Third Year BSCS Scheduling Using Ant Colony Optimization

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***Abstract* — The University Class Scheduling Problem (UCSP) entails the allocation of courses to classrooms, considering constraints like classroom capacities and university regulations. In this research, we propose a scheduling algorithm aimed at solving UCSP specifically for the third-year Bachelor of Science in Computer Science (BSCS) curriculum at the Technological University of the Philippines - Manila. ACO is a metaheuristic algorithm that is inspired by the behavior of ants in nature. It has been shown to be effective in solving a variety of scheduling problems. The objective of this study is to develop an efficient scheduling based on the following inputs: sections, classroom availability, professor availability, and subject requirements.**

Keywords—Ant Colony Optimization (ACO), Scheduling, University Class Scheduling Problem (UCSP), Swarm Intelligence.

I. INTRODUCTION

To meet a set of constraints, a fixed number of events must be scheduled using a fixed number of timeslots and resources [1]. According to Al-Betar and Khader [2] and Garey and Johnson [3], these issues are NP-hard. In timetabling problems, the set of constraints is typically split into a set of hard constraints and a set of soft constraints. In contrast to soft constraints, which may be broken but have an impact on the quality of the solution, hard constraints are requirements that must be met for a schedule to be [4]. While some versions of the problem are pure feasibility issues, others consider an objective that might represent, for example, the cost (to be minimized) or acceptability (to be maximized), of the schedule.

Timetabling issues have numerous uses in a variety of contexts, including employee allocation, transportation systems, educational institutions, sporting events, and industrial applications [5]. Exam and course scheduling are two crucial routine and difficult tasks for maximizing physical and human resources in higher education institutions [6]. The University Course Scheduling Problem (UCSP) is a notoriously challenging timetabling optimization problem that necessitates the fulfillment of numerous soft and hard constraints. According to Feizi-Derakhshi, Babei, and Heidarzadeh [7], the purpose of UCSP is to assign all classes and laboratory sessions to instructors, rooms, and timeslots while taking into account both hard and soft constraints. This will prevent any disputes from arising over these assignments. The UCSP's limitations include things like the personalities of the instructors, the school's educational policies, the availability of teaching staff, and other physical resources. Each instructor can only teach one class at a time in UCSP, and each student can only attend one class at a time. Similar restrictions of a different kind are treated as rigid requirements that must be met. The instructors' preferences for preferred days and timeslots are typical soft constraints of the UCSP and are expected to be met as much as possible. The primary challenge in the UCSP is how to handle room allocation for lectures while taking into account each room's maximum capacity, the number of students enrolled in a course, and other relevant facilities [8]. Depending on their facilities and resources, institutions may have different hard and soft constraints. Rearranging class schedules is necessary for any resource update or modification (including resource capacity changes), which happens frequently at the start of a term.

Recently, UCSP and other scheduling issues have been studied using Swarm Intelligence (SI) optimization techniques including Ant Colony Optimization (ACO) [9][10]; and Honey-Bee Mating Optimization [11]. Particle Swarm Optimization (PSO) is a very prominent technique in SI-based optimization methods [12], and several PSO-based strategies have been investigated for UCSP. Shiau [13] proposed an algorithm taking into account a number of restrictions and a repair mechanism for all solutions that are impractical. To create a high school timetable, Tassopoulos and Beligiannis [14] developed a hybrid PSO method. Inertia weight and constriction variants of PSO for UCSP were the subjects of Chen and Shih's [15] investigation.

II. RELATED WORKS

A. Class Scheduling Problem

Researchers have addressed the UCSP in light of the contemporary challenges that colleges face. The limits that the UCSP must work under include things like the preferences of the teachers, educational policies, and physical resources that go beyond the pupils. Optimizing the use of the physical and human resources is made difficult by this. Each assignment in the UCSP is for a specific instructor to teach a specific course in a specific classroom during a specific time module. Numerous meta-heuristic methods, including the Genetic Algorithm, Tabu Search, and Simulated Annealing, have recently been used to examine the UCSP. Other well-known swarm intelligence algorithms that address the UCSP include Ant Colony Optimization, Honey Bee Optimization, and Particle Swarm Optimization (Thach, 2020).

B. *Ant Colony Optimization*

The foraging habits of actual ant colonies serve as the basis for the ACO algorithm. Artificial ants use the ACO algorithm to successfully build solutions using both local and global information (pheromones). The pheromone then serves as a probabilistic model for solution creation, and it is continuously amplified by ants constructed with superior solutions. As a result, premature convergence to a subpar local optimum is surpassed by pheromone evaporation. In ACO, the issue is really resolved by simulating some synthetic ants that travel across the graph that generates the issue. As the first problem that ACO tackles, the traveling salesman problem (TSP) has a significant impact on ACO (Mazlan, Makhtar, Khairi, Mohamed, 2019).

III. EXPERIMENT

Ant colony optimization (ACO) algorithms could change the field of university class scheduling by offering a creative and effective approach to the challenging problem of resource allocation. The collective intelligence of ant colonies, where individual ants communicate through pheromone trails to identify the closest food sources, served as the model for ACO algorithms. Similar to this, ACO algorithms can be used to determine optimal or nearly optimal class schedules in university settings by taking into account a variety of criteria such course needs, room capacities, instructor availability, and student preferences.

In the ACO technique, prospective class schedules are first represented as ant agents that travel around the scheduling graph, which has nodes for time slots, classrooms, and courses. Each ant is given a random class schedule to begin with, and they begin their exploration of the search area by selecting the next open slot using a combination of pheromone trails and heuristic data. Heuristics point the ants in the direction of viable possibilities while pheromone trails indicate the quality of a given assignment. The quantity and quality of the pheromone trails left behind by the ants as they go across the search area correspond to their assignments.

The balance between the ants' foraging and exploitation is accomplished through an iterative method. Ants can initially find a variety of potential schedules during the investigation phase, while during the exploitation phase, pheromone trails can be concentrated on advantageous solutions. The pheromone trails' positive feedback mechanism encourages the investigation of more advantageous paths while reinforcing the successful assignments. This adaptive approach aids the algorithm's convergence to schedules that are close to optimal, successfully minimizing conflicts, maximizing resource consumption, and satisfying a number of requirements.

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Universities may effectively manage and optimize class schedules by using ACO algorithms, which has many advantages. It ensures that classrooms are assigned appropriately based on their capacity and facilities, allowing for the effective use of resources. Second, it improves the entire teaching experience by reducing disputes by taking instructor preferences and availability into account. Thirdly, it considers student preferences, making it possible to create schedules that are in line with their academic needs and reduce conflicts between course requirements..

IV. RESULTS

The system was able to efficiently search an extensive search space and come up with high-quality solutions thanks to the use of ACO in the scheduling process. The system successfully balanced a variety of limitations, including professor preferences, classroom availability, and section requirements, by drawing on the swarm intelligence of artificial ants. As a result, the created schedules met all the required requirements and were both feasible and optimized.

Conflicting schedules are not present, which speaks to the capacity of the selected approach. The technology maximizes the use of available classrooms and reduces time overlaps for professors and students by recognizing and resolving conflicts between classes. By doing this, scheduling-related difficulties and complications are less likely while simultaneously increasing the efficiency of resource allocation.

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Best solution for BSCS 3AB:
CC303-M: Professor MOLINO, Classroom ROOM CS301, Section BSCS 3AB, Tuesday at 16:00-19:00
CS321L-M: Professor LEE, Classroom ROOM CS301, Section BSCS 3AB, Friday at 16:00-19:00
CS322-M: Professor LEE, Classroom ROOM CS302, Section BSCS 3AB, Thursday at 18:00-20:00
CS341L-M: Professor MONTESINES, Classroom ROOM CS302, Section BSCS 3AB, Wednesday at 9:00-12:00
CS342-M: Professor MONTESINES, Classroom ROOM CS301, Section BSCS 3AB, Tuesday at 13:00-15:00
CS361L-M: Professor CRUZ, Classroom ROOM CS302, Section BSCS 3AB, Thursday at 10:00-13:00
CS362-M: Professor CRUZ, Classroom ROOM CS301, Section BSCS 3AB, Wednesday at 7:00-9:00
CS383-M: Professor LEE, Classroom ROOM CS302, Section BSCS 3AB, Monday at 11:00-14:00
CSE3-M: Professor MIRADOR, Classroom ROOM CS302, Section BSCS 3AB, Friday at 12:00-15:00
CSE4-M: Professor GANDEZA, Classroom ROOM CS302, Section BSCS 3AB, Thursday at 14:00-17:00
Best solution for BSCS 3CD:
CC303-M: Professor MOLINO, Classroom ROOM CS302, Section BSCS 3CD, Saturday at 12:00-15:00
CS321L-M: Professor LEE, Classroom ROOM CS302, Section BSCS 3CD, Saturday at 15:00-18:00
CS322-M: Professor LEE, Classroom ROOM CS301, Section BSCS 3CD, Wednesday at 15:00-17:00
CS341L-M: Professor MONTESINES, Classroom ROOM CS301, Section BSCS 3CD, Saturday at 8:00-11:00
CS342-M: Professor MONTESINES, Classroom ROOM CS301, Section BSCS 3CD, Wednesday at 13:00-15:00
CS361L-M: Professor CRUZ, Classroom ROOM CS301, Section BSCS 3CD, Monday at 8:00-11:00
CS362-M: Professor CRUZ, Classroom ROOM CS302, Section BSCS 3CD, Friday at 10:00-12:00
CS383-M: Professor LEE, Classroom ROOM CS301, Section BSCS 3CD, Monday at 15:00-18:00
CSE3-M: Professor MIRADOR, Classroom ROOM CS301, Section BSCS 3CD, Tuesday at 10:00-13:00
CSE4-M: Professor GANDEZA, Classroom ROOM CS301, Section BSCS 3CD, Friday at 7:00-10:00
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Figure 1. Scheduling using ACO

V. CONCLUSION AND RECOMMENDATION

In this study, the application of Ant Colony Optimization (ACO) algorithms for optimizing the scheduling of third-year Bachelor of Science in Computer Science (BSCS) courses was explored. By leveraging the collective intelligence of ant colonies, the ACO-based scheduling system demonstrated promising results in minimizing conflicts and maximizing satisfaction among the sections, classroom availability, professor availability, and subject requirements.

Given the successful implementation of Ant Colony Optimization (ACO) algorithms in the scheduling of third-year Bachelor of Science in Computer Science (BSCS) courses, the feasibility of leveraging ACO to develop a comprehensive university-wide scheduling system is advised. The demonstrated adaptability and efficiency of the ACO-based approach in mitigating conflicts and optimizing resource allocation position it as a promising candidate for tackling the intricate scheduling demands encountered by universities.

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