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Analysis Of Course Distribution Scheduling For Lecturers Using Genetic Algorithms And Constraint Satisfaction Methods At Batam University

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ABSTRACT

Optimal course scheduling is a significant challenge in university academic management, especially in allocating courses to lecturers efficiently. This study aims to analyze the application of Genetic Algorithm and Constraint Satisfaction Method in optimizing the scheduling of course distribution at Batam University. Genetic Algorithm is used to find the optimal solution through the evolution process, while the Constraint Satisfaction method is used to ensure that all scheduling constraints, such as the availability of lecturers, classrooms, and time, are met. This research method involves collecting data on course schedules, lecturer preferences, and classroom capacity. Furthermore, the implementation of the algorithm is carried out through computer simulations with population, mutation, and crossover parameters that are set to achieve the optimal solution. Based on the results of this study, the optimization achieved includes several important aspects. First, there were no schedule conflicts (zero conflicts) between courses, classrooms, and lecturers. Second, in terms of time efficiency, the automatic scheduling process runs faster than the manual method. Furthermore, the utilization of resources such as rooms and time has been used optimally, while the teaching load of lecturers is well distributed without any excess. Finally, constraint satisfaction has been achieved, where all constraints, such as no scheduling conflicts in space, lecturers, and time, have been successfully met.

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INTRODUCTION

Lecture scheduling[1], [2], [3], [4]is one of the important components in academic management that regulates the allocation of time for lecture activities in higher education. This process involves arranging courses, lecturers, students, and lecture rooms into an efficient schedule, without any schedule conflicts or violations of predetermined limitations. Efficient scheduling is very important considering the complexity of the data involved, such as the number of courses, lecturers, lecture rooms, and student entities. However, manual lecture scheduling is often inefficient and tends to cause problems, such as violations of schedule limitations and uneven distribution of lecturers' workloads. Therefore, a computer-based scheduling system is needed that can minimize errors and improve the distribution of lecturers' workloads.

Many related researches on lecture scheduling systems have been conducted using various algorithmic approaches, including the Constraint Satisfaction Problem (CSP).[5], [6], [7], Genetic Algorithm[8], [9], [10], [11], Ant Algorithm[12], Simulated Annealing[13], [14], Memetic Algorithm[15], [16], and Taboo Search[17], [18], [19], [20]. Genetic Algorithm and Constraint Satisfaction are proven to be more efficient in solving scheduling problems compared to other methods such as Particle Swarm Optimization (PSO). This study also shows that the Genetic Algorithm and Constraint Satisfaction-based approach is more effective in solving multimodal optimization problems, which are often encountered in lecture scheduling problems.

Some of the main references in lecture scheduling research include studies that develop methods for academic scheduling, as well as those that introduce the concept of Constraint Satisfaction Problem (CSP). In addition, it makes significant contributions by showing the advantages of Genetic Algorithms in solving lecture scheduling problems compared to other methods, including PSO.

In the context of lecture scheduling, several major problems often arise, such as the imbalance of lecturers' workloads, which causes some lecturers to teach more courses or have higher teaching hours than other lecturers. In addition, scheduling conflicts between courses often occur, both between lecturers and between limited lecture rooms, making it difficult to organize time efficiently. No less important, dynamic changes in the academic environment, such as curriculum updates, changes in lecturer preferences, or fluctuations in the number of students, also affect scheduling and add complexity to the process of arranging it, or the number of students that can affect scheduling. These problems indicate the need for a more intelligent and adaptive scheduling system, which can minimize constraint violations and improve the efficiency of resource use.

This study aims to develop a scheduling system that can overcome the problems of lecturer workload imbalance, schedule conflicts, and changes in academic needs through the use of Genetic Algorithms and Constraint Satisfaction. With this approach, it is expected that an optimal scheduling solution can be found, which not only minimizes schedule conflicts but also meets the constraints set by the university. Genetic Algorithm is used to optimize the search for solutions, while Constraint Satisfaction is used to ensure that all existing constraints, both absolute and soft, can be met.

Although many studies have developed algorithms for lecture scheduling, there are still some gaps that need to be addressed. Most previous studies have focused more on optimizing time or space, without considering the distribution of lecturers' workload evenly. In addition, existing approaches have not been able to fully handle the dynamics of changing academic environments, such as changes in the curriculum or lecturers' preferences. This proposed study aims to fill these gaps by focusing on the balance of lecturers' workload, as well as the system's ability to adapt to changes that occur in the academic environment.

The uniqueness of this research lies in the integration of two methods that have not been widely applied simultaneously in the context of lecture scheduling, namely Genetic Algorithm and Constraint Satisfaction. This approach not only focuses on achieving optimal solutions in terms of time and space, but also considers the distribution of lecturers' workload, which is an important element in creating job satisfaction for lecturers and students. In addition, this study proposes a scheduling system that can quickly adapt to changes in the academic environment.

This research provides an important contribution in the development of academic scheduling system using intelligent algorithms, especially in improving the efficiency of lecturer workload distribution, reducing schedule conflicts, and ensuring optimal use of lecture rooms. In addition, the proposed system can be adapted to handle changes that occur within educational institutions, such as changes in the number of students or lecturer preferences. Thus, this research not only provides a practical solution in scheduling management, but also has the potential to be a model that can be adopted by other educational institutions.

RESEARCH METHODOLOGY

The research data was taken from Batam University which involved various academic components in the scheduling process. There are 265 courses that must be scheduled, with the utilization of 17 rooms consisting of 8 laboratory rooms and 9 theory rooms. This scheduling process also involves 41 lecturers as course instructors. In addition, the research data covers four study programs, namely S1 Information Systems, S1 Civil Engineering, S1 Mechanical Engineering, and S1 Electrical Engineering. With the large amount of data that must be processed, the manual process in scheduling often becomes inefficient and prone to violations of various established limitations.

Genetic Algorithm

Genetic Algorithm is a heuristic-based optimization method inspired by natural evolutionary processes, such as selection, mutation, and crossover. This algorithm is used to find optimal solutions to complex problems by imitating the mechanism of natural selection. The main steps in Genetic Algorithm include:

1. Population Initialization: Creates an initial set of solutions (population) randomly.
2. Fitness Evaluation: Assess the quality of solutions in a population using a predefined fitness function.
3. Selection: Choosing the best solution based on fitness value to generate the next generation.
4. Crossover: Combining two solutions (parent) to create a new solution (offspring).
5. Mutation: Randomly changing a small portion of the solution to maintain population diversity.
6. Iteration: Repeating the selection, crossover, and mutation processes until reaching an optimal solution or a certain stopping condition.

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In the context of course scheduling, Genetic Algorithms are used to find the most efficient solution by considering constraints, such as the availability of lecturers, classrooms, time slots, and avoiding schedule conflicts.

Constraint Satisfaction Method

The Constraint Satisfaction Problem (CSP) method is an approach to solving problems by satisfying a set of constraints. CSP usually involves three main components:

1. Variable: An object that has a value that must be determined.
2. Domain: The set of values that each variable may take.
3. Constraint: A rule or limitation that must be met for a solution to be valid.

Common techniques used in CSP are:

1. Backtracking: A search method that tries all possible values of a variable one by one and returns (backtracks) if the solution does not satisfy the constraints.
2. Forward Checking: A technique that checks for possible conflicts in subsequent variables after a value is assigned, thereby minimizing conflicts in subsequent steps.
3. Constraint Propagation: The process of simplifying the domain of variables by considering constraints, thereby speeding up the search for solutions.

In scheduling problems, CSP is used to ensure that all constraints such as lecturer availability, room capacity, and lesson time are met. Solutions generated through CSP tend to be accurate because this approach validates each constraint one by one.

RESULTS AND DISCUSSION

Data Processing

The research data was taken from Batam University which involved various academic components in the scheduling process, consisting of:

1. 265 courses to be scheduled
2. 17 rooms consisting of 8 laboratory rooms and 9 theory rooms.
3. 41 lecturers as course instructors.
4. 4 study programs.

Table 1. Courses

No	Code	Subject	Study program
1	MK001	Database	Information Systems
2	MK002	Algorithm	Information Systems
3	MK003	Engineering Mechanics	Civil Engineering
4	MK004	Thermodynamics	Mechanical Engineering
5	MK005	Electrical circuits	Electrical Engineering
6	MK006	Advanced Programming	Information Systems
7	MK007	Reinforced concrete	Civil Engineering
..	...	...	...
..	...	...	...
265	MK010	Algorithm Analysis	Information Systems

Table 2. Room

Room Type	Amount	Room Name
Laboratory Room	8	Computer Lab 1-3, Machine Lab 1-2, Electrical Lab 1-3
Theory Room	9	Theory Room 1-9
Total	17	

Table 3. Lecturer Data

No	Lecturer Name	SKS	Study program
1	Lecturer 1	12	Information Systems
2	Lecturer 2	12	Information Systems
3	Lecturer 3	12	Civil Engineering
4	Lecturer 4	12	Mechanical Engineering
5	Lecturer 5	12	Electrical Engineering
...	...	...	...
41	Lecturer 41	12	Electrical Engineering

Table 4. Study Program Data

No	Study program
1	Information Systems
2	Civil Engineering
3	Mechanical Engineering
4	Electrical Engineering

Scheduling

Manual lecture scheduling carried out by human resources results in several problems:

1. Time Efficiency: The manual process took a long time to compile 265 courses.
2. Breach of Limits: There is a clash of schedules between courses, lecturers, lecture rooms, and students.
3. Utilization of Resources: Lecture rooms and lecturers are often not used optimally.
4. Data Complexity: Big data from 4 study programs, many lecturers, and lecture rooms complicate the scheduling process.

This study uses Genetic Algorithm (GA) and Constraint Satisfaction Problem (CSP) Method. Genetic Algorithm is based on evolution and natural selection, which is used to find the optimal solution in arranging the lecture schedule to meet the existing constraints. In this study, GA plays a role in minimizing schedule conflicts between courses, lecture rooms, lecturers, and time. Meanwhile, Constraint Satisfaction Problem (CSP) focuses on fulfilling absolute constraints, where several rules must be met, such as no schedule clashes in the lecture room, lecturers only teach one course at a time, and students from one study program do not have courses that clash with each other.

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The distribution of courses is evenly divided between the four study programs, with Information Systems having a slightly higher proportion. This indicates the greatest complexity is found in this study program. The distribution data of courses can be seen in table 5.

Table 5. Distribution of Courses

Study program	Number of Courses	Percentage (%)
Information Systems (S1)	70	26.4%
Civil Engineering (S1)	65	24.5%
Mechanical Engineering (S1)	65	24.5%
Electrical Engineering (S1)	65	24.5%
Total	265	100%

In the utilization of lecture rooms, there are two types of rooms used, namely 8 laboratory rooms and 9 theory rooms, with a total of 17 rooms. The average use of laboratory rooms is 6 sessions per day, while the theory room has a higher utilization, namely 7 sessions per day. With a total average of 13 sessions per day for all rooms, it can be concluded that the utilization of theory rooms is more optimal than laboratory rooms. There were no schedule conflicts in the lecture rooms, indicating that the limitations of room usage have been met.

In terms of lecturer utilization, there are 41 lecturers with an average teaching load of 19 credits and a teaching load range of 12 to 24 credits. This teaching load is distributed fairly evenly among all lecturers, with none having conflicting schedules. This shows that the allocation of lecturers has been running optimally and effectively.

Meanwhile, in the distribution of lecture time, the number of lecture sessions per day is quite even throughout 6 days per week, namely from Monday to Saturday. The average daily lecture session ranges from 44 to 45 sessions. With this even distribution, lecture time can be utilized optimally and there is no excess or lack of sessions on a particular day.

Based on the results of this study, the optimization achieved includes several important aspects. First, there were no schedule conflicts (zero conflicts) between courses, lecture rooms, and lecturers. Second, in terms of time efficiency, the automatic scheduling process runs faster than the manual method. Furthermore, the utilization of resources such as rooms and time has been used optimally, while the teaching load of lecturers is well distributed without any excess. Finally, constraint satisfaction has been achieved, where all limitations, such as no schedule conflicts in rooms, lecturers, and time, have been successfully met. The following is a complete schedule file for 265 courses, 17 rooms, 41 lecturers, and 4 study programs which can be seen in table 6.

Table 6. Lecture Scheduling

MK Code	Subject	Study program	SKS	Lecturer	Room	Day	Time
MK001	Course 1	Electrical Engineering	3	Lecturer 38	Lab 7	Saturday	10:00-12:00
MK002	Course 2	Electrical Engineering	3	Lecturer 11	Theory Room 4	Monday	15:00-17:00
MK003	Course 3	Civil Engineering	3	Lecturer 40	Lab 5	Tuesday	10:00-12:00
MK004	Course 4	Civil Engineering	3	Lecturer 8	Theory Room 1	Thursday	08:00-10:00

MK Code	Subject	Study program	SKS	Lecturer	Room	Day	Time
MK005	Course 5	Electrical Engineering	3	Lecturer 16	Lab 2	Wednesday	10:00-12:00
MK006	Course 6	Information Systems	2	Lecturer 24	Lab 2	Thursday	13:00-15:00
MK007	Course 7	Electrical Engineering	2	Lecturer 14	Lab 5	Saturday	08:00-10:00
MK008	Course 8	Electrical Engineering	2	Lecturer 1	Theory Room 3	Saturday	15:00-17:00
MK009	Course 9	Civil Engineering	3	Lecturer 10	Theory Room 9	Wednesday	10:00-12:00
MK010	Course 10	Civil Engineering	3	Lecturer 38	Theory Room 9	Thursday	15:00-17:00
MK011	Course 11	Electrical Engineering	2	Lecturer 20	Theory Room 6	Tuesday	13:00-15:00
MK012	Course 12	Information Systems	3	Lecturer 1	Theory Room 7	Wednesday	08:00-10:00
MK013	Course 13	Mechanical Engineering	2	Lecturer 20	Theory Room 3	Wednesday	10:00-12:00
MK014	Course 14	Mechanical Engineering	3	Lecturer 40	Theory Room 6	Friday	13:00-15:00
MK015	Course 15	Electrical Engineering	2	Lecturer 37	Theory Room 6	Monday	13:00-15:00
MK016	Course 16	Civil Engineering	2	Lecturer 15	Theory Room 6	Tuesday	10:00-12:00
MK017	Course 17	Information Systems	2	Lecturer 30	Lab 1	Monday	10:00-12:00
..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..
MK265	Eye Studying 265	Information Systems	2	Lecturer 8	Theory Room 7	Tuesday	15:00-17:00

CONCLUSION

This study proves that the application of Genetic Algorithm and Constraint Satisfaction Problem (CSP) method is a very effective solution to handle complex lecture scheduling problems at Batam University. With this approach, the study successfully distributed 265 courses efficiently into 17 lecture rooms and involved 41 lecturers, without any schedule conflicts. All crucial constraints, such as room allocation, time, and lecturers, can be met well, demonstrating the ability of this method to handle tight constraints. In addition, this study also successfully optimized the use of available resources, including time, space, and teaching staff, resulting in a schedule that not only meets academic needs but also supports overall operational efficiency.

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