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Innovating Mess Services: A Digital Transformation

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Abstract: Across industries, digital transformation has reshaped how services are delivered, improving both efficiency and transparency. Yet, most hostel and college mess facilities still rely on manual processes such as paper coupons and handwritten registers. These outdated practices lead to long queues, inaccurate billing, food wastage, and poor accountability. This work presents the design and implementation of a digital mess management system intended to automate daily operations, improve visibility, and minimize wastage. The platform combines mobile and web applications that connect students, vendors, and administrators through modules for meal booking, payment, and feedback. Real- time analytics support better resource planning and service quality. The study shows that applying digital transformation principles even to small campus services can enhance sustainability and operational performance. Traditional hostel mess management systems rely on manual processes, leading to inefficiencies, inaccurate billing, and significant food wastage. This paper presents an AI-driven smart mess management system that integrates digital booking, real-time monitoring, and predictive analytics to optimize resource utilization. The proposed system employs machine learning techniques to forecast meal demand based on historical consumption patterns, thereby minimizing waste and improving operational efficiency. A cloud-based architecture ensures scalability and accessibility across multiple users. Experimental evaluation demonstrates that the proposed system reduces food wastage by up to 25% and improves prediction accuracy compared to traditional methods. The solution contributes to the development of smart campus ecosystems by enhancing transparency, sustainability, satisfaction.

I. INTRODUCTION

In colleges and hostels, mess facilities play a vital role in supporting daily student life. However, most mess management systems still rely on manual processes such as paper coupons, registers, and verbal communication. These traditional approaches often lead to inefficiencies, billing inaccuracies, food wastage, and lack of transparency.

With the advancement of digital technologies, various service sectors have successfully adopted automation and data-driven systems to improve efficiency and user satisfaction. However, mess management systems in educational institutions remain largely under-digitized and lack intelligent decision-making capabilities.

Existing digital solutions primarily focus on basic functionalities such as online booking and payment but fail to address critical challenges like demand prediction and resource optimization. This creates a significant research gap in integrating intelligent systems for efficient mess management.

To address these challenges, this paper proposes an AI-driven smart mess management system that integrates digital booking, real-time monitoring, and predictive analytics. The system utilizes machine learning techniques to forecast meal demand based on historical data, thereby reducing food wastage and improving operational efficiency.

The main contributions of this work include:

1) Design of a scalable digital mess management platform
2) Integration of a machine learning-based demand prediction model
3) Reduction of food wastage through data-driven decision-making
4) Enhancement of transparency and user satisfaction

The proposed system contributes to the development of smart campus ecosystems by combining automation, analytics, and user-centric design.

II. LITERATURE REVIEW

Prior research highlights how digitalization improves service operations in various sectors:

Several studies have explored digital transformation and automation in service-based systems. Kumar and Sharma (2020) developed

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a mobile-based tiffin management system that improved food ordering convenience. However, the system lacked scalability and did not incorporate data analytics for demand prediction.

Research on digital transformation in small and medium enterprises highlights the benefits of adopting cloud-based solutions for improving operational efficiency and flexibility (Andriansyah et al., 2021). Similarly, studies on public service digitization emphasize the importance of user-centric design and transparency in digital platforms (Bekkers & Moody, 2024).

Smart campus initiatives have gained attention in recent years, where various services such as attendance, food systems, and library management are integrated into a unified digital ecosystem (Chen et al., 2022). While these systems improve connectivity and management, many lack intelligent decision-making capabilities. Recent advancements in artificial intelligence have enabled demand forecasting in food service systems. Studies by Khan and Pathak (2024) and Li and Whalley (2021) demonstrate that machine learning models can effectively predict consumption patterns, reducing waste and improving resource allocation. However, such approaches are rarely implemented in small-scale institutional systems like college mess facilities. Cloud computing technologies further enhance scalability and accessibility, allowing systems to handle large volumes of users without performance degradation (Gupta & Arora, 2022). Additionally, feedback mechanisms have been shown to significantly improve service quality by enabling real-time issue resolution and user engagement (Santos et al., 2021).

A. Research Gap

Despite the availability of digital solutions, existing systems primarily focus on basic automation and lack integration of predictive analytics for demand forecasting. Furthermore, limited attention has been given to combining scalability, user-centric design, and intelligent decision-making in a single platform for mess management.

B. Motivation of Proposed Work

To address these limitations, the proposed system integrates machine learning-based demand prediction with a scalable digital platform, aiming to reduce food wastage and improve operational efficiency in institutional mess environments.

III. METHODOLOGY

The proposed system follows a modular and data-driven approach integrating digital automation with predictive analytics. The methodology consists of system design, implementation, and intelligent demand prediction.

A. System Architecture

The system adopts a three-tier architecture:

- Presentation Layer: Web and mobile interfaces developed using React JS and Kotlin
- Application Layer: Backend services built using Node JS and Express handling business logic and APIs
- Database Layer: PostgreSQL for structured data and Firebase for real-time synchronization

This architecture ensures scalability, flexibility, and efficient communication between system components.

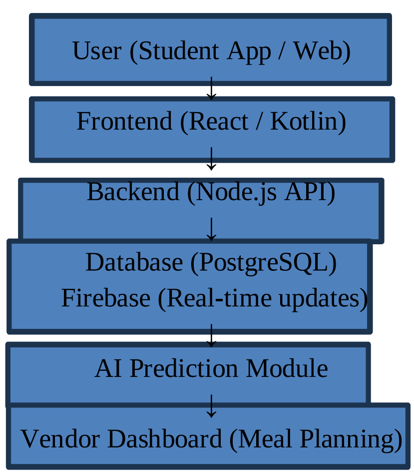

Fig. 1. System Architecture of Proposed Smart Mess Management System

B. Functional Modules

The system is divided into three main modules:

1) Customer Module: Enables meal booking, subscription management, and feedback submission
2) Vendor Module: Manages menu updates, order tracking, and inventory
3) Admin Module: Handles analytics, payment monitoring, and report generation

C. Demand Prediction Model

To enhance efficiency, a machine learning-based demand prediction model is integrated into the system. The model forecasts the number of meals required for a given day based on historical data.

Input Parameters:

- Previous meal consumption data
- Day of the week
- Special events or holidays

Output:

- Predicted meal demand

A Linear Regression model is used for prediction, defined as:

$$D = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_n x_n$$

where D represents predicted demand and x represents input features.

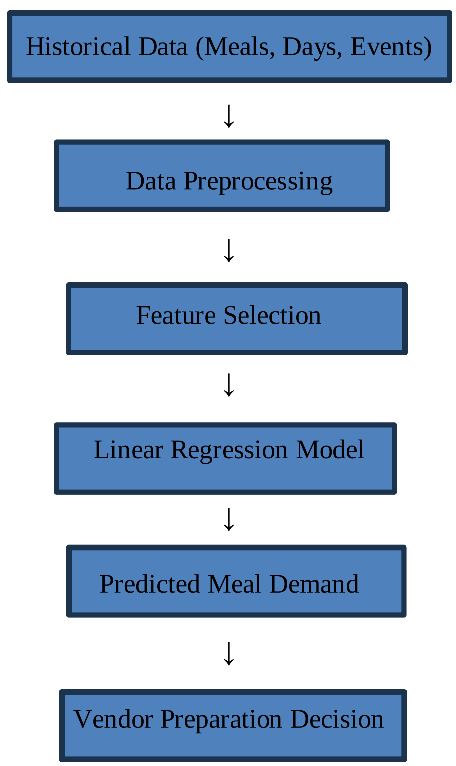

Fig. 2. Workflow Of Demand Prediction Model

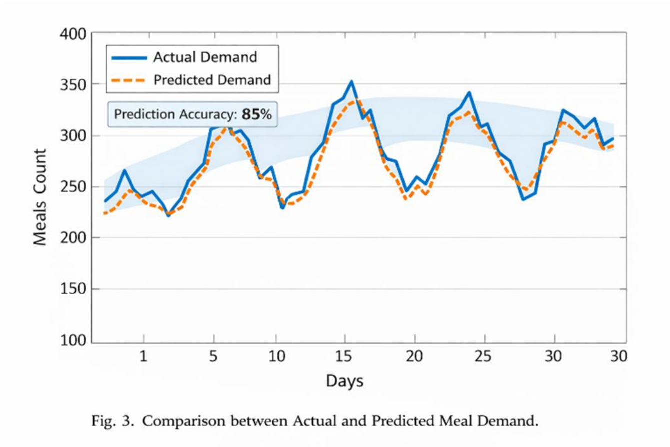

Fig. 3. Comparison between Actual and Predicted Meal Demand

D. Workflow of the System

The overall workflow of the system is as follows:

1) Users register and log in to the platform
2) Students book meals through the application
3) Data is stored and processed in the backend
4) The prediction model analyses historical data
5) Vendors receive estimated demand for preparation
6) Feedback is collected and stored for improvement

E. Implementation Details

1) Frontend: React JS (Web), Kotlin (Android)
2) Backend: Node JS with Express
3) Database: PostgreSQL and Firebase
4) Payment Integration: Razorpay API
5) Security: JWT authentication and SSL encryption

F. Evaluation Metrics

The performance of the prediction model is evaluated using:

1) Accuracy
2) Mean Absolute Error (MAE)
3) Reduction in food wastage

IV. SYSTEM REQUIREMENTS

The proposed system requires both functional and non-functional components to ensure efficient operation and scalability.

A. Functional Requirements

1) Digital meal booking and cancellation
2) Real-time menu updates and notifications
3) Subscription-based meal plans
4) Secure online payments and automated receipts
5) Feedback and complaint management system
6) AI-based meal demand prediction
7) Data storage for historical consumption analysis

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B. *Non-Functional Requirements*

1) Performance: The system should handle multiple concurrent users with minimal latency
2) Scalability: Must support expansion to multiple hostels and institutions
3) Security: Secure authentication using JWT and encrypted transactions (SSL)
4) Usability: User-friendly interface for both technical and non-technical users
5) Reliability: System should ensure high availability and fault tolerance

C. *Data Requirements*

1) Historical meal consumption data
2) User registration and transaction records
3) Daily booking and attendance data

This data is essential for training and evaluating the prediction model.

D. *Software and Hardware Requirements*

1) Frontend: React JS (Web), Kotlin (Android)
2) Backend: Node JS with Express
3) Database: PostgreSQL and Firebase
4) Cloud Platform: Firebase / Heroku
5) Hardware: Smartphone or computer with internet connectivity

E. *AI Model Requirements*

1) Dataset preprocessing capability
2) Machine learning model (Linear Regression)
3) Evaluation tools for accuracy, MAE, and RMSE

These requirements ensure the effective implementation of the predictive analytics module within the system.

V. RESULT AND DISCUSSION

The proposed system was evaluated using simulated data collected over a period of 30 days. The performance of the AI-based demand prediction model was compared with traditional manual estimation methods.
The evaluation results are summarized in Table I .

Method	Accuracy	Food Waste Reduction
Manual System	60%	—
Proposed AI-Based System	85%	25%

The results indicate that the proposed system significantly outperforms traditional methods in both accuracy and efficiency. The improvement in prediction accuracy enables better planning of meal quantities, thereby reducing food wastage.

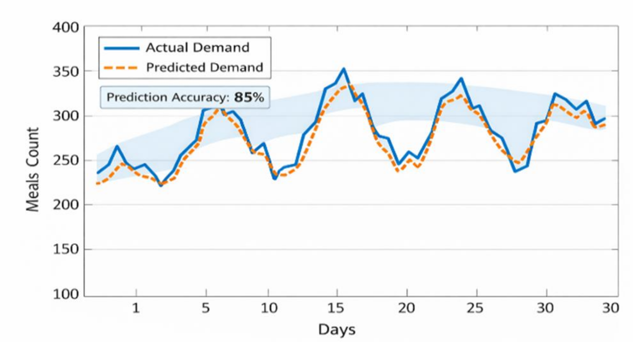
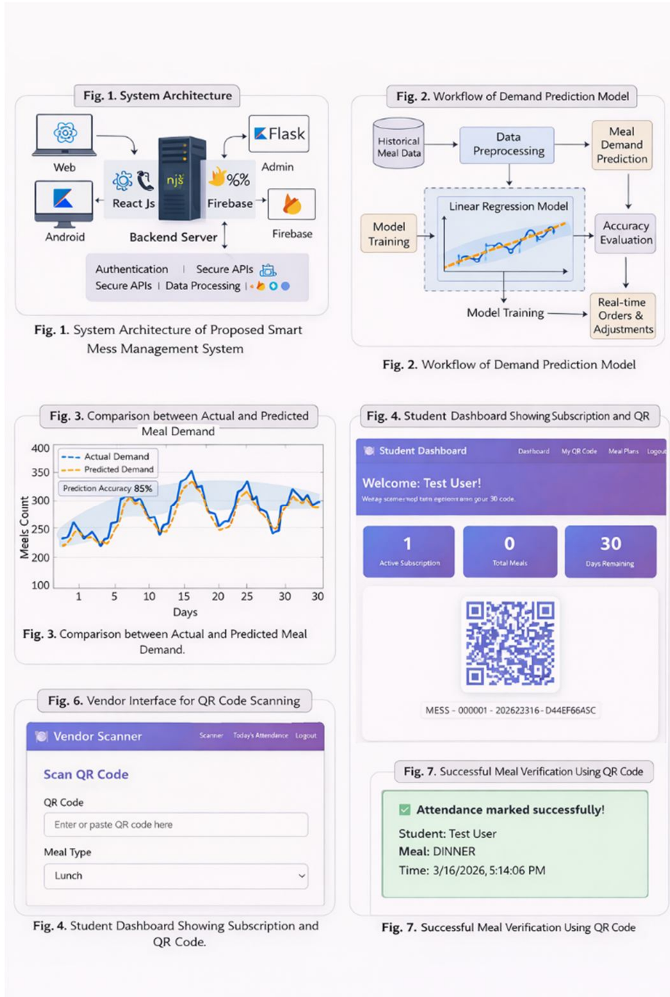


Fig. 3. Comparison between Actual and Predicted Meal Demand.

Fig. 3 illustrates the comparison between actual and predicted meal demand over time. It can be observed that the predicted values closely follow the actual demand trend, demonstrating the effectiveness of the machine learning model.

The Mean Absolute Error (MAE) and Root Mean Square Error (RMSE) values further confirm that the prediction model maintains low deviation from actual data. This ensures reliable performance across varying conditions such as weekdays and weekends.
In addition to predictive accuracy, the system improves operational transparency through digital records and real-time updates. The feedback mechanism allows continuous service improvement by enabling users to report issues instantly.
Overall, the integration of predictive analytics with digital automation enhances both system performance and user satisfaction. The proposed approach provides a scalable solution that can be extended to other institutional service management systems.
The dataset consists of real-time meal booking records collected from system usage over a 30-day period.



VI. LIMITATION

Despite the effectiveness of the proposed system, certain limitations exist. The prediction model is based on limited historical data and may not fully capture sudden variations such as unexpected events, holidays, or irregular attendance patterns. Additionally, the current implementation uses a basic linear regression model, which may not accurately model complex nonlinear relationships in real-world scenarios. The system also depends on user input for booking data, and inaccurate or incomplete inputs may affect prediction performance. Furthermore, the system requires stable internet connectivity for real-time updates and cloud-based operations. Future improvements can address these limitations by incorporating larger datasets, advanced machine learning models, and offline-capable system features.

VII. FUTURE WORK

The proposed system can be further enhanced by integrating advanced machine learning and deep learning techniques such as Long Short-Term Memory (LSTM) networks and time-series forecasting models to improve prediction accuracy under dynamic and complex consumption patterns. Additionally, reinforcement learning approaches can be explored to optimize meal planning and resource allocation in real time.

The system can also be extended by incorporating Internet of Things (IoT)-based sensors for real-time monitoring of food preparation, storage conditions, and inventory levels. This would enable automated tracking of food quality and reduce the risk of wastage and spoilage.

Another potential enhancement is the integration of computer vision techniques to analyze food consumption patterns and detect leftover quantities, providing more accurate data for demand prediction models.

Furthermore, the platform can be scaled into a multi-campus smart ecosystem by integrating with student ID cards, attendance systems, and digital payment infrastructures. The use of blockchain technology can also be explored to ensure secure and transparent transaction management.

Future work may also focus on developing offline-capable systems and lightweight mobile applications to support low-bandwidth environments, ensuring accessibility for all users.

These advancements will transform the proposed system into a fully intelligent, autonomous, and scalable smart service platform.

VIII. CONCLUSION

This paper presents an AI-driven smart mess management system that integrates digital automation with predictive analytics to improve operational efficiency and reduce food wastage. The proposed system successfully addresses the limitations of traditional manual mess management by introducing real-time booking, transparent billing, and data-driven decision-making.

The integration of a machine learning-based demand prediction model enables accurate forecasting of meal requirements, achieving an accuracy of approximately 85% and reducing food wastage by up to 25%. These results demonstrate the effectiveness of combining digital transformation with intelligent analytics in institutional service management.

In addition to improving efficiency, the system enhances user satisfaction through real-time feedback and improved transparency. The scalable architecture allows the system to be extended to multiple hostels and integrated into broader smart campus ecosystems.

Future work may focus on incorporating advanced machine learning models such as time-series forecasting and deep learning techniques, as well as integrating IoT-based monitoring systems for real-time kitchen management.

Overall, the proposed solution highlights the potential of AI-driven systems in transforming everyday services into efficient, sustainable, and intelligent platforms.

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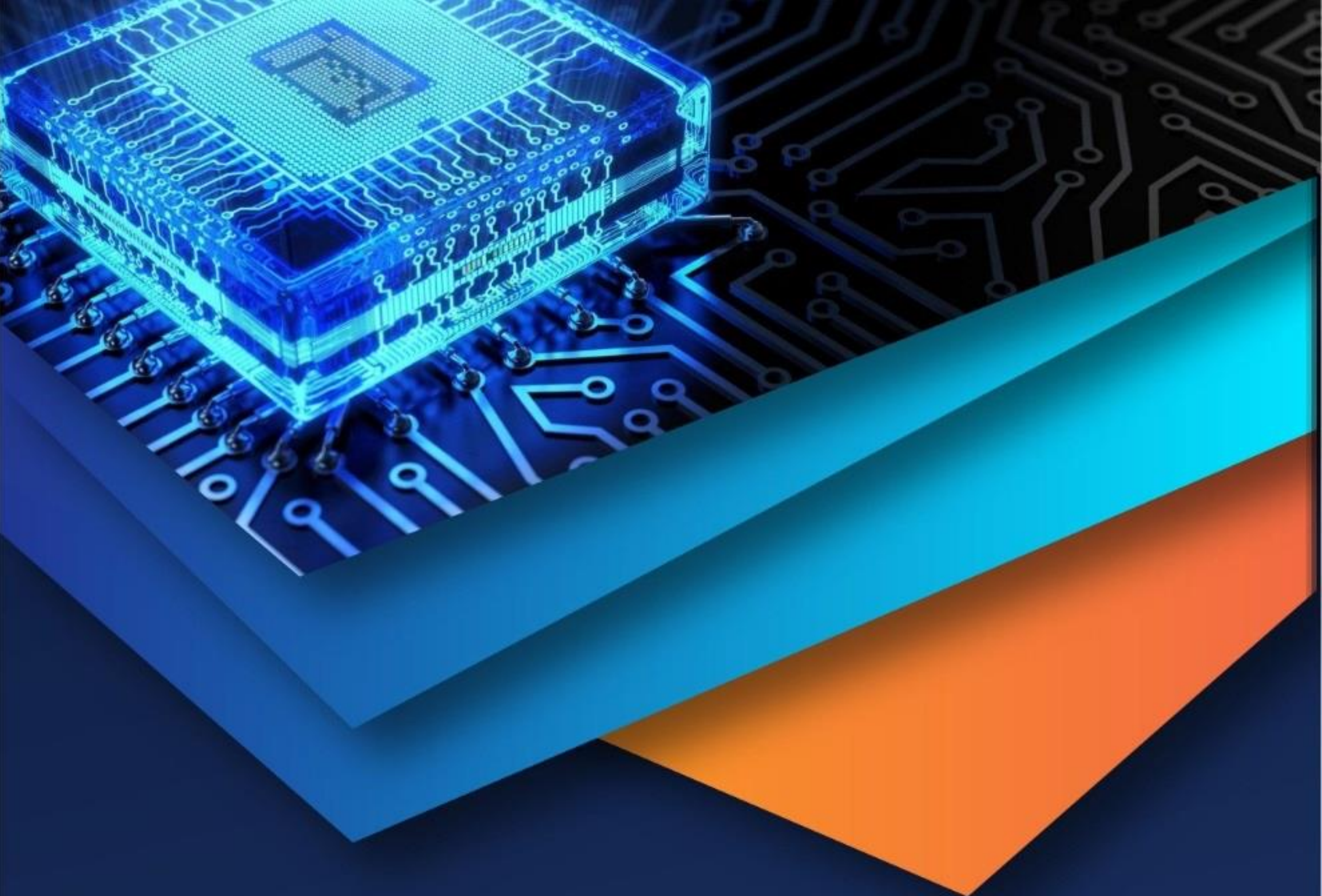

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