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Development and Evaluation of a Comprehensive Web-Based Canteen Food Ordering System

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Abstract: ***This research paper presents the development of a web application aimed at introducing and optimizing the canteen ordering process within institutional and work environments. Focused on reducing wait times and enhancing user experience, the application facilitates menu browsing, order placement, and cashless payments via e-wallet or UPI. By leveraging technology to promote efficiency, the app seeks to address common challenges faced by students, faculty and employees during peak hours. The paper discusses design strategies, technical implementation, and potential implications for canteen operations, emphasizing the importance of user-centric solutions in enhancing overall satisfaction and productivity.***

Keywords: Canteen Management System, Web Application, Personalized Recommendation, UPI (Unified Payment Interface), Real Time Inventory Updates.

I. INTRODUCTION

The traditional way of handling school canteens, the reliance on paper-pen records, cash transactions, and manual calculations are getting less effective in this fast-participated world. Being aware of this low efficiency, we propose the restructuring of canteen operations through an integrated web and a mobile application for menu items and orders management.

The proposed application has numerous benefits which are meant to improve efficiency and give the overall canteen experience a boost to both the customers and staff. We offer the opportunity of placing orders through the application directly which results in a substantial saving of time lost standing in queues. Customers are enabled to browse through the menu, place orders on advance and make payments online thus dispensing with the need to carry cash and waiting for change delivery.

The basic advantage of our system is that it lightens the canteen staff burden. By automating the order taking, our system enables saving time and resources, thus letting the staff to concentrate on the management of other canteen areas. All orders made through the application are smoothly transferred into a centralized database which can be accessed anytime on the canteen admin's end via a desktop application.

All order details are shown on the desktop application in an easy-to-read format, the item selections, options and supply details being included here as well. The streamlined approach of order management not only increases the operational efficiency but also engages the customer for greater accuracy and speed.

In addition, our Canteen Management system is intended to be flexible and scalable and therefore it can be used in a variety of canteens setting from large institutions down to catering services for small business enterprises. Whether it is a university campus or a corporate cafeteria, our system provides customized solutions catering to the distinct requirements of every surrounding.

II. PROBLEM DEFINITION – EXISTING SYSTEM

Today's cafeteria management systems depend heavily on manual processes. This leads to many inefficiencies for both students and cafeteria staff.

A. Problems

1) *Long queues and time consuming:* If there is no existing system, students often spend a lot of time waiting in long lines to place orders. This can be especially problematic during peak hours, such as during short breaks or lunch breaks. This leads to frustration and loss of rhythm.
2) *Delays in order processing:* After the order has been submitted, students must wait for food to be prepared and delivered. Because this process requires people to do the work themselves, dealing with large orders becomes difficult. This is especially true when there are many food sources available.
3) *Not all orders can be served on time:* due to the large number of people, cafeteria staff may have difficulty preparing and serving all orders within the required two time periods. This helps students learn skills, return to lectures or practice and improve their general experience.

4) *Lack of order tracking:* The current system does not provide real-time order status updates. Students are not sure when the food will be ready. This will increase or decrease the waiting time.

B. *Proposed System*

To overcome the problems faced by existing system, we proposed a complete computerized canteen management system to order food online through web application so that the preparation of food may begin before the user reaches the canteen. Food ordering feature will only be available to the users who have registered with the application and have logged in. There will be a lot of modes of payment, like domestic and international credit & debit cards, UPI and other mobile wallets. The items of a placed order shall be displayed on the screen in the kitchen which will indicate the cooks to prepare the items and the message "ORDER PLACED SUCCESSFULLY" shall be displayed on the user screen. When the order is delivered, its status is updated to "COMPLETED".

III. LITERATURE SURVEY

A comprehensive study of the available canteen management systems indicates different approaches and implementations directed towards enhancing the efficiency of food ordering and delivery processes. This literature survey will examine various systems and applications, their methods, and their effectiveness in addressing the issues faced by university canteens and food service management.

A. *Design of a Pre-Ordering System*

Traditional canteen systems often have problems of long queues and time delays in food preparation, hence causing considerable wastage of students' time. To minimize such problems, a pre-ordering system was proposed and emphasized to automate the ordering process [1][2]. In this study, a Canteen Management System (CMS) has been developed, which is web-based and allows students to order food online.

The front-end of the system was coded in HTML, CSS, JavaScript, and React.js. To manage the back-end of the system, it is using Node.js, Express.js, and MongoDB [3]. Some of the other features offered by the CMS include real-time tracking of food preparation, notification systems for alerting students that their food is ready, and the categorization of orders by their cooking, delivered, or cancelled status. Student Accounts can be created; more detailed menus can be available along with multiple payment options [5][6][7]. It would have the waiting time drastically reduce in the queue, so all those ordering food will make this process more efficient thereby ensuring an improved user experience in students and reduced stress among the canteen staff [1]. There would be better tracking of the sales and student data thus enabling the canteen management to have much greater control and insight in all the operations.

B. *Marketing Habituation and Process Study of Online Food Industry: Case Study of Zomato*

This analysis of the online food business, especially on sites such as Zomato, gives insight into how consumers prefer ordering food digitally instead of receiving it from in-person service. Online food delivery applications have gained popularity over the years due to several factors, including convenience, accessibility, various payment methods, and increasing cashless transactions [8]. These applications make it easy for customers to order, and through customized recommendations, special deals, and past order histories, they can easily decide on their meal [9]. The case of Zomato illustrates how a good design of an application reduces the friction points of users and allows them to select from different varieties of food coming from multiple restaurants [10][11].

Consumers do not need to carry menus or even place calls anymore since everything can be done right from their smartphones. Besides, such apps have been motivating competition between restaurants, where restaurants are being forced to serve better deals and services, which is a plus to consumers. For example, online Indian food industry was pegged at $350 billion in 2019 and set to reach $420 billion in 2020. Therefore, it is a goliath market. For university canteens, it is going to be an efficient way of modernizing the experience in ordering food, considering the technologically savvy nature of students. They would love it since it saves them time and is convenient with so many options [13].

C. *vCanteen: A Campus Innovation Solution to Improve University Canteen Services*

vCanteen is an innovative crowd-friendly platform solely developed to especially address the common problem of high crowd density during peak hours at university canteens [14]. It integrates, in one solution, an online food ordering platform with a virtual queuing mechanism and a machine learning-based crowd estimation tool [12]. The system was tested at the Faculty of Engineering, Chulalongkorn University, Thailand, and showed promising results toward reducing queuing times.

The core functionality of the vCanteen MCNN multi-column convolution neural network would estimate actual time real crowd density on the canteen while informing people as to at what particular moment they might need to make an order or to be in a queue [15][16]. Further, the system provided above gives the present statuses of the meal orders and virtual allocations to the students regarding prepared meals and distribution in terms of optimum reduced congested timing for them in general. This method has reduced waiting time and tends to generally improve the experience of dining, making it highly appropriate for university campuses where crowd management is an on-going issue [3]. The use of such a system in canteens in universities will improve service delivery and allow students to make better utilization of their limited break times.

D. Web-Based Canteen Payment and Ordering System

The creation of an online canteen payment and ordering system is one of the latest trends in the management of university canteens. According to Fonggo et al. (2020), a web-based system will simplify both the order and the payment process, eliminate physical cash transactions, and diminish the possibilities of human errors [17]. This system allows students to view menus, place orders online, and make payments directly on the platform using credit cards, debit cards, and e-wallets [18].

In this system, the canteen management benefits from automated order tracking, inventory management, and customer data collection that helps in improving decision-making and managing stock levels. The system also provides an overview of sales data and performance metrics through which the canteen operators can make sound decisions in their services. This reduces long queuing times for students. The system is also integrated with mobile devices for an order from anywhere in the campus. Ease of access and use is, in this case, an important factor in modernising canteen services and general food delivery [3].

E. Canteen Management through an Android-based e-wallet Application

Rameshwari et al. (2019) carried out a research that included an e-wallet system in the context of a canteen management Android application. This system creates an environment of cash lessness as no need for physical currency would arise. The e-wallet recharges the accounts and lets the students make digital payments while buying food items in a more efficient and secured way.[19]

By having an e-wallet, canteen management has helped students in having easy and cashless transactions; hence they can easily keep the accounts by having all the transaction information. The system captures in real-time orders, payment, and user balance tracking. This minimizes overall waiting time, even more, especially during peak times. Students can now have the option to order meals ahead of time, selecting an appropriate pick-up time and thus further reducing wait time for meals. This solution exploits growing uptake in digital payment systems to keep university canteens abreast of modern trends in financial technologies [1].

F. IoT and QR-Code Based Food Ordering Systems

In this world of technological advancements, IoT and QR-code-based food ordering systems provide a highly efficient model for canteen management. For example, proposed by Khan and Desai (2017) and Reddy and Kumar (2019), are the kinds of systems in which the student can browse the menu through the scanning of QR codes located in multiple places across the campus to place an order and to make the payment [17][23]. These systems will reduce physical interactions that need to happen so that the students' orders are dealt with virtually. Canteen staff then stand to benefit in ensuring that most of their high peak demands can be addressed during time of operation.

The integration of the canteen infrastructure with the IoT devices will update students and the management about real-time order status, kitchen workload, and inventory level. It will also help streamline food ordering for students by offering easier methods of placing and keeping track of orders without the waiting lines in the queue. This trend of contactless services in public areas aligns with the current need, and hence it becomes a useful solution for modern canteen management systems [20][21].

IV. FUNCTIONALITY

A. Key Features

1) *Order Management:* Core functionalities allow customers to view menus available in the canteen, choose dishes to include in their orders, alter their orders to be prepared and count all of it hassle-free. Ordering is made easy through both web and mobile interfaces. This allows viewing options based on preferences, dietary restrictions, or popular items. In doing so, the process goes right to the kitchen for its preparation after an order has been placed; hence it streamlines the workflow on both sides, eliminating any standing lines and increasing efficiency.

2) *Real-time Updates:* This ensures total transparency in the complete order cycle. The users will be able to see the status of the order right from the confirmation, preparation phase, dispatch, and delivery at real-time levels. Reminders such as updated wait time help plan and manage accordingly. For the canteen staff, it would make easier for them to organize their order through updates of their status, thus avoiding confusion and any bottlenecks during high-peak hours.
3) *Payment Integration:* It can have a smooth integrated billing system which automatically calculates the total on selected items using available offers or discounts. There may also be digital wallet, UPI, credit card and debit card, so these digital payments are supported. Further, contactless payments may also be supported going forward. Cash handling is reduced in the canteen as well. The process is done rapidly, which promotes cashless convenience.
4) *User Authentication:* This security ensures that only an authenticated and authorized user could post an order on the site; meanwhile, it keeps track of user-based customer preferences, previous order, and payment history. For the administrative department, authentication will involve more security so that they make sure only proper authenticated people could view other kinds of sensitive information for financial records or inventory.
5) *Inventory Management:* inventory tracking in real time where the system updates the amounts of stock for every single order and then places the back orders to replenish the system. Overstocking does not occur and is sufficiently available when it is supposed to be so. Notifies the employees when the items are running low, making replenishment before they run out thus preventing food waste because of overstock and shortage items.
6) *Reporting and Analytics:* There would be inbuilt analytics tools which would report on frequency of orders, customer preference, peak hours, and revenue trend. Such facts might make it possible for the canteen management to come up with well-informed decisions-be it adjustment of the menu to popular demands or improving operational efficiencies in certain areas. In fact, such a visual dashboard can be interpreted more effectively about time trends.

B. Mobile Technology Integration

As the smartphone becomes the hub of your life, the system uses mobile technology to make everything as easy and accessible as possible. The mobile application will contain push notifications when the order status changes or when there are offers. Recommendations from previous orders and preferences will, in turn, make decisions easy for users.

This product will automatically integrate itself with your native features on your smartphone, such as taking photographs using your camera, to immediately open your menus, or even your payment system without lifting a finger. Such features ensure maximum comfort in the use of contactless interaction services, as valuable to technology-savvy individuals today as ever before.

V. METHODOLOGY AND TECHNOLOGY

A. Development Approach

The project is developed using Agile Development Methodology, which allows the development to be flexible and iterative. Agile lays emphasis on frequent revisions, which allows the team to integrate continuous feedback at each step of development. This style of development ensures that the project changes with changing conditions in accordance with real-world requirements from users.

It is divided into different phases. The first phase is requirement gathering, where all the user needs and system specifications are identified. It is a very important part of this process because it will directly influence the core features of the system, which should include the online ordering platform, real-time inventory tracking, and payment integration.

The definition of architectural elements in the design phase includes database structures, the front-end and back-end interactions of the system, and definitions concerning the user interface. Again, the focus is on making it a responsive, mobile-friendly web platform accessible even in institutional environments.

Then follows implementation, where the Minimum Viable Product is produced. Our first deployment would be to our institution's canteen. Since the canteen can serve as a test site for the core functionalities, which are order processing, inventory update, and personal recommendation, we shall then further improve the system through addition of other functionalities like collaborative filtering in order to recommend a personalized menu and crowd management using IoT.

It gets deployed after testing, that is assessing the system against performance metrics, such as order processing speed, security, and user satisfaction. When validated in our institutional environment, we will scale and adapt it for use elsewhere: in other institutions, and ensuring its adaptability across diverse kinds of canteen operations.

B. Technology Stack

The project makes use of the MERN stack as a strong technology combination. It is created to help provide a smooth, scalable, and efficient platform for canteen management. The stack has its appropriateness to web applications that need to have high scalability and require real-time updates, both factors which can make or break the project.

1) *MongoDB:* MongoDB is a NoSQL database and thus perfect for managing large amounts of unstructured or semi-structured data, such as dynamic datasets like menu items, user orders, and real-time inventory levels. It features flexible schema design that makes it suitable for adaptation in case changes occur within the canteen's operations without extensive reconfigurations.
2) *Express.js:* The back-end framework using Express.js provides a rock-solid foundation for handling logic on the server side and makes routing easier, integrated middleware, and manages the sessions for smooth data flux between the front-end side and the database. These are light in weight that can easily scale the applications with multiple concurrent requests at once without much difficulty.
3) *React.js:* Front-end framework React.js ensures dynamic, responsive user experience. One of the interesting architectures associated with it is its "components," and with all of them available, their use will considerably cut time from development into users experiencing more fun and flexibility while playing around with menu options as well as to be capable of keeping track on order.
4) *Node.js:* The server-side logic of the application is Node.js, which allows for asynchronous processing and the efficient handling of I/O operations. This makes sure that real-time features like updating inventory and processing orders are performed rapidly and reliably without causing any delays or downtime.
5) *Stripe API:* The system integrates Stripe for safe payment processing, enabling user-friendly and secure cashless transaction. Stripe ensures PCI compliant transactions and supports various payment methods besides offering advance features like fraud detection and automated reconciliation, which make the system's overall payment infrastructure pretty secure and reliable.

C. Systems Models

The system is designed using a variety of UML diagrams to visually present and explain the key functionalities and interactions involved in the canteen management platform. These models help in designing and communication of system architecture and behavior across different stakeholders involved in the project.

1) *Block Diagram:* The block diagrams break down the system architecture into its simple, high-level presentation and functional blocks. These diagrams explain the major system components relationship with other subsystems as is illustrated above. User Interface Block; all web and mobile apps' user interfaces are a representation through which students, staff, and administrators of this organization interact with this system. Order Management Block; these involve the creation of order modifications and tracking. Inventory Management Block; it maintains the level of stock levels and informs inventory about the placed orders. Payment System Block; the payments are governed. Each transaction is safeguarded. Reporting and Analytics Block; aggregates information to give insights on how the canteen's performance is going-on, such as user preferences and the trend in sales.

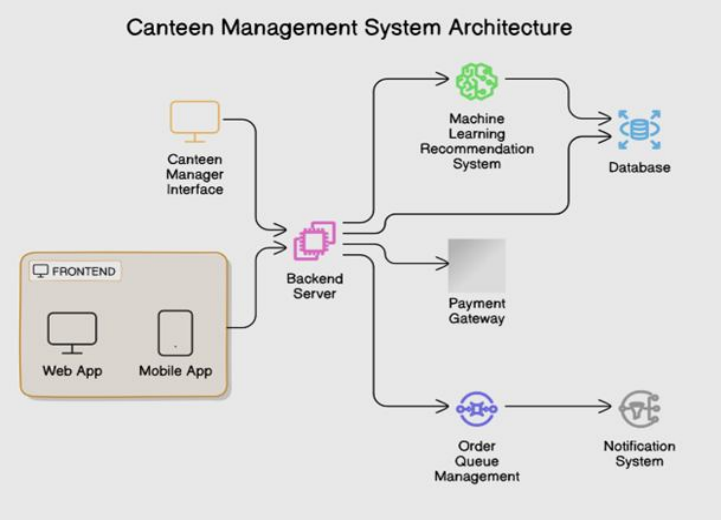

Fig. 1. Block Diagram of the System

2) *Class Diagram:* It highlights the structural organization as well as the interaction among multiple classes in the canteen management system. Usually, a class diagram focuses more on defining classes with attributes and methods and showing how they relate to each other. User Interface (UI); it comprises classes related to the user and their interactions. It has the User and Admin classes. The User class keeps track of the user information such as user id, name, email, and password, which gives features like registration, login, order placement, and history of orders. The Admin class comprises adminId, name, email, and password and functions to manage menus, view orders, and update the status of orders.

Order Management System (OMS); this module consists of two classes: Order and MenuItem. The Order class has properties such as orderId, userId, items, totalAmount, and status. Some methods can be used to calculate the total amount and update the status of orders. The MenuItem consists of itemid, name, price with a method to give out the details of any item. Billing and Payment System; the classes of this subsystem are PaymentGateway and PaymentDetails. It handles the payment and interacts with the classes Order and PaymentDetails. The class attributes include cardNumber, expiryDate, cvv, and a method for validation to check the payment. ML Recommendation System; this module consists of the MLRecommendationSystem class, which provides recommendations for items based on user preferences. It has a method called recommendItems that takes a User object as an argument for providing personalized suggestions. Notification System; this module consists of the NotificationSystem class, which is responsible for sending notifications to users. The sendNotification method sends messages to users regarding order updates. Order Queue Management; this is the OrderQueueManagement class that will handle order queue management. It ensures that there is proper order processing, because order queues are managed through the OrderQueueManagement class, which provides methods for adding orders to the queue and retrieval of the next order to be processed.

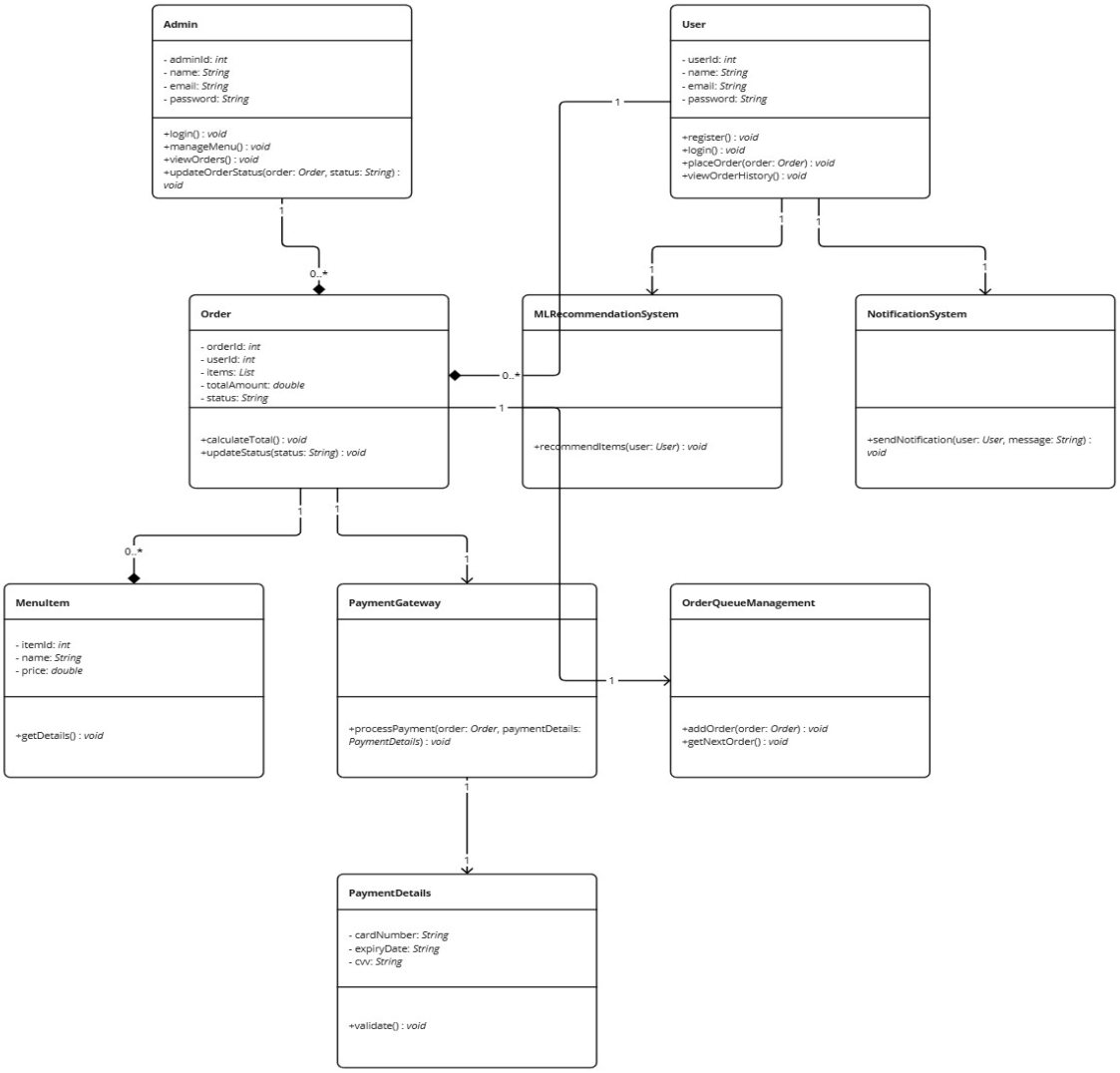

Fig. 2. Class Diagram of the System

VI. PERFORMANCE AND VALIDATION

A. Key Performance Metrics

With specific key performance metrics, canteen management system will be judged against the benchmark performance at various aspects with respect to efficiency, usage, and response. Therefore, quantitative improvement and both functional/nonfunctional performances can be addressed.

1) *Order Processing Time:* This is the duration between when an order has been placed and the actual time of its completion. The shorter the order processing time, the greater will be the efficiency, swifter service, and satisfied user. The system wants to decrease the average time in order processing by making a few steps automated. Those processes include order management, stock updation, and clearing of payments.
2) *User satisfaction:* Surveys and comments of the users, including the students, staff, and administrators, will be conducted after the system is launched. The ease of usage, convenience, and the overall satisfaction of the users with the ordering process would be assessed. The bottom line is to maintain higher levels of user satisfaction in terms of intuitive interfaces, dependable operations, and consistent delivery of service.
3) *System Response Time:* This refers to the speed at which the system responds to a user's request, say placing an order, checking the inventory, or processing a payment. A low response time of the system enhances user experience and real-time updates, especially when the system is under high usage. The target for response times should be to keep them below a few seconds even in high traffic scenarios.
4) *Reduction in Overcrowding:* The system primarily aims to reduce the actual queuing for food items and hence the crowding at counters of the canteens. Count on crowds in both days - one pre and the other post system roll out, are to be taken to conduct a comparison. The information that there is real time provision on the status of order has informed every customer about how long it took for that order to prepare, allowing it to pick up once the status readies rather than accumulating around that point of location and crowding it which will otherwise ensue at its consumption point.

B. Key Performance Metrics

Despite all the advantages of this canteen management system, several challenges and limitations in its development and implementation have to be overcome to ensure effective performance and user satisfaction, such as real-time handling of data under peak usage conditions, smooth payment systems, security, and performance.

1) *Real-Time Data Handling:* It is such an important feature of the system since it addresses dealing with and reflecting actual levels of inventory in real-time. At the same time, this feature throws great technical challenges. For example, in a high peak environment, where many users are placing orders live, the information of the inventory must be correct to avoid overselling or selling of non-existent stock. Such a huge volume of requests will surely call for optimizations, on the server side, and robust in its form and structure along with some efficient load balancing techniques to counter latency issues with bottleneck on real-time synchronization of data.
2) *Payment Integration:* The system also contains another critical point in a secure, hassle-free process about payment processing. The processing should integrate well with an API such as Stripe. It should be integrated, and cannot delay itself at the processing side. It will eventually become hard, for example, once it increases traffic, to become generally a source of low performance for payments processing at peak times. In addition, it needs to provide some feedback and alternatives to the user in case the transaction cannot be processed in order to accommodate the probable failure in the processing of payment. Another very important consideration with regard to maintaining PCI-DSS compliance is protection of sensitive financial information.

VII. FUTURE WORK AND EXPANSION

A. Scalability and Deployment

As it is a case for launching canteen management system at our institution, the next stage to be developed is that it will be extendable to be applied further use in other types of learning institutions as well as corporate ones too. As its structure seems modularity, hence customization would be feasible for applying such systems at places after modification on required changing necessities from that another place of application.

1) *Modular Design:* It has been designed in a modular fashion where architecture is flexible and built that way. In this case, even something like menu options, payment methods, or even inventory management systems can easily be turned on and off. Such flexibility ensures that institutions can customize to the system as they want based on operational needs and thus not very invasive on major reconfiguration.

There is an institution that would never need the module of recommendation: easily switched off to prevent turning on the module; others can opt for administrative dashboards with advanced analytics.

2) *Cloud-Based Scalability:* The system would easily be able to accept any and all fluctuations of traffic patterns with cloud architecture in place because the node server and mongo database are engineered to add more computational units horizontally based on user volumes going into them. This basically means computation resources can increase dynamically- the more that use to access the system. Thereby, there is provision for supporting numerous concurrent access in peak periods for large installations without slowing it down for service interruption to occur in the system.
3) *Future Expansion:* Since this system can be run in any canteen operations setup, its applications and implications are much beyond the scope of meal management. Orders of bookstore and event catering can thus become part of the canteen management system in every institution, and other features such as faculty meal handling can easily be added within the already existing framework, which extends the adaptability that supports long-term adoption for both sectors and institutions involved.

B. IOT Development

In the phase of the future development of the canteen management system, Internet of Things sensors will be spread across the organization to monitor crowds in real time, thus providing enhanced information for the optimization of the user experience and operational efficiency:

1) *Crowd Level Monitoring:* Strategically positioned IoT sensors throughout the canteen can detect and monitor crowd levels. Information will be passed in real time to the system, allowing users to make decisions on when to place orders and where to order. This is possible with the current display of crowd levels on the platform, as users avoid peak times and visit at times when seats are available.
2) *Seating Availability:* With the management of orders, the system shall be able to give information to the user about real-time seating availability. Thus, users can check their occupancy before going to the canteen, therefore reducing congestion and waiting lines. In this manner, the user will have an all-around smooth dining experience as well as align their preference according to real-time data.
3) *Operational Efficiency:* For canteen management, the use of IoT will enhance control of operations. It could scan the available foot traffic patterns and peak periods, among others, to optimize personnel and resource deployment. Management can thus dynamically adjust operations in response to continually shifting demand, thereby enhancing efficiency in general and user satisfaction.

VIII. CONCLUSION

The Canteen Automation System is a modern and efficient way to address the apparent inadequacies of a traditional canteen operation through web technologies that enhance user experience through real-time inventory management, secure cashless payments, and personalized ordering, while enabling administrators of the canteen to have critical data analytics, thus making informed decisions and optimizing operations. Such architecture of a modular and scalable system would easily adapt to various kinds of institutions, such as educational campuses and corporate environments. Eventually, this system will become the one that changes institutional canteen services and makes them streamlined, efficient, and easy to use. Incorporation of further technologies such as IoT certainly cements its place within modern food service management; therefore, the system positions itself to be sustainable and versatile so that it can be implemented on a mass scale.

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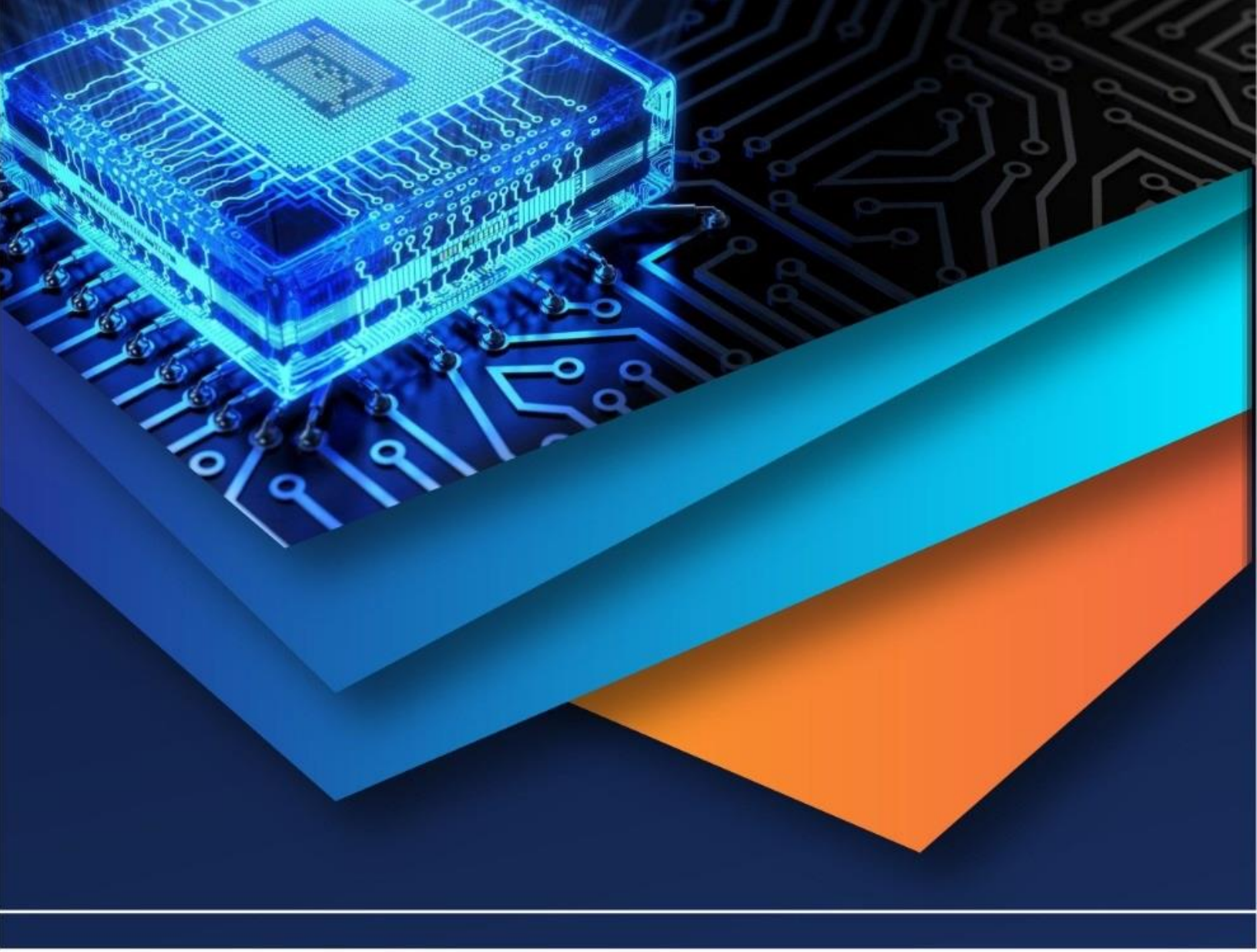

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