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Development of an Integrated Students' Information Management System

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ABSTRACT

The evolution of Information Management Systems, particularly within universities, has witnessed substantial investment, aimed at streamlining tasks like student registration and result processing. The current systems are often cumbersome and error-prone, hindering efficient data processing and utilization. Thus, this research explores advanced computational methods like Ant Colony Optimization (ACO) Model and Advanced Encryption Standard Model to enhanced usage experience. The Ant algorithm stands out as a highly efficient polynomial algorithm renowned for its effectiveness in approximating solutions. It excels in tackling route search problems within graphs and are leveraged to enhance software efficiency and streamline optimization efforts. The result of the system allows users to access their desired output within a few clicks thereby enabling system's effectiveness through the optimized efficiency, security indices and user experience.

1.0 INTRODUCTION

Students are the main characters in educational institutions. It is imperative that academic institutions achieve excellence in creating highly qualified graduates and postgraduates. Modern schools work hard to maintain their reputation for excellence and respect in the academic community. In actuality, schools put their reputation above the caliber of instruction. But strict accrediting requirements force schools to create and put into practice creative ways to maintain their standards. Numerous governmental and accrediting organizations guarantee that educational establishments maintain a superior learning environment [1][2]. The institutes are looking for novel approaches in order to maintain their standing.

Educational institutions adopt cutting-edge technologies such as Online Registration Portals and Result Processing and Management Systems, enabling them to gather vast amounts of data pertaining to students and the learning environment [3]. This data encompasses student documentation, behaviors, assessment performance, demographic information, and administrative records. To optimize decision-making processes, institutions seek innovative practices to effectively leverage this collected data. Additionally, various computer technologies offer conveniences in simplifying complex materials, making them more accessible and memorable for users [4].

The computer, particularly in the realm of information management systems, possesses the capability to receive and store raw data, execute data processing based on a predefined set of instructions, and retain the results of this processing for future reference [5]. Its inherent flexibility and versatility allow it to adapt to a wide array of human endeavors. By simply altering the processing instructions, known as commands, the machine can seamlessly transition to a different operational mode tailored to meet specific objectives. Over the past few decades, there has been an exponential growth in Information Management Systems, particularly within university environments, with institutions investing substantial resources in their development [6][7][8]. Some of these systems date back to the 1990s, initially implemented in colleges and universities with database systems to manage tasks such as student registration, result processing, storage, and overall data management. The widespread adoption of these systems is attributable to their ability to efficiently handle large volumes of complex routine tasks, often with remarkable speed and accuracy [9].

One of the primary goals of educational institutions is to effectively manage and monitor students' academic performance[10], with a specific focus on identifying those who are experiencing inadequate progress [11]. Identifying struggling students enables teachers to design and implement preventive measures to address their needs promptly. Therefore, the development of sophisticated prediction models is crucial to forecast students' final outcomes accurately, facilitating proactive intervention strategies by educators [12]. Several prediction models are utilized to monitor student performance, primarily through analyzing their academic results. Numerous such models have been deployed to complement machine learning algorithms, serving as valuable tools in predicting students' academic progress based on their performance data in their results [13].

A result serves as an official school report detailing a student's academic record, encompassing the courses undertaken and the corresponding grades received. Integral to student registration, it plays a crucial role in processes such as admission, transfer credit unit processing, and graduation processing. The student's result serves as a fundamental measure of their academic prowess within the school environment, evaluating their capability across various courses. Without a robust results processing system in place, the intended purpose of producing results may not be fulfilled, and errors in the process could potentially escalate into significant issues [14].

Results processing encompasses a continuous process of converting data comprising grade points, scores and credit units, into cohesive and significant information, such as result statements and transcripts [15]. These outcomes serve as vital tools for evaluating each student's performance across different courses. However, the existing approach to academic results processing has been identified as laborious and time-consuming, particularly when handling a substantial number of students. This inefficiency renders the entire process burdensome and susceptible to errors [16]. This research study takes into consideration, the application of ACO to solve the inefficiencies.

The Ant Colony Optimization (ACO) algorithm represents a meta-heuristic strategy aimed at optimizing computational challenges through probability-based approaches. It employs artificial ants to mimic the natural behaviors and movements observed in real ant colonies, gathering essential data to address problem-solving tasks. Despite their lack of sight, ants navigate their environment by probabilistically selecting paths while foraging for food and shelter (nests). During foraging trips, ants deposit pheromones, acting as a form of communication, along their traveled routes, linking the nest to food sources and vice versa. As a result, when subsequent ants search for food, they tend to follow paths marked with pheromone trails, leading to the eventual establishment of the shortest route between nest and food source, with richer pheromone trails indicating shorter paths. The Ant Colony Algorithm finds widespread application in solving diverse combinatorial problems, including vehicle routing, internet routing, the traveling salesman problem, scheduling, image processing, knapsack problems, pollution control, and more.

Currently, the existing information management system for students' registration and result processing, encompassing online program modules, milestone management, activity monitoring, process management, data sharing, and collaborative synchronous functions, falls short in enhancing usage experience, necessitating an efficient system that allows users to access their desired output within a few clicks. Therefore, there is a pressing need to reorganize the system structure to enhance usage mining efficiency, security and reduce the memory requirements for storing data, pages, and user browsing history. This paper focuses on the innovative application of ant colony optimization (ACO) techniques to resolve the short falls.

2.0 RELATED WORKS

Given the extensive range of scholarly resources accessible for study, numerous literature sources pertaining to ant colony optimization were consulted and thoroughly examined to stay updated on the concept. These reviews encompassed diverse applications of the ant colony optimization technique, as elucidated in the paper [17] presents a research paper titled Efficiency Engine: Designing and Implementing an Academic Management System with the aim to streamline and automate various administrative and academic processes within educational institutions. The research work make use of ERP diagram to provides administrators, faculty, staff, and students with access to real-time information, enabling better communication, collaboration, and decision-making. The research work include registration and record management without the use of a secured channel.

[18] presented the design and implementation of Baggao North Central School Computer-Based Record Management System to streamline the administrative tasks of the school, from keeping track of student records to generating reports. The system make use of design science research (DSR) framework to utilized, gather, process, and analyze data. The result shows ease navigation through the system, reducing the chance of human error during record-keeping but the system focus basically on just the implementation of result processing using waterfall model.

[19] presented a new student registration platform innovation based interactive virtual customer relationship management (vCRM) to optimize the use of Rangers 2.0, to measure the quality improvement obtained. The study utilizes Interactive Virtual Customer Relationship Management as the method to provide better services and approaches virtually. It provides great service for prospective new student relations in registration but focus majorly on the use of support to ease course registration.

[20] presented a secured student portal using cloud to suggest a secured student data portal by providing security to the students, faculty data, and the question papers of concerned examinations. The portal make use of mac address of the laptops and Wi-Fi routers and the image of them with time stamp to created a secured portal for students. The secured system is based on the mac address of the laptops and Wi-Fi routers and the image of them with time stamp to secure the portal which is not enough to prevent sql injection.

[21] developed an online integrated student management information system to provide a simple and effective way of managing student information and manage student-related data. The system was developed using technologies such as PHP, HTML, Jquery, JavaScript, CSS and MySQL. It enables the generation of semester grade reports, student transcripts, batch details, placement details, and other resource-related information. The system doesn't provide an optimized information management, and it doesn't prevent against SQL Injection.

[22] presents a secure data acquisition and processing

system to execute one or more secure data acquisition processes during interaction with a mobile computing device operated by a user. The system make use of a secure server to executes secure data acquisition processes and tracks information uniquely identifying the mobile computing device interacting with it. The research presents a secure data acquisition and processing system that includes a secure server and a security engine . The system doesn't put anything in place for SQL Injection and optimization.

[29] conducted a study centered on a relay routing algorithm for remote concentrated ammeter reading using ant colony optimization. They surveyed methods to enhance remote concentrated ammeter reading, proposing a relay routing algorithm utilizing ant colony optimization to derive an optimal relay route. Analysis and extensive simulation of the proposed algorithm revealed improved reliability in ammeter reading, resistance to route destruction, and high efficiency. [30] devised an enhanced ant colony optimization algorithm focusing on Minion ants (MANT) and its application to the traveling salesman problem. They addressed challenges encountered in solving complex traveling salesman problems by modifying the ant colony optimization approach, introducing the MAnt algorithm. Executed with a desired pheromone evaporation rate, the MAnt algorithm substantially reduced tour costs across various traveling salesman problems, demonstrating its efficacy beyond this specific domain.

[31] extensively analyzed the utilization of ant colony optimization techniques for solving the traveling salesman problem. Shuqeir and Qublan (2014) concentrated their research on a hybrid algorithm combining ant colony optimization and genetic algorithm for task allocation in a network of homogeneous processors. They integrated ant colony optimization and genetic algorithms to address task allocation issues, proposing a TAP-ACO-GA hybrid algorithm that outperformed individual ant colony optimization and genetic algorithm approaches in subsequent testing.

3.0 METHODOLOGY

Mathematically modeling ACO entails incorporating elements such as randomization, pheromone trail management, and updating, alongside calculating the optimal tour length and adjusting pheromone levels. ACO, as a meta-heuristic optimization approach, is inherently stochastic. It mirrors the natural movement and behavior of ants to tackle optimization challenges. Given that ants lack sight, their movement is characterized by randomness as they select paths probabilistically from one location to another. The methods used for the development of student information management system are the Ant Colony Optimization Model (ACO) for optimization and AES for data security.

3.1 Ant Colony Optimization model for optimization

Many jobs are optimized using the ant algorithm. It aid in enhancing and optimizing system performance in this work [23]. There are several operators in the program code. The program may work more slowly if it goes through a lengthy process to switch operators for a particular reason. The following is how an appropriate set of operators are conceptualized as an ant colony.

i = 1, where the *i*th ant colony is shown by n.

The ants are first placed as part of the work schedule, and then they begin to move. Equation 1's formula is used to determine the likelihood of a direction change. [24]: The system of Equation 1 is useful to determine the pheromone update for a definite evaporation rate. Expanding at a rapid pace, the demand for food is on an upward trajectory. The increasing need for food, coupled with evolving consumer preferences, has presented formidable challenges to the agriculture sector, making it imperative for the industry to devise techniques and

$$P_i = \frac{l_i^q f_i^p}{\sum_{k=0}^{N} l_k^q f_k^p} \quad (1)$$

P_i - like change to the path i.
l_i - length of the i-th path.
f_i – pheromone amount in the i-th path.
q – greediness of the algorithm.
p –colony of the algorithm

The algorithm consists of several steps.

Step 1: Operators are likened to ants, with each operator assigned to a node. Memory blocks are then created to store various parameters, including the visited nodes and the path length.

Step 2: The initial pheromone is uniformly distributed along the path, while algorithm parameters such as α (greediness factor), β (pheromone influence on solution search), P (pheromone evaporation rate), and Q (pheromone distribution) are defined.

Step 3: The iteration process begins for each ant, where all potential path options are evaluated using Equation 1 to derive probabilities for each operator.

Step 4: The visited operator is recorded in the ant's memory along with the calculated distance.

Step 5: Upon completion of the iteration for each ant, the pheromone levels along the paths are adjusted, leading back to Step 2.

Step 6: The stored values guide the search for the minimum distance while adhering to sequence rules.

An ant serves as a simple computational agent that seeks viable solutions to a designated optimization problem employing ant colony optimization techniques [25]. To utilize an ant colony approach, the optimization problem needs to be redefined as the task of identifying the shortest path within a weighted network. At the start of each cycle, every ant generates a solution randomly, determining the sequence for traversing the edges in the graph. In the subsequent phase, the paths discovered by different ants are compared. The ultimate stage involves updating the levels of pheromones on each edge.

```
proc ACO_Meta_Heuristic is
   while not_terminted do
      generateSolutns()
      daemonActns()
      pheromoneUpd()
   repeat
end proc
```

The metaheuristic has three algorithmic components, whose activation is controlled by the scheduled activities construct, and an initialization step. Until a termination requirement is satisfied, this construct is repeated [26]. Typically, requirements include a maximum CPU time or a limit number of repeats.
The scheduling and synchronization of the three algorithmic components are not specified by the scheduled activities construct. However, in the majority of ACO applications to NP-hard problems, the three algorithmic components run through a loop wherein (i) all ants produce solutions, (ii) local search algorithms are used to (optionally) refine these solutions, and (iii) the pheromones are updated.The operators are executed in compliance with the regulation and written in a certain sequence. The system optimization is a process that is frequently neglected, which might cause the application to operate slowly. An ant algorithm is used to expedite performance and arrive at results in the least amount of time.

3.2 Aes Algorithm For Encryption

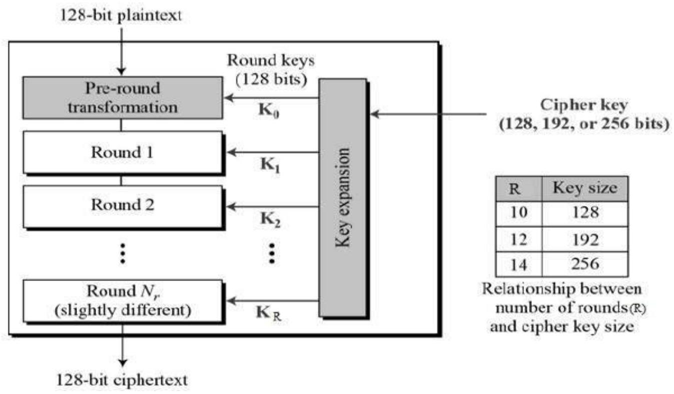
All examination procedures encrypt and decrypt using an AES-based approach. The symmetric encryption method known as AES (Advanced Encryption Standard) was created by two Belgian cryptographers named Joan D and Vincent R. [27]. With support for block lengths of 128 bits and key lengths of 128, 192, and 256 bits, it was created with efficiency in mind for both software and hardware. Since the United States uses this encryption technique to protect sensitive and unclassified material, it has a high level of security. The AES-192, AES-256, and AES-128 block ciphers [28]. Each cipher uses cryptographic keys of lengths of 128-, 192-, and 256-bits, respectively, to encrypt and decode data in blocks of 128 bits. Furthermore, AES uses bytes rather than bits for all of its computations. As a result, AES interprets the 128-bit block's input plaintext as 16 bytes. The AES structural schematic is seen in Figure 3.

The length of the key determines how many rounds there are in an AES transaction. For 128-bit keys, AES utilizes 10 rounds; for 192-bit keys, it uses 12 rounds; and for 256-bit keys, it uses 14 rounds. The original AES key is used to produce a unique 128-bit round key for each of these rounds.

Figure 1**:** AES Encryption Process

3.3 Encryption Process

based on an AES encryption cycle that is standard. Every round consists of four smaller procedures. Figure 2 shows how the first round procedure is shown.



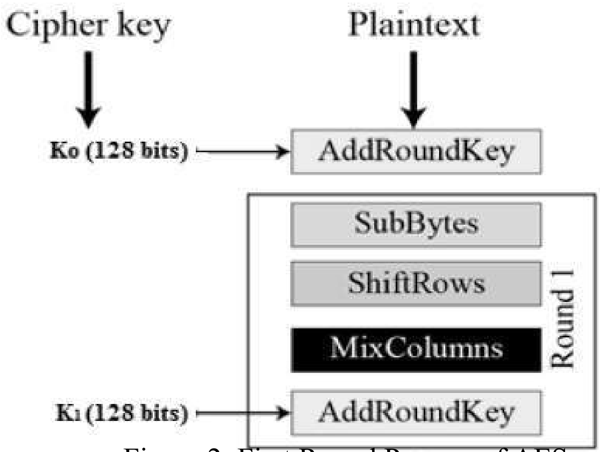


Figure 2: First Round Process of AES.

- Byte Substitution (SubBytes): A fixed table (S-box) provided in the design is searched for in order to replace the 16 input bytes. A matrix with four rows and four columns represents the outcome.
- Shiftrows: The matrix's four rows are all moved to the left. Re-inserting any entries that "fall off" will occur on the row's right side.
- MixColumns: A unique mathematical function is now used to convert each column of four bytes. Four bytes from a single column are entered into this function, which generates four brand-new bytes to replace the original column. Another fresh matrix with 16 additional bytes is the outcome. It should be mentioned that the previous round did not include this stage.
- Addroundkey: The 128 bits of the round key are XORed with the 16 bytes of the matrix, which are now regarded as 128 bits. The ciphertext is the output if this is the final round. If not, the 128 bits that are obtained are translated into 16 bytes, and we start over with a similar process.

Decryption Process

An AES ciphertext's decryption procedure is comparable to its encryption procedure when done in reverse.

4.0 RESULT AND DICUSSION

The optimality of any path is determined probabilistically and the path with the highest chance of been taken is the optimal path using equation 2. From the iterations, the optimum tour length is 210m represented L_k. Where L_k is the optimum tour length.

$f_{ij} = (1\text{-}\rho)f_{ij\ old} + \sum_{k=1}^{n} \Delta\ f_{ij}$ … (2)

f_{ij} is the amount of pheromone deposited at time (t). t is calculated as

$t = 1/\ L_k = 1/210 = 0.00476$ per meter

$(1\text{-}p)f_{ij\ old}$ is the volatile pheromone remaining in the path. ρ is the rate of pheromone evaporation rate. $f_{ij}$is the current pheromone update to be determined at a specific pheromone evaporation rate. Δf_{ij} Is the amount of pheromone deposited at time.

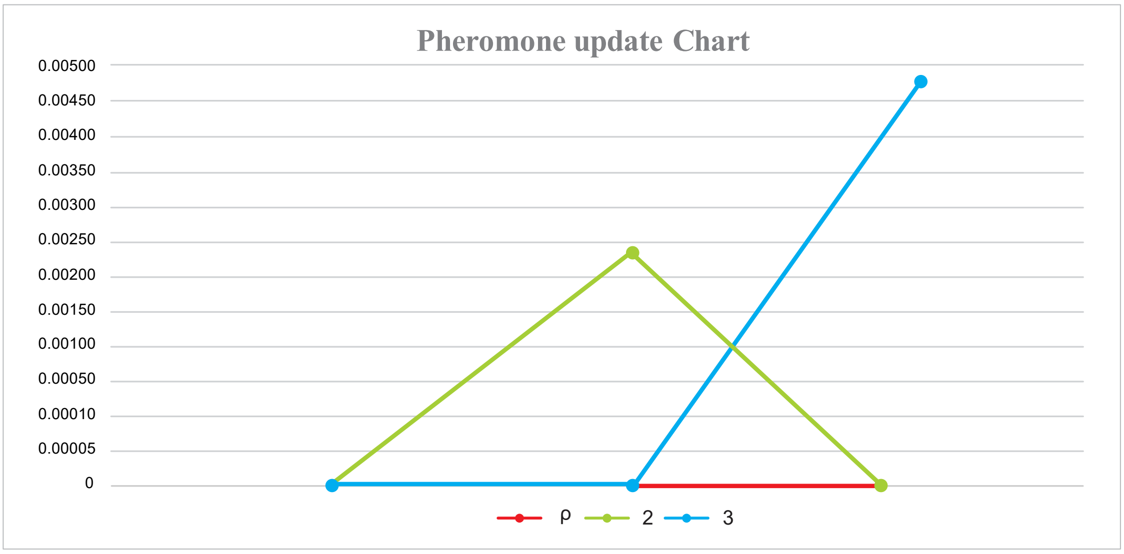


Figure 3: Update Chart for Pheromone

Using equation 3, hence assuming pheromone evaporation rates of 0, 0.5 and 1 the amount of pheromone deposited on the routes or edge is determined.

At ρ = 0 the pheromone deposited do not evaporate hence

$f_{ij} = (1\text{-}0)f_{ij\ old} + (0^* \sum_{k=1}^{n} \Delta\ f_{ij})$ … (3)

$f_{ijnew} = f_{ijold} = 0$

At ρ = 0.5 the pheromone deposited along the path evaporates at a steady rate hence

$f_{ijnew} = (1\text{-}0)0 + (0.5^*0.00476)$

$f_{ijnew} = 0.00238$ per meter

At ρ = 1 the pheromone deposited along the path evaporates immediately and makes it difficult for ants to sense it.

$f_{ijnew} = (1 - 1)\ 0.00238 + (1 * 0.00476)$

$f_{ijnew} = 0.00476$ per meter

$f_{ijmin} = 0 < f_{ijbest} = 0.0.00238 \leq$

$f_{ijmax} = 0.00476$ … (4)

The equation 4 above shows that the minimum amount of pheromone update is always less than the best pheromone update amount which is less than or equal to the maximum amount of pheromone update. The probability of choosing the path can be determined from the updated chart.

To efficiently tackle the Traveling Salesman Problem (TSP), the measurement of distances between locations plays a pivotal role, typically depicted in a chart illustrating the distances between each pair of locations. Given the probabilistic nature of Ant Colony Optimization (ACO), the foraging behavior of ants is simulated iteratively. The number of iterations reflects the repetition of this simulation process. Through experimentation, specific routes are consistently favored by the ants due to the heightened concentration of pheromones along those paths.

In each iteration, the paths taken by ants, particularly ant 1 and ant 5, exhibit the shortest tour length, thus indicating the presence of the most substantial pheromone trail or concentration. To refine this tour length, a process of pheromone optimization is applied, resulting in a maximum pheromone update of 0.00476 per meter and an optimal update of 0.00238 at various rates of evaporation.

Analysis of the pheromone update chart as shown in Figure 1 reveals that the evaporation rate conducive to enhancing usage mining efficiency, security and reduce the memory requirements for storing data, pages, and user browsing history.

5.0 CONCLUSION

This paper proposed a novel application of the ant colony optimization algorithm by utilizing the traveling salesman problem approach for the shortest path to enhance usage mining efficiency, security and reduce the memory requirements for storing data, pages, and user browsing history. As shown in the iterative aspect of the paper, it was observed that the utilization of a low pheromone evaporation rate ensures the availability of pheromone trail for a longer period. This is the secret towards achieving the best possible solution in ant colony optimization problem. Conclusively, this paper has shown the effectiveness of the ant colony optimization technique in the development of an integrated students' information management system.

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