Deploying an Intelligent Online Food Ordering System to Optimize College Canteen Operations

Pranav Bari, Yuvraj Patil, Neerajkumar Sathawne, Tushar Suroshe and Atharva Patil
Department of Computer Science & Business Systems, JSPM's Rajarshi Shahu College of Engineering, Pune, Maharashtra, India

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Abstract: College canteens often face issues like long lines, slow service, and crowded spaces, especially during peak hours. To address these challenges, this paper explores a practical approach to building an online food ordering system specifically designed for college campuses. Our solution uses familiar web and mobile tools, combined with modern technologies like the MERN stack (MongoDB, Express, React, Node.js) and simple machine learning techniques, to make ordering food easier and faster for students and staff. Key features include a web application where users can place orders, pay digitally, and get personalized recommendations based on past choices. This system not only reduces wait times but also helps canteen staff manage orders more efficiently. Testing shows that the new system significantly improves order accuracy, speeds up the process, and creates a more enjoyable experience for users. This paper provides a practical blueprint for colleges looking to upgrade their canteen services and keep pace with students' expectations in today's digital world.

1 INTRODUCTION

For students and staff on college campuses, lunchtime can be a hectic experience. With everyone trying to grab a meal during short breaks, college canteens often become crowded, leading to long lines, delayed service, and occasional order mix-ups. These issues not only disrupt the flow of a busy day but also affect the overall satisfaction and productivity of students and staff.

In recent years, digital solutions have transformed many industries, including the food service sector. Online food ordering apps have become a part of everyday life, offering convenience and saving time. Inspired by these advancements, we see an opportunity to bring similar benefits to college canteens by implementing an online ordering system tailored for campus use. This system would allow students and staff to browse the menu, place their orders ahead of time, pay digitally, and simply pick up their meals when ready, skipping the usual wait in line.

This paper presents the design and implementation of an online ordering system built specifically for college canteens. We explore how the MERN stack (MongoDB, Express, React, Node.js) provides a flexible and scalable foundation for creating a system that can handle high traffic, especially during peak hours. Additionally, by incorporating simple machine learning models, the system can suggest personalized menu options based on a user's order history, making it easier for them to choose meals they enjoy.

Beyond convenience for users, this system also benefits canteen staff by streamlining order management. Orders come through in real-time, minimizing miscommunication, and allowing staff to focus on preparing food rather than handling long queues. In this way, the system is not just a digital replacement for manual processes—it's a tool to improve overall efficiency and create a smoother dining experience. In the following sections, we'll delve into the specifics of the system's design, the technologies used, and how this approach can be

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adapted for other campuses looking to modernize their canteen services.

2 RELATED WORK

The Local Food Delivery System (Shah, Shah, et al. , 2021) connects local vendors, such as street hawkers and grocery stores, directly with customers, addressing the demand for convenient food delivery in urban areas. The application allows users to browse local menus, place orders, and track their status in real-time, enhancing user experience while empowering local businesses. Additionally, the system offers health-conscious food suggestions for users with specific dietary needs, promoting healthier eating habits . Built on ASP.NET and MS SQL Server, it ensures robust data management and integrates payment processing and location tracking for efficient deliveries . Overall, this system not only improves food delivery services but also supports the economic empowerment of local vendors.

The Automated Canteen Ordering System by Sharma et al. (2022) (Pandey, Sharma, et al. , 2022) exemplifies advancements in food service automation, addressing inefficiencies in traditional ordering methods. This system allows users to place orders online via an interactive e-menu, significantly reducing wait times and enhancing customer satisfaction. Utilizing modern web development standards, the system features a user-friendly interface and a robust backend for efficient order processing and inventory management. By automating the ordering process, it minimizes human error and alleviates staff workload, leading to improved operational efficiency. While designed for canteens, the system's principles can be adapted for various food service environments. Future enhancements could include AI-driven recommendations and integrated payment gateways. This work serves as a foundational reference for our implementation, highlighting the transformative potential of technology in food service operations.

(Masurah, 2021) The development of recommendation systems has gained significant attention, particularly in the context of food ordering applications for school students. Previous studies have highlighted the importance of integrating nutritional information with user preferences to enhance the effectiveness of food recommendation systems. For instance, the Mobile School Canteen Food Ordering System proposes a solution that not only facilitates food selection but also recommends healthy meal options based on dietary criteria, addressing the challenges faced by students during school breaks.

This research (Mohamad, 2021) builds upon existing literature in restaurant recommendation systems, particularly those utilizing collaborative filtering and content-based filtering techniques. Notably, the proposed system distinguishes itself by leveraging the number of orders as a primary input, a novel approach not previously explored in the field. The methodology incorporates k-nearest neighbor techniques to identify similar buying patterns among clients, enhancing the accuracy of recommendations and addressing the challenges posed by sparse datasets and evolving consumer preferences.

The proposed "Online Canteen Food Order System" (Kogta, 2020) aims to enhance efficiency in college cafeterias by automating the ordering process, which traditionally relies on paper-based systems. Previous studies have highlighted the limitations of such systems, including time-consuming billing processes and the risk of lost records. Innovations in mobile technology and cloud-based applications have been explored to improve customer experience and streamline operations, emphasizing the need for a more effective communication channel between consumers and food service providers.

The "Canteen Food Ordering and Managing System" (Antony, 2022) by Chanchal Antony et al. (2022) presents a comprehensive digital solution for canteen operations, addressing common issues such as long queues and manual paperwork. The system allows users to create accounts, browse a digital menu, place orders, and make online payments. 1 It also features a virtual queue to minimize wait times and provides a platform for customer feedback. 2 The admin interface includes functionalities for managing food items, tracking orders, viewing transactions, and generating reports. 3 This system aims to enhance efficiency and customer satisfaction in canteen services by leveraging digital technology.

A clustered database food recommendation system (Shaikh, Shetgaonkar, et al. , 2019) utilizes K-means clustering to speed up the process by grouping similar items, which is particularly effective with large datasets. An automated food ordering system leverages an Android application to streamline order placement and customization, using JAVA for the front end and MySQL for the backend. The Zigbee-based e-menu ordering system offers an affordable solution for restaurants, featuring a user-friendly graphical interface that simplifies order placement and billing, even for illiterate users. Another proposed system employs wireless touch-panel menus to digitize the ordering process, reducing the need for waitstaff and minimizing errors. This system uses Zigbee for wireless communication and a PIC microcontroller for menu coding. Additionally, an automated food ordering system integrates data mining algorithms like Apriori and K-means to perform association mining and clustering, aiming to reduce counter staff, eliminate calculation errors, and manage queues efficiently. These systems collectively highlight the potential of technology to transform food service operations by improving speed, accuracy, and user experience.

3 PROPOSED SYSTEM

The process begins at the Home page, which serves as the main entry point for both users and admins. From here, users can initiate the login process by going to the User Login screen. Upon a successful login, users are directed to the Menu List, which presumably lists various meal options or items available for ordering.

After viewing the mess list, users can proceed to the Menu for the particular mess or canteen. At this point, the system checks the Authenticity of the request, which could mean verifying the user's identity or checking if the requested item is available. If this check fails (No), the user may be redirected or notified accordingly. But if everything is in order (Yes), the system moves on to a more detailed validation step involving Credit Points or Item Availability. This step likely ensures that the user has sufficient credits to place the order, or it verifies that the requested item is still available in stock.

Once these verifications pass, users are given the chance to add items to their Cart. After adding items, a confirmation step appears, labeled as Confirmation, where users review their orders before proceeding. If users are satisfied and confirm the order (Yes), the next step generates a Token for their transaction. This token is crucial as it likely tracks the user's position in a Queue, ensuring orders are processed in sequence.

Parallelly, there is an Order Page accessible from the Queue, where the system performs another check labeled Check User Eligibility. This might involve double-checking user details, ensuring they meet specific requirements, or perhaps confirming they haven't exceeded any ordering limits. If a user fails this eligibility check (No), the system notifies them through Msg to User, potentially explaining the reason for rejection. If eligible (Yes), the order gets processed further.

From here, the order moves to the backend where it is saved in the Database (DB). At this point, data is gathered for ML Prediction and Data Analysis processes. The ML Prediction step could use data patterns to forecast future item availability or user preferences, while Data Analysis could provide insights for optimizing operations or managing stock.

Admins also have a role in this system, with a separate Admin Login route from the Home page. Upon logging in, admins gain access to the backend tools, including an option to Update Availability of Items. This feature allows them to adjust stock levels, ensuring the menu reflects real-time availability. Through this update mechanism, admins can communicate changes in availability to users, which can trigger the Through Msg to User step, updating users on item status in case of shortages or other adjustments.

In summary, outlines of system designed to handle user authentication, item selection, order validation, stock management, and data processing for predictions and analysis. The structured interaction between users and admins ensures smooth operation, while backend processes enable better management and insights for future improvements.

For this project, we're using the MERN stack, which includes MongoDB, Express, React, and Node.js. This stack allows for a smooth flow of data from the frontend to the backend, making it highly efficient and suitable for building dynamic, responsive web applications. MongoDB serves as our database, storing user information, orders, item availability, and other crucial data. Express is used for routing and setting up the server-side logic, while React is handling the user interface, allowing for interactive and real-time updates. Node.js brings everything together, providing the runtime for our backend operations.

We also incorporated Nodemailer to handle OTP (One-Time Password) verification via email, which is essential for confirming user authenticity. When users sign up or log in, they receive an OTP, which they must enter to proceed, adding an extra layer of security to the process.

For authentication, we're using JWT (JSON Web Tokens). JWT tokens help verify users without having to check their credentials every time they make a request. When a user logs in successfully, a JWT token is issued and sent to the frontend, where it can be stored. For every subsequent request, this token is passed back to the server for verification.

Lastly, role-based authorization is implemented through Express middleware. Different roles like User and Admin have different access privileges; for example, only Admins can update item availability. This role management setup ensures that only authorized users can perform certain actions, keeping the system organized and secure.

Overall, the MERN stack, combined with tools like Nodemailer and JWT-based authentication, provides a reliable foundation for building a full-featured application with enhanced security and structured access control.

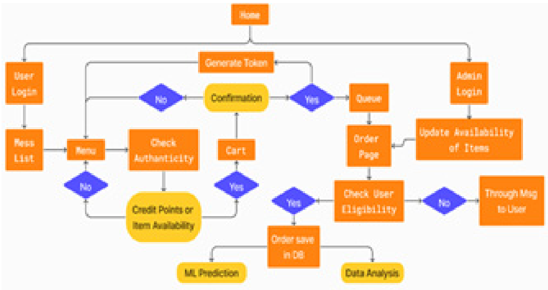

Figure 1: Order Management System Flowchart

3.1 Algorithm Used: Priority Queue Algorithm

The Priority Queue algorithm is designed to help a canteen process orders in the most efficient way possible, balancing customer satisfaction and profit while considering key operational constraints. It prioritizes takeaway orders by calculating a "priority score" based on several important factors: the profit margin of each order, the time it takes to prepare, how complex the order is, the customer's preferences, and how urgent the order is.

Here's how each factor plays a role:

1. **Profit Margin (P)**: This is how much money the canteen makes from an order. Orders that generate higher profits should be given more attention.

2. **Preparation Time (T)**: The time needed to prepare the order. Shorter orders that can be prepared quickly are given higher priority to maximize efficiency during busy periods.

3. **Order Complexity (C)**: This reflects how difficult or time-consuming an order is to prepare. Complex orders, which require more ingredients or steps, are deprioritized to keep the process smooth.

4. **Customer Preference (CP)**: If a customer has ordered a particular dish before or if it is a popular dish, the system prioritizes that order to enhance the customer's experience and satisfaction.

5. **Urgency (U)**: This factor determines how quickly the order needs to be completed. Urgent orders, such as those that need to be ready within a short time frame, are given higher priority.

The algorithm calculates a **priority score** for each order using the formula:

$$\boldsymbol{Priority\ Score} = (\boldsymbol{P} / \boldsymbol{T}) - \boldsymbol{C} + \boldsymbol{CP} + \boldsymbol{U} \quad (1)$$

Where:

- **P / T** gives a higher priority to orders that offer a good profit relative to the time required to prepare them.
- **C** reduces the priority for complex orders.
- **CP** increases the priority for orders that reflect customer preferences.
- **U** ensures that urgent orders are handled first.

Once each order has a priority score, the orders are sorted from the highest to the lowest score, ensuring that the most important and profitable orders are handled first. The system also checks whether the necessary ingredients are available, and if certain items are out of stock, those orders are given lower priority.

This algorithm allows the canteen to dynamically manage its orders, ensuring that it maximizes profit, keeps customers happy, and works within the constraints of time, resources, and complexity.

3.2 Recommendation Algorithm Using Cosine Similarity

The recommendation algorithm utilizes cosine similarity to suggest items to a target user based on their past interactions and the behaviors of similar users. The process starts by calculating how similar each user is to the target user using cosine similarity, a metric that measures the angle between two vectors of user-item interactions. This similarity score helps identify users who have similar tastes or preferences to the target user.

Once the similarity scores are computed, the algorithm selects the most similar users and examines the items **they** have interacted with, especially those that the target user has not yet rated or purchased. By aggregating the ratings or interactions from the similar users, the algorithm generates a prediction score for each item that the target user has not interacted with.

Finally, the items are ranked based on these scores, and the top recommendations are presented to the target user. This method ensures that the recommendations are personalized, taking into account not just the target user's past behavior but also the preferences of users who are most similar to them.

Input:

- A user-item interaction matrix *M*, where rows correspond to users, columns correspond to items, and the matrix elements represent interaction values (e.g., ratings or purchase frequency).
- The target user U_t, for whom recommendations are to be generated.
- The number of desired recommendations *N*.

Steps:

1. **Calculate User Similarities**: For each user U_i in the dataset:
   - Compute the similarity between U_t and U_i using the cosine similarity formula:

$$Similarity\ (U_t, U_i) = \frac{\sum_{j=1}^{n} U_t[j] \cdot U_i[j]}{\sqrt{\sum_{j=1}^{n} U_t[j]^2} \cdot \sqrt{\sum_{j=1}^{n} U_i[j]^2}} \quad (2)$$

   Rank Users by Similarity: Arrange all users U_i based on their similarity scores in descending order. Select the top K users who are most similar to U_t.

2. **Aggregate Scores for Unrated Items**: For each item I_j, that the target user U_t has not interacted with:
   - Compute a weighted score using the interaction data from the top K similar users:

$$Score\ (I_j) = \sum_{k=1}^{k} (Similarity(U_t, U_k) \cdot M[U_k, I_j] \quad (3)$$

   - Here, $M[U_k, I_j]$ represents the interaction value of user U_k with item I_j.

3. **Recommend Top Items**: Rank all items I_j based on their computed scores in descending order. Select the top N items as recommendations for U_t.

Output:

A list of N items recommended for the target user based on their **similarity** with other users and aggregated scores for unrated items.

4 EXPECTED OUTCOMES

By implementing this system, several key improvements in user experience and operational efficiency can be achieved:

Reduced Wait Times: The queue management system, paired with real-time item availability updates and user eligibility checks, helps streamline the ordering process. With each order processed in sequence, **users** experience shorter wait times, especially during peak hours. The system also minimizes bottlenecks by only allowing eligible users to place orders, preventing unnecessary load and delays.

Improved Order Accuracy: The system's layered verification process, including credit checks and item availability confirmation, significantly improves order **accuracy**. Each order goes through multiple validation steps, ensuring that only items in stock and available for the user's credit level are added to the cart. Additionally, the OTP verification step prevents unauthorized access, reducing the chances of errors due to fraudulent orders.

Enhanced User Experience: With the user-friendly interface powered by the React frontend, and a smooth backend flow managed by Node.js and Express, users can navigate through the menu, add items to the cart, and complete orders seamlessly. The role-based access control ensures that users and admins have customized, relevant options, which further contributes to a streamlined experience.

Data-Driven Insights: By incorporating data analysis and machine **learning** prediction models, the system allows for better forecasting of user preferences and inventory needs. This leads to proactive stock management, where items can be replenished before they run out, further enhancing order accuracy and availability.

5 CHALLENGES FACED

One of the primary challenges encountered in this project involves integrating the payment gateway. While the gateway facilitates smooth and secure transactions, it also imposes a 2% brokerage fee on each transaction. This brokerage can become costly over time, especially with high transaction volumes, reducing the overall profitability and increasing operational expenses.

To address this, alternative solutions are being considered to minimize these costs. Options might include exploring payment providers with lower transaction fees, integrating a direct bank transfer system, or possibly incorporating a wallet or prepaid credit system within the application. These alternatives could help reduce dependency on external gateways and improve cost efficiency. However, each alternative requires careful evaluation for security, user convenience, and compatibility with existing infrastructure.

Balancing a seamless payment experience for users while managing transaction fees remains a complex challenge, and ongoing adjustments will be essential to find the most cost-effective yet user-friendly approach.

6 CONCLUSION

The implementation of the Intelligent Online Food Ordering System for college canteens represents a significant advancement in addressing the challenges faced by students and staff during meal times. By utilizing the MERN stack and integrating machine learning techniques, we have developed a robust platform that not only streamlines the ordering process but also enhances user experience through personalized recommendations and real-time order management.

The system effectively reduces wait times, minimizes order inaccuracies, and alleviates the congestion typically associated with traditional canteen operations. Furthermore, it empowers canteen staff to focus on food preparation rather than managing long queues, thereby improving overall operational efficiency.

As we move forward, it is essential to continue refining the system based on user feedback and technological advancements to ensure it meets the evolving needs of college communities. This implementation serves as a practical blueprint for other institutions looking to modernize their dining services and align with the digital expectations of today's students. By embracing such innovations, colleges can significantly enhance the dining experience, ultimately contributing to the satisfaction and productivity of their campus populations.

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