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Smart Canteen Pre-Ordering System

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Abstract: ***Canteens in educational institutions frequently encounter operational challenges such as long waiting queues, inefficient order processing, and inadequate payment verification mechanisms. These issues often result in delays, overcrowding, and a diminished user experience, particularly during peak hours. To address these limitations, this paper presents a Smart Canteen Pre-Ordering System, a web-based solution designed to digitize and streamline canteen operations in a structured and secure manner. The proposed system is developed using Flask and MySQL, and supports multiple user roles, including students, staff, and administrators, through a robust role-based access control mechanism. A key contribution of this work is the integration of a secure UPI payment verification system. Overall, the proposed system significantly improves efficiency, strengthens transaction security, and delivers a seamless and user-friendly experience for all stakeholders.***
Keywords: Smart Canteen, Pre-Ordering System, Flask, MySQL, Payment Verification, Image Hashing, Role-Based Access Control

I. INTRODUCTION

A. Background

In many educational institutions, canteen operations continue to rely on traditional manual processes. Students are required to physically visit the canteen, wait in long queues, place their orders, and remain on-site until their food is prepared. While this approach may be manageable during non-peak hours, it becomes highly inefficient during busy periods such as lunch breaks [14, 15]. This situation affects both operational efficiency and user satisfaction.

B. Problem Statement

Conventional canteen systems face multiple limitations that hinder their effectiveness. These include prolonged waiting times, absence of a structured mechanism for order tracking, and lack of reliable payment verification processes [11, 12]. Additionally, manual handling of orders increases the likelihood of human errors, such as incorrect order entries or missed transactions [13]. Together, these challenges lead to inefficiencies, reduced service quality, and a suboptimal user experience.

C. Objective

The primary objective of this work is to develop a digital platform that enables users to pre-order food efficiently, thereby minimizing waiting times and reducing congestion within canteen premises. The system also aims to ensure secure and reliable payment validation, while providing an organized framework for managing orders, menus, and administrative operations.

II. LITERATURE REVIEW

A. Review of Existing Canteen Systems

Several research works have focused on improving food ordering and canteen management systems through digital solutions. A QR-based canteen management system was proposed to digitize ordering and payment processes using QR-based login and cashless transactions. While the system improves efficiency, it does not include secure payment verification, duplicate detection, or role-based administrative control [1]. Inorder to address these issues, a web-based canteen management system was developed to reduce manual operations and improve accessibility; however, it lacks secure payment validation and advanced management features [2]. Similarly, an online food ordering system using web technologies has been proposed that enhances user convenience but does not provide structured order tracking or fraud prevention mechanisms [3]. To avoid this drawback, a campus food ordering system integrating web and mobile platforms improves usability and accessibility, but it does not address transaction authenticity or duplicate payment detection [4]. Another smart restaurant ordering system focuses on improving user experience, yet it lacks secure backend processing and administrative control features [5]. To address these problems, a web-based food ordering system simplifies ordering operations; however, it does not include role-based access or advanced security mechanisms, limiting its scalability [6].

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In addition, a food ordering and management system improves operational efficiency but lacks real-time order tracking and payment verification capabilities [7]. Addressing these issues, Image hashing techniques have been introduced for detecting duplicate images, which are effective for identifying repeated data, but their application in payment verification systems is not explored [8]. The OWASP Top 10 report highlights major security risks in web applications and emphasizes the need for secure system design; however, it does not provide specific solutions for transaction verification in ordering systems [9]. REST-based architectural principles support scalable and modular web applications, but they do not address domain-specific challenges such as payment validation and order management [10].

Overall, existing systems primarily focus on basic ordering functionality and user interaction. However, they lack comprehensive role-based architecture and administrative control features. Most of the existing solutions do not support role-based access for users, staff, and administrators, and do not provide modules such as menu management, canteen management, or staff management. Additionally, they lack advanced analytical features such as revenue summary dashboards for monitoring system performance.

Furthermore, existing systems are typically designed for single-canteen environments and do not support multi-canteen management. In contrast, the proposed system introduces a centralized approach where multiple canteens can be efficiently managed and controlled by the administrator. This enables better coordination, scalability, and operational control.

These limitations highlight the need for an integrated system that not only supports digital ordering but also incorporates secure payment verification, role-based management, multi-canteen control, and analytics capabilities, as addressed in the proposed work.

B. Limitations of Existing Systems

Traditional canteen systems exhibit several inherent limitations that negatively impact both operational efficiency and user experience. One of the major issues is the excessive waiting time caused by unorganized order handling and high customer volume during peak hours. The lack of a structured order tracking system further complicates the process, making it difficult for both users and staff to monitor order progress effectively. In addition, manual handling of orders increases the likelihood of human errors, including incorrect entries and missed transactions. The absence of secure payment verification mechanisms exposes the system to potential fraud and inconsistencies. UPI payments are widely used. There is also a lack of effective mechanisms to detect and prevent duplicate or fraudulent transaction proofs. Furthermore, existing systems rarely incorporate simple yet efficient techniques to provide near real-time updates.

C. Motivation for the Proposed System

The limitations and gaps identified in existing systems create a strong motivation for developing an improved, technology-driven solution. An effective system should automate the ordering process, reduce waiting times, and establish clear communication between users and staff. It should also provide a structured workflow that minimizes human errors and enhances overall operational efficiency. To address security concerns, the system must incorporate reliable payment verification mechanisms capable of ensuring transaction. By integrating these features within a unified platform, the proposed system aims to deliver a secure, efficient, and user-friendly canteen management.

III. PROPOSED SYSTEM

A. System Overview

The Smart Canteen Pre-Ordering System is designed as a centralized web-based platform that seamlessly integrates food ordering, payment verification, and administrative management into a unified environment. The primary objective of the system is to reduce dependency on manual processes while enabling smooth and efficient interaction between users, canteen staff, and administrators. By digitizing core operations, the system enhances overall efficiency, minimizes delays, and improves service quality.

B. Order Processing Workflow

The system incorporates a well-defined and structured workflow to manage the entire order lifecycle efficiently. Initially, users browse the available menu items and select their desired food items through the web interface. After selecting items, users choose their preferred payment method, such as cash or UPI, and proceed to place the order. Once confirmed, the order details are securely stored in the database for further processing. Upon order placement, the staff receives the order request through the system interface and begins preparation. Once the preparation is completed, the order status is updated accordingly, indicating that it is ready for delivery. This structured workflow ensures transparency, efficient coordination between stakeholders, and accurate tracking of orders.

C. *Payment Verification Workflow*

To ensure secure and reliable transactions, the system implements a multi-layered payment verification mechanism for UPI-based payments. Users opting for digital payment are required to upload a screenshot of the transaction along with a valid 12-digit reference ID. The system first performs format validation to ensure the correctness of the entered reference ID, followed by a duplicate check to prevent reuse of the same transaction ID.

In addition to reference validation, the system employs image hashing techniques to generate a unique digital fingerprint for each uploaded screenshot. This approach ensures that even if the same image is uploaded with a different file name, it can still be identified as a duplicate. By combining reference ID validation with image hashing, the system effectively prevents fraudulent or duplicate transaction submissions.

D. *Order Control Mechanism*

The system incorporates a controlled order cancellation mechanism to maintain operational efficiency and prevent misuse. Users are permitted to cancel their orders only before the preparation process begins. Once the order status is updated to the preparation stage, cancellation is restricted, and a unique token is generated to confirm order processing. This control mechanism ensures that unnecessary food wastage is minimized and prevents confusion in order handling. It also allows staff to focus on preparing confirmed orders without interruptions or last-minute changes workflow.

IV. SYSTEM ARCHITECTURE

A. *Architectural Design*

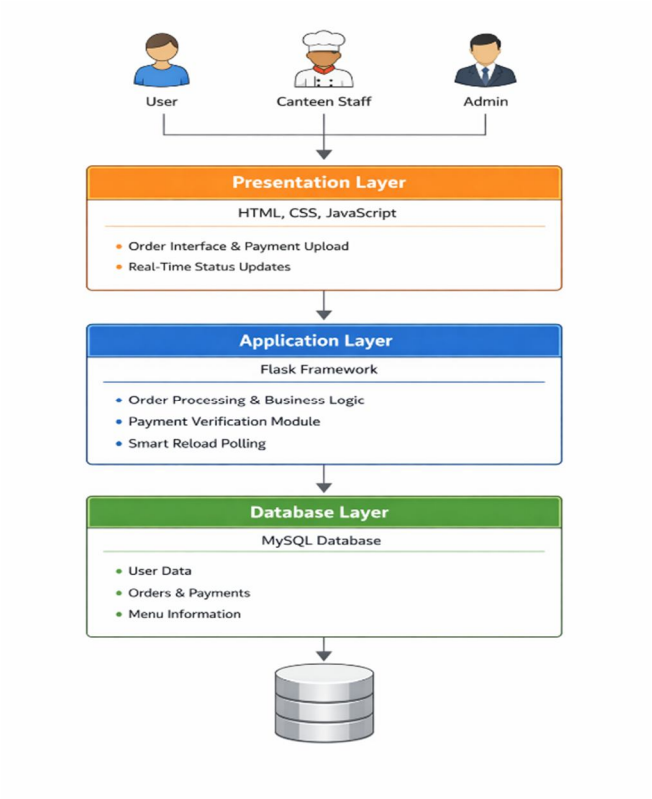


Fig. 1. System Architecture

The Smart Canteen Pre-Ordering System is designed using a three-tier architecture comprising the presentation layer, application layer, and database layer. This layered approach ensures a clear separation of concerns, which enhances system scalability, maintainability, and overall performance. By dividing responsibilities across distinct layers, the system becomes easier to manage, debug, and extend. Each layer is responsible for a specific set of functionalities, allowing independent development and testing. Fig.1 illustrates the architecture of the proposed system.

B. Presentation Layer (Frontend)

The presentation layer serves as the user interface of the system and is developed using HTML, CSS, and JavaScript. It provides an interactive and responsive environment for all user roles, including students, staff, and administrators. The design focuses on usability and accessibility, ensuring that users can easily navigate through different features of the system. Through this layer, users can browse menu items, place orders, upload payment screenshots, and monitor the status of their orders. It also incorporates client-side validation techniques to ensure that user inputs meet required formats before being sent to the server.

C. Application Layer (Backend)

The application layer is implemented using the Flask framework and acts as the core processing unit of the system. It is responsible for handling incoming requests, executing business logic, and managing communication between the frontend and the database. Key functionalities such as authentication, session management, order processing, and payment verification are performed within this layer. In addition, the backend enforces role-based access control, ensuring that each user can only access functionalities permitted to their assigned role.

D. Database Layer (Data Layer)

The database layer is implemented using MySQL and is responsible for storing and managing all structured data within the system. This includes information related to users, orders, menu items, payments, categories, and canteens. The database is designed using normalization principles to minimize redundancy and maintain data.

V. ROLE-BASED ARCHITECTURE

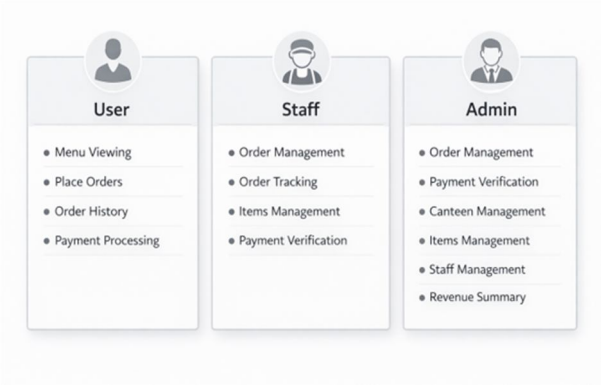


Fig. 2. Role Based Architecture

The Smart Canteen Pre-Ordering System is designed using a role-based architecture to ensure secure access control, structured functionality, and efficient system operation. In this approach, users are assigned specific roles, and each role is granted access only to the functionalities required for its responsibilities. This separation of roles minimizes system complexity, prevents unauthorized access, and enhances overall security and maintainability. Fig. 2 illustrates the Role Based Architecture. The proposed system primarily consists of three roles: users (students), staff, and administrators. Students act as end users of the system and are responsible for initiating interactions such as browsing menu items, placing orders, uploading payment details, and tracking order status. Their access is restricted to user-level functionalities, ensuring that they cannot modify system data or interfere with administrative operations. Staff members are responsible for handling operational activities related to order processing. They access a dedicated interface that allows them to view incoming orders, update order status, generate tokens when preparation begins, and mark orders as completed.

VI. KEY FEATURES

A. Secure Payment Verification

The system incorporates a robust dual-layer payment verification mechanism to ensure the authenticity of transactions. For every UPI payment, users are required to provide a valid 12-digit reference ID, which is validated for correct format and checked against the database to prevent duplication.

The system also provides an option for the administrator to reject payments if the submitted proof is found to be invalid or suspicious. This combination of automated validation, manual verification, and controlled rejection significantly improves transaction reliability and minimizes fraudulent activities.

B. Image Hashing-Based Duplicate Detection

To further strengthen payment security, the system employs image hashing techniques for detecting duplicate payment proofs. Each uploaded screenshot is processed to generate a unique hash value, which acts as a digital fingerprint of the image. This hash is compared with previously stored values in the database. If a match is found, the system identifies the image as a duplicate and rejects it.

C. Order Cancellation Control

The system includes a controlled order cancellation feature to maintain operational efficiency. Users are allowed to cancel their orders only before the preparation stage begins. Once the staff updates the order status to “Preparing” the cancellation option is automatically disabled. This restriction prevents unnecessary food wastage and avoids disruptions in the preparation process. It also ensures that staff can proceed with order fulfilment without unexpected changes, thereby maintaining a smooth workflow and system accountability.

D. Canteen Availability Control

The system allows administrators to dynamically manage canteen availability by marking them as open or closed. When a canteen is closed, users are restricted from placing orders from that canteen. This feature is useful for handling operational hours, maintenance schedules, or unexpected closures, ensuring that users interact only with active canteens.

E. Item Availability Management

Each menu item is associated with an availability status indicating whether it is currently in stock. Administrators can update this status in real time based on inventory conditions. Unavailable items are either hidden or disabled in the user interface, preventing invalid orders and improving overall system accuracy.

F. Analytics Dashboard

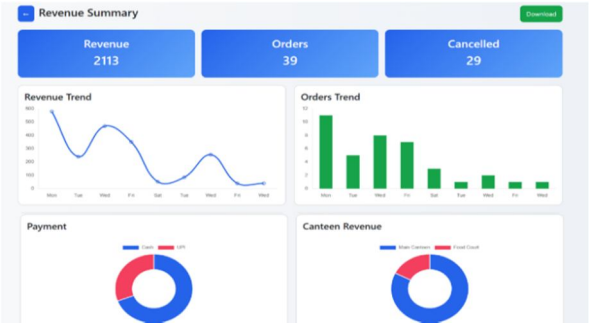


Fig. 3. Revenue Summary Dashboard

The system includes an analytics dashboard that provides insights into canteen operations. It displays key metrics such as total orders, revenue trends, and popular items. These insights enable administrators to monitor system performance, analyze usage patterns, and make data-driven decisions to improve efficiency and service quality. Fig. 3 illustrates the revenue summary dashboard.

VII. IMPLEMENTATION

A. Development Environment

The system is developed using a modern web technology stack to ensure flexibility and efficient performance. The backend is implemented using the Flask framework in Python, while MySQL is used for structured data storage and management. The frontend is designed using HTML, CSS, and JavaScript to provide an interactive and user-friendly interface. This combination of technologies enables seamless integration and supports scalability.

B. Backend Implementation

The backend is designed using a modular approach in Flask, where each functionality is handled through dedicated routes. Core operations such as user authentication, order management, and payment verification are implemented as separate modules, improving maintainability and clarity. Session management is used to maintain user state, and role-based access control ensures that users can access only the functionalities assigned to their roles. This enhances both security and system organization.

C. Database Implementation

The database is structured using normalization techniques to maintain data integrity and reduce redundancy. Tables are created for users, orders, menu items, payments, and canteens, with relationships defined using foreign keys. To improve performance, indexing is applied to frequently accessed attributes such as order IDs and payment reference IDs. This allows the system to handle multiple users efficiently.

D. Validation and Error Handling

The system incorporates both frontend and backend validation to ensure data accuracy and reliability. Frontend validation provides immediate feedback to users, while backend validation ensures security and correctness of data processing. Validation includes reference ID format checking, duplicate detection, image file validation, and price verification

E. Security Implementation

Security is ensured through multiple layers, including password hashing and input sanitization. These measures protect user data and prevent common vulnerabilities. Additionally, the system incorporates secure payment validation techniques such as duplicate detection and image hashing, which help prevent fraudulent transactions and ensure transaction integrity.

VIII. RESULTS AND DISCUSSION

The Smart Canteen Pre-Ordering System is a significant improvement over traditional canteen operations by introducing a structured and technology-driven approach. The implementation of a pre-ordering mechanism allows users to place orders in advance, effectively reducing waiting time and eliminating long queues, particularly during peak hours. This leads to a more organized and efficient canteen environment. The system ensures smooth coordination among users, staff, and administrators through a well-defined workflow. Users can track their order status in real time, while staff members can efficiently manage and process incoming orders. The payment verification mechanism plays a crucial role in ensuring secure and reliable transactions. By combining reference ID validation with image hashing techniques, the system effectively prevents duplicate and fraudulent payments. Additionally, the administrator verification and rejection mechanism provides an extra layer of control, allowing invalid transactions to be identified and handled with proper feedback to users. Moreover, the smart reload mechanism enhances user experience by providing near real-time updates without requiring manual page refresh. This improves system responsiveness and ensures that users receive timely updates regarding order status and payment verification, resulting in a seamless interaction experience.

IX. LIMITATIONS

The proposed system is designed primarily for local deployment, and its scalability may be limited when handling many users without integration of cloud-based infrastructure. As the user base grows, additional optimization and distributed deployment strategies may be required to maintain performance. Furthermore, the system depends on stable internet connectivity for its operation. Any network disruptions may affect order placement, payment verification, and real-time updates, thereby impacting user experience.

X. CONCLUSION AND FUTURE WORK

The proposed system presents a comprehensive and effective solution to the challenges associated with traditional canteen operations. By replacing manual processes with a structured digital platform, the system significantly improves efficiency, reduces waiting time, and eliminates long queues, especially during peak hours. Furthermore, by integrating reference ID validation, image hashing, and administrative verification, the system ensures transaction authenticity and effectively prevents duplicate or fraudulent payments. The inclusion of a rejection mechanism with proper feedback further enhances transparency and builds user trust. The analytics dashboard provides valuable insights into system performance through visual representations of orders, revenue, and usage patterns. These insights support data-driven decision-making and help optimize canteen operations. The system also demonstrates stable performance under multiple user interactions, supported by efficient backend processing and optimized database design.

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In conclusion, the proposed system not only enhances operational efficiency and transaction security but also delivers an improved user experience through real-time interaction and intelligent system design. It serves as a practical, scalable, and reliable solution for modern canteen management and can be effectively implemented in educational institutions and similar environments.

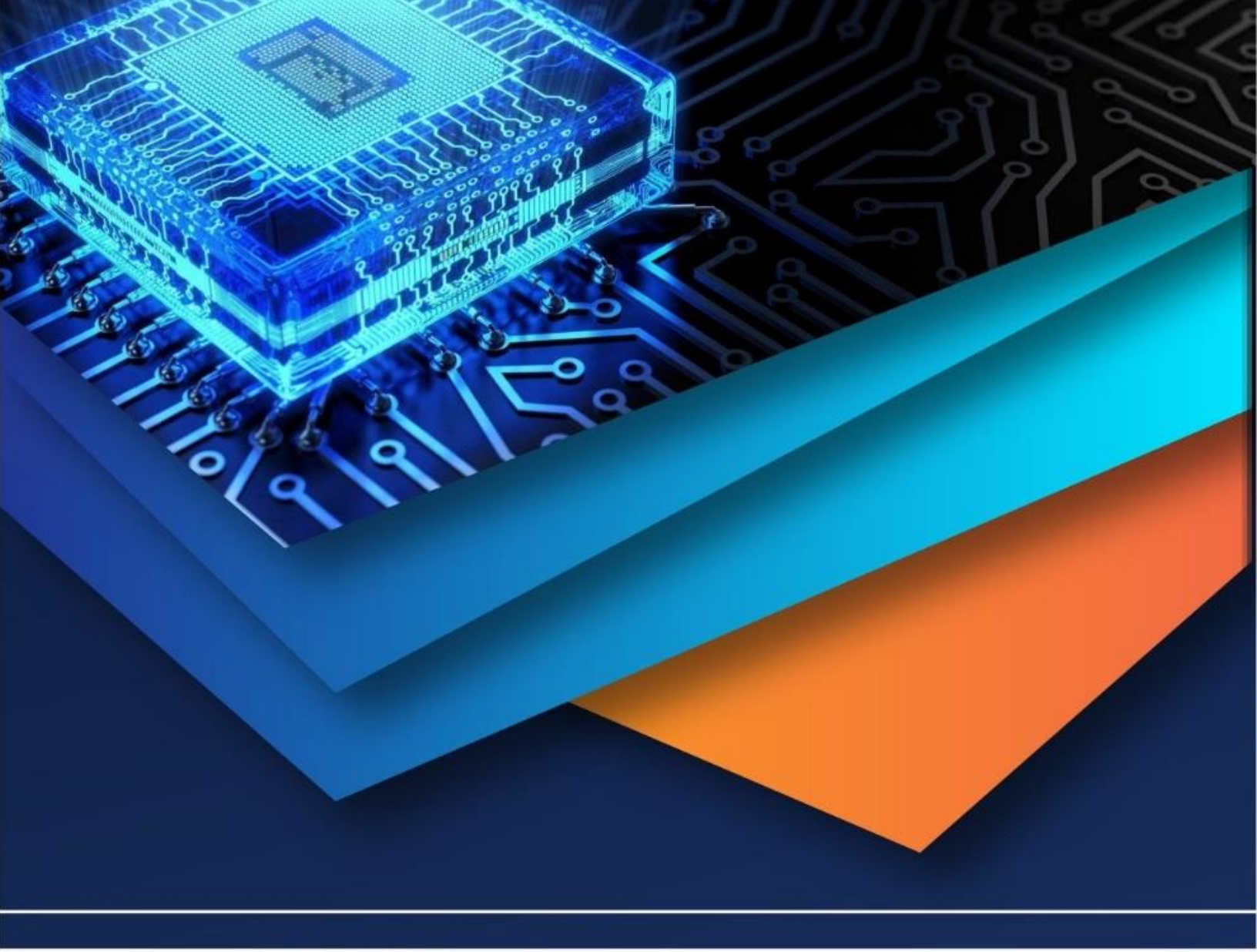
Although the proposed Smart Canteen Pre-Ordering System performs effectively, several enhancements can be incorporated. One of the primary areas for future development is the integration of online payment gateways, which can automate the payment verification process and eliminate the need for manual validation by administrators. This would reduce workload and enable faster transaction processing. The system can also be extended through the development of dedicated mobile applications, providing users with greater accessibility and convenience. A mobile platform would allow users to place orders, make payments, and receive notifications seamlessly from their smartphones.

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