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Hybridization of Genetic Algorithm and Tabu Search in the Lecture Scheduling System (Case Study: Universitas Teknokrat Indonesia)

Fenty Ariany, Irman Hermadi, Agus Buono

Abstract— Scheduling lecture courses in any educational institution is a very complex problem, which involves many entities in preparing the lecture schedule. The Genetic Algorithm and Tabu Search can assist in the preparation of lecture schedules, specifically the lecture schedule at the Universitas Teknokrat Indonesia. Universitas Teknokrat Indonesia has 3 faculties, which are the Faculty of Engineering and Computer Science, Faculty of Literature and Education, and Faculty of Economics and Business. The case study of this research focuses on Information Systems and Informatics Engineering departments. In this research, the author aim was to improve the previous researches in scheduling problem by combining two algorithms in scheduling lecture by reducing the domain of search and determining tabu values according to the case in Universitas Teknokrat Indonesia. The experiment has been carried out using combination data of 3.753.552 on which the total slot in 1 population as 303 data. The result is the fitness value of 0.022 can be found in 1 individual with the crossover probability value is 90% and the mutation probability value was 0.2, and the total iterations were 100.

Index Terms— Crossover probability, fitness, genetic algorithm, mutation probability, scheduling, tabu search.

1 INTRODUCTION

Genetic Algorithm and Tabu Search is a Metaheuristic algorithm that does not depend on the type of problem (Kazarlis 2005), from the results of the experiments conducted, the results show that all metaheuristic methods can produce a very good solution compared to manual allocation. Settlement of scheduling problems using the Genetic Algorithm has been used since 1990 (Colorni 1992).

Genetic Algorithm was first founded by John Holland (Ahmad Basuki, 2003), this algorithm works with a population consisting of individuals, each of it presents a solution. If the Genetic Algorithm is well designed, then the population will experience convergence and get an optimum solution.

Tabu Search can produce an optimum solution. According to Glover (2002), there are three primary schemes in Tabu Search. The first scheme is the used of memory structure based on flexible attributes that were designed to allow evaluation criteria and past search result to be exploited further. The second scheme is the used of mechanism or conditions that can limit or free up an ongoing search process. This second scheme is known as tabu restriction and aspiration criteria mechanism, and the third scheme is the involvement of a memory function with a different time span in the form of short-term memory and long-term memory to carry out intensification and diversification strategies in the process of finding solutions.

Intensification strategy is a search strategy that directs or focuses searches in a particular area, while diversification strategy is a search strategy that directs searches in a new area (Michela Gendreau, 2010). This scheme differentiates tabu search with other applications (Glover, 1997), where optimization method that was used based on the local search where the search process moves from one solution to the next solution by choosing the best solution in the current environment (Glover 2002).

The combination of the genetic algorithm with the tabu search will produce a very optimal lecture scheduling. An optimal lecture scheduling certainly involves several factors, among them, are lecturers/teachers. The presence of the team teaching in the learning process will certainly produce a good scheduling system, where the system formed not only considers classrooms, lecture hours, and lecturers but also considers team teaching, so that when it occurs in lecturers scheduling who have been determined to be unable to attend, the team teaching can replace other lecturers who are unable to attend (Hasibuan et al 2014).

There are several past researchers that discuss the combination of genetic algorithm and tabu search. Kanoh and Sakamoto (2008) finished course timetabling by using the combination of local search and genetic algorithm to find an optimal solution in fulfilling soft constraints. Zhang et al (2013) finished a dynamic job shop scheduling problem with random job arrivals, Meeran, S., and M.S. Morshed (2012) the proposed model has been applied to a combination of a shop scheduling problem in real life without modification, Aldy Gunawan (2004) finished lecture scheduling problem using three metaheuristic method, namely: simulated annealing (SA), tabu search (TS), and genetic algorithm (GA). From the experiments conducted, the result shows that the performance of the TS algorithm is much better than the SA and GA algorithms in the quality

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limit of the resulting solution, and the SA algorithm has a faster computation time rather than the TS and GA algorithms. Merging two algorithms in an optimization system produce more optimal results (Fernando, 2016).

The above researches are used as references to conduct further research on the combination of the two algorithms, namely the genetic algorithm with the tabu search on the lecture scheduling system at Universitas Teknokrat Indonesia.

The magnitude of the complexity that exists in Universitas Teknokrat Indonesia in making scheduling is an existing problem. Where with 299 classes and 42 classrooms and 40 lecturers who were able to teach in the current semester, and there were 54 courses in one semester, resulting in a very large number of schedule combinations namely 3,179,520 schedule combinations that might occur in the odd semester of the academic year of 2015-2016.

The magnitude of the current combinations in making scheduling often experiences a problem that is certainly disturbing in the lecture process. Among the examples is where one lecturer teaches in two courses at the same hour and day, or the opposite occurs and the use of classroom that exceeds capacity and many more problems that arise in the process of making this scheduling. Therefore, the researcher aims to make the lecture schedule using method that is combined by two algorithms, namely genetic algorithm, and tabu search so that there are no problems as above.

2 Research Method

The stages that will be conducted in this research showed in Figure 1 as below.

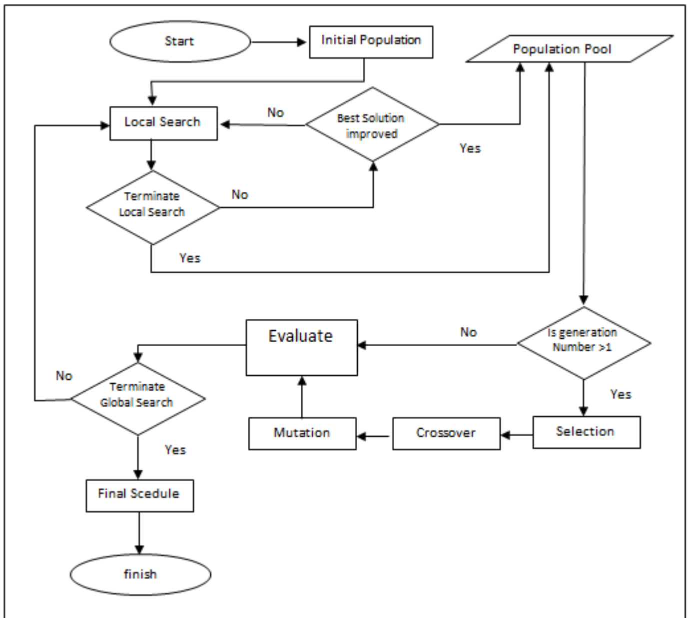

Figure 1 Research Method.

2.1 Chromosome Initialization

The initialization is done to generate a random set of a new solution consisting of a number of chromosomes. Where the size of a population is determined by the number of individuals or chromosomes that are accommodated in the population. The chromosome design presented in Figure 2 below.

MKDsn	HR	WK	R

Figure 2 The Chromosome Design.

with :
MKDsn = Courses and Lecturers
HR = Day
WK = Time
R = Room

The Tabu Search process is as follows

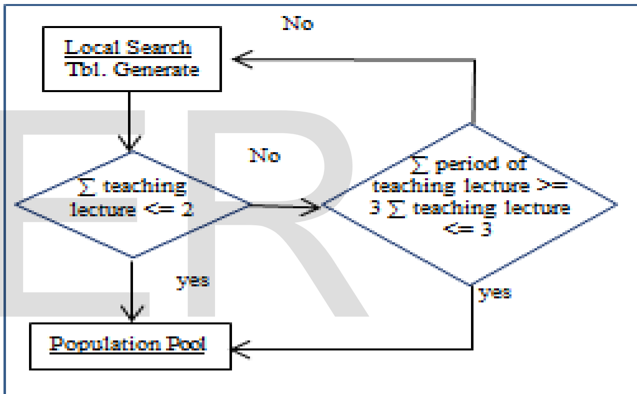

Figure 3 Tabu Search Proses.

The tabu list value is the number of lecturer courses in 1 week is 2 types of subjects and the aspirations criteria are lecturer can teach more than 2 subjects if the number of lecturers teaches more or equal to 3 years.

2.2 Selection

The selection process used in this research is using a roulette wheel method or commonly referred to as stochastic sampling with replacement. Where this method mimics the roulette-wheel game, where each chromosome occupies a circle piece on roulette-wheel according to its fitness value. Chromosomes that have a greater fitness value will occupy a larger circle compared to chromosomes with low fitness values.

The stages carried out during selection using the roulette wheel method are as follows:

a. Calculates the fitness value (fk) of each individual.
b. Calculates the probability of selection values (pk) of each individual where

$$Pk = \frac{fk}{\sum fk} \quad \text{.......................................} (1)$$

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c. Randomize a number [0,1]
d. Choose individuals where that random numbers are as parents
e. Do steps d and e as many as the number of individuals in the population.

2.3 Fitness Value Calculating Process

At this stage, random sampling is carried out as much as n, then proceed with finding fitness value on each individuals using equation (1),

$$F = \frac{1}{1+(\sum bk + \sum br + \sum mk + \sum dsn)} \quad \text{.......................................(2)}$$

Where:

bk = the number of class clashes occurred (the same class, day, hour)

br = the number of room clashes occurred (the same room, day, hour)

mk = the number of subject clashes occurred (the same subject, lecturer, day)

dsn = the number of lecturers teach subject > 12 x in a week

2.4 Crossover Process

The crossover process uses the one point method, where not all individuals do a crossover. This is due to the selection of individuals based on crossover probabilities, the crossover process illustration is shown in Figure 4. It is the individual with the best fitness value will do the crossover.

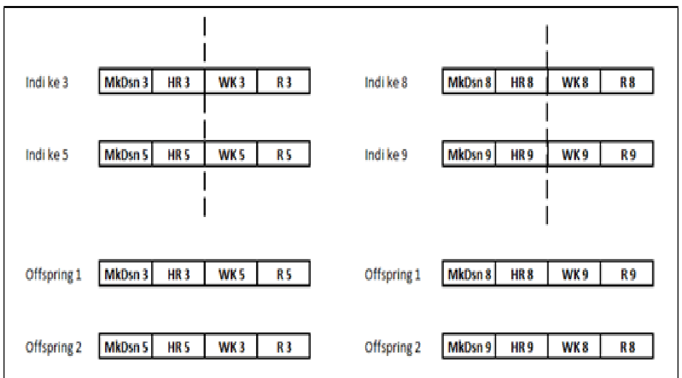


Figure 4 The Illustration of Crossover.

The crossover process flowchart is presented in Figure 5.

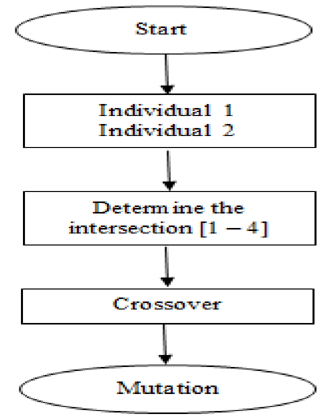


Figure 5 Crossover Process.

2.5 Mutation Process

The mutation process is carried out to produce a valid chromosome so that the mutation process carried out in a certain way that can produce chromosome from mutation process is carried out by :

a. Search for the value of the number of genes that mutated using formula. The Number of Mutation Genes (x) = (∑column * ∑line) * PM .... (3)
Where PM is the desired Probability of Mutation
b. Gene swap process is carried out by randomized the column length on chromosomes
c. Random results in gene swap using n - 1

2.6 Evaluation Process

The value generated by the fitness function represents the number of requirements that are violates so that in the case of lecture scheduling the smaller the number of violations producs, the better the solution will be. In the optimization problem, the solution sought is maximizing the h function (known as the maximization problem) so that the fitness value used is the value of the h function, which is f = h (f is fitness). But if the problem is to minimize yhe h function, then the h function , then the h function can't be directly used. This is due to the rules that individuals who have high fitness value are said to be better able to survive in the next generation. Therefore the fitness value that can be used is f = 1/h, where the smaller the h value, the greater the f value, this will be a problem if h is worth 0, which causes f to has infinite value. So to overcome this, h needs to add a number that is considered small [0....1] so that the fitness value becomes :

$$f = \frac{1}{(h + a)} \quad \text{.. (4)}$$

Where a is a small number between [0...1] according to the problem to be solved. In this scheduling case, the smaller the number of violations produced, the better the solution will be. If a violation occurs, then it will be given a value of 1. To avoid an infinite fitness value, the total number of all violations are added to 1.

2.7 Termination Condition

Iteration is carried out continuously until the termination condition is reached. Some criteria can be used for the termination process as follows:

a. The iteration stops until n generation. The n value is determined previously based on several past experiments, the higher the problem size and complexity, the greater the n value. Then n value is determined so that the population convergence is reached and it will be difficult to obtain a better solution after n iterations(Yogeswara et al 2009)
b. The iteration stops after n successive generations not finding a better solution (Mahmudy et al 2012b)
c. The iteration stips after time unit is reached(Mahmudy 2013)

3 Results and Discussion

3.1 Research Data

The data used in this study are lecture scheduling data of 2015 – 2016 academic year in the odd semester in the Faculty of Engineering and Computer Science in the Informatic Engineering and Information System study programs.

3.2 Research Stages

This study began with population initialization, where the population consisted of several entities, tbl_dosen, tbl_matakuliah, tbl_pengampu, tbl_kesanggupan mengajar, tbl_jam, tbl_kelas, tbl_hari, tbl_ruang, tbl_input_kelas entities. Where all these entities are related between one entity and another entity. The table as shown in figure 6 below:

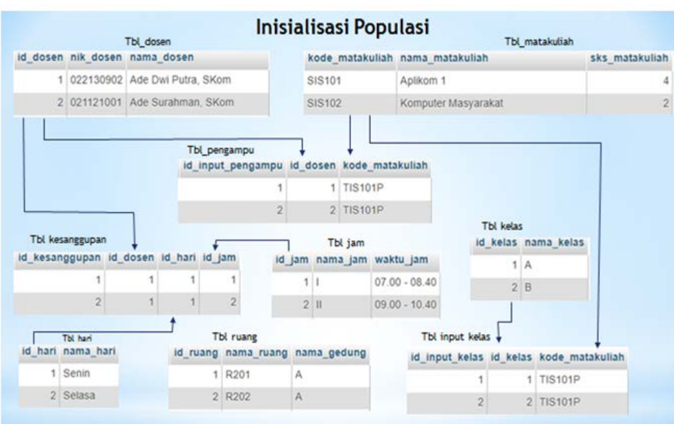
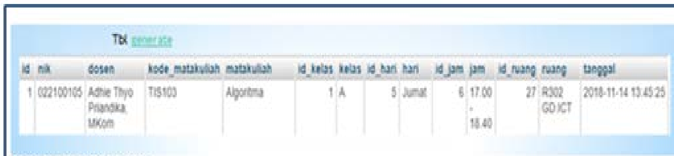


Figure 6 Population Initialization

This experiment is using data as many as 40 lecturers, the number of subjects is 54 courses, the amount of space is 42 spaces (space capacity is 60 students), the number of hours is 7 hours, the number of days is 6 days, the data used is 3.719.520 data eith chromosome length is 303

The first process is do generate data process which is then forwarded to a tabu search process, where the tabu value from the first condition is the number of subjects taught <= 2 subjects, and the second condition is the number of subjects > 2 and <= 3 if the teaching experiece > 3 years. Then the data will be obtained as follows, as shown in Figure 7 below:


Tbl generate

id	nik	dosen	kode_matakuliah	matakuliah	id_kelas	kelas	id_hari	hari	id_jam	jam	id_ruang	ruang	tanggal
1	022100105	Adhie Thyo Priandika, MKom	TIS103	Algoritma	1	A	5	Jumat	6	17.00 - 18.40	27	R302 GD ICT	2018-11-14 13:45:25

Figure 7 Initial Generate

The next process is individual withdrawal. In this process the researcher made 10 individual withdrawals, tje number of iterations was 100 iteration and cgromosome length is 303. The iteration process will stop if n values are consecutive (5 times) with a constant fitness value (fixed).

3.3 Crossover Process

The experiment was carried out 4 times to find out the best parameter from several parameters, the crossover parameters used, among them, were 60%, 70%, 80% and 90% as cutoff parameters. The results as shown in Table 1.

Table 1
CROSSOVER COMPARISON

Indi to -	PC 60	PC 70	PC 80	PC 90
1	0,02	0,021	0,022	0,022
2	0,016	0,017	0,019	0,017
3	0,016	0,014	0,015	0,016
4	0,014	0,017	0,018	0,02
5	0,016	0,015	0,016	0,019
6	0,018	0,016	0,017	0,017
7	0,019	0,017	0,017	0,022
8	0,018	0,017	0,016	0,019
9	0,014	0,02	0,017	0,018
10	0,022	0,018	0,014	0,016
average	0,0173	0,0172	0,0171	0,0186

The first experimental results show that the most optimal probability value is at 90% crossover probability. The following is a comparison table and violation chart for the best crossover probability. The results as shown in Figure 8.

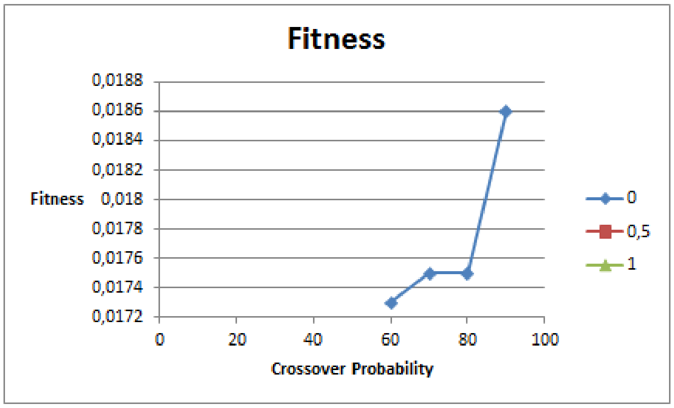


Figure 8 Violation Chart

3.4 Mutation Process

The second experimental results are to find the most optimal value of mutation probability is at the mutation probability of 0,2 , The following is a comparison table and violation graph for best mutation probability

TABLE 2
MUTATION COMPARISON

Indi to -	PM 0,6	PM 0,5	PM 0,4	PM 0,3	PM 0,2	PM 0,1
1	0,021	0,019	0,02	0,021	0,022	0,019
2	0,016	0,017	0,02	0,016	0,017	0,018
3	0,015	0,016	0,019	0,018	0,016	0,016
4	0,015	0,015	0,017	0,019	0,02	0,017
5	0,018	0,015	0,017	0,015	0,019	0,017
6	0,018	0,019	0,019	0,019	0,017	0,016
7	0,017	0,015	0,016	0,02	0,022	0,017
8	0,016	0,018	0,019	0,017	0,019	0,017
9	0,017	0,017	0,014	0,014	0,018	0,017
10	0,02	0,019	0,017	0,017	0,016	0,017
average	0,0173	0,017	0,0178	0,0176	0,0186	0,0171

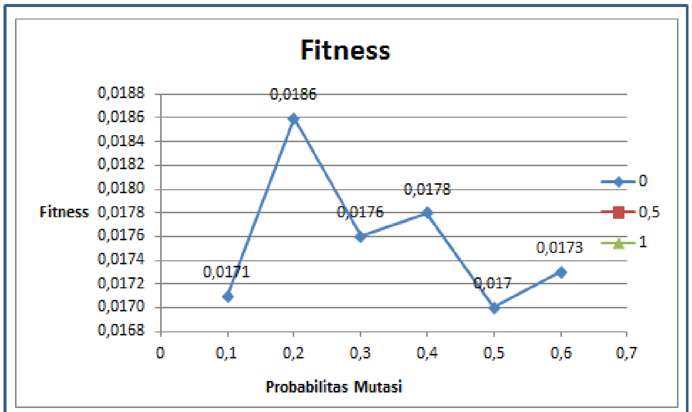


Figure 9 Violation Chart

4 CONCLUSION AND SUGGESTION

4.1 Conclusion

The analysis result of this research found that to avoid the occurrence of one lecturer teaching two courses at the same hour and day using the hybridization of genetic algorithm and tabu search algorithm method will produce a lecture schedule that can overcome scheduling problems.

The crossover probability of 90% and the mutation probability of 0,2 resulted in the magnitude of the violation occurring ie 0,0022. This is due to the existence of one parameter that affects the fitness value, namely the ability of the lecturers to reach..

4.2 Suggestion

Try to do research by ignoring the ability of the lecturers to teach

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