SMART TIMETABLING USING SIMULATED ANNEALING ALGORITHM

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ABSTRAK

Timetabling at a university or college, is very important for the sustainability of lectures in each semester. To resolve the scheduling problems, need a scheduling optimization algorithms. This research used a simulated annealing algorithm (SA). All required data will be inputed to the application required and will be processed.

Based on the problems that have been described, the proposed solution is to create an smart timetabling system that is able to make a schedule of courses with Simulated Annealing algorithm to avoid violations of hard constraints and soft constraint. The data used in this research is dataset from IF UNIKOM. Experiments performed is to see how fast this algorithm in solving the scheduling courses problem.

The results obtained from the experiments is a schedule of courses in one semester with no violations of the hard constraints and soft constraints are applied. Based on the experiment, it can be concluded that the Simulated Annealing algorithm can solve timetabling problem without create new solution process, although the final result is not optimize 100%, and create first solution with random process could effect the duration to search the solution.

Kata kunci : course timetabling, simulated annealing algorithm, smart timetabling.

1. PENDAHULUAN

Scheduling courses at a university or college is very important for the sustainability of lectures in each semester. This is one of the problems faced by each university and college today. Scheduling subjects are things that need to be taken into account well considering the number of conditions that must be met such as the number of courses, the limited number of faculty, limited time / day and limited classroom teaching [1]. Of the many problems and constraints that exist, we can conclude there must be no lecturers, class or room that appeared at the same time [2].

To resolve scheduling problems, we need a scheduling optimization algorithms. This study used an algorithm Simulated Annealing (SA) because of the results of a study comparing the Genetic Algorithm and Simulated Annealing in scheduling flow shop, in terms of performance and processing time by the criteria of minimizing makespan and total flowtime, shows the simulation results Simulated Annealing superior than Genetic algorithm up to 90%. Genetic Algorithms only excel within a single process but the trend is believed to be a process that is formed on the problem with a combination of a lot of jobs and machines, Simulated Annealing algorithm can be faster than the Genetic Algorithm [5]. Simulated Annealing is developed based on the idea of behavioral mechanisms of cooling and crystallization process (annealing) of hot material. These algorithms make improvements to iteratively improve the resulting solution techniques of scheduling heuristics, in this case is an initial solution made with heuristic techniques, or random, iterated repeatedly by the method of annealing using local perturbation until no improvement or until the number of iterations desired has been reached [5].

Another study using the algorithm Simulated Annealing in determining the sequence of production scheduling to say that the algorithm Simulated Annealing yielded significant results than the method of brute force and FIFO (First In First Out), premises conclusion that the long process of SA longer compared to FIFO, but makespan produced shorter and shorter processing time SA of Brute Force but makespan produced the same 100% [6].

Based on the problems and the limitations of the expectation of this research is the creation of a smart timetabling system that is able to generate a schedule of lectures were spared from constraint-constraint so that lectures can take place every semester.

2. RESEARCH CONTENTS

2.1 Definition Timetabling

Scheduling with regard to all activities to create a schedule. In the Collins Concise Dictionary (4th Edition) states that the schedule is a table arrangement activities based on time and place. This activity is usually a meeting between several parties at the same time and place. The schedule should meet several requirements and fulfill the wishes of all parties involved as possible. Time of activity should be structured in such a way that no one else component has more than one activity at the same time [7].

Course timetabling is planning learning settings which include courses, lecturers, time and room availability. In general, scheduling of teaching and learning activities are presented in a table the day of the week which consists of the time slot is comprised of subjects, days, hours, and according to the instructor who taught subjects [8].

2.2 Limitations in Scheduling

In scheduling problems have several kinds of restrictions that may cause the resulting output to be one. In applying the limits in a problem, it is usually not too similar to each issue [8]. The limit consists of:

1. Edge Constraint

Edge constraint are restrictions governing the two events may not occupy the same time slot. For example, on Monday at 07:30 until 08:10 A teacher may not teach in the classroom 1A and 5A teaching in the classroom.

2. Ordering Constraint

Ordering constraint is a restriction that keeps the sequence of events in the timetable. Examples of subjects A must be done before the subjects B.Usually limitation problem is rarely used because it can cause scheduling becomes more complicated.

3. Event-spread constraint

Event—spread constraint are restrictions governing the spread of the incident on a timetable. The example in undergoing the exam, a student is allowed max 3 subjects tested within 1 day.

4. Presents pecification and exclusion

Present specification and exclusion is to determine in advance the time slot to be used by an event before the process of finding solutions do. Examples of religious subjects combined with a class 1-A and 1-B will be determined the same time for both classes so as not bothered to draw up other subjects.

5. Capacity constraints

Capacity constraints are the constraints related to the capacity of the room. For each class can only be filled by 40 students.

6. Hard and soft constraints

Hard constraints are boundaries that should never be violated, while the soft constraint is a restriction sought as much as possible not to be violated but, if broken, it is still acceptable.

2.3 Definition of Artificial Intelligence

Artificial intelligence is one part of computer science that make the machine (computer) can do the job and is as good as done by humans. At the beginning of creation, the computer only used as calculators alone. But along with the times, the role of computers increasingly dominate the life of mankind. Computer no longer just used as a tool to count, more than that computers are expected to be empowered to do everything that can be done human.

Understanding artificial intelligence can be viewed from various perspectives, among others:

a. Viewpoint intelligence

Artificial intelligence will make a machine to be intelligent (able to do what was done by humans)

b. Research Standpoint

Artificial intelligenceis the study of how to make so that the computer can do something as good as done by humans

c. Business Standpoint

Artificial intelligenceis a very powerful set of tools and methodological in solving business problems.

d. Programming Standpoint

Artificial intelligenceencompasses the study of symbolic programming, problem solving (problem solving) and search (searching).

2.4 *Simulated Annealing*

Simulated Annealing is one of the algorithms for optimization to be generic. Gelett introduced by Kirkpatrick and Vechi (1983) and Cerny (1985). This algorithm is based on probability and statistical mechanics to find a global optimum approach to the solution of a problem.

Simulated Annealing is developed based on the idea of behavioral mechanisms of cooling and crystallization process (annealing) of hot material. These algorithms make improvements to iteratively improve the resulting solution techniques of scheduling heuristics, in this case is an initial solution made with heuristic techniques, or random, iterated repeatedly by the method of annealing using perturbation locally until no improvement or until the number of iterations desired has been reached [5]. Simulated Annealing is one of the algorithms - the best algorithm currently in virtually all of the optimization problem solving. With a little modification, Simulated Annealing will work very well in all optimization problems [6].

2.5 Algoritma *Simulated Annealing*

Simulated Annealing algorithm structure in general are as follows [12]:

1. Pilih solusi awal *Sol* secara acak.
2. Pembobotan *E=f(Sol).*
3. Bangkitkan solusi baru *Solnew*
4. Hitung Bobot = *f(Solnew).*
5. Jika *f(solnew)* > *f(Sol)* maka *Sol* = Solnew dan *E = Enew.*
6. Berhenti jika telah mencapai kriteria pemberhentian, jika tidak kembali ke langkah 3.

In this research, step 2 is taken from the value of the weighting derived from constraint-constraint checking. Modification of research carried out at the stage of 3-7, which is to Solnew is a solution that has a poor weighting value (step 3), so it will be weighted again (steps 4 & 5). If there is still a bad meal solutions randomization solution between good and bad solutions, this is done to increase the obtained solution.

2.6 Problem Analysis

Problem analysis can be defined an overview of the issues raised in the writing of scheduling optimization usingalgorithm. *Simulated Annealing*College scheduling problem is a complex issue because of the various components consisting of courses, faculty, classrooms, and lecture activities with time to see the dataset also limits where the professor teaching schedule and mechanisms used dataset refers to scheduling at the IF Prodi UNIKOM. Where such restrictions should not be infringed or called *hard constraint.* There are also restrictions that may be violated or so-called *soft constraint.*

2.7 Analysis Data Input

Data input will be analyzed here based on data from Prodi IF WELCOME. Data relating to the schedule are:

1. Data Subjects

Data subjects are taken courses in the second semester of the 2015/2016 academic year

2. Lecturer Data

Data taken lecturers are lecturers who teach the courses the second semester of the 2015/2016 academic year.

3. Data Room
4. Data Subjects Lecturer

Lecturer courses are courses taught by each faculty.

2.8 Timetabling Rules

To obtain an optimal schedule of the courses required restrictions or rules in scheduling. If all the rules set can be met, then the scheduling of courses can be said to be optimal. Here are the limits(hardconstraints and softconstraints)to be applied in making scheduling:

a) Hard constraint in the scheduling department of the Digital IF is as follows:

i. Clashes room and teaching time, when the hours, days or rooms filled in the same time.

ii. Clashes lecturer, when professors teach at the same hour, the same day or the same faculty.

iii. Clashed with a time of Friday prayers.

iv. Conflicting desires time lecturers.

b) Soft constraint (soft limit) in the scheduling department of the Digital IF is as follows:

1. The lecturer who has a limited time to teach lectures

Implementation of these restrictions can be done by providing a specific value for each weight limits can not be met.

2.9 System Design

System design is required for the purposes of iden-fying and problem analysis. The design of the existing system will be used as a reference in the manufacture of the system to fit the needs. Model pe-design of the system used in
this study are:

1. Context Diagram (DFD Level 0)
Context diagram is used to describe the first system in outline. Diagram context is also a data flow diagram*(dataflow diagram(DFD))*at the top level (top level).

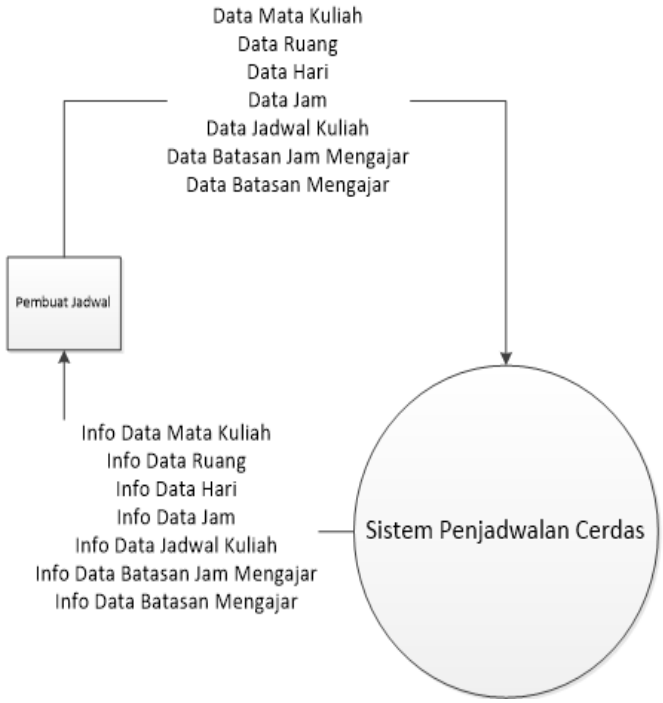


Figure 1. Context Diagram

2. *Entity Relationship Diagram(ERD)*

Analysis is an analysis of data base collection of interrelated data and stored in a particular storage media without repetition (redundancy). The data obtained will be used to design the database along with the attributes of each entity and the relationships between these entities. In designing a database, data model that will be used is the Entity Relationship Diagram (ERD).

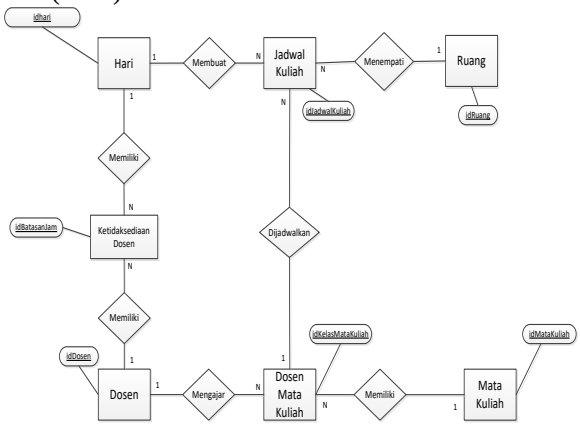


Figure 2. ERD

3. *DFD level 1*

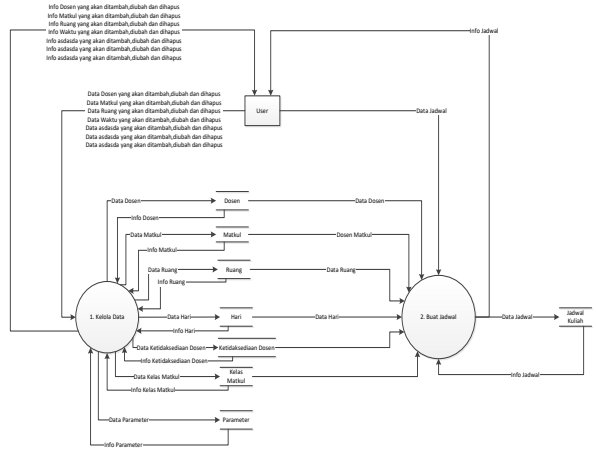


Figure 3. DFD Level 1

2.10 Simulated Annealing Algorithm Analysis

Simulated Annealing Process Stages contained in Figure 4.

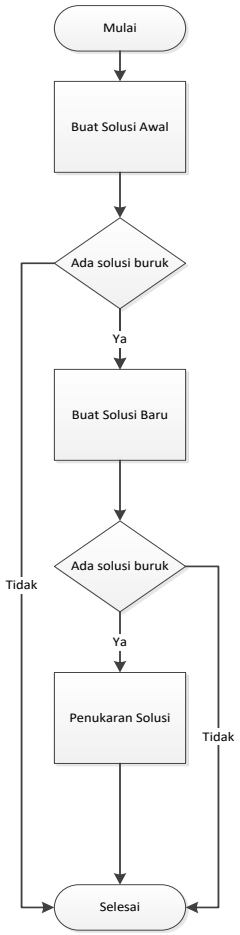


Figure 4. Simulated Annealing Algorithm Process

2.10.1 Create Initial Solution

In setting the initial schedule will be generating a schedule consisting of Lecturer, Subjects, Hours Day and space. The sequence of the process in Figure 5:

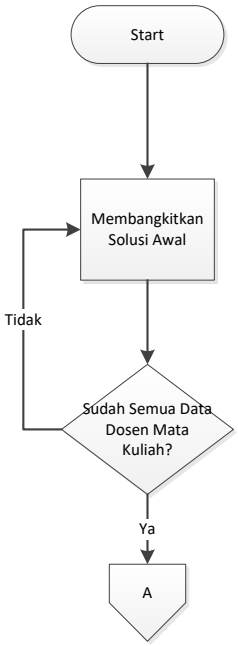


Figure 5. Proses Membuat Solusi Awal

For initial soulution can be seen in Table 1.

Nomor	Kode_MK	Kode_dosen	Nama_kelas	Hari	Ruang	Jam Mulai	Jam Selesai
1	1	1	B.IND-1	1	R610	07:00:00	08:30:00
2	1	1	B.IND-2	1	R2505	07:00:00	08:30:00
3	1	1	B.IND-3	2	R610	08:30:00	10:00:00
4	1	1	B.IND-4	3	R5404	10:00:00	11:30:00
…	…	…	…	…	…	..	..
325	25	74	KSI-K	2	R5305	13:00:00	15:15:00

Table 1. Initial Solution Sample

2.10.2 Check Constraint and Weighting

A schedule is said to be not optimal if there are violations. Violations were found from the weight constraint applied (Hard and Soft Constraint Constraint). Each violation will eat rated with weight +1. The formula for determining the weights are as follows:

Total Bobot=Bobot 1 + Bobot 2 + Bobot 3 + Bobot 4

2.10.3 Menetapkan Temperatur Awal, Nilai Reduksi Suhu dan Jumlah Iterasi

Before the process of finding a solution, three components must be determined beforehand. Here will be determined as follows:

a. Initial temperature adjusted to a lot of the lecturer will be scheduled, in this case as many as 325 (as a lecturer).
b. The temperature reduction value is more space available in this case are 19 rooms, so every room is full of so many of the rooms will be reduced to the room or the subjects already elected all.
c. The number of iterations = 1.

2.10.4 Create New Solution

In Simulated Annealing if the initial schedule had an optimal schedule (no violations) then used the initial schedule, so no need to search the new schedule. If not, it will do a search with the new schedule search of neighborhood structures. So, if the schedule is in violation of Monday, the meal will be sought neighbors are Tuesday, Wednesday, and so on. Solutions with the smallest weights will be swapped position with greater weight. For the process of making the new solution can be seen in Figure 6.



Figure 6. New Solution Process

For new solution sample can be seen in Table 2.

Nomor	Kode_MK	Kode_dosen	Nama_kelas	Hari	Ruang	Jam Mulai	Jam Selesai
1	1	1	B.IND-1	1	R610	07:00:00	08:30:00
2	1	1	B.IND-2	1	R2505	07:00:00	08:30:00
3	1	1	B.IND-3	2	R610	08:30:00	10:00:00
4	1	1	B.IND-4	3	R5404	10:00:00	11:30:00
…	…	…	…	…	…	..	..
325	25	74	KSI-K	2	R5305	13:00:00	15:15:00

Table 2. New Solution Sample

2.11 Implementation of Supporting Tool

Hardware specifications that are used to build this application is as follows:

1. *Processor 3.00 (4 CPUs)* GHz.
2. 4 GB RAM.
3. Screen with a resolution of 1366 x 768 pixels.
4. *Keyboard.*
5. *Mouse.*

2.12 Implementation of Supporting Tool

Software Specification used to build this application is as follows:

1. Operating system Windows 7 Ultimate 32 Bit.
2. The programming language C #.
3. DBMS MySQL 5.5.

2.13 Relation Scheme

Relationschema is used to describe the relation of each table in the database to be designed.

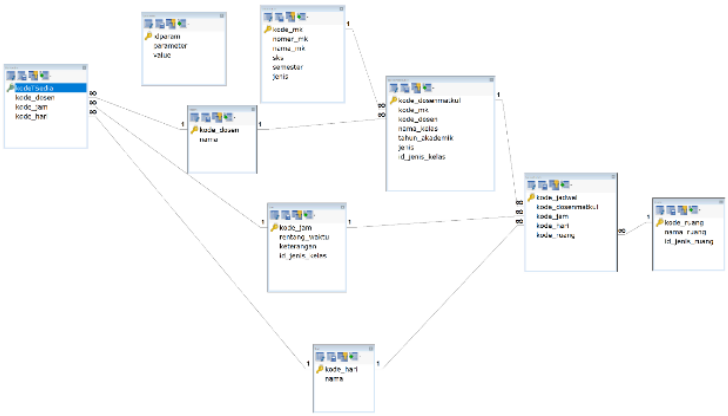


Figure 7. Relation Scheme

2.14 Struture Menu Design

Architectural design is the relationship between the major structural elements of the program. The design architecture can provide a picture of the structure of the program.



Figure 8. Struture Menu

2.15 Testing Results

Algorithm used in the manufacture of this timetabling program is Simulated annealing Algorithm.

The working principle of simulated annealing algorithm is as follows:

1. First is the process of entering the dataset that will be in the process, such as data lecturers, courses, rooms, lot of time, time availability of lecturers. After all the data is entered, the system can make a schedule.
2. The second is a process of simulated annealing algorithm.
   a. The first step is to generate the initial solution by taking the data lecturer, space, day and time, and is calculated and compared to its weight.
   b. A process performed until all data is scheduled.
   c. After raising the Home Solutions, if there is a constraint that is violated then continued to manufacture New Solution but if all constraints are violated, there is no process is complete
   d. c process repeated until all of the courses are given weight.
   e. If there is still no solution will be sorted then exchange solutions by taking a good solution and a bad solution at random and checking constraintnya, this is done until there are no more bad solution.
3. The third is the result of the processing of algorithm. *simulated annealing*

2.15.1 Testing Simulated Annealing Algorithm

Algorithm testing conducted to observe how quickly the simulated annealing algorithm to create a schedule with a predetermined constraint. Results of the test can be seen in Table 3

Percobaan	**Waktu yang dibutuhkan (detik)**
1	10
2	8
3	11
4	9
5	14
Presentasi tingkat keberhasilan tiap pengujian	**60%**
Kecepatan Proses Rata-rata	00:00:10

Table 3 Testing Results

2.16 Testing Conclusion

Based on the results testing shown in table 3 it can be concluded even though the data tested in the same, but have different completion time variation. This is because the data retrieval process is done randomly.

3. PENUTUP

Based on the results obtained in this research, obtained information the use of simulated annealing algorithm can solve the problem of scheduling without having to go into the stage of creation of new solutions, even though the result is not 100% optimal. The process of making the initial solution is carried out random can affect in the length of the algorithms in the search for solutions.

Based on the results of the research that has been done, still need to do some further study. As for suggestions for further research that is changing the initial solution search algorithms can be defined by means of its own so that the results obtained can be up to 100%.

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