

Application Of Metaheuristic Methods For Education Scheduling (Case Study Of Bali State Politechnic)

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Abstract—Lecture Scheduling Problems are very complex problems, where the core of the scheduling is how to schedule several components consisting of students, lecturers, space, time, and courses by taking into account certain limitations and constraints. The aim to be achieved is to apply the Tabu Search Metaheuristic method which is applied in the Lecture Scheduling system. Every step taken by Tabu Search is taken based on the results of the cost calculation carried out in each iteration to select a neighbor solution which will be the next current best solution. In this study an application was designed to apply Tabu Search Metaheuristic method through lecturing scheduling applications by using Microsoft Visual Basic programming language by entering several parameters namely Data Lecturer, Course, Room, and several variables from each parameter which were then processed to produce scheduling lecture. The results obtained from the use of Tabu Search Metaheuristic method are scheduling odd semester and even semester lectures in the Informatics Management Study Program, Electrical Engineering Department, Bali State Polytechnic.

Keywords: *metaheuristic; tabu search; constraint; scheduling lectures*

I. INTRODUCTION

Scheduling problems in general are assignment activities related to a number of constraints, a number of events that can occur in a certain period of time and place / location so that the objective function is as close as possible. Submission of information to academic institutions is very important, especially information related to lecture activities. One of them is information on class schedules. Lecture scheduling problems or the University Course Timetabling Problem (UCTP) are very complex problems that are often faced by every university. The essence of scheduling lectures is how to schedule a number of components consisting of class, space, and time with a number of restrictions and certain constraints. Lecture scheduling is not an easy job, where the core of this problem is how to schedule various components consisting of students, lecturers, space and time by taking into account certain limitations and conditions. In research conducted in the Information Management Study Program, Electrical Engineering Department, Bali State Polytechnic.

A. Research Method

The object under study is the lecture scheduling system in the Informatics Management Study Program, Electrical Engineering Department, Bali State Polytechnic by applying Tabu Search metaheuristic method. This Information Scheduling System can also apply to all departments in the Bali State Polytechnic according to user needs. This lecture scheduling system is expected to be able to help the academic section to make scheduling of courses per semester in accordance with the level of importance of each department more optimally. This research is carried out following the information retrieval process to ensure interconnection between interacting processes, as shown in Figure 1.

II. SCHEDULING LECTURES

Submission of information to academic institutions is very important, especially information related to lecture activities. One of them is information on class schedules. Lecture scheduling is not an easy job, where the core of this problem is how to schedule various components consisting of students, lecturers, space and time by taking into account certain limitations and conditions. From the problems of existing lecture scheduling optimization, a mathematical model will be built in which this mathematical model is a graph form whose inter-node connectivity is a representation of constraints that the system should not violate. The constraints that are hard constraints are as follows:

- Class is only scheduled once for each subject [hard constraint I].
- The same class cannot study in different spaces at one time [hard constraint II].
- The same class cannot study more than one subject at a time [hard constraint III].
- The course will be given a continuous time allocation according to the credits owned by the subject (no credit from the course is cut by another schedule or there is a change of day) [hard constraint IV].
- If the time given is not sufficient for scheduling, the system will not produce a schedule [hard constraint V].

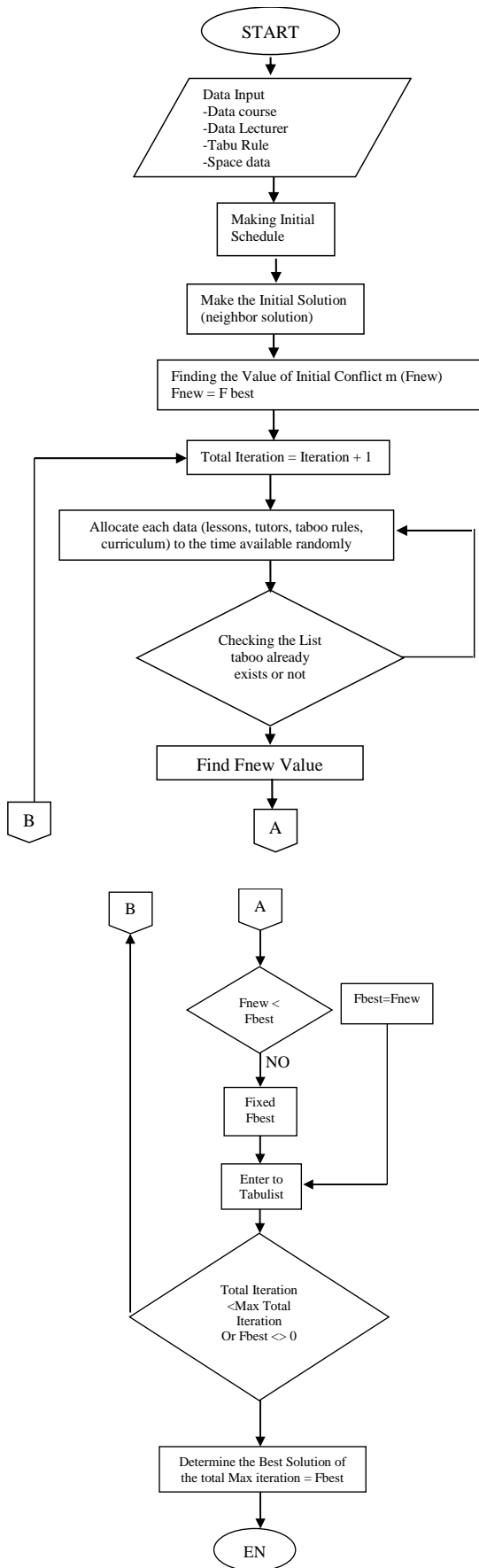


Fig. 1. Flowchart Lecture Scheduling System with Tabu Search Metaheuristic Method

Good scheduling is scheduling that does not contain clashes between scheduled components, in this case in the form of class, time, and space. In addition to hard constraint, the scheduling of lectures also defined some soft constraints so that the results obtained were better solutions. The things that should be fulfilled as soft constraints are as follows:

- The space used by a class in one day is expected to be in the same building [soft constraint I].
- From the five days of lectures in one week, it is expected that each class should get one or two days of empty lectures [II soft contradiction].
- In one day of study, it is expected that the number of lecture hours for one class is not too much and not too little, preferably between four to six hours of lectures [III soft contradiction].

This soft constraint is not necessarily fulfilled, but it is expected to be fulfilled so that the solution obtained is a better solution. Based on the hard constraint above, a graph will be built which is a mapping of the event (the event is a representative of class, level, semester and course code) which will be scheduled against time and placed in space, which will be solved using Tabu Search algorithm so resulting in scheduling lectures with good solutions.

A. Application Design Will Be Developed

The implementation of Tabu Search metaheuristic method for scheduling courses follows the following stages.

B. Constraint Classification

The regulations that are owned by a university in making the class schedule can be summarized and grouped into 2 groups according to the level of obligation the regulation is fulfilled. These two groups are described in the Hard Constraint and Soft Constraint sections.

1) *Hard Constraint:* Hard Constraint is defined as a mandatory constraint that must be met in the algorithm calculation process. The following is a list of Hard constraints in college scheduling problems and their explanations:

- The lecturer schedule cannot clash.
- The room used must not clash. Lecturers must teach courses that are in accordance with the provisions of the Chairperson of the Department
- Lecturers may not get a teaching schedule exceeding their credit quota.
- All classes opened must get lecture time and space.
- The number of students in one class must not exceed the capacity of the room.
- Class courses that require a special room must be scheduled in the right room.
- Course classes that are more than 1 meeting per week must receive sequential schedules.

2) *Soft Constraint:* Different from hard constraints, the constraints included in the soft constraint category are obstacles that cannot always be fulfilled in the process of forming class schedules. The following is a soft constraint list of lecture scheduling problems, along with an explanation:

- For each class that is opened, there will be lecturers teaching.
- A lecturer cannot get a teaching schedule of more than 3 meetings a day.
- Schedule of teaching lecturers in a day is arranged in sequence without pause.
- Student class schedules in a day are arranged in sequence without a break.
- The number of students allocated to one classroom is as close as possible to the capacity of the room
- The same subject classes are arranged for different days and hours.
- Lecturers must get a teaching schedule in accordance with the time of their willingness to teach.

III. CORE ALGORITHMS

The basic principle of the Tabu Search algorithm is to process an empty initial solution until it becomes a final solution. This algorithm uses class and subject relations as variables and uses lecturers, subjects, time, and room as values that will be entered into variables

Every step taken by Tabu Search is taken based on the results of the cost calculation carried out in each iteration to select a neighbor solution which will be the next current best solution. Termination of the process occurs if the number of scheduled classes has met the requirements or interaction of the user requires the termination of the process.

IV. COST CALCULATION

Cost calculations in Tabu Search are detecting constraint violations in each class. Detection of these violations was carried out to determine which class should be corrected, then selecting lecturers and lecture hours that must be selected to improve the class schedule. The calculation of the cost in the Tabu Search algorithm has been designed to produce a value of 0, if the class has the best composition of lecturers and lecture time, which does not violate all existing constraints. The formula for calculating the cost value of a class is as follows (Riwansyah, 2005):

The change in cost will be a long chain reaction if the class that gets resource allocation is a Multimatakuliah class with a sufficient number of sub subjects. The higher the cost, it can be concluded that the schedule owned by the class contains many soft constraints. For the desired solution to be achieved, each constraint violation is defined as the value of the different costs.

V. DATA INPUT

For the data input process, it consists of:

- Data entry process in the form of lecturer data, course data, space data, and lecture data. Lecturer data is filled by the lecturers themselves by filling in the teaching data form, while the room is determined by the Program Secretariat, scheduling lectures and examinations to be stored in the database.
- The process of entering the subject data is offered each semester, including the determination of the number of

classes offered by the lecture that are adjusted to the ability of the teaching lecturer.

VI. OUTPUT DATA

The output data produced is:

- Report (print out) the class schedule, which contains data on the course of the course held each semester. This report is then used by students for college key-ins.
- Report (print out) the lecturer schedule, is a lecturer teaching report submitted to the lecturer concerned to find out the teaching schedule.

VII. RESULT AND DISCUSSION

A. Main Menu

This Main Menu is the initial form displayed when the software is run. In the main menu there are menus that have functions related to data entry, and data processing as shown in Figure 2 below



Fig. 2. Main Menu Interface

Information:

- Home Menu: This menu is used to display the system menu view.
- Data Input Menu

B. Lecturer Data Input

This menu is used for inputting data of lecturers who teach, whether permanent lecturers or non-permanent lecturers.

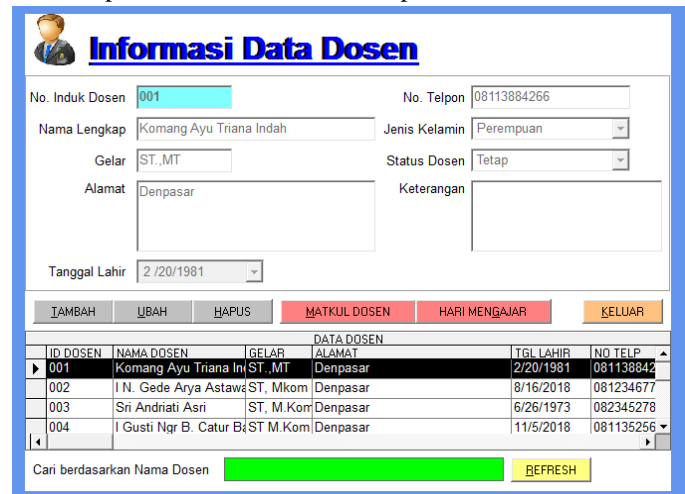


Fig. 3. Lecturer Menu

C. Input Data Room

This menu is used for entering the room data used.

KD RUANG	LANTAI	RUANG	KAPASITAS
11C	11	C	401
1A	1	A	40
1B	1	B	40
1D	1	D	40
2A	2	A	40

Fig. 4. Classroom Menu

D. Input Subject Data

This menu is used to enter the course data, either odd semester or even semester.

KODE	MATA KULIAH	SKS	SEMESTER
MKB-4320	Jaringan Komputer	4	Genap
MKB-5320	Jaringan Komputer II	4	Ganjil
MPB05324	Kesehatan dan Keselamatan Kerja	3	Genap
MPB-5320	Proyek Sistem Informasi	4	Ganjil
TIF2101	Jaringan Komputer	3	Ganjil
TIF2103	Matematika Diskrit	4	Ganjil
TIF2107	Pengantar Teknologi Informasi	2	Ganjil

Fig. 5. Subject Menu

E. Input Match / Match data

This menu is used to match input data with lecturer teaching request data.

KODE	THN AJARAN	SEMESTER	KD MATAKUL	SKS	ID DOSEN	RUANGAN	HARI	JAM
CD.001	2017/2018	Ganjil	MKB-5320	002	1D	3	1	
CD.002	2011/2012	Ganjil	TIF2107	2	002	1C	4	1
CD.003	2013/2014	Ganjil	MPB-5320	4	001	4A	3	1
CD.004	2011/2012	Ganjil	TIF2101	3	002	3B	2	6

Fig. 6. Match Menu

F. Scheduling Process Menu with Tabu Search

This menu is used to process scheduling lectures.

Fig. 7. Scheduling Menu

G. Menu Exit

This menu is used to exit the system

H. Output Database

The following is the output display from the menu contained in the scheduling program application. Scheduling output can be seen in figures 8,9 and 10

I. Lecturer Data Output

Laporan Data Dosen

No	ID Dosen	Nama Dosen	Gelar	Alamat	Tgl. Lahir	No. Telp	JenKel	Status
1	001	Komang Ayu Triana Indah	ST_MT	Denpasar	20 Feb 1981	08113884266	Perempuan	Tetap
2	002	I N. Gede Arya Astawa	ST_Mkom	Denpasar	16 Aug 2018	081234677688	Laki-Laki	Tetap
3	003	Sri Andriati Anri	ST_MKom	Denpasar	26 Jun 1973	082345278968	Perempuan	Tetap
4	004	I Gusti Ngr B. Catur Bawa	ST M Kom	Denpasar	05 Nov 2018	081135256587	Laki-Laki	Tetap
5	005	Ni Wayan Wisswani	ST,MT	Badung	03 Jun 1980	083452726257	Perempuan	Tetap
6	006	I Wayan Suasnawa	ST_MT	Denpasar	11 Oct 1975	08123453244	Laki-Laki	Tetap
7	007	Putu Gede Sukarata	ST_MT	Denpasar	03 Aug 1972	081338546786	Laki-Laki	Tetap
8	008	Putu Manik Pihardini	ST_MT	Denpasar	17 Mar 1980	08123457786	Perempuan	Tetap
9	009	I Wayan Budi Santana	ST_M Ko	Denpasar	11 May 1981	08235657765	Laki-Laki	Tetap
10	013	I Wayan Candra Winetra	ST_M Ko	Denpasar	31 May 1980	085547858979	Laki-Laki	Tetap
11	014	Putu Indah Ciptayani	ST_M Ko	Denpasar	13 Apr 1985	081236549865	Perempuan	Tetap

Fig. 8. Lecturer Data Output

J. Classroom Data Output

Laporan Data Ruang

No	Kd Ruang	Lantai	Ruang	Kapasitas
1	1A	1	A	40
2	1B	1	B	40
3	1C	1	C	40
4	1D	1	D	40
5	2A	2	A	40
6	2B	2	B	40
7	2C	2	C	40
8	2D	2	D	40
9	3A	3	A	40
10	3B	3	B	40
11	3C	3	C	40
12	3D	3	D	40
13	4A	4	A	40
14	4B	4	B	40
15	4C	4	C	40
16	4D	4	D	40

Fig. 9. Classroom Data Output

H. Output Course Data

Laporan Data Mata Kuliah

No	Kd. MataKuliah	Nama MataKuliah	SKS	Semester
1	MKB-4320	Jaringan Komputer	4	Genap
2	MKB-5320	Jaringan Komputer II	4	Ganjil
3	MPB05324	Kesehatan dan Keselamatan Kerja	3	Genap
4	MPB-5320	Proyek Sistem Informasi	4	Ganjil
5	TIF2101	Jaringan Komputer	3	Ganjil
6	TIF2103	Matematika Diskrit	4	Ganjil
7	TIF2107	Pengantar Teknologi Informasi	2	Ganjil
8	TIF2108	Pemrograman Terstruktur	3	Ganjil
9	TIF2202	Manajemen Proyek Sistem Informasi	3	Genap
10	TIF2204	Pemrograman Visual	4	Genap
11	TIF2209	Algoritma & Pemrograman	2	Genap
12	TIF3101	Sistem Digital	3	Ganjil
13	TIF3218	Praktikum Alpro	1	Genap
14	UIN1206	Bahasa Inggris	2	Genap

Fig. 10. Output Course Data

From the course data for the period 2017/2018 then inputted to the matching process (taboo list). In table 1 shows some local solutions are in a taboo list which in turn will be the next current best solution in the form of tabu search scheduling.

TABLE I. MATCHING TABLE (TABU LIST)

pencocokan									
kd_cocok	thn_ajaran	Semester	kd_matakuliah	sk s	id_dosen	kd_ruangan	hari	jam_ke	const
CD.001	2017/2018	Ganjil	MKB-5320		002	1D	3	1	2
CD.002	2017/2018	Ganjil	TIF2108	3	004	2A	3	1	3
CD.004	2017/2018	Ganjil	TIF2107	2	007	1C	3	1	3
CD.005	2017/2018	Ganjil	TIF2103	4	005	2C	2	5	3
CD.006	2017/2018	Ganjil	TIF3101	3	003	2A	3	5	3

From Table 1, there are several matching codes which are made as Local Solution for Tabu Search and placed in Tabu List (Match code database). A value of 0 is Global Min, and is the best Cost value. From Local Solution above, Final Solution is obtained from the results of scheduling Tabu Search in table 2 above as follows:

TABLE II. TABU SEARCH SCHEDULING

jadwal_tabu							
thn_ajaran	hari	kd_matakuliah	id_dosen	semester	kd_ruangan	jam_ke	cons
2017/2018	3	MPB-5320	001	Ganjil	4A	1	3
2017/2018	4	TIF2107	002	Ganjil	1C	1	3
2017/2018	1	BARU0101	004	Ganjil	1C	2	2
2017/2018	1	BARU0102	005	Ganjil	1B	4	2
2017/2018	3	BARU0103	006	Ganjil	2A	3	0

VIII. SCHEDULING USING THE TABU SEARCH ALGORITHM

Tabu search optimization analysis on lecturing scheduling is an iteration calculation based on the number of days and the number of courses is as follows:

Because the number of courses in one period (2011/2012) is approximately 140 courses, it is assumed to simplify the calculation:

Number of days (X) = 5 and Course (Y) = 4

X1 X2 X3 X4 X5
Y1 1616 1680 120 120 2520
Y2 24 24 2520 24 1515
Y3 120 24 2415 120 180
Y4 10 2424 16 180 2415

Need to add Y5 with the cost for each day is 0

X1 X2 X3 X4 X5
Y1 1616 1680 120 120 2520
Y2 24 24 2520 24 15
Y3 120 24 2415 120 180
Y4 10 24 24 16 180 2415
Y5 0 0 0 0 0

Initial assignments 1-2-3-4-5 with Iteration = 5, then obtained:

Initial Assignment =
1 2 3 4 5 = 1616 + 24 + 2415 + 180 + 0 => Total Cost = 4235
Global Min = 4235

1st Iteration:

Taboo List:

1 1 2 3 4 5

Next Alternative Assignment:

1st Iteration

Tabu List :

1 1 2 3 4 5

Penugasan Alternatif berikutnya :

P-1. 1 2 3 4 5 ==> 1616 + 24 + 2415 + 180 + 0 = 4235

P-2. 1 2 3 5 4 ==> 1616 + 24 + 2415 + 2415 + 0 = 6470

P-3. 1 2 4 3 5 ==> 1616 + 24 + 120 + 16 + 0 = 1776

>> Best So Far = 1776

P-4. 1 2 4 5 3 ==> 1616 + 24 + 120 + 2415 + 0 = 4175

P-5. 1 2 5 3 4 ==> 1616 + 24 + 180 + 16 + 0 = 1836

P-6. 1 2 5 4 3 ==> 1616 + 24 + 180 + 180 + 0 = 2000

P-7. 1 3 2 4 5 ==> 1616 + 2520 + 24 + 180 + 0 = 4340

P-8. 1 3 2 5 4 ==> 1616 + 2520 + 24 + 2415 + 0 = 6575

P-9. 1 3 4 2 5 ==> 1616 + 2520 + 120 + 2424 + 0 = 6680

P-10. 1 3 4 5 2 ==> 1616 + 2520 + 120 + 2415 + 0 = 6671

P-11. 1 3 5 2 4 ==> 1616 + 2520 + 180 + 2424 + 0 = 6740

P-12. 1 3 5 4 2 ==> 1616 + 2520 + 180 + 180 + 0 = 4496

P-13. 1 4 2 3 5 ==> 1616 + 2415 + 24 + 16 + 0 = 4071

P-14. 1 4 2 5 3 ==> 1616 + 2415 + 24 + 2415 + 0 = 6470

P-15. 1 4 3 2 5 ==> 1616 + 2415 + 2415 + 2424 + 0 = 8870

P-16. 1 4 3 5 2 ==> 1616 + 2415 + 2415 + 2415 + 0 = 8861

P-17. 1 4 5 2 3 ==> 1616 + 2415 + 180 + 2424 + 0 = 6635

P-18. 1 4 5 3 2 ==> 1616 + 2415 + 180 + 16 + 0 = 4227

P-19. 1 5 2 3 4 ==> 1616 + 15 + 24 + 16 + 0 = 1671

>> Best So Far = 1671

P-20. 1 5 2 4 3 ==> 1616 + 15 + 24 + 180 + 0 = 1835

P-21. 1 5 3 2 4 ==> 1616 + 15 + 2415 + 2424 + 0 = 6470

P-22. 1 5 3 4 2 ==> 1616 + 15 + 2415 + 180 + 0 = 4226

P-23. 1 5 4 2 3 ==> 1616 + 15 + 120 + 2424 + 0 = 4175

P-24. 1 5 4 3 2 ==> 1616 + 15 + 120 + 16 + 0 = 1767

P-25. 2 1 3 4 5 ==> 1680 + 24 + 2415 + 180 + 0 = 4299

P-26. 2 1 3 5 4 ==> 1680 + 24 + 2415 + 2415 + 0 = 6534

P-27. 2 1 4 3 5 ==> 1680 + 24 + 120 + 16 + 0 = 1840

P-28. 2 1 4 5 3 ==> 1680 + 24 + 120 + 2415 + 0 = 4239

P-29. 2 1 5 3 4 ==> 1680 + 24 + 180 + 16 + 0 = 1900

P-30. 2 1 5 4 3 ==> 1680 + 24 + 180 + 180 + 0 = 2064

P-31. 2 3 1 4 5 ==> 1680 + 2520 + 120 + 180 + 0 = 4500
P-32. 2 3 1 5 4 ==> 1680 + 2520 + 120 + 2415 + 0 = 6735
P-33. 2 3 4 1 5 ==> 1680 + 2520 + 120 + 10 + 0 = 4330
P-34. 2 3 4 5 1 ==> 1680 + 2520 + 120 + 2415 + 0 = 6735
P-35. 2 3 5 1 4 ==> 1680 + 2520 + 180 + 10 + 0 = 4390
P-36. 2 3 5 4 1 ==> 1680 + 2520 + 180 + 180 + 0 = 4560
P-37. 2 4 1 3 5 ==> 1680 + 2415 + 120 + 16 + 0 = 4231
P-38. 2 4 1 5 3 ==> 1680 + 2415 + 120 + 2415 + 0 = 6630
P-39. 2 4 3 1 5 ==> 1680 + 2415 + 2415 + 10 + 0 = 6520
P-40. 2 4 3 5 1 ==> 1680 + 2415 + 2415 + 2415 + 0 = 8925
P-41. 2 4 5 1 3 ==> 1680 + 2415 + 180 + 10 + 0 = 4285
P-42. 2 4 5 3 1 ==> 1680 + 2415 + 180 + 16 + 0 = 4291
P-43. 2 5 1 3 4 ==> 1680 + 15 + 120 + 16 + 0 = 1831
P-44. 2 5 1 4 3 ==> 1680 + 15 + 120 + 180 + 0 = 1995
P-45. 2 5 3 1 4 ==> 1680 + 15 + 2415 + 10 + 0 = 4120
P-46. 2 5 3 4 1 ==> 1680 + 15 + 2415 + 180 + 0 = 4290
P-47. 2 5 4 1 3 ==> 1680 + 15 + 120 + 10 + 0 = 1825
P-48. 2 5 4 3 1 ==> 1680 + 15 + 120 + 16 + 0 = 1831
P-49. 3 1 2 4 5 ==> 120 + 24 + 24 + 180 + 0 = 348
>> Best So Far = 348
P-50. 3 1 2 5 4 ==> 120 + 24 + 24 + 2415 + 0 = 2583
P-51. 3 1 4 2 5 ==> 120 + 24 + 120 + 2424 + 0 = 2688
P-52. 3 1 4 5 2 ==> 120 + 24 + 120 + 2415 + 0 = 2679
P-53. 3 1 5 2 4 ==> 120 + 24 + 180 + 2424 + 0 = 2748
P-54. 3 1 5 4 2 ==> 120 + 24 + 180 + 180 + 0 = 504
P-55. 3 2 1 4 5 ==> 120 + 24 + 120 + 180 + 0 = 444
P-56. 3 2 1 5 4 ==> 120 + 24 + 120 + 2415 + 0 = 2679
P-57. 3 2 4 1 5 ==> 120 + 24 + 120 + 10 + 0 = 274
>> Best So Far =274
P-58. 3 2 4 5 1 ==> 120 + 24 + 120 + 2415 + 0 = 2679
P-59. 3 2 5 1 4 ==> 120 + 24 + 180 + 10 + 0 = 334
P-60. 3 2 5 4 1 ==> 120 + 24 + 180 + 180 + 0 = 504
P-61. 3 4 1 2 5 ==> 120 + 2415 + 120 + 2424 + 0 = 5079
P-62. 3 4 1 5 2 ==> 120 + 2415 + 120 + 2415 + 0 = 5070
P-63. 3 4 2 1 5 ==> 120 + 2415 + 24 + 10 + 0 = 2569
P-64. 3 4 2 5 1 ==> 120 + 2415 + 24 + 2415 + 0 = 4974
P-65. 3 4 5 1 2 ==> 120 + 2415 + 180 + 10 + 0 = 2725
P-66. 3 4 5 2 1 ==> 120 + 2415 + 180 + 2424 + 0 = 5139
P-67. 3 5 1 2 4 ==> 120 + 15 + 120 + 2424 + 0 = 2679
P-68. 3 5 1 4 2 ==> 120 + 15 + 120 + 180 + 0 = 435
P-69. 3 5 2 1 4 ==> 120 + 15 + 24 + 10 + 0 = 169
>> Best So Far =169
P-70. 3 5 2 4 1 ==> 120 + 15 + 24 + 180 + 0 = 339
P-71. 3 5 4 1 2 ==> 120 + 15 + 120 + 10 + 0 = 265
P-72. 3 5 4 2 1 ==> 120 + 15 + 120 + 2424 + 0 = 2679
P-73. 4 1 2 3 5 ==> 120 + 24 + 24 + 16 + 0 = 184
P-74. 4 1 2 5 3 ==> 120 + 24 + 24 + 2415 + 0 = 2583
P-75. 4 1 3 2 5 ==> 120 + 24 + 2415 + 2424 + 0 = 4983
P-76. 4 1 3 5 2 ==> 120 + 24 + 2415 + 2415 + 0 = 4974
P-77. 4 1 5 2 3 ==> 120 + 24 + 180 + 2424 + 0 = 2748
P-78. 4 1 5 3 2 ==> 120 + 24 + 180 + 16 + 0 = 340
P-79. 4 2 1 3 5 ==> 120 + 24 + 120 + 16 + 0 = 280
P-80. 4 2 1 5 3 ==> 120 + 24 + 120 + 2415 + 0 = 2679
P-81. 4 2 3 1 5 ==> 120 + 24 + 2415 + 10 + 0 = 2569
P-82. 4 2 3 5 1 ==> 120 + 24 + 2415 + 2415 + 0 = 4974
P-83. 4 2 5 1 3 ==> 120 + 24 + 180 + 10 + 0 = 334
P-84. 4 2 5 3 1 ==> 120 + 24 + 180 + 16 + 0 = 340
P-85. 4 3 1 2 5 ==> 120 + 2520 + 120 + 2424 + 0 = 5184
P-86. 4 3 1 5 2 ==> 120 + 2520 + 120 + 2415 + 0 = 5175
P-87. 4 3 2 1 5 ==> 120 + 2520 + 24 + 10 + 0 = 2674
P-88. 4 3 2 5 1 ==> 120 + 2520 + 24 + 2415 + 0 = 5079

P-89. 4 3 5 1 2 ==> 120 + 2520 + 180 + 10 + 0 = 2830
P-90. 4 3 5 2 1 ==> 120 + 2520 + 180 + 2424 + 0 = 5244
P-91. 4 5 1 2 3 ==> 120 + 15 + 120 + 2424 + 0 = 2679
P-92. 4 5 1 3 2 ==> 120 + 15 + 120 + 16 + 0 = 271
P-93. 4 5 2 1 3 ==> 120 + 15 + 24 + 10 + 0 = 169 --> Best So Far
P-94. 4 5 2 3 1 ==> 120 + 15 + 24 + 16 + 0 = 175
P-95. 4 5 3 1 2 ==> 120 + 15 + 2415 + 10 + 0 = 2560
P-96. 4 5 3 2 1 ==> 120 + 15 + 2415 + 2424 + 0 = 4974
P-97. 5 1 2 3 4 ==> 2520 + 24 + 24 + 16 + 0 = 2584
P-98. 5 1 2 4 3 ==> 2520 + 24 + 24 + 180 + 0 = 2748
P-99. 5 1 3 2 4 ==> 2520 + 24 + 2415 + 2424 + 0 = 7383
P-100. 5 1 3 4 2 ==> 2520 + 24 + 2415 + 180 + 0 = 5139
a.
P-101. 5 1 4 2 3 ==> 2520 + 24 + 120 + 2424 + 0 = 5088
P-102. 5 1 4 3 2 ==> 2520 + 24 + 120 + 16 + 0 = 2680
P-103. 5 2 1 3 4 ==> 2520 + 24 + 120 + 16 + 0 = 2680
P-104. 5 2 1 4 3 ==> 2520 + 24 + 120 + 180 + 0 = 2844
P-105. 5 2 3 1 4 ==> 2520 + 24 + 2415 + 10 + 0 = 4969
P-106. 5 2 3 4 1 ==> 2520 + 24 + 2415 + 180 + 0 = 5139
P-107. 5 2 4 1 3 ==> 2520 + 24 + 120 + 10 + 0 = 2674
P-108. 5 2 4 3 1 ==> 2520 + 24 + 120 + 16 + 0 = 2680
P-109. 5 3 1 2 4 ==> 2520 + 2520 + 120 + 2424 + 0 = 7584
P-110. 5 3 1 4 2 ==> 2520 + 2520 + 120 + 180 + 0 = 5340
P-111. 5 3 2 1 4 ==> 2520 + 2520 + 24 + 10 + 0 = 5074
P-112. 5 3 2 4 1 ==> 2520 + 2520 + 24 + 180 + 0 = 5244
P-113. 5 3 4 1 2 ==> 2520 + 2520 + 120 + 10 + 0 = 5170
P-114. 5 3 4 2 1 ==> 2520 + 2520 + 120 + 2424 + 0 = 7584
P-115. 5 4 1 2 3 ==> 2520 + 2415 + 120 + 2424 + 0 = 7479
P-116. 5 4 1 3 2 ==> 2520 + 2415 + 120 + 16 + 0 = 5071
P-117. 5 4 2 1 3 ==> 2520 + 2415 + 24 + 10 + 0 = 4969
P-118. 5 4 2 3 1 ==> 2520 + 2415 + 24 + 16 + 0 = 4975
P-119. 5 4 3 1 2 ==> 2520 + 2415 + 2415 + 10 + 0 = 7360
P-120. 5 4 3 2 1 ==> 2520 + 2415 + 2415 + 2424 + 0 = 9774
>> >> Best So Far = 169,
at the 69th assignment, Received

TABLE III. MATRIX COST

	X1	X2	X3	X4	X5
Y1	120	2520	1680	1616	120
Y2	2520	1524	24	24	15
Y3	2415	180	24	120	120
Y4	16	2415	2424	10	180
Y5	0	0	0	0	0

And so on until the 5th Iteration (the process until the 5th iteration is in the attachment section). From the Iteration process to 5th iteration, the final results are obtained as follows:

- Best assignment = 3 5 2 1 4
- Total Cost = 169 Information:

A value of 9999999 = is the value given to an assignment that has the same value, so as not to take the same smallest value.

From the above calculation, tabu search algorithm can be analyzed in the scheduling process. The matching process is a taboo list of several data inputs namely Lecturer Data, Subject Data and Room Data which are local solutions compared to neighbor solutions. This algorithm uses class and subject relations as variables and uses lecturers, subjects, time, and space as values that will be included in the existing variables. Every step taken by Tabu Search is taken based on the results

of the cost calculation carried out in each iteration to select a neighbor solution which will be the next current best solution. Termination of the process occurs if the number of scheduled classes has met the requirements or interaction of the user requires the termination of the process.

IX. CONCLUSION

- Lecture scheduling application using Tabu Search method is designed using Microsoft Visual Basic programming by entering several parameters namely Data Lecturer, Course, Room, and several variables from each parameter which are then processed so as to produce lecture scheduling. In Tabu Search, parameters of Course Data, Lecturer, and Room are local searches that are entered in the matching process (taboo list) first which then results in the schedule output of the course.
- Violations of the constraints on the Tabu Search Method method are violations of 8 and the time used to obtain a schedule with a 90% truth level is tabu search where the process is faster, and the best results from the iteration process (Global min).

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