Subject Scheduling Using Genetic Algorithms (Case Study: SMK Negeri 1 Labang-Madura-Indonesia)

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Abstract. The manually scheduling system is considered less effective and efficient because it requires a long time. Problems will become more complex if the number of components or data used is increasing. The schedule is expected not only not to experience clashes, but also to adjust to some limitations that must be met. Genetic Algorithm is one of the heuristic search algorithms that are very well used in solving optimization problems. The problem of scheduling genetic algorithms is considered to have good performance in finding the optimal solution. Genetic Algorithms implement an evolutionary process by randomly producing chromosomes from each population These chromosomes produce a solution to the problem raised, namely scheduling subjects. The conclusion of this study is to be able to arrange the schedule of subjects efficiently, by overcoming obstacles such as clashing schedules without eliminating the constraints that must be met. Keywords: Scheduling System, optimization problems Genetic Algorithm.

1. Introduction
The definition of a schedule is the division of time based on a work order arrangement plan; list or table of activities or plan of activities with a detailed division of the time of implementation, while the definition of scheduling is a process, method, action schedule or include in the schedule [1]. So scheduling is something that must be present in every activity. Scheduling techniques vary depending on the size, complexity, duration of the activity [2] [3]. One activity that requires scheduling is an activity in the world of education in the form of a schedule of subjects. The lesson schedule is used as a guideline by teachers, students or principals in carrying out the teaching and learning process. Understanding of the lesson schedule is a set of learning sequences that are used as guidelines and must be followed in the process of teaching and learning activities.

Labang 1 State Vocational School is a vocational high school that has a problem in terms of unique scheduling which has 27 classes, there are 6 vocational majors with 4 types of subjects namely normative, adaptive, mulok (Local Content) and vocational subjects. In the process of teaching and learning activities SMK Negeri 1 Labang has a total of 50 lesson hours per week for each class with a total of teachers. There are several aspects that must be considered to get an effective and efficient lesson schedule. The related aspects of scheduling include: no occurrence of clash of subjects in the same class and at the same time, no teacher who teaches subjects more than one different class at the same time and the number of hours of subjects in accordance with total time of week.

The method for making lesson schedules that has been done so far is still manual, that is by doing it by searching for any columns that are still empty, then placing a schedule in that column. The schedule
produced in this way takes a long time and tends to ignore these various aspects. Therefore it is necessary to develop a lesson scheduling system that can accommodate various aspects that are considered above.

There are several methods and algorithms that can be used to solve scheduling problems where each algorithm has advantages and disadvantages. One method and algorithm is Genetic Algorithm. Genetic Algorithm is one algorithm that adopts the mechanism of natural genetics that was developed to find solutions to problems such as scheduling [4] [5]. Genetic algorithms find solutions, namely in the initialization process. Processing is done to get a solution improvement [6]. With the use of genetic algorithms, scheduling will be obtained in accordance with the appropriate aspects.

2. Methodology
2.1. Data Collection
The data used in this study include subject data, teacher data, class data, study hours and data assignments of teaching teachers in the 2017-2018 school year at 1 Labang Vocational High School. Table 1 shows the input data used.

| No | Data Input   | Jumlah         |
|----|--------------|----------------|
| 1  | Teacher      | 44 Teachers    |
| 2  | Subjects     | 20 Subjects    |
| 3  | Class        | 9 classes      |
| 4  | Time allocation | 50 hours / week |

2.2. Genetic Algorithm
Genetic Algorithm is an optimization method to find the optimal solution to a problem. Genetic algorithms are search algorithms that are based on natural system mechanisms namely genetic and natural selection [7] [8] [5]. In contrast to conventional search techniques, genetic algorithms depart from a set of randomly generated solutions.

![Figure 1. Flowchart of genetic algorithms for scheduling](image)

This set is called a population. Whereas every individual in a population is called a chromosome which is a representation of a solution. Chromosomes evolve in a continuous iterative process called generation. In each generation, chromosomes are evaluated based on an evaluation function. After several generations the genetic algorithm will converge on the best chromosome, which is expected to be the optimal solution. Genetic Algorithms have a simple optimization methodology as follows:

1. Determine the population of a certain number of solutions
2. Calculating fitness value functions all solutions in the population
3. Choose several solutions with the highest function fitness value
4. Perform optimization by means of mutations and crossover as much as needed
5. Determine the best solution as a solution to the problem being optimized

Finish Steps:
1) Initial Parameters
The parameters specified in the genetic algorithm are:
   a. Fitness function (objective function) that is owned by each candidate scheduling to determine the individual’s fitness level with the criteria to be achieved.
   b. Population number of individuals involved in each generation through a selection process.
   c. The maximum number of generations that occurs
   d. The probability of a cross ($pc$) in a generation.
   e. The probability of a mutation ($pm$) in each individual.

2) Encoding Techniques
The coding technique is a method of coding / initializing genes from chromosomes. Each chromosome contains a number of genes containing information stored on the chromosome. In this study using coding techniques in the form of string bit / varchar which is used in genetic programming.

3) Set Population and Chromosome Representations
Determining the initial population is the process of generating a number of chromosomes randomly. Chromosomes represent one possible alternative solution. Chromosomes can be said to be the same as individuals. Population size depends on the problem to be resolved. After population size is determined, then initial population generation is carried out by initializing possible solutions into a number of chromosomes. The length of one chromosome is determined based on the problem under study.
The length of one chromosome is the multiplication of the number of lesson hours per week with the number of classes available. One gene contains information on subjects, classes, and lesson hours. For example for initialization of chromosome formation, for example there is a distribution of subjects in table 2, distribution of time in table 3.

4) Calculation of Fitness Value
Individuals in the population have been formed, the next step is to calculate the fitness value of each individual. Fitness will be calculated based on the number of violations found in the individual. The value generated from the function indicates how optimal the solution is. In the case of subject scheduling, the smaller the number of violations produced, the better the solution will be.

$$F = \frac{1}{1 + (\sum BG + \sum BK + \sum BJ)}$$  \hspace{1cm} (1)

Keterangan:
BG : Teacher clashes at the same time
BK : Clash of classes at the same time
BJ: Clash of lesson hours

Limits used to calculate fitness values:
1. Teachers may not teach more than once at the same time
2. One class may not be scheduled more than once at the same time
3. One subject may not be scheduled more than once at the same time

5) Selection
In this study the method used is roulette wheel selection. In this selection, individuals are selected based on their fitness values to choose which individuals will experience the marriage process or crossovers, the better the quality of an individual the greater the chance to be chosen. In the roulette wheel selection process, the cumulative value of the fitness probability of each individual will be calculated. Examples of selection steps using roulette wheel:

a. Calculate the total fitness value
b. Calculate the probability of each chromosome, how: fitness value / total fitness
c. Look for intervals for each chromosome
d. Generate 0-1 random numbers as many as existing chromosomes Eg 0.75; 0.25; 0.9; 0.5
e. Search for each random number at which chromosome interval.
f. Then the results of the new population obtained from the selection are

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| Chromosome 1 | Chromosome 3 |
|--------------|--------------|
| PAI6         | MUL4         |
| BIG4         | TKJ2         |
| MUL3         | T9           |
| FIS3         | T5           |
| BIG6         | TKJ2         |
| BIG3         | TKJ1         |
| P1D2         | TKJ1         |
| FIS1         | TKJ1         |

Chromosome 2

| Chromosome 2 | T1 | T21 |
|--------------|----|-----|
| TKJ2         |    |     |
| TKJ2         |    |     |
| TKJ2         |    |     |
| TKJ1         |    |     |
| TKJ1         |    |     |
| TKJ2         |    |     |
| TKJ1         |    |     |
| TKJ1         |    |     |
| TKJ1         |    |     |
| TKJ1         |    |     |
| TKJ1         |    |     |
| TKJ1         |    |     |
| TKJ1         |    |     |
| TKJ2         |    |     |
| TKJ1         |    |     |
| TKJ1         |    |     |
| TKJ1         |    |     |
| TKJ1         |    |     |
| TKJ1         |    |     |
| TKJ1         |    |     |
| TKJ2         |    |     |
| TKJ1         |    |     |
| TKJ1         |    |     |
| TKJ1         |    |     |
| TKJ1         |    |     |
| TKJ1         |    |     |
| TKJ1         |    |     |
| TKJ1         |    |     |

6) Crossover
Crossover is done by crossing 2 mothers to produce offspring. In the crossing process, the method used is one-cut-point crossover by taking several genes from the first parent which are then combined with the genes in the second parent. The child number of the reproductive process is determined by determining the pc value (crossover probability) which is random from a value between 0 and 1.

Examples of crossover steps:

a. Determine pc value
b. Generate random numbers for each chromosome
c. Search for random numbers that are less than a pc
d. Awaken random numbers (1 to the length of the chromosome) to determine the cut point.
e. Perform crossover, for example the crossover that will be done is chromosome 2 and 4, with cut point:

| Chromosome 1 | Chromosome 2 |
|--------------|--------------|
| PAI6         | MUL4         |
| BIG4         | TKJ2         |
| MUL3         | TKJ2         |
| FIS3         | TKJ1         |
| BIG6         | TKJ2         |
| BIG3         | TKJ1         |
| P1D2         | TKJ1         |
| FIS1         | TKJ1         |
| T1           | T21          |
| T9           | TKJ2         |
| T5           | TKJ2         |
| T9           | TKJ1         |
| T15          | TKJ2         |
| T19          | TKJ1         |
| T17          | TKJ2         |
| T19          | SIM1         |
| T15          | TKJ1         |
| T15          | TKJ1         |
| T21          | TKJ2         |
| T15          | TKJ1         |
| T15          | TKJ1         |
| T23          | TKJ2         |
| T15          | TKJ1         |
| T15          | TKJ1         |
| T23          | TKJ2         |
| T15          | TKJ1         |
| T21          | TKJ2         |
| T15          | TKJ1         |
| T15          | TKJ1         |
| T15          | TKJ1         |
| T15          | TKJ1         |
| T21          | TKJ2         |
| T15          | TKJ1         |
| T15          | TKJ1         |
| T15          | TKJ1         |
| T15          | TKJ1         |
| T15          | TKJ1         |
| T15          | TKJ1         |
| T15          | TKJ1         |
| T23          | TKJ2         |
| T15          | TKJ1         |
| T15          | TKJ1         |
| T15          | TKJ1         |
| T21          | TKJ2         |
| T15          | TKJ1         |
| T15          | TKJ1         |
| T15          | TKJ1         |
| T15          | TKJ1         |
| T15          | TKJ1         |

f. Use the crossover population for the next process
7) Mutations
Mutation is a process of reproduction by modifying the arrangement of genes from a parent. From one mutation process to one parent will produce one child. Before the reproduction process is carried out using mutations, it is necessary to determine the value of \( pm \) (probability of mutation), which is generated from a value between 0 and 1, which is the function of \( pm \) to determine how many children must be produced in the mutation process. The steps of the mutation process:

a. Calculate total genes, total genes = many genes on one x chromosome many chromosomes in the population
b. Many genes are transferred = total gene \( \times pm \). For example, the total genes = 16 and \( pm = 0.1 \), many genes that are mutated are \( 1.6 \approx 2 \)
c. Generate random numbers 0 to 1 as many genes as possible
d. Search for genes with random numbers < \( pm \)
e. If the results are less than mutated genes, then all are used. If more than the maximum mutated gene, random to take as many genes that are mutated.
f. Perform the mutation process, by changing the time component in the gene

| Before mutation | BIG4 | TKJ1 | T9 |
|-----------------|------|------|----|
| After mutation  | BIG4 | TKJ1 | T3 |

g. Use the mutation population for the next process

8) Stop Conditions
Iteration will continue to run and will stop if one of the following conditions has been fulfilled
a. After several successive generations the best fitness value of the population has not changed
b. The maximum number of generations has been reached
c. If the minimum best fitness value has been reached. If there is no violation of the chromosome

3. Result and Discussion
In this test the author uses several parameters that will be applied to the genetic algorithm process. Test parameters can be seen in the following table 4 below:

| Parameter                 | Value |
|---------------------------|-------|
| Number of Individuals     | 10    |
| Crossover probability     | 0.7   |
| Mutation Probability      | 0.1   |
| Many Generation           | 100   |

Figure 2. Data
Figure 3. Generate Schedule
CONCLUSIONS

Based on the results and discussion, the conclusions that can be obtained from this study are as follows:
1. The performance of genetic algorithms is good enough for subject scheduling
2. To achieve optimization it is best influenced by several parameters applied
3. The more number of generations that are raised, the fewer the number of crashes that occur, the better the solution will be.

Table 5 Accuracy

| Generation | Total Crash | Accuracy  |
|------------|-------------|-----------|
| 10         | 32          | 93.03 %   |
| 20         | 31          | 93.13 %   |
| 50         | 23          | 93.17 %   |
| 80         | 19          | 94.00 %   |
| 100        | 16          | 95.88 %   |

ACKNOWLEDGMENT

The authors state that there is no issue of interest with the agencies listed in this paper. We would like to thank our colleagues at the University of Trunojoyo Madura - Indonesia, the Laboratory of Network and Multimedia team who helped author in completing this research. It gave the author opportunities in using the equipment of the laboratory.

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