



Scheduling Subject used Genetical Algorithms (Case Studies: SMP Negeri 1 Delitua)

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ARTICLE INFO

ABSTRACT

Article history:

Received Jan 24, 2024

Revised Jan 31, 2024

Accepted Feb 12, 2024

Keywords:

Genetic Algorithm;
Roulette Wheels;
Scheduling.

It is known that the preparation of subject scheduling at SMP Negeri 1 Deli Tua has gone through a process that is less efficient and effective due to several long procedures such as dividing study hours, adjusting teaching hours, and allowing for similarities in teaching hours or clashes between teaching hours. A genetic algorithm is an optimization technique whose working method imitates the process of evolution and changes in genetic structure in living things. The research aims to apply genetic algorithms to the subject scheduling system at SMP Negeri 1 Delitua. Research was conducted at SMP Negeri 1 Deli Tua. This research has used a genetic algorithm using the roulette wheel method and a GUI (Graphic User Interface) created with PHP and MySQL. The research results show that the application of genetic algorithms in scheduling systems can make scheduling more accurate and in a shorter time, with a mutation probability of $3.6 = 4$ genes.

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1. INTRODUCTION

The package system has been chosen by SMP Negeri 1 Deli Tua to organize educational programs. In this package system, students are required to take part in all learning programs in its implementation. Then the learning load has been adjusted for each class according to the curriculum structure that applies at SMP Negeri 1 Deli Tua. The study load in each of these subjects will be expressed in units of learning hours which are commonly known as lesson schedules. (George and Kavita, 2018) task scheduling is one of the most significant issues in many pieces of research works, and the main goal of scheduling is to map several tasks to proper processors so that it could optimize one or more objectives at an acceptable time.

The Big Indonesian Dictionary defines a schedule as a division of time based on a plan for arranging work sequences, a list or table of activities or an activity plan with a detailed distribution of implementation times. Meanwhile, the definition of scheduling is the process, method, act of scheduling or including it in a schedule (KBBI, 2022). Then

Reksohadiprojo interprets scheduling as a dynamic process in the form of part of the production supervision function which determines the time when each activity must be carried out on a particular machine so that the product delivery time can be met, while Hantor interprets scheduling as a systematic sequencing of the production process, so that the process sequence can run smoothly with utilize all existing facilities within the company (Sagala, 2018). Scheduling can be divided into two types of problems, allocation scheduling or advance scheduling (Dai et al., (2021), Jiang et al., (2020), Saure et al., (2020). Some studies have tried to develop an effective assembly scheduling method, including mathematical modeling optimization and simulation modeling Ma et al.,(2021). However, these previous studies show that the traditional project scheduling technology often the solution efficiency is relatively low (Xie, et al., 2021).

The preparation of the subject schedule at SMP Negeri 1 Deli Tua is usually carried out before entering the new school year and will be carried out by the Deputy Principal for Curriculum who has been assisted by SMP Negeri 1 Deli Tua staff. However, this activity has been faced with several problems, one of which is related to scheduling management which is still carried out using a manual system which causes the process of making manual lesson schedules to be ineffective because it tends to take a long time and the resulting schedule information is less accurate. It is known that the preparation of subject scheduling at SMP Negeri 1 Deli Tua is a process that is less efficient and effective because it contains several long procedures such as dividing study hours, adjusting teaching hours and allowing for similarities in teaching hours or clashes between teaching hours. Because of this, there is often repetition in making course schedules which of course involves more working hours. The learning load for face-to-face activities per week at SMP Negeri 1 Deli Tua is 38 hours of learning for classes VII, VIII & IX. (Squires, et al., 2022) mention that the manual scheduling is a complex, time consuming, and error prone task. Furthermore, there is no guarantee a manually generated schedule maximises the operational efficiency of the centre. Abdalkareem et al., 2021) mention that scheduling systems have the potential to improve efficiency through optimal resource allocation. Gen & Lin, (2023) mention that many scheduling problems are quite complex in nature and very difficult to solve by conventional optimization techniques.

(Ananda, 2021) previously created a subject scheduling application at the Yaspi Foundation using a genetic algorithm and stated that this algorithm is very suitable for use in scheduling school subjects because it can solve problems with various criteria and objectives modeled by biological and evolutionary processes. Thus, the idea of genetic algorithms can be used to create schedules in schools. Additionally, scheduling applications that use web-based genetic algorithms do not require a client installation process, which makes them easier to use and user-friendly.

Genetic algorithms differ from conventional search methods by starting conditions with an initial set of random solutions called a population. Each individual in the population is called a chromosome, which functions as a representation of the solution to the problem. Generation is a repeated process of chromosome evolution. Several fitness measures are used to evaluate chromosomes during each generation. Offspring chromosomes are formed by uniting two chromosomes from the initial generation or changing them with mutation operators. Selection of several parents and offspring according to fitness values and deletion of other chromosomes is carried out to form a new generation. The most suitable chromosome has the greatest probability of being selected. The algorithm produces the best expected chromosomes after several generations. The algorithm produces the best chromosomes after several generations, which are expected to be the best or suboptimal solution to the problem (Sugeha, 2019).

(Suyanto, 2018) stated that genetic algorithms have been widely used to solve problems and modeling in the fields of technology, business and entertainment. These genetic algorithms include automatic programming, optimization, machine learning,

economic models, immunization system models, ecological models, and the interaction of evolution and learning. One of the main advantages of using genetic algorithms for problems related to optimization is that these algorithms do not require much mathematics to handle optimization problems. In addition, genetic algorithms are very effective in global search because they are easy to use evolutionary operators. Additionally, genetic algorithms can be used in conjunction with domain-dependent heuristic methods to achieve efficient implementations for specific problems.

MySQL is a relational database management system that is "open" (open source) and has extraordinary performance, processing speed, and robustness compared to other large commercial databases, such as ORACLE, Sybase, Unify, and so on (Hasugian, 2020). The MySQL database system supports features such as multithreaded, multi-user and SQL Database Management System (DBMS) (Sudaria, et al., 2021).

Therefore, based on the background that the author has explained above, it is necessary to develop research on scheduling systems using genetic algorithms as the practical and theoretical implications of this research, where the research object is aimed at SMP Negeri 1 Deli Tua.

2. RESEARCH METHOD

The location and implementation of this research is at SMP Negeri 1 Deli Tua, Jalan Taruna APDN, number 13 Deli Tua, Deli Serdang District, North Sumatra Province. This research was carried out in the even semester of the 2021/2022 academic year.

The materials used for this research are student lesson schedules, teacher name data and classroom data in the form of .xlsx format, namely a Microsoft Excel Open XML Spreadsheet file created using the Microsoft Excel application. Data was taken from SMP Negeri 1 Deli Tua school through an interview process with the principal, Curriculum, and also administrative staff of SMP Negeri 1 Deli Tua. Then the tools in this research are hardware and software, with the following details are hardware likes Intel® Core (TM) i5-1135G7 @ 2.40GHz 2.42 GHz, RAM 4.00 GB (3.70 GB usable), System type 64-bit operating System, Mouse ASUS 5V- 100mA. Software likes Operating System Windows 10 PRO 64 BIT, XAMPP, PHP, MySQL, Microsoft Word 2019, Mendeley, Notepad ++ and Visual Studio Code.

A framework is known as a basic conceptual structure used to break down or handle complex problems. In the field of reusable software and management, the term is often used to describe the idea of allowing the same treatment for different types of businesses. This framework includes the steps that will be taken to resolve the problems to be discussed. The planning for this research framework was carried out based on the following stages :

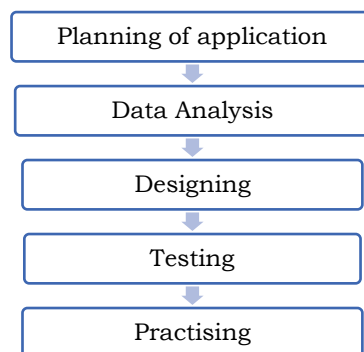


Figure 1. Research Framework

Genetic algorithms provide an option for determining parameter values by imitating the method of genetic reproduction, the formation of new chromosomes and natural selection as occurs in living creatures. Each algorithm is a logical mathematical stage and can be proven correct in aggregated form. Therefore, the author is interested in using genetic algorithms as a solution in scheduling systems. The general flow diagram depicted in the scheduling system process using a genetic algorithm is as follows:

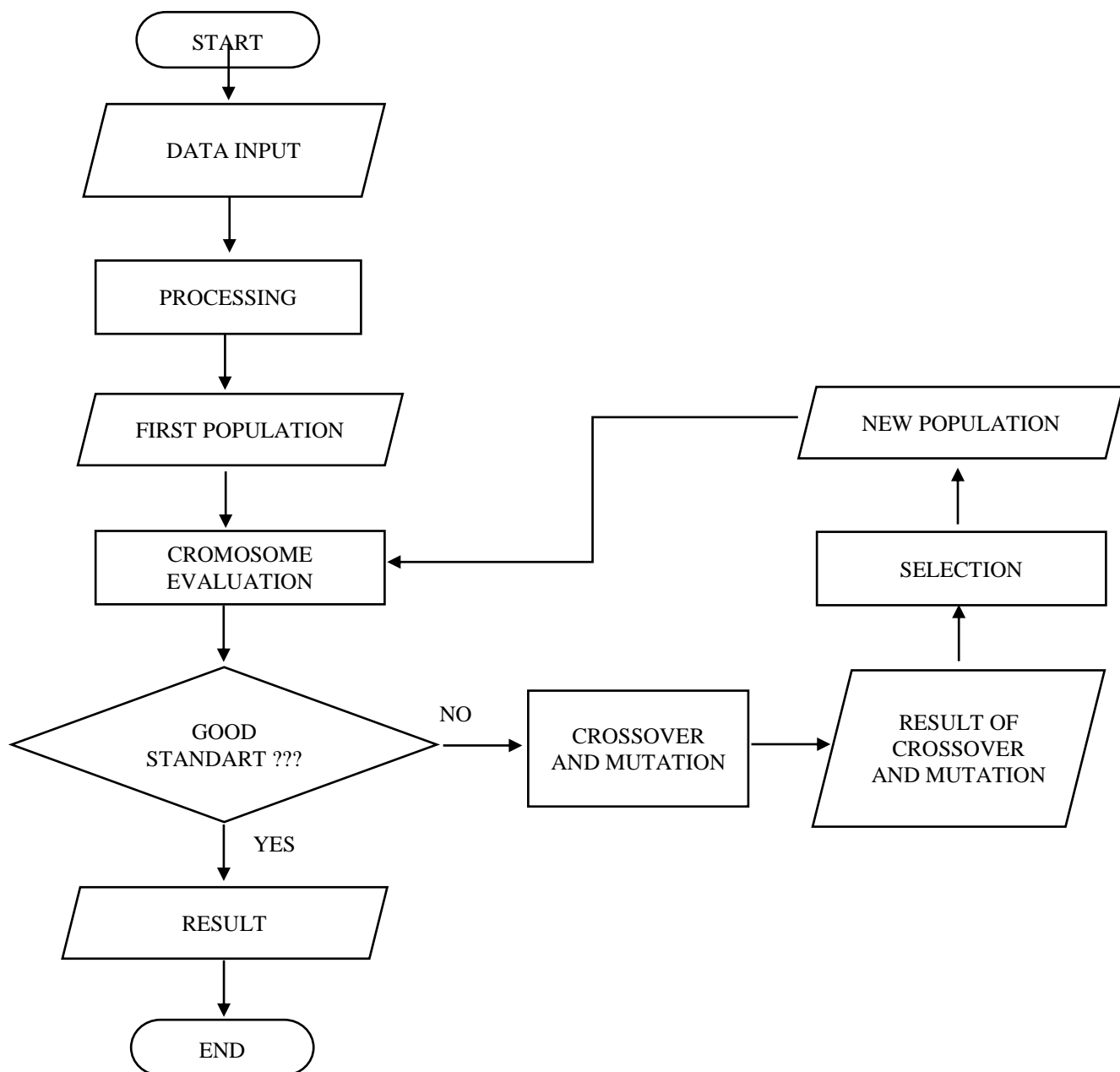


Figure 2. Flowchart of scheduling subject used genetical algorithms

Genetic algorithm testing is carried out using a web-based application method, which will check the performance between the components that have been built and also

perform performance testing to test the parameters of the genetic algorithm so as to produce optimal scheduling. Testing is carried out by lay users and quality testers by using the system directly. The system will be tested on classes where clashes occur, which are chosen randomly in each class. Testing will start with an explanation of the program to the person, and they will be asked to input or fill in the number of iterations (maximum number of generations allowed), crossover rate, and mutation rate. After the participant inputs and then presses the execute button, there will be looping and program execution in the form of selection, crossover, and mutation that occur behind the scenes. This process can take 0 to several seconds. Then, if the iteration process succeeds in getting the maximum fitness value, the scheduling table will appear (Figure 3). Liu, et al., (2020) said to ensure the scheduling system meets the users' requirements various tests are needed.

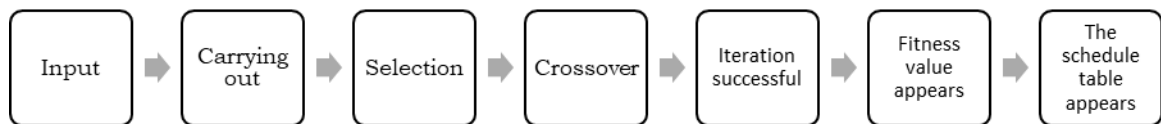


Figure 3. Procedure for Testing SMP Negeri 1 Delitua's Scheduling Table

The application or use of this application is that the interface design is a form of GUI (Graphic User Interface) implementation created with PHP and MySQL to make it easier to use and read the program. This interface design consists of several windows that state the contents of the program, which is useful for helping ordinary people prepare class entry schedules for teachers who teach and for helping WKS Curriculum and school operators prepare schedules.

The initialization stage is the stage of creating initial individuals randomly using a certain procedure. Initialization is carried out to generate a new set of solutions randomly. Selection is looking for individuals with the best fitness values to get parents; namely, individuals with the best fitness values are selected for the reproduction process. Fitness functions measure the quality of the chromosomes formed (Christioko et al., 2019).

Table 1. Initialization of Initial Population

	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12
Chromosome 1	1	1	1	1	1	1	2	3	3	3	3	3
Chromosome 2	1	1	1	1	1	1	3	3	3	3	3	3
Chromosome 3	1	1	1	1	1	1	2	2	2	2	2	2
Chromosome 4	1	1	1	1	1	1	2	2	2	3	3	3
Chromosome 5	1	1	1	1	1	1	2	2	2	3	3	3
Chromosome 6	1	1	1	1	1	1	2	3	3	2	2	2

Example of chromosome representation of a population with a population size of 6 from the case of subject scheduling at SMP Negeri 1 Deli Tua (Table 1).

The second step is to calculate the probability of each chromosome by dividing the fitness value of each chromosome by the total fitness value (Table 2). The total of fitness value] can be seen in table 2 below. The formula and calculations are as follows:

Table 2. Total of *Fitness Value*

Chromosome	<i>Fitness Value</i>
1	0.5
2	0.25
3	0.5
4	0.25
5	0.5
6	1
Total	3

The third step is to place each chromosome in the value interval [0-1]. The placement of each chromosome in the value interval [0-1] can be seen in table 3 below. The formula and calculations are as follows:

Table 3. The placement of each chromosome in the value interval

Chromosome	<i>Fitness Value</i>
1	0.5
2	0.25
3	0.5
4	0.25
5	0.5
6	1
Total	3

To determine the composition of the new population resulting from selection, a random number between 0 and 1] is generated. For example, if the number generated is [0.25; 0.1; 0.35; 0.5; 0.75; 0.6; 0.9; 0.65], then the chromosome arrangement of the new population resulting from selection is:

Table 4. New Population of Selection

	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12
Chromosome 1	1	1	1	1	1	1	2	3	3	3	3	3
Chromosome 2	1	1	1	1	1	1	2	2	2	2	2	2
Chromosome 3	1	1	1	1	1	1	3	3	3	3	3	3
Chromosome 4	1	1	1	1	1	1	2	2	2	3	3	3
Chromosome 5	1	1	1	1	1	1	2	2	2	3	3	3
Chromosome 6	1	1	1	1	1	1	2	3	3	2	2	2

Crossing over is used as a random chromosome-cutting method. The most commonly used crossover method is one-point crossover. A cut point is chosen randomly, and then the first part of parent chromosome 1 is combined with the second part of parent chromosome 2. The random number generated to determine the position of the cut point is [1-N], where N is the number of genes. in one chromosome. For this example, the crossover probability (Pc) is determined to be 0.6. For example, if, from the existing example, the values for chromosomes 1, 2, 3, and 4 are less than the predetermined crossover probability (Pc) and the random number for the crossover point position is at the 3rd gene position, then the crossover process is:

Table 5. Chromosomes resulting from the crossover process

	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12
Chromosome 1	1	1	1	1	1	1	2	2	2	2	2	2
Chromosome 2	1	1	1	1	1	1	2	3	3	3	3	3
Chromosome 3	1	1	1	1	1	1	2	2	2	3	3	3
Chromosome 4	1	1	1	1	1	1	2	2	2	2	2	2

Table 6. Chromosomes resulting from the mutation process

	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12
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Chromosome 1	1	1	1	1	1	1	2	2	2	2	2	2
Chromosome 2	1	1	1	1	1	1	2	3	3	3	3	3
Chromosome 4	1	1	1	1	1	1	2	2	2	2	2	2

To get the position of the gene to be mutated, it is necessary to calculate the total number of genes in a population, namely, total genes = number of genes in one chromosome x number of chromosomes present. Based on the existing example, the total number of genes is $12 \times 3 = 36$. The mutation probability is generally set between 0 and 1], for example, 0.1, so the expected mutation that occurs is: $0.1 \times 36 = 3.6 = 4$ genes. will experience mutations. The selection of the position of the gene to be mutated is done randomly. It is assumed that the genes that get numbers below the mutation probability are genes 5, 6, 17, and 25. The values of the genes affected by the mutation process will be changed randomly. After the process stops, the mutated chromosomes will be evaluated. Liu et al., (2019) said the algorithm genetic introduces several changes such as a new selection operator to select parents to recombine; a modified two-point crossover operator with a specific crossover order; and a linearly decreasing probability-based mutation operator. Chromosomes resulting from the mutation process will be displayed in Table 6.

The results of the calculation above show that chromosomes 1 and 3 have the best fitness value because there is no violation of the constraints that have been set. Because the first activity on chromosome 3 can be carried out on the first day, chromosome 1 is the best result and the most optimal solution (Table 7).

Table 7. The Best Chromosome

	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12
Chromosome 1	1	1	1	1	1	1	2	2	2	2	2	2

On chromosome 1, it can be explained that gene X1 has a value of 1, indicating that activity 1.1 is carried out on schedule day 1, and activity 1.12 is carried out on the 3rd day and schedule. Abreu, et al., (2020) said a new genetic algorithm with knowledge of the problem domain, aiming at presenting high-quality solutions within admissible computation times. Some specific constructive heuristics are proposed to generate the initial population.

3. RESULTS AND DISCUSSIONS

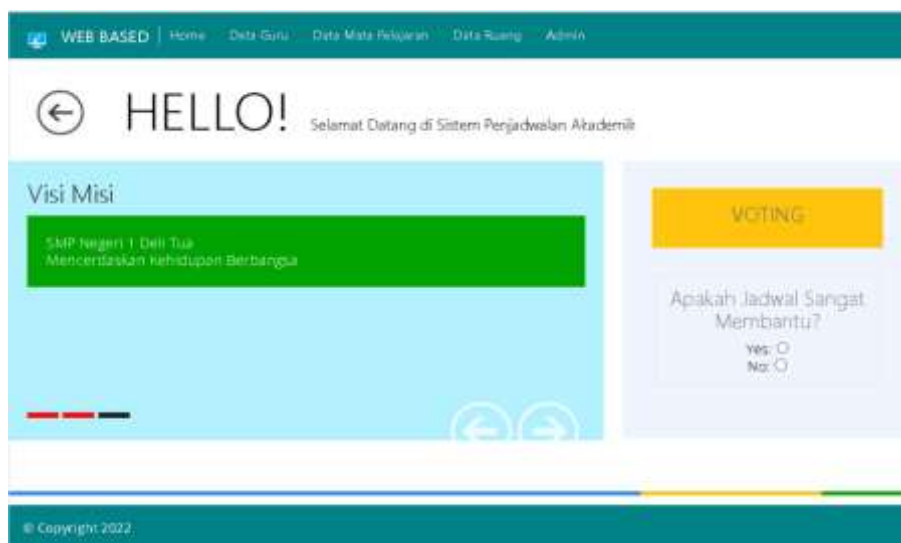
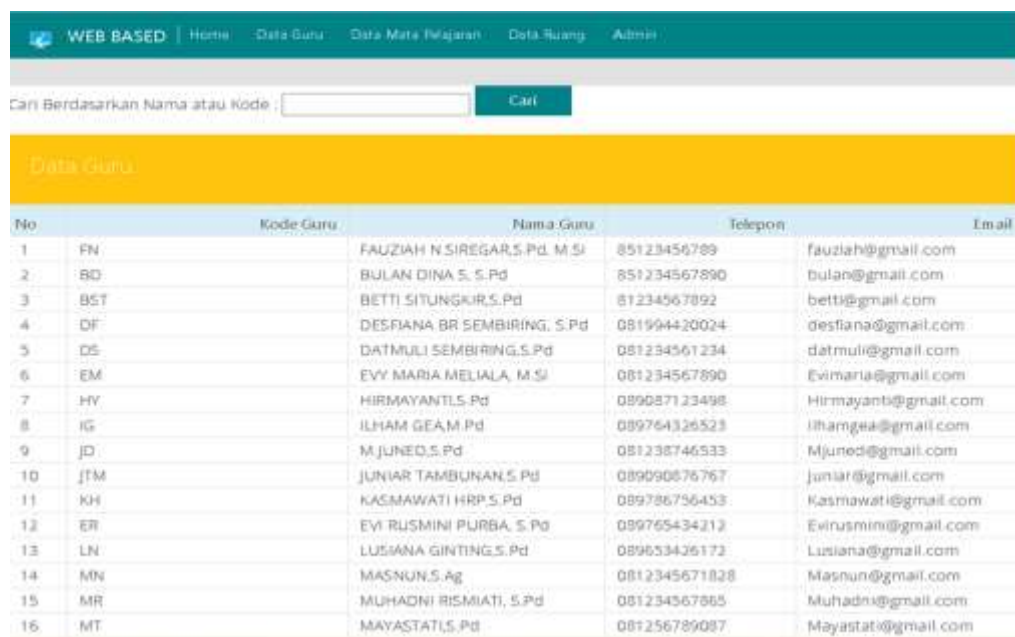


Figure 4. Homepage

The results of the design will be implemented in the program and become a web-based lesson schedule system application. This application still has many shortcomings and still needs refinement and development to optimize its performance. However, the application can now be used. For future developments, this website-based application can be used for other purposes, such as archiving files, storing data or school profiles, describing the situation and condition of the school, spreading news about achievements and appreciation received by the school, becoming a place for teachers to input personal profile data themselves, and also looking for data and profiles belonging to other school residents. Mouhamadou et al., (2019) Genetic algorithm can realise the retrieval of the curriculum for all the levels of users in the university system, including students, teachers, and administrators, and can print the results of the query. The following is the home display of the genetic algorithm scheduling system application. In the home feature, there is a welcome greeting display and also pictures that can move and be filled in according to the school information you want to display. At the top of the application, you will find teacher, subject, room, and admin data. Below, teacher data will be displayed (Figure 4).



No	Kode Guru	Nama Guru	Telepon	Email
1	FN	FAUZIAH N.SIREGAR,S.Pd, M.Si	85123456789	fauziah@gmail.com
2	BD	BULAN DINA S. S.Pd	851234567890	bulan@gmail.com
3	BST	BETTI SITUNGUR,S.Pd	81234567892	betti@gmail.com
4	DF	DESFIANA BR SEMBIRING, S.Pd	081994420024	desfiana@gmail.com
5	DS	DATMULI SEMBIRING,S.Pd	081234561234	datmuli@gmail.com
6	EM	EVY MARIA MELIALA, M.Si	081234567890	Evimaria@gmail.com
7	HV	HIRMAYANTI,S.Pd	089087123498	Hirmayanti@gmail.com
8	IG	ILHAM GEAM,Pd	089764326523	ilhamsai@gmail.com
9	JD	M.JUNED,S.Pd	081238746533	Mjuned@gmail.com
10	JTM	JUNJAR TAMBUNAN,S.Pd	089090876767	junjar@gmail.com
11	KH	KASMAWATI HRP,S.Pd	089786756453	Kasmawati@gmail.com
12	ER	EVI RUSMINI PURBA, S.Pd	089765434213	Evirusmini@gmail.com
13	LN	LUSIANA GINTING,S.Pd	089653426172	Lusiana@gmail.com
14	MN	MASNUN,S.Ag	0812345671828	Masnun@gmail.com
15	MR	MUHADNI RISMIATI, S.Pd	081234567885	Muhadni@gmail.com
16	MT	MAYASTATI,S.Pd	081256789087	Mayastati@gmail.com

Figure 5. Display of Teachers

In the teacher data display, there is a search bar, which is useful for searching for more specific teacher names or data. Then there is a table containing information about the teachers at SMP Negeri 1 Deli Tua. This information consists of the teacher code, teacher name, telephone number, and teacher email. The next piece of data is subject data. Irfan et al., (2022) said scheduling using genetic algorithms can generate schedules automatically, displaying the plan on the day and hour of each teacher's teaching schedule, thus creating an optimal solution for scheduling. In addition, applying the Genetic Algorithm is faster and easier in the process of making a schedule for setting teacher teaching hours so that it does not take a long time.

No	Kode Matapelajaran	Nama Matapelajaran	SKS	Sem ester	Jumlah Pengambil
1	BI	Bahasa Indonesia	7	1	3
2	BS	Bahasa Inggris	7	1	3
3	IP	Ilmu peng alam	7	1	3
4	IS	Ilmu Peng Sosial	7	1	5
5	MM	Matematika	7	1	1
6	PA	Pendidikan Agama	7	1	3
7	PJ	Pendidikan Jasmani R	7	1	3
8	PP	PPKN	7	1	3
9	PR	Prakarya	7	1	3
10	SB	Seni Budaya	7	1	3

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Figure 6. Display of Subject

In the subject data display, there is a search bar that is the same as the previous teacher data. Search functions to search for specific subject data. Then there is information about the subjects that students study at SMP Negeri 1 Deli Tua, such as subject codes, subject names, class hours, and the number of teachers who take these subjects. Next, the room data will be displayed.

No	Kode Ruang	Kapasitas
1	7.1	30
2	7.2	30
3	7.3	30
4	7.4	30
5	7.5	30
6	7.6	30
7	7.7	30
8	8.1	32
9	8.2	32
10	8.3	32
11	9.1	30
12	9.2	30
13	9.3	30
14	9.4	30
15	9.5	30
16	9.6	30

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Figure 7. Display of Roomclass

Space data contains information about the classrooms at SMP Negeri 1 Deli Tua, along with the capacity of each classroom. This data can only be edited by users who have access. One of the users who has access is the one who acts as admin. Therefore, you need a username and password to log in as an admin. The method is to enter your

username and password to access this application. The username and password required are: *Username* and *Password* was admin.

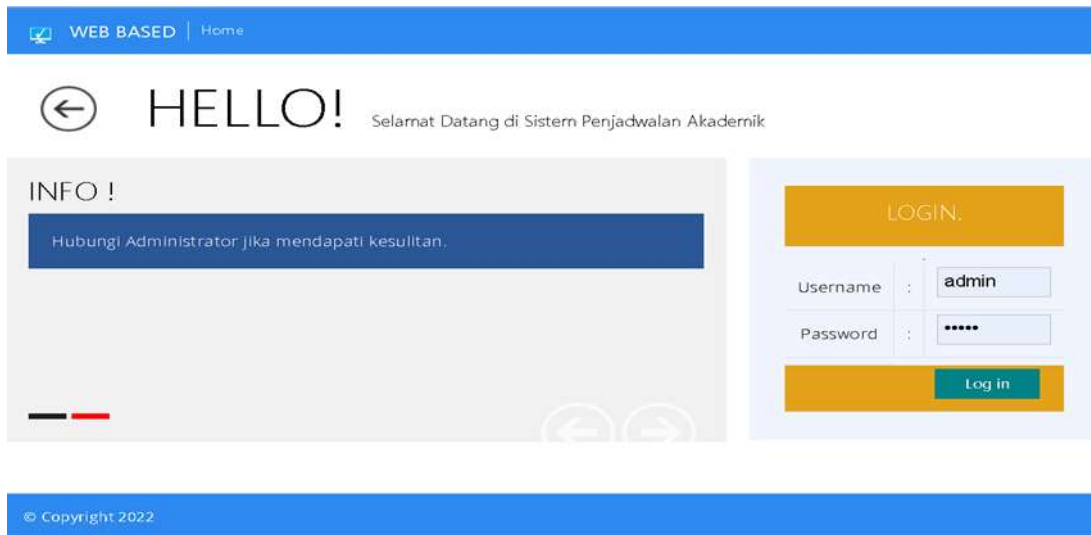


Figure 8. Display of admin page

After we enter the password and username as admin, click login and the Dashboard display will appear which the admin uses to enter data and edit data, as well as generate schedules. The display showed on Figure 9 as below :



Figure 9. Display of Admin's Dashboard

In the admin dashboard display there are features such as viewing data, inputting data and generating schedules according to data that has been entered using a genetic algorithm. The results of the schedule showed on Figure 10.

The screenshot shows a web application interface for generating a schedule. The main content area displays a table titled "Hasil Generate Jadwal SMP Negeri 1 Delitua" with the subtitle "Menggunakan Algoritma Genetika". The table has columns for "Hari", "Jam", "Waktu", and several subject/teacher assignments. The data is as follows:

Hari	Jam	Waktu	VR-1	Guru	VR-2	Guru	VR-3	Guru	VR-4	Guru	VR-5	Guru	
Senin	1	07:30-08:30	UPACARA BENDERA										
	2	08:30-09:10	PABP	DESFIANA BR SEMBIRING, S.Pd	PJOK	Drs. REKSA KARDI KARDI	BI	EVI RUDHNE PURBA, S.Pd	PJOK	Drs. SELESAI OT	SBUD	RO SAI	
	3	09:10-09:50	PABP	DESFIANA BR SEMBIRING, S.Pd	PJOK	Drs. REKSA KARDI KARDI	BI	EVI RUDHNE PURBA, S.Pd	PJOK	Drs. SELESAI OT	SBUD	RO SAI	
	4	09:50-10:05	ISTIRAHAT										
	5	10:05-10:45	PABP	DESFIANA BR SEMBIRING, S.Pd	PJOK	Drs. REKSA KARDI KARDI	BI	EVI RUDHNE PURBA, S.Pd	PJOK	Drs. SELESAI OT	SBUD	RO SAI	
	6	10:45-11:25	PA	BETTI SITURKIR, S.Pd	SBUD	ROSMELIANNI SARAGIH, S.Pd	BI	EVI RUDHNE PURBA, S.Pd	PABP	DESFIANA BR SEMBIRING, S.Pd	PABP	RO SAI	

Figure 10. The results of the schedule

The results of the generated schedule for SMP Negeri 1 Deli Tua consist of days, hours, and times, classrooms, as well as the names of teachers entering each subject. Then the schedule will appear according to what was generated, as shown in the display above. This web-based application still needs to be further developed to be used optimally. However, currently, this web-based application can be used for the feature of creating lesson schedules using genetic algorithms, especially the Application for Creating Student Lesson Schedules for SMP Negeri 1 Deli Tua. Elva, (2019) mention genetic algorithm is an optimization technique whose working method imitates the process of evolution and changes in genetic structure in living things. The main principles of how genetic algorithms work are the natural process of natural selection and the principles of genetic science. Genetic algorithms can also specifically solve optimization problems well. Pirozmand et al., (2021) said it is better to use scheduling algorithms that can optimize time and energy usage. Chen et al., (2021) found that the algorithm worked well in the course scheduling system and provided strong support for solving the tedious scheduling work of the educational administration staff. Sardjono et al., (2021) found the implementation of genetic algorithms in work shift scheduling is obtained optimally where there are no clashes between employee shift schedules and for female employee shifts, night work shifts are not found as calculated in the genetic algorithm process.

4. CONCLUSION

The research results have shown that the application of genetic algorithms in scheduling systems can be utilized to solve scheduling problems with more accurate schedules and shorter time. Then scheduling can be created automatically so that there are no schedule conflicts. The implications and contributions of this research is a an application subject for SMP Negeri 1 Delitua. The limitations of this research are the application only designed according to the needs of SMP Negeri 1 Delitua. The suggestions for future research is necessary to develop a system that can be a general model and can be widely applied and that does not require an internet network

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