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AI-Based Smart Management System for Universities

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Abstract: ***The study proposes a mobile-based university management system that use Artificial Intelligence to improve the administrative efficiency and campus service management through automated processes. The application integrates core university management functions including student management, staff management, department management, class management, and fee administration within a single mobile platform. A key component of the system is an AI-based timetable generator that applies the Constraint Satisfaction Problem (CSP) approach to produce optimal and conflict-free class schedules based on user-defined academic inputs. The system also includes a Smart Exam Hall Allocation module that applies a multidimensional constraint satisfaction model to generate structured seating arrangements for examinations by considering examination details and hall-capacity constraints. In addition, the application provides a live college bus tracking feature that allows students and administrators to monitor bus locations in real-time using the driver's mobile GPS integrated with the OpenStreetMap API. The proposed system reduces manual effort in timetable and examination management while improving operational transparency and efficiency. By combining mobile technology with AI-driven optimization techniques, the application offers an intelligent and scalable solution for modern university management.***

Keywords: Artificial Intelligence, University Management System, Constraint Satisfaction, Exam Hall Allocation System, Smart Campus Management, Mobile Application, GPS-based Bus Tracking, OpenStreetMap API, Educational Management System.

I. INTRODUCTION

The rapid advancement of digital technologies has significantly transformed educational institutions. Universities and colleges manage a large volume of academic and administrative activities, including student records, staff management, class scheduling, examination management, and transportation services. Traditional manual or semi-digital systems often lead to inefficiencies, creating the need for automated solutions that can optimize university management processes. Artificial Intelligence (AI) is widely used to address complex scheduling and resource allocation problems. Techniques such as Constraint Satisfaction Problem (CSP) can effectively handle multiple constraints and generate optimal solutions in scenarios where manual planning becomes difficult. Integrating AI with mobile technologies provides an opportunity to develop smart institutional management systems that are accessible, scalable, and efficient. This research proposes an AI-based Smart University Management Mobile Application designed to streamline various administrative and academic operations within a single platform. The system integrates essential management functionalities while incorporating intelligent modules for automated timetable generation, smart examination hall allocation, and real-time college bus tracking using GPS and map-based services. By combining AI-based optimization techniques with mobile application technology, the proposed system aims to reduce manual effort, improve resource utilization, and enhance communication between students, faculty, and administrators. The implementation of such an intelligent management system contributes to the development of smart campuses by improving operational efficiency and supporting data-driven decision-making in higher education institutions.

II. OBJECTIVES OF THE STUDY

The main objectives of this research are as follows:

1) To develop an AI-based smart university management mobile application that integrates academic and administrative operations within a single platform.
2) To design and implement an automated timetable generation system using the Constraint Satisfaction Problem (CSP) approach to generate conflict-free academic schedules.
3) To develop a smart exam hall allocation system that generates seating arrangements based on multiple examination and hall constraints.

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4) To implement a real-time college bus tracking system using GPS location sharing integrated with map-based services for transportation monitoring.
5) To reduce manual workload and administrative complexity in university scheduling, examination management, and transportation coordination.
6) To improve operational efficiency and resource utilization within higher education institutions through intelligent automation.
7) To provide a mobile-based platform that enhances accessibility and communication among students, staff, and administrators.

III. CONCEPT

A. AI-based Timetable Generator

One of the key features of the proposed smart university management mobile application is the AI-based timetable generator. Timetable scheduling is a critical task in educational institutions because it involves organizing multiple classes, subjects, faculty members, and time slots without conflicts. In many institutions, this process is still performed manually, which can be time-consuming and prone to errors such as overlapping classes, double-booked staff members, or uneven subject distribution. To address these issues, the proposed system uses an automated timetable generation approach based on the Constraint Satisfaction Problem (CSP) technique. Before generating the timetable, certain basic academic information must be entered into the system. The administrator first adds department details, followed by class details such as academic year, semester, and section. After that, staff information and subject details are added to the application database. Once these details are available, the timetable generation module allows the user to provide inputs such as department name, year, semester, section, subject name, staff name, and the weekly teaching hours required for each subject. Multiple subjects can be assigned to a single class, and the same process can be repeated for different classes such as second year, third year, and final year. The system uses the Constraint Satisfaction Problem (CSP) approach to generate the timetable automatically. A Constraint Satisfaction Problem is a computational approach used to determine the values for variables while ensuring that predefined constraints are satisfied. In simple terms, CSP attempts to determine the best possible combination of values for variables while ensuring that all constraints are satisfied. A CSP generally consists of three main components: variables, domains, and constraints. Variables represent the elements that need to be assigned values. Domains represent the possible values that each variable can take. Constraints represent the rules that restrict how the variables can be assigned. In the context of timetable generation, the variables represent the time slots or class periods available during the week. The domain represents the subjects that can be assigned to those time slots. The constraints include conditions such as a faculty member cannot teach two classes at the same time, a subject must be allocated the required number of hours per week, and a class cannot have more than one subject scheduled in a single time slot.For example, consider a second-year class that has the following subjects: Data Structures (4 hours per week), Database Systems (3 hours per week), and Operating Systems (3 hours per week). The system must distribute these subjects across the available weekly time slots. If the timetable contains five days with five periods per day, the algorithm assigns subjects to different slots while ensuring that the respective staff members are available and no conflicts occur. The CSP algorithm evaluates possible combinations and selects a schedule that satisfies all constraints. After the user provides all required inputs and clicks on the Generate Timetable button, the system processes the data using the CSP algorithm and automatically generates a complete and conflict-free timetable. Once the timetable is generated, it is automatically assigned and made accessible to the respective staff members and students through the mobile application. Additionally, the system includes a smart staff substitution feature. If a staff member is absent on a particular day or hour, the system can analyze the timetable and identify other staff members who are free during that specific time slot. Based on availability, the system suggests alternative faculty members who can temporarily handle the absent staff member's class. This feature helps maintain the continuity of academic sessions and minimize class disruptions. By applying the Constraint Satisfaction Problem (CSP) technique along with intelligent scheduling and staff substitution mechanisms, the proposed system provides an efficient and automated solution for timetable management in educational institutions.

B. College Bus Live Tracking Using Driver's Mobile Device

The second major features of the proposed Smart University Management mobile application is a college bus live tracking system using the driver's mobile device. Transportation management is a vital service offered by many educational institutions, particularly for day scholar students who rely on college buses for daily commute. However, students often experience uncertainty regarding bus arrival times, especially during the early morning hours. To address this issue, the proposed system introduces a real-time bus tracking mechanism within the mobile application.

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The tracking module is implemented through a map-based interface supported by the OpenStreetMap API, which enables map visualization enables map visualization and location-based navigation service. OpenStreetMap was selected because it is an open-source and freely available mapping platform, making it a cost-effective option for integrating geolocation services into the application. Since the map interface depends on online data access, internet connectivity is required to load the map and display real-time location updates. The system follows a role-based access control (RBAC) model to ensure secure and organized transportation management. Initially, the administrator assigns each driver to specific bus number or route within the application. The transport manager is also authorized to create, modify, or manage thes4e assignments when necessary. This structured access model improves operational efficient transport administration within the institution. When bus driver logs into the mobile application, a "Share Location" option becomes available. Once selected, the application requests permission to access the mobile device's GPS-based location service. After permission is granted and location sharing is enabled, the application continuously captures and updates the driver's current position. The collected location data is then transmitted to the system and displayed through the map interface. Authorized users, including students, administrators, and transport managers, can view the live location of the bus in real time within their mobile application. This functionality enables its arrival time with greater accuracy. This feature is especially beneficial for day scholar students, as it allows them to monitor the approaching bus without having to contact classmates or drivers for updates. By providing real-time location visibility, the system enhances transportation transparency reduces uncertainty, and improves convenience for both students and staff. Over, the integration of GPS-based live tracking, a map-based visualization service, and a role-based mobile application framework offers an efficient and practical solution for monitoring and managing college transportation services.

C. Smart Exam Hall Allocation Using a Multi-Dimensional Constraint Satisfaction Problem

The third major features of the proposed Smart University Management mobile application is the smart Exam Hall Allocator, which automates the process of assigning students to examination halls and generating seating arrangements. In many educational institutions, examination hall allocation was still performed manually, making the process time-consuming and susceptible to human error. Manual allocation may result in inefficient hall utilization, uneven student distribution, and confusing during seating arrangement preparation. To address these challenges, the proposed system employs a Multi-Dimensional Constraint Satisfaction Problem (CSP) approach to automatically generate an optimized and structured seating plan. Before generating the seating arrangement, the system requires two categories of input: exam details and hall details. In the exam details section, the administrator enters information such as the subject name, subject code, examination date, session (forenoon or afternoon), and the list of eligible students scheduled to attend the examination. This information enables the system to determine the total number of candidates and the timing of the examination. In the hall details section, the administrator provides information related to the available examination halls, these details include the hall name, number of benches and number of seats per bench, block name and floor name. Based on these inputs, the system calculates the total seating capacity of each examination hall. The seat allocation process is modeled as a Multi-Dimensional Constraint Satisfaction problem, in which multiple constraints must be satisfied simultaneously. In this model the variables represent the available seating positions across different examination halls, while the domain represents the students who must be assigned to those positions. The constraints ensure that the number of students does not exceed the available seating capacity, prevent over crowding and support balanced distribution across halls and benches. Additional constraints may also enforce a structured seating pattern to maintain spacing, improve invigilation efficiency, and preserve examination discipline.

For example, consider an examination involving 120 eligible students and two available halls. Hall A contains 20 benches, each with 3 seats, resulting in a total capacity of 60 seats. Similarly, hall B contains 20 benches with 3 seats per bench, providing a additional 60 seats. The CSP-based allocation algorithm evaluates these constraints and distributes the 120 students across both halls in an organized manner by assigning each student to a specific hall, bench and seat position while ensuring that seating capacity and arrangement rules are satisfied. Once the administrator selects the relevant examination and the available halls, the system processes the input using the multi-dimensional CSP algorithm. After the "Generate Seat Arrangement" option is selected, the application automatically produces a complete seating plan that specifies the hall, bench, and seat position assigned to each student.

The generated seating arrangement can then be viewed and shared with administrator, invigilators, and other authorized users through the application. This automated approach substantially reduces the manual effort, minimizes allocation errors, and improves the effective utilization of examination hall resources.

Overall, by applying a multi-Dimensional Constraint Satisfaction Problem model, that Smart Exam Hall Allocator offers a systematic and intelligent solution for examination seating management in educational institutions, thereby enhancing operational efficiency, resource utilization, and organizational accuracy.

D. Notice

The Notice module enables the administrator to publish important announcements and institutional updates through the mobile application. It allows students and staff to access notices in real time, eliminating the dependency on traditional physical notice boards.

E. Fee

The Fee module is designed to manage student fee records, including fee structures, payment details, and payment status. It assists administrators in tracking fee transactions and maintaining accurate financial records for each student.

F. Student

The student module stores and manages student-related information, including name, registration number, department, semester, contact details, and academic records. It supports efficient access, organization, and maintenance of student data within the system.

G. Staff

That Staff module maintains information related to faculty and non-teaching staff members, including personal details, department, designation, and assigned responsibilities, this module supports effective staff record management within the institution.

H. HOD

The HOD (Head of Department) module allows the administrator to manage department heads and assign them to their respective departments. The HOD can view and manage all the operations done within the department.

I. Library

The library module manages the library resources, including books, book categories and borrowing records. It enables students and staffs to view available books while assisting administrators in maintaining accurate library records.

J. Sports

The Sports module provides information related to the sports activities conducted within the institution. The college sports team and the members name will be allocated by the respective PET staffs. It can be used to manage sports events, student participation, and associated announcements.

K. Hostel

The Hostel module is used to assign the rooms and room members for the students. The students can also convey their suggestions related to the hostel through the mobile application.it supports efficient hostel management and record maintenance.

L. Transport

The Transport module manages transportation details like number of drivers, number of busses, which driver is assigned to which bus, how many busses are operating daily, what are the expenses for the fuel and toll gate, and the repair details about the busses.

M. Exam Cell

The Examination module handles examination-related activities including examination schedules, notifications and coordination of examination processes. The exam hall seat allocator AI feature is integrated with the exam cell. It supports systematic planning and management of institutional examinations.

N. Placements

The Placement module manages campus recruitment activities, including company visits, placement drives, and student placement records. It assists in organizing placement operations and maintaining recruitment-related data.

O. Department

The Department module enables administrators to create, manage, and maintain academic departments within the institution. It supports structured organization of departmental information.

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P. Subjects

The Subject module stores the subject name, subject code, department and semester. It helps to organize and maintain academic curriculum data and the subjects are used in the time table generator module.

Q. Office In charge

The office in charge module manages the information related to students, staffs, fees details, salary details, scholarship details, out pass details, staff permission details, late comer details, and other forms. It is responsible for office operations and institutional documentation. It is efficient for handling the office administrative activities.

R. Classes

The Class module manages the class-related information, including academic year, semester, section, and department. It helps to organize the students into specific academic groups and manage their leave and other letters along with a valid proof.

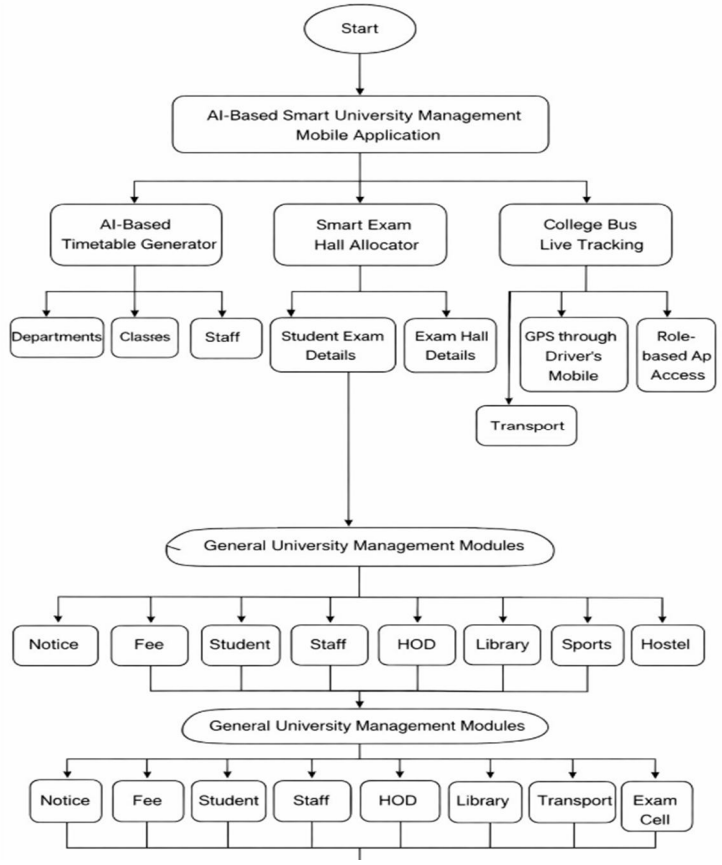
S. Complaints

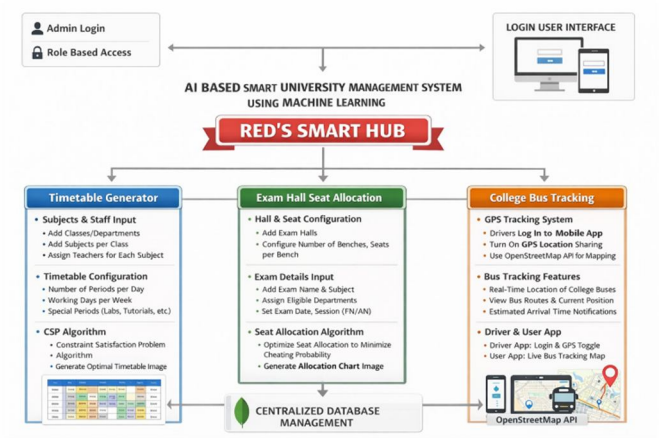
The Complaint module allows the students and staff to submit complaints or issues through the mobile application. The respective class coordinator will review the letter and approve it if it is valid. Then the letter is passed to the HOD so on. Step by step the letter will be approved if it is valid.

T. Canteen management

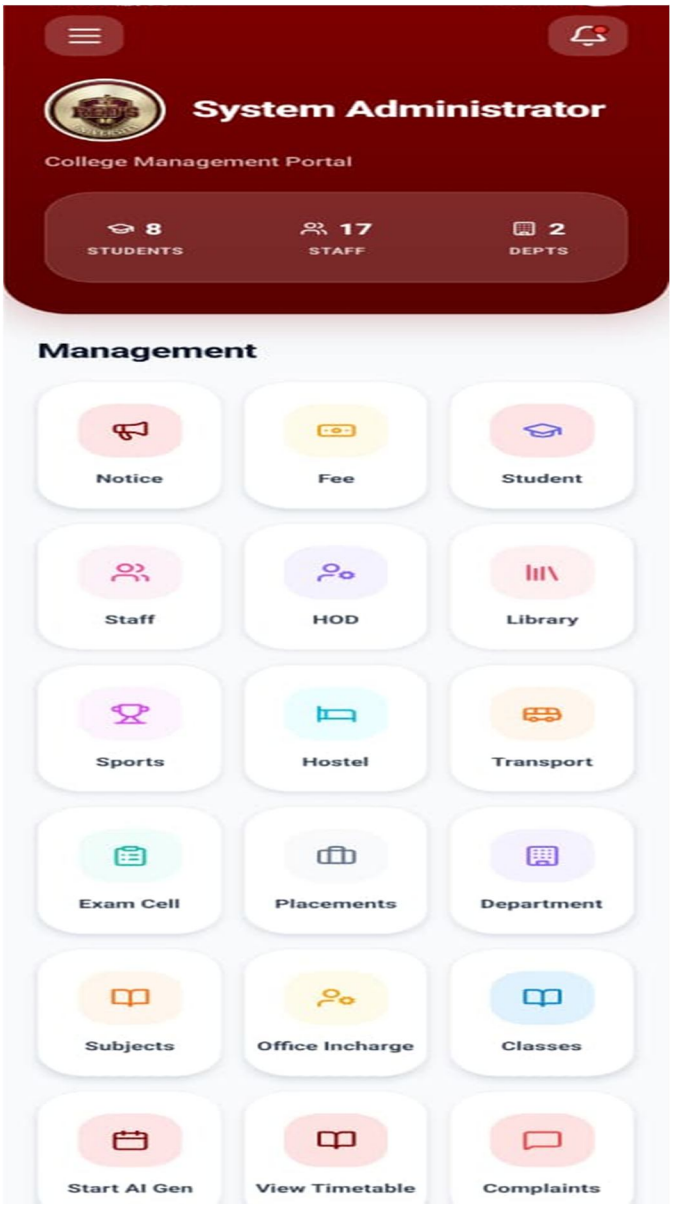
The food and snack items will the displayed in the mobile app. The students, staffs can order their needs through the app it helps to manage the crowd in the canteen. It is similar to the existing food delivery apps.

IV. FLOWCHART





V. IMAGE REPRESENTATION



VI. APPLICATIONS OF THE PROPOSED SYSTEM

1) Automation of academic process: The proposed system automates critical academic operations such as timetable generation and examination hall allocation, thereby reducing the manual effort and improving administrative efficiency.
2) Reduction of scheduling conflicts: By employing constraint-based algorithms, the system generated class schedules and examination seating arrangements with minimal conflicts, ensuring smooth academic planning and execution.
3) Efficient resource utilization: The application optimizes the utilization of institutional resources, including classrooms, staff schedules, and examination halls, thereby improving operational efficiency.
4) Real-Time Bus tracking: The GPS-based bus tracking feature enables students and administrators to monitor the live location of college busses, enhancing transportation visibility and convenience.
5) Centralized data management: The system provides a centralized platform for storing and managing institutional data, including student information, staff records, departmental details, and academic data, thereby improving accessibility and data organization.
6) Improved Communication: The notice and complaint modules facilitate effective communication among students, staffs, and administrators by enabling timely announcements, feedback submission, and issue resolution.
7) Time savings in Administration: By Automating routine academic and administrative processes, the system significantly reduces the time required for schedule management, examination planning, and institutional record maintenance.
8) User-Friendly Mobile Access: As a mobile-based platform, the application allows users to access academic and administrative services anytime and anywhere, thereby improving usability and accessibility.
9) Cost-effective implementation: The proposed system was implemented using open-source technologies and freely available APIs, which reduces overall development and deployment costs.
10) Support for smart campus development: By integrating multiple academic and administrative services into a single intelligent platform, the application contributes to digital transformation of educational institutions and supports smart campus development.

VII. FRONTEND AND BACKEND DEVELOPMENT

1) JavaScript: JavaScript serves as the primary language for both frontend and backend development in the proposed system, its use across the full technology stack enables seamless communication between application components and supports efficient full-stack development using a unified programming language.
2) React Native: React Native is used to develop the mobile application interface. It supports cross-platform mobile development through reusable components and provides a responsive, native-like user experience, especially for android devices,
3) Node.js: Node.js is employed for server-side development. It provides a fast and scalable runtime environment capable of handling multiple client requests efficiently, making it suitable for backend service implementation.
4) MongoDB: MongoDB is used as the data base for storing the application data such as student records, staff details, subject information, class data and examination-related records. As a NoSQL Database, it provides flexible schema design, scalable data storage, and efficient handling of semi-structured information.
5) Constraint Satisfaction Problem (CSP) Algorithm: The CSP algorithm is used in the AI-based timetable generation module. It generates conflict free schedules by considering multiple constraints, including subject hour requirements, staff availability, and class time slots.
6) Multi-Dimensional Constraint Satisfaction Algorithm: Multi-Dimensional constraint satisfaction algorithm is used in the Smart Exam Hall Allocator module. It evaluates multiple constraints, including the number of students, hall capacity, seating arrangements, and examination sessions, to generate an optimized seating plan.
7) GPS Location Services: GPS location services are used to obtain the real-time position of the college bus through the driver's mobile device. This enables accurate live tracking of bus movement within the application.
8) OpenStreetMap API: The OpenStreetMap API is used for map rendering and live bus location visualization. It is selected because it is open-source and freely available, making it a cost-effective choice for implementing location-based services.

VIII. CONCLUSION

The proposed AI-based Smart University Management Mobile Application offers an integrated and efficient solution for managing a wide range of academic and administrative functions within educational institutions. By incorporating intelligent features such as automated timetable generation, smart exam hall allocation, and real-time college bus tracking, the system significantly reduces manual effort while improving operational accuracy and efficiency.

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The use of modern technologies leads to conflict free in scheduling and decision-making and resource utilization. Overall, the proposed system supports the transformation of traditional campus operations into a more intelligent, and digitally managed smart campus environment.

IX. FUTURE ENHANCEMENTS

1) Smart Staff Substitution in Timetable: When a faculty member is absent, the application can identify other available staff members who are free during the corresponding time slot and recommend suitable substitutes.

2) Shortest Path and Estimated Arrival Time in Bus Tracking: The system should determine the optimal travel path and estimate the expected arrival time at designated stops, thereby helping students plan their commute more efficiently.

3) Bus Arrival Notification system: A notification-based enhancement can be introduced to alert students when the college bus is approaching their designated stop. This feature can reduce unnecessary waiting time and improve convenience, particularly for day scholar students who rely on institutional transportation.

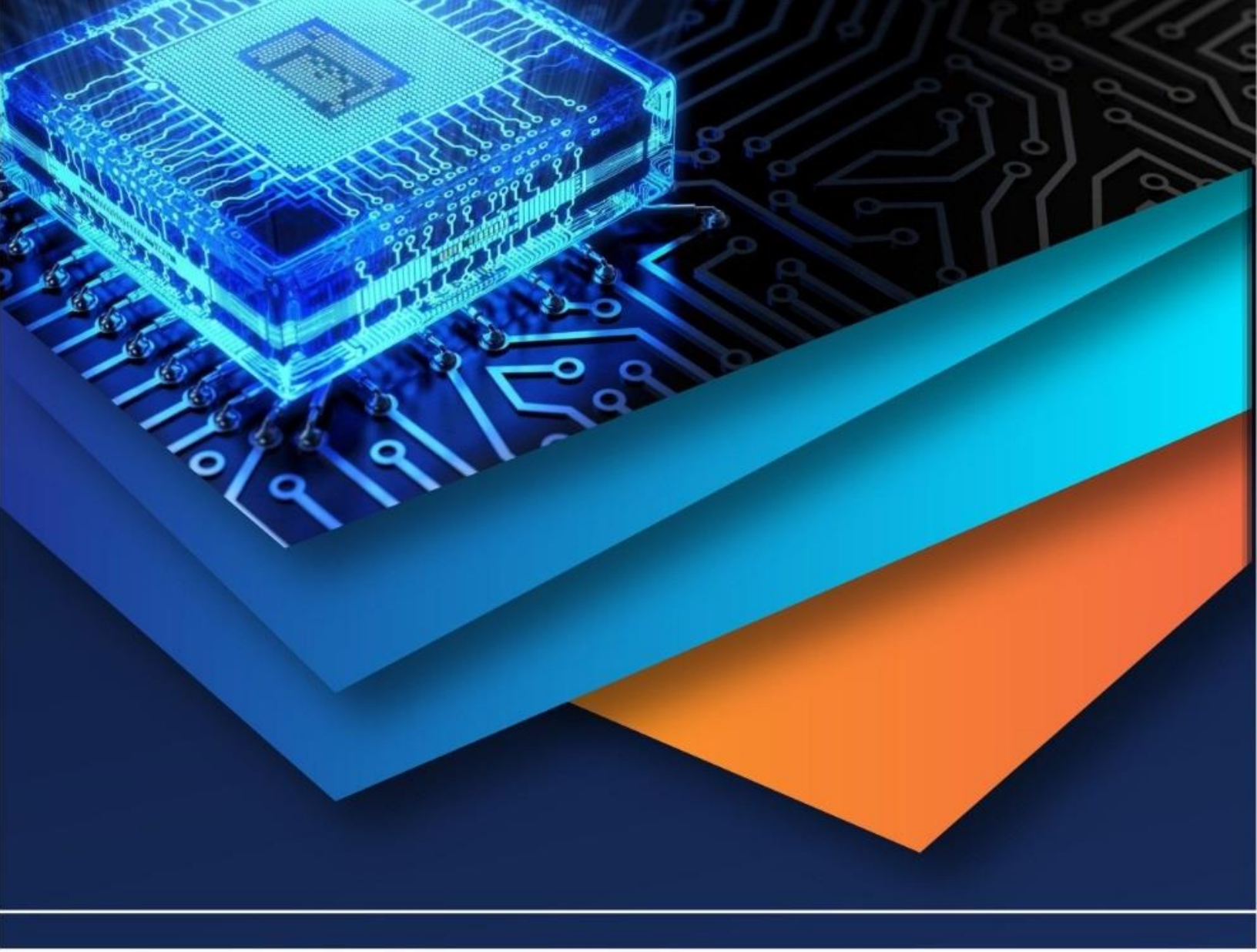
4) Integration with Learning Management Systems (LMS): It is used to provide seamless access to course materials, assignments, attendance records, and other academic resources with a unified platform. This integration would improve the overall digital learning experience for students and staffs.

5) Smart Complaint Analysis Systems: Artificial Intelligence Techniques can be incorporated into the complaint management module to automatically analyze, classify, and prioritize complaints based on their type and urgency. This enhancement can support faster issue resolution and improve administrative responsiveness.

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