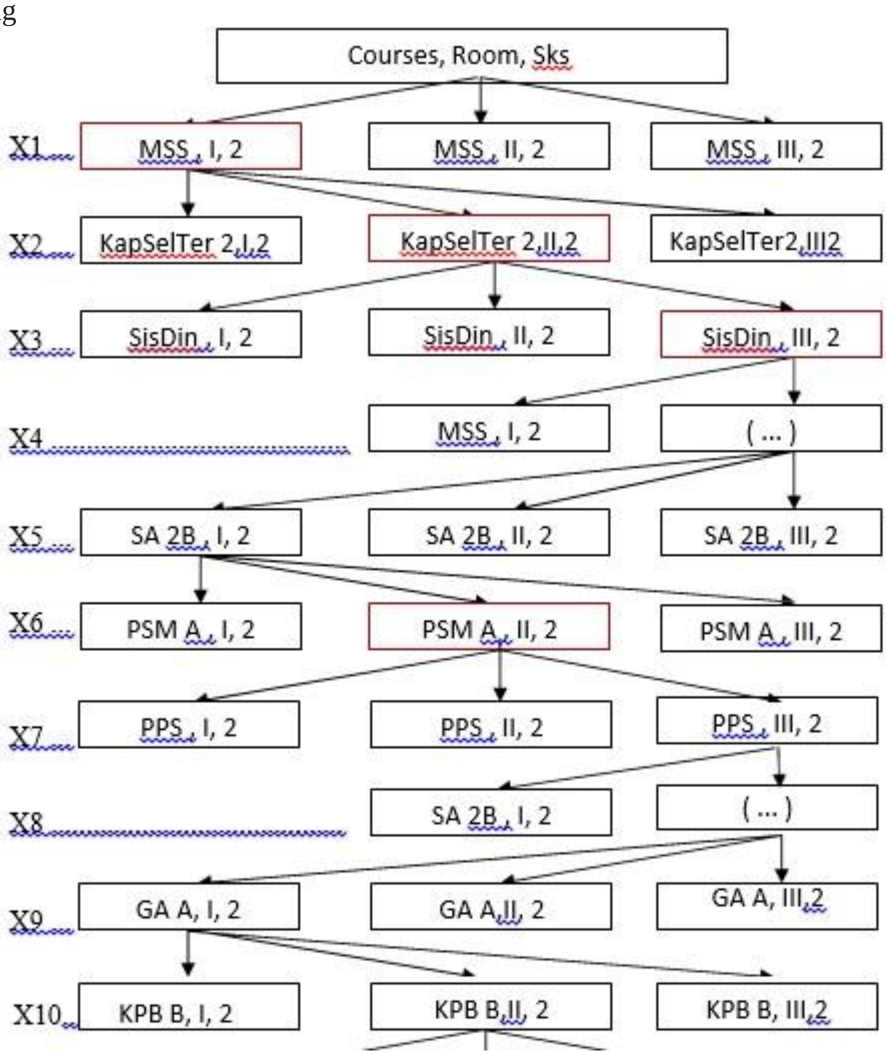

X4
PSM B, I, 2
( ... )
X5
OP 1A, I, 2
OP 1A, II, 2
OP 1A, III, 2
X6
GDP A, I, 2
GDP A, II, 2
GDP A, III, 2
X7
SisDin, I, 2
SisDin, II, 2
SisDin, III, 2
OP 1A, I, 2
( ... )
X8
X9 ...
Alin A, I, 3
Alin A, II, 3
Alin A, III, 3
X10
MetStat 1B, I, 3
MetStat 1B, II, 3
MetStat 1B, III, 3
X11
GeoAks, I, 3
GeoAks, II, 3
GeoAks, III, 3
Alin A, I, 3
( ... )
X12
X13
GA A,I,2
GA A,II,2
GA A,III,2
X14
KPB B , I, 2
KPB B, II, 2
KPB B, III, 2
X15
ART , I, 2
ART , II, 2
ART , III, 2
GA A,I,2
( ... )
X16
X17
KapSelTer1,I, 2
KapSelTer1, II, 2
KapSelTer1,III,2
X18
Calculus IA,I,2
Calculus IA,II,2
Calculus IA,III,2
X19
B. Indonesian,I,2
B. Indonesian, II, 2
B. Indonesian,III,2
KapSelTer1,I,2
( ... )
X20

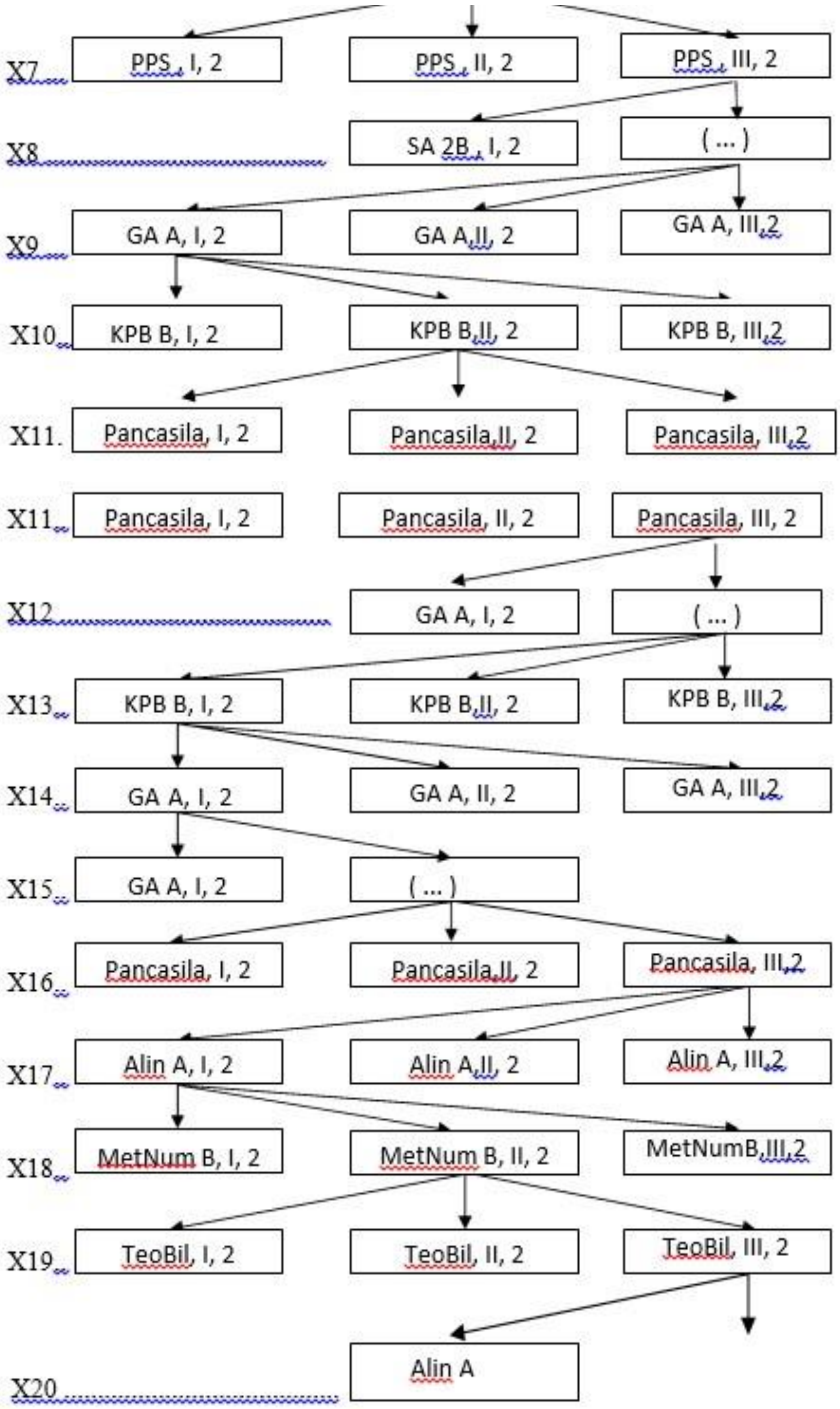
Thursday's scheduling






Friday scheduling






From Friday's scheduling there is a backtracking that means he will go back to the beginning to find another solution when he does not find a solution.

### 3.1.5. College Scheduling Results Using Backtracking Algorithm

Then it can be obtained the lecture schedule Table 5, Table 6, Table 7, Table 8 and Table 9, of Mathematics Study Program, Faculty of Mathematics and Natural Sciences, Universitas Jenderal Sudirman.

**Table 5:** Monday's scheduling results

| Day | Time | B1.1 | B1.2 | B1.3 |
|---|---|---|---|---|
| Monday | 07.00-07.50 | Calculus I (A) | GA(B) | MPP |
| | 07.55-08.45 | | | |
| | 08.50-09.40 | KPB (A) | Anriil 1 (B) | JDU |
| | 09.45-10.35 | | | |
| | 10.40-11.30 | | | |
| | 11.35-12.25 | Alin (B) | MetNum (A) | TeoBil |
| | 12.30-13.20 | | | |
| | 13.25-14.15 | Calculus I (B) | SA II (B) | ALT |
| | 14.20-15.10 | | | |
| | 15.15-16.05 | | | |
| | 16.10-17.00 | | | |

**Table 6:** Tuesday's scheduling results

| Day | Time | B1.1 | B1.2 | B1.3 |
|---|---|---|---|---|
| Tuesday | 07.00-07.50 | GA (A) | Anriil 1 (A) | B. English |
| | 07.55-08.45 | | | |
| | 08.50-09.40 | KPB (B) | GDP (A) | PTI |
| | 09.45-10.35 | | | |
| | 10.40-11.30 | PLMH (B) | MetStat 1 (A) | Introduction to actuarial |
| | 11.35-12.25 | | | |
| | 12.30-13.20 | | | |
| | 13.25-14.15 | Op 1 (B) | GDP (B) | MatKeu 2 |
| | 14.20-15.10 | | | |
| | 15.15-16.05 | SA 2(A) | GA (B) | SNP |
| | 16.10-17.00 | | | |

**Table 7:** Wednesday's scheduling results

| Day | Time | B1.1 | B1.2 | B1.3 |
|---|---|---|---|---|
| Wednesday | 07.00-07.50 | PSM (B) | Calculus I (B) | KapSelAl |
| | 07.55-08.45 | | | |
| | 08.50-09.40 | Op 1(A) | GDP (A) | Data Structure |
| | 09.45-10.35 | | | |
| | 10.40-11.30 | Aline (A) | MetStat (B) | Axiomatic Geometry |
| | 11.35-12.25 | | | |
| | 12.30-13.20 | | | |
| | 13.25-14.15 | GA (A) | KPB (B) | AR T |
| | 14.20-15.10 | | | |
| | 15.15-16.05 | KapSelTer 1 | Calculus I (A) | B. Indonesian |
| | 16.10-17.00 | | | |

**Table 8:** Thursday's scheduling results

| Day | Time | B1.1 | B1.2 | B1.3 |
|---|---|---|---|---|
| Thursday | 07.00-07.50 | Anriil 1 (B) | KPB (A) | Survival Analysis |
| | 07.55-08.45 | | | |
| | 08.50-09.40 | PSM (A) | Op1 (B) | Pancasila |
| | 09.45-10.35 | | | |
| | 10.40-11.30 | MetNum | PLMH (A) | TeoBil |
| | 11.35-12.25 | | | |

| | | | | |
|---|---|---|---|---|
| | 12.30-13.20 | (B) | | |
| | 13.25-14.15 | Op1 (A) | Anriil 1 (A) | GDP |
| | 14.20-15.10 | | | |
| | 15.15-16.05 | KapSelStat1 | KapSelAn 1 | Math Computing |
| | 16.10-17.00 | | | |

**Tabel 9:** Friday scheduling results

| Day | Time | B1.1 | B1.2 | B1.3 |
|---|---|---|---|---|
| Friday | 07.00-07.50 | PSM (B) | KapSelTer 2 | SisDin |
| | 07.55-08.45 | | | |
| | 08.50-09.40 | | PSM (A) | PPS |
| | 09.45-10.35 | | | |
| | 10.40-11.30 | | | |
| | 11.35-12.25 | | | |
| | 12.30-13.20 | | | |
| | 13.25-14.15 | | | |
| | 14.20-15.10 | | | |
| | 15.15-16.05 | | | |
| | 16.10-17.00 | | | |

## 4. Conclusion and Suggestions

### 4.1. Conclusion

In-depth analysis of this paper starting from the stage of planning an idea or idea, the depiction of an idea, and the implementation of an idea can be explained logically and simply. This paper can also be one of the references and even solutions for agencies that will make the scheduling of lectures both at the department and faculty level but while still paying attention to the criteria set. Efficiency and systematic in the creation of schedules can also be felt if the schedule maker remains careful. With backtracking algorithms can avoid problems that will arise such as clashing courses let alone mandatory courses that are very fatal.

### 4.2. Suggestions

The advice that can be given is to always pay attention to certain criteria in the preparation of the lecture schedule, arrange the course schedule carefully so that the results are more efficient, the institution can use the backtracking algorithm as an alternative in avoiding problems in the scheduling of lectures.

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