SMART SCHEDULING OPTIMIZATION USING MEMETIC ALGORITHM

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Abstract

Lecture scheduling system has a complex problem due to various components that consists of elective courses, lecturers, the classroom and lecture time slots with attention to the limitations and certain conditions that must be met. In the implementation, when many lecturers of courses that must be scheduled and rescheduling process requires a long time and high precision. For that memetic algorithm applied to solve this problem. According to some journal memetic algorihm considered better than other heuristic algorithm in solving the problems of the great scheduling data.

The steps the memetic algorithm analyzed starting from the development of the chromosomes the chromosomes that later will become candidates for the solution and search for the value of fitness, selection, crossover (move across), mutations, and local search. Based on the results of the tests, memetic algorihm able to solve the problem of scheduling data that many. Local search process is very helpful in the improvement of the quality of the individual each his generation. Local search process can also overcome the optimal local values that often occurs in the genetic algorithm when his input omitted data is very much. The parameter value that is obtained is 0.95 to crossover probability and 0.10 to probability of mutation. Obtained also when the number of lecturers who have soft constraint more then soft constraint being violated will be more.

Key Words : Memetika, genetics,
LocalSearch Heuristic, Scheduling System.

1. Introduction

1.1 The background of the Problem

The memetic algorithm (AM) is the expansion of the genetic algorithm. The advantages of AG is on how it works in parallel. AG work in the search space that uses many individuals at the same time so that the possibility of AG to be trapped in the local extreme is smaller than the other methods[6]. Heuristic method is one method solutions that use the concept of the approach. Some heuristic algorithms have been developed among others memetic algorihm. Memetic algorihms have the process of local search is able to resolve the problem of debt rescheduling. According to Albar Ali M [1] on cases that have time slots numbered large memetic algorihm with good resolve the problem. According to Albar Ali M, Sadaf N. Local Wisdom, and Shengxiang [1] [2] local search process that is owned by memetic algorihm is also very helpful in the search for optimal solution closest to improve the quality of the individual. According to the Garg Poonam [3] memetic algorihm is better than the genetic algorithm in this space search the solution, according to Ray Pillarrichie and Suyanto [4] there are differences in the quality of the chromosomes that is produced is seen from the value of fitness centers from every generation. The scheduling problem is the problem of the complex lecture due to various components that consists of elective courses, lecturers, the classroom and lecture time slots with attention to the limitations and certain conditions that must be kept or met. In the implementation, when many lecturers of courses that must be scheduled and rescheduling process requires a long time and high precision.

For that memetic algorihm is applied to solve this problem. The stages on the essentially the same memetic algorihm with steps on the genetic algorithm, only in add stages local search usefullness has been described previously. Where its phases starting from the development of the chromosomes the chromosomes that later will become candidates for the solution and search for the value of fitness, the selection process, crossover process (move across), and the process of mutation and stages of local search is intended to perform local improvement.

1.2 The aim of the Research

From the problems that have been explained and the purpose of this research is to know from memetika optimization algorithm in solve problems in the case of debt rescheduling.

1.3 Research restrictions

The case study in the Prodi Teknik Informatika UNIKOM Bandung. With data sets taken semester data is fulfilled 2015/2016 school year as much as 325 data (not including entrepreneurship courses).

1.4 The Genetic Algorithm

According to David E. Goldberg [7] the algorithm is computing algorithm in the inspiration of the theory of evolution Darwin stated that the survival of a living being influenced by the rules of "the strong are winning". Darwin also states that the survival of a living being can be maintained through the process of reproduction, crossover, and mutations. The concept in the theory of evolution Darwin was then adopted into computing algorithm to find the solution of the issues in a way that is more "natural". A solution that is raised in the genetic algorithm is referred to as the chromosomes, while the chromosomes the chromosomes is referred to as the population. A chromosomes formed from the components of the building blocks which is called as genes and its value can be a number of binary numeric, symbols or characters depending from the problems that want to be resolved. The chromosomes chromosomes will be evolved by sustainable development which is called with the next generation. In every generation of chromosome chromosomes are evaluated the level of success of the value of the solution to the problem that you want to complete (Thefunction_objective) using the size of which is called the fitness centers.

To select the chromosomes that is maintained for the next generation is done with a process called natural selection. The selection process the chromosomes using the concept of the rule of Darwinian evolution that has been mentioned previously that the chromosomes that have a high fitness value will have a greater opportunity to elect again on the next generation. The chromosomes of new chromosome that is called by the offspring, formed with how to perform a marriage between the chromosomes the chromosomes in one generation is referred to as the process of crossover. The number of chromosomes in the population that have crossover is determined by the parameters that called with crossover_rate (probability crossover). The mechanism of the structure of the elements of the building blocks of living beings as the result of natural factors that is called by the mutation is represented as a process of changing one or more of the value of the genes in the chromosomes with a random value. The number of genes in the population undergoing mutation is determined by the parameters named mutation_rate (probability of mutation). After several generations will be produced chromosomes the chromosomes that the value of their genes convergence to a specific value that is the best solution that is produced by the genetic algorithm to issues that want to be resolved.

1.5 Memetic algorihm

The memetic algorithm (MA) is the expansion of the genetic algorithm. The advantages of GA is on how it works in parallel. GA work in the search space that uses many individuals at the same time so that the possibility of GA to be trapped in the local extreme is smaller than the other methods. Lack of GA is in terms of time because computing must evaluate fitness centers on all of the solution in each iteration so that AG can be more slowly than with other methods. [5] But have known that the GA is not good enough to look for solutions that are very close to the optimal solution. This shortage can be in accommodation with how to add a method Local Search on GA. The results of this merger is known with the title the memetic algorithm (MA). MA is a heuristic search methods that have the same characteristics with GA combined with Local Search methods that together can improve the quality of the solution search (Moscato, 1989). On MA, Local Search aims to make local improvements that can be applied before or after the selection process, crossover, and mutations. Local Search can also be useful to control the greatness of the solution search space. MA can provide better results than GA, but require a longer computing time[1].

1.6 Local Search

Local search is an exchange or the placement of the information brought by the genes in the chromosomes of the son with the hope that can improve the quality of the chromosomes. Local Search can be done by changing the two genes or permutasi some genes without reducing the quality of the previous chromosome. In certain cases, local search is only done to the genes affected by penalties, this means that only the information less right

Exchanged between genes in one of the same chromosome[1].

According to Olivia and Paetcher Rossi-Doria Ben [6], in effective local search scheduling consists of two stages namely stage improve stage and improve the quality of the schedule. The explanation of this stage is as follows.

a. Stage improve timetable of which does not qualify to be worthy is to reduce the time slot used.
b. Stage to improve the quality of the schedule worthy is to reduce violations on soft constraints.

According to Sadaf N. Local Wisdom, Shengxiang [2], local search process is divided into 3 stages:

a. Change the time slot in the genes sequentially.
b. Changed time slots from 2 chromosomes in 1 individual.
c. Do permutasi.

1.7 Initialization

The formation of the population of the initial work on the population, a collection of the individual in which there are chromosomes or a solution that will be updated on each of his generation. The formation of the initial population that contains the collection of the individual as much as the size of the population. This initialization process is usually done in random order.

1.8 The function of the Fitness

The function of the penalties penalty function has a value of the chromosomes that determine the quality or feasibility problem solution. The value of the penalty shows the weight of the violations against an obstacle or limitations. In the optimization problem, the value of the penalty usually is minimized so that the obtained solution by the number of violations of obstacles that at least. The smaller the value of the penalty will increase the quality of the solution while the solution feasibility is determined by the constraint a penalty value. The formula of the fitness function that is used is equation 1 :

$$\text{Fitness} = \frac{1}{(1+\sum_{i=1}^{5} \text{penalty}-i)} \qquad (1)$$

1.9 Natural Selection

The selection of the parents the parent selection is part of evolution is the process of approaching candidates problem solution is expected. The parent selection operator is the memetic algorithm conducted in each generation to select the chromosomes the chromosomes of the population who will become parents for the next generation. According to Sri Kusumadewi[15] ,first steps in this selection is a search value of fitness centers. The individual in a place of natural selection will receive reproductive probability that depending on the value of the objective of the individual against all of the individual in the place of natural selection. Rank Selection method is one of the selection method that belongs to the genetic algorithm. The Method Rank Selection working with the first me-ranking or sort chromosomes in the population based on the fitness-him. Then give the value of the new fitness centers based on the sequence. The chromosomes with the worst fitness centers will have a new fitness centers worth 1, the second worst worth 2, and so on. So the chromosomes that have the best fitness centers will have the same fitness value is the number of chromosomes in a population. After the sorting process and the giving of the value of the new fitness centers in each of the chromosomes will have a smaller chance to elect, so that this method cause slow convergence.

1.10 Crossover

Move cross-reference (crossover) move cross-reference (crossover) is the most important component in the genetic algorithm and memetika because of this process that can approach the chromosomes the chromosomes as candidates for the expected solution. The chromosomes that lead to better penalty value obtained from the process move silangkan two chromosomes that obtained from the selection of the parents. Cross-switch can produce one or several chromosomes commonly called the chromosomes of children. Cross-switch can cause bad if the number of population is very small because a chromosomes with the genes that lead to solutions (chromosomes that expected) will very quickly spread to the chromosomes of other chromosome. To resolve the issue move cross-sell can only be done for certain probability. Move cross-reference done if a random number (0.1) who raised less than specified. In general, determined approaching one, e.g. 0.8. According to Suhartono E[8], crossover probability value ranges from 85% to 90%. According to Suyanto [16], move cross-sell the simplest is one point crossover. In one point crossover two points selected by random to share the first parents, then first gene until the selected point lowered into the chromosomes of children according to the position, while the other parents checked, if there is a value of the gene that is not yet in children, then added to the chromosomes of a child in the way left-to-right.

1.11 Mutation

Mutation is the process of the exchange or change the information brought by each of the genes in the chromosomes of children cross switch results. Mutation is done on some genes in the chromosomes of the son with the probability of mutation is relatively small. The opportunity of mutation is defined as a percentage of the total number of genes in the population undergoing mutation. Chance mutations control many new genes that will be raised to be evaluated. If the probability of mutation is too small, many genes that might be useful never evaluated. When the probability of mutation is too large and it will be too many random disturbances, so that children will lose the similarity of the mother. Usually of with n is the number of genes in the chromosomes. The process of mutation is controlled by the value of the probability of mutation. According to Suhartono E[8], to the value of the probability of mutation is recommended small between 5 percent to 10%. Mutation serves to replace the lost genes from the population as a result of the selection process that allows the emergence of the gene that does not appear on the initialize the population.

2 The contents of the research

At this stage will discuss about the issues that will be analyzed. Some of the things that there are in this stage is about the analysis of the problem, analysis system that will be built as well as the method used to resolve the issue.

2.1 Problem Analysis

The scheduling problem is the problem of the complex lecture due to various components that consists of elective courses, lecturers, classrooms, and time courses activities with attention to the limitations and certain conditions. In the creation of the schedule there are some limitations that should be noted that the schedule is created can be used. Where the limits of is not to be there that is broken or called hard constraint. There is also the limits of that be broken or called soft constraint.

The Hard constraint (hard) restrictions in scheduling Prodi Bear Unikom is as follows :

a. Clashed pool and teaching time, when the hours of the day or pool fully charged in the same time.
b. Clashed lecturer, when a lecturer teaching at the same hour the same day or the same lecturer.
c. Clashed with the Friday prayer.
d. Clashed time availability of special lecturer.

Soft constraint (limitations software) is a limitation in which if broken will not damage the schedule, will only reduce the quality of the schedule. Soft constraint is obtained based on the limitations of a government agencies. Soft constraint effect on schedule, when the number of soft constraint that violated the more small then the quality of the schedule the better. While the Soft constraint (limitations software) there is clashed time availability of lecturers.

2.2 Input Data Analysis

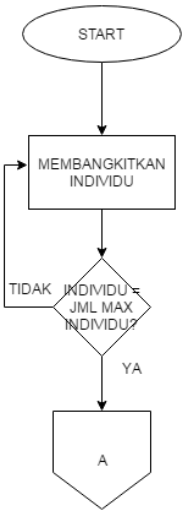
Input data that is used is a lecturer data as much as 76 data, lecturer as much as 325 data, courses as much as 25 data, space as much as 18 data, and time slots as much as 120 slot.

2.3 Method Analysis

Analysis of the method is the process of outlining or explain the stages of the memetic algorithm. Now its phases of the formation of chromosomes, check the value of fitness centers, the selection process, crossover process, the process of mutation and the local search process. All the steps are done as much as the desired generation by the user. After all the steps passed there are some conditions are found solutions and the solution is not found after reaching the last generation.

2.3.1 The raising of the Chromosomes

The raising of the chromosomes is the process of the formation of chromosomes that later will become a solution (schedule). This chromosome consists of the genes contents lecturer, hours of the Day, space. The individual is raised in accordance with the input data by the user. The more individuals in the input by the user and the more also candidates for a solution that is produced and more also differences between individuals that allows the discovery of the solution quickly. Number of population that must be entered must be worth fulfilled. In one individual there are chromosomes that amount as much as lecturers of courses (can be seen in the picture 3.4 and complete in the attachment data lecturer). The giving of the values into the gene was done in random order. Except for the genes of courses, value taken sequentially. The path from initialization process is as follows (picture 1):



Pictures 1. Flowchart Initialization process.

2.3.2 Check the Constraint and the value of Fitness

At this stage of the individual that has been raised will be in the check constraint that is broken and the value of fitness-him. Where the value of fitness influenced by the number of violations in the individual. For each violation and will be subject to the penalties +1.

For Hard constraint that analyzed is as follows :

1. Collide space, the day and the same hour (Penalty). Meaning when there is the schedule that has the same hour the same day and the same space. This Constraint can be divided again :
   a. When the credits >=2 and second clock = hours 1 other courses plus the day and the same room.
   b. When the credits >= 3 and the third hour = hours 1 other courses plus the day and the same room.
   c. When the credits >=4 and the fourth hour = hours 1 other courses plus the day and the same room.

2. Clashed lecturer, when the same lecturer teaching in hours and the same day(penalties2). This Constraint can be divided again :
   a. When the credits >=2 and second clock = hours 1 other courses plus the same day.

b. When the credits >=3 and the third hour = hours 1 other courses plus the same day.
c. When the credits >=4 and the fourth hour = hours 1 other courses plus the same day.

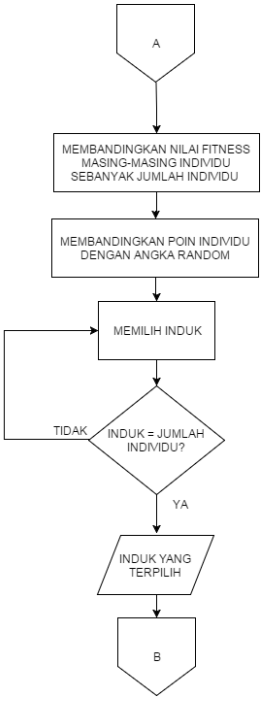
3. Clashed Friday prayer(penalties3), when elective courses in the schedule at the time of the Friday prayer. The time is used for the Friday prayer can be seen in the table (3.3). The time slot used slot 7,8,9. Constraint is divided into :
   a. When the credits >=2 and second clock = hours 1 time Friday prayer.
   b. When the credits >=3 and the third hour = 1 hours time Friday prayer.
   c. When the credits >=4 and the fourth hour = 1 hours time Friday prayer.

4. Clashed with the desire of the special lecturer(penalties4), when the clock and the desire of the lecturers with scheduled.

5. Clashed with the desire of the special lecturer (penalties5), when the clock and the desire of the lecturers with scheduled

2.3.3 Natural Selection

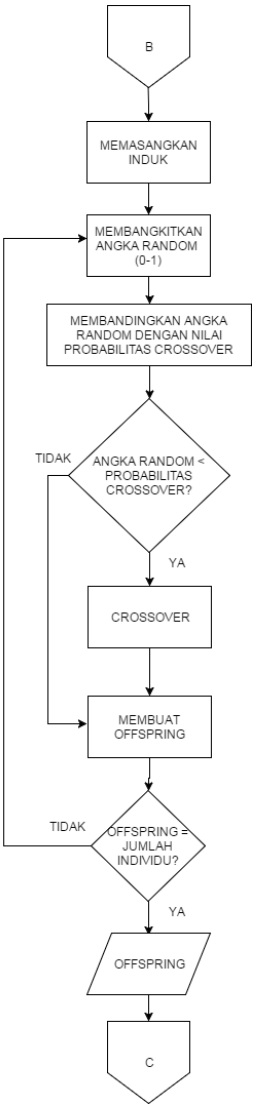
The process of natural selection is the process of selecting individuals to be the mother based on the ranking of the individual. The larger the ranking of the individual and the greater the possibility for selected to become the mother. The Ranking obtained by comparing the value of the fitness of each individual. The value of each individual is taken from the add points to each individual after compared with other individuals, the larger the value of approaching the population and the greater the value of the individual. The individual with the same points with 1 is the individual with the rank of the smallest. The election of societies embracing done first with raised numbers random ranged between (1 to with many individuals) and compared with the points of the individual. So that the individual with great points have the possibility of greater elected. This process is done until the mother numbered with the number of individuals. After the process of me-ranking was then obtained the mother.



Pictures 2. Flowchart Selection Process.

2.3.4 Crossover

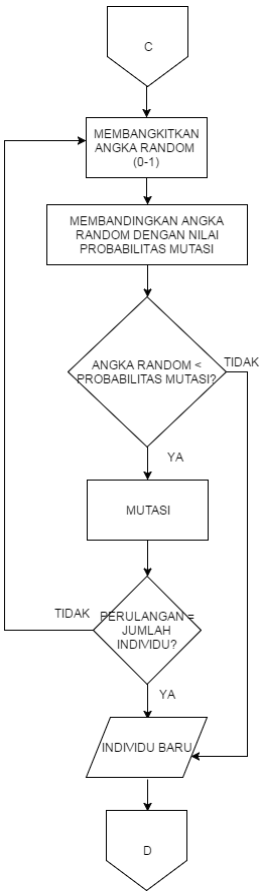
The process of crossover is the process of exchanging some genes mother with other parent genes. This process is done when the value of the random (0 to 1) less than probability crossover that has been determined (0 to 1). When the number of random more than probability and not done the process of crossover and offspring created its genes with the genes of the mother. The genes that changed the genes hours, day and space. This process is done hope produce new individuals who is better than the individual previously.



Pictures 3. Flowchart Crossover process.

2.3.5 Mutation

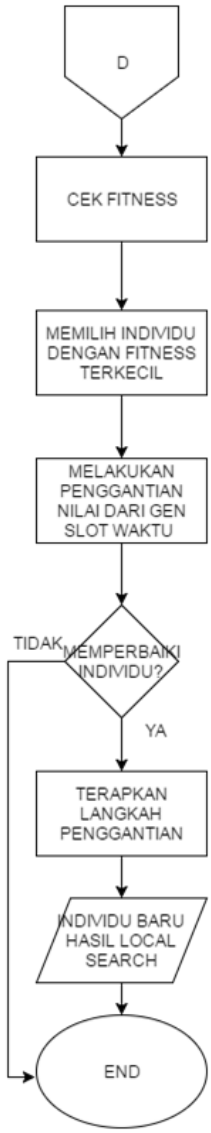
The process of mutation is the process of changing the contents of the genes on one chromosome numbers in one individual. The genes that changed value is the genes hours of the day and the pool. Replacement value is done in a random. This process is done when the value of the random (0-1) is less than the probability of mutation that has been determined(0-1).



Pictures 4. Flowchart process of mutation.

2.3.6 Local Search

Local search process that is used is to replace the less accurate information in one individual who has the largest penalties. The process by changing the time slot. The time slot changed only time slot chromosomes have penalties, meant that the quality of the individual remain good.



Pictures 5. Local Search Process Flowchart.

2.4 The test results

Parameter testing done to algorithm observing how the influence of the crossover probability and mutation probability against the number of generations and the time required to find the solution. The parameters that will be used in accordance with the test plan in the table 4.4. The Parameters - the parameter will be tested to achieve the value of fitness centers reached 1 (no constraint being violated). The tests are performed as much as 10x on each of the parameters value. With the purpose to get what size parameter that matches to find the optimal schedule solution.

2.4.1 Crossover Parameter Testing

Parameter testing Crossover done as much as 10x and obtained the results in Table 1.

The Table 1. Testing table Crossover parameters.

The Parameters	The value of P Crossover	
	0.90	**0.95**
Needed time (minutes)	188.7 minutes	**158.2 minutes**
The generation of	16822	**12029**
Average Fitness Value	0.3075	**0.3164**

The results of the test obtained that crossover probability with the value of 0.95 better compared with 0.90 in the side of the time until it reaches the generation of the optimal solution and the average fitness value produced.

2.4.2 Testing the parameters of mutation

Based on the test from the previous crossover probability, then the value of the crossover probability used is 0.95. Mutation parameters testing done as much as 10x and obtained the results in Table 2.

The Table 2. The table testing the parameters of mutation.

The Parameters	The value of P Mutation	
	0.05	**0.10**
Needed time (minutes)	140.7 minutes	**118 minutes**
The generation of	11325	**9971**
Average Fitness Value	**0.3164**	0.3118

The results of the test is obtained that the probability of mutation with the value of 0.10 better compared with 0.05 in the side of the time, and generation to achieve optimal solution, but not with the average value of fitness centers that produced. Because of the difference in the average fitness centers that is not too far then taken 0.10 to the value of the probability of mutation.

2.4.3 Testing the Soft Constraint

Soft constraints that is used is the availability of regular lecturer, where applied to the lecturers gradually, ranging from 1 to 5 lecturers. All lecturers have not prepared as much as 100 slot in the slot time. Testing using parameter with the value of the crossover probability 0.95, probability of mutation 0.10, generations as much as 1000000, and the population as much as 18. After done experiment. Then obtained the results in table 3.

The Table 3. The table testing of Soft Constraint.

The Experiment	The number of lecturers	That Is Broken
1	1	2
2	2	5
3	3	8
4	4	15
5	5	17

It can be seen the value of soft constraint being violated every experiment has increased. Then the conclusions can be made when the number of lecturers who have soft constraint more then soft constraint being violated will be more. This means that the schedule that formed there are still soft constraint so that the schedule has not been fully optimum said.

2.5 The conclusion of the Test

Based on the results of the tests are shown in table 1 and 2 obtained the optimal parameters to complete the scheduling problems with as much data 325 namely the value of the crossover probability of 0.95 and probability of mutation 0.10 . With the population of 18 and generation as much as 1000000000. And based on the table 3 obtained that the more the number of lecturers who have soft constraint then the more the number of soft constraint is breached and this makes the schedule less than fully optimize.

3. Conclusion

3.1 Conclusion

Based on the results obtained in this research, obtained usage information memetic algorihm can solve problems with scheduling data that many (no hard constraint that is broken or the value of fitness with 1). But the schedule is produced there is still a soft constraint so that the schedule is not optimal can be said to be fully. Local search process is very helpful once in the improvement of the quality of the individual or increase the value of fitness each his generation. Local search process can also overcome the optimal local values that often occurs in the genetic algorithm when the data his input omitted numbered very much. Test results from some parameters obtained that parameter with the value of the crossover probability of 0.95 and mutations 0.10 will optimize the search process optimal solution. Obtained also when the number of lecturers who have soft constraint more, then the soft constraint being violated will be more. This resulted in the quality of the schedule is reduced.

3.2 Suggestions

Based on the results of the research that has been done, still need to do some further study. Now the suggestions for further research are:

1. Using the population is much more likely to achieve optimal solution more quickly.
2. Optimize the local search process in order to more quickly resolve scheduling problems with many data.

3. To tackle the soft constraint, so that the schedule produced really optimal fully.

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