"END-TO-END CANTEEN AUTOMATION ROBOT: ORDER TAKING, BILLING, AND DELIVERY"

[1] Dr.S.KISHORE REDDY, [2] S LAKSHMI PRIYADHARSHINI, [3] PATHIPAKALA ROHITH, [4] ENUGURTHI SHASHANK, [5] MAMILLA ARUN TEJA

[1]Associate professor, [2,3,4,5] UG STUDENT

[1,2,3,4,5]DEPARTMENT OF ELECTRONICS AND COMMUNICATIONS ENGINEERING

[1,2,3,4,5]AVANTHI INSTITUTE OF ENGINEERING AND TECHNOLOGY

Gunthapally(V), Abdullapurmet(M), R.R Dist - 501512

Abstract

The End-to-End Canteen Automation Robot: Order Taking, Billing and Delivery is a smart cloud-based system to automate the process of ordering food, billing, payment and delivery in institutional canteens. Traditional canteen management is manual. The orders are taken manually. The bills are written manually. The communication between the customer and kitchen staff is verbal. This often results in long queues, billing errors, order mismatches, and inefficient service. This project solves these issues by offering an integrated digital platform where users can order food through a mobile app or web interface for faster and more accurate service.

The cloud backend of the proposed system is a Firebase Realtime Database that synchronises the customer's order, billing information, payment status, and kitchen updates in real time. The ESP8266/ESP32 Wi-Fi microcontrollers enable communication between the cloud database and the kitchen display system. Once the order is placed, the system will automatically generate the bill and enable UPI/QR based digital payments and generate a unique token number to facilitate organised food collection. Orders come in real-time on a digital dashboard in the kitchen, eliminating paper slips and reducing communication errors.

Furthermore, the system offers real-time order status updates, allowing customers to track their orders from preparation to completion. Options like RFID authentication, QR code login, thermal token printing, buzzer & LED alerts, and digital notifications make the process more efficient and improve user experience. The modular architecture allows for future integration of advanced technologies such as Artificial Intelligence (AI), machine learning based food recommendations, automated inventory management, voice assisted ordering and robotic food delivery.

Experimental tests show that the system is good in terms of billing accuracy, reliable cloud synchronisation, unique token generation and low communication latency. This implementation greatly reduces the waiting time of the customer, reduces human intervention, increases the transparency of operations and improves the overall efficiency of the canteen. The proposed solution is in line with the concept of Smart Campus and provides a scalable, secure and user-friendly canteen automation platform suitable for colleges, universities, corporate cafeterias, hospitals and other institutional food service environments.

Keywords: Canteen Automation, Internet of Things (IoT), Firebase Realtime Database, Automated Billing, Real-Time Order Tracking.

I.INTRODUCTION

The fast development of digital technologies has changed the way of providing services in different spheres of life, like education, healthcare, banking and retail. However, many institutional canteens still rely on traditional methods for food ordering, billing, and order delivery, leading to long waiting queues, manual billing errors,

communication gaps between customers and kitchen staff, and inefficient service management. These problems are exacerbated at peak times, such as lunch hour, resulting in customer dissatisfaction and increased workload for canteen staff. Thus, the need for an intelligent and automated system for canteen operation is increasing with better service quality and operational efficiency.

The proposed End-to-End Canteen Automation Robot: Order Taking, Billing and Delivery system automates the entire food service process with the help of a cloud connected digital platform. The system allows customers to see the menu, order food through a mobile app or web-based interface, make safe digital payments using UPI or QR codes and receive a unique token for food pickup. The Firebase Realtime Database provides real time communication of all order information, ensuring accurate communication and eliminating the need for paper slips and verbal order exchanges.

The system uses Internet of Things (IoT) technology through ESP32/ESP8266 microcontrollers to ensure reliable communication between customer interface, cloud database, billing counter and kitchen display. Automated billing, real-time order sync, status updates and central data storage greatly improve service transparency and reduce manual intervention. Optional modules like RFID authentication, QR-based authentication, thermal token printing, and notification alerts also help improve system usability and operational efficiency.

The proposed solution is modular and scalable in architecture that can accommodate the future integration of advanced technologies such as Artificial Intelligence (AI), machine learning based food recommendations, automated inventory management, voice-assisted ordering, and robotic food delivery systems. This flexibility means the system can be updated to meet evolving technological demands without major architectural changes.

The primary aim of this project is to reduce the customer waiting time, improve billing accuracy, eliminate order mismatches and provide a smooth digital ordering experience. The system automates the whole workflow from placing an order to delivering food, thus increasing customer satisfaction, reducing operating costs and ensuring efficient resource utilisation. Furthermore, the cloud-based infrastructure allows administrators to monitor orders, create sales reports, analyse customer demand, and keep secure digital records for future reference.

The End-to-End Canteen Automation Robot: Order Taking, Billing and Delivery system suggested is an innovative and practical solution to the modern institutional food service management. This supports Smart Campus initiatives providing a reliable, scalable, secure and user-friendly automation platform that increases productivity, reduces manual work and provides a faster and more organised dining experience.

II. LITERATURE REVIEW

Many researchers have proposed digital solutions for improving the efficiency of institutional canteen operations by automating conventional manual processes. Most of the existing studies focus on minimising customer waiting time, improving billing accuracy and improving communication between customers and kitchen staffs by using mobile application, cloud computing and Internet of Things (IoT) technologies.

The initial stages of canteen management were primarily concerned with the digitisation of the food ordering process utilising Android or web-based applications. These systems allowed customers to look at digital menus and order remotely, helping to ease congestion at ordering counters. These solutions greatly enhanced customer convenience but many lacked real-time synchronisation between the ordering interface, the billing system and kitchen operations, thereby limiting their overall effectiveness.

Several researchers have proposed canteen management systems based on RFID to automate customer identification and to ease user authentication. The RFID technology enables fast and secure login with the identity cards of institutions, reducing the time for manual verification and improving the tracking of transactions. Nevertheless, RFID-based solutions need extra hardware infrastructure, which increases the cost of deployment and reduces the flexibility in environments where contactless QR-based authentication might be more practical.

In recent years, cloud-based canteen management systems have been paid much attention due to the advantages such as centralised data storage, real-time synchronisation and remote accessibility. Systems like the Firebase Realtime Database facilitate real-time communication across customer interfaces, the billing counter, and kitchen displays, and also provide digital storage of orders, payments, and transaction history. These systems enhance operational transparency and support administrative monitoring and reporting.

Digital payment integration has also become an important aspect of modern canteen automation systems . Several studies have integrated UPI, QR-code, and e-wallet payment methods to minimise cash handling, speed up billing, and maintain secure records of digital transactions. Cashless payment systems reduce billing delays and also enhance customer convenience and financial transparency.

Recent advances have brought about improvements in the automation of canteens through the implementation of intelligent technologies like Artificial Intelligence (AI), machine learning, and recommendation systems. These methods study customer preferences and past ordering behaviour to offer personalised food recommendations, demand prediction and operational efficiency. While these intelligent features enhance the user experience, they demand large datasets and sophisticated computational models, thus they are more appropriate for future improvements rather than being critical elements of fundamental automation systems.

The proposed End-to-End Canteen Automation Robot: Order Taking, Billing and Delivery system, is a combination of several technologies into one system as compared to previous research. The proposed solution combines mobile or web ordering, auto billing, real-time cloud sync using firebase, ESP32/ESP8266 IoT communication, digital payment integration, token generation and kitchen dashboard synchronisation into one architecture. Moreover, the modular architecture enables the easy integration of AI-based food recommendations, automatic inventory management, voice-assisted ordering, and robotic food delivery in the future with minimal modifications to the existing system architecture.

So, the suggested method overcomes many of the drawbacks of existing canteen management solutions. The proposed system presents an automation framework that is scalable, secure, cloud-connected and user friendly which can enhance the efficiency of the service, cut down the manual intervention, reduce the waiting time of customers and support the vision of Smart Campus infrastructure.

III. METHODOLOGY

In this paper, we proposed End-to-End Canteen Automation Robot: Order Taking, Billing and Delivery system, which is developed using modular and systematic approach to automate the complete food ordering and delivery process in the institutional canteens. The methodology integrates cloud computing, Internet of Things (IoT), real-time communication, automated billing, and digital payment technologies to offer an efficient and reliable canteen management solution.

The development process starts with the requirement analysis. The limitations of conventional canteen systems are studied. The existing manual processes like collection of orders through hand writing, verbal communication, manual billing and distribution of tokens on paper are analysed to identify operational challenges like long waiting queues, billing errors, mismatch in orders and inefficient communication between customers and kitchen staff. The functional and non-functional requirements of the proposed system are defined based on these observations.

After the requirement analysis, the system architecture is designed based on a layered approach. The architecture comprises customer interface layer, cloud backend layer, billing layer, kitchen display layer and notification layer. The system lets customers browse through the menu items and place food orders using a mobile app or web dashboard. The application communicates with the cloud server through Firebase Realtime Database which is used to store menu information, customer orders, payment status, token numbers and order history, while it provides real time synchronisation amongst all the system components.

The implementation phase consists of IoT hardware and cloud platform. ESP32 or ESP8266 Wi-Fi microcontrollers develop the communication between customer interface, Firebase database, billing counter and kitchen display. Once a customer places an order, the system automatically uploads the order details to the cloud database, and the kitchen dashboard can immediately access it. This removes the need for manual contact and the processing time is significantly shorter.

An automated billing module calculates the total order amount according to the predefined menu prices stored in the database. Upon successful generation of the bill, the customers pay using UPI or QR based digital payment modes. Once the payment is confirmed, the system automatically generates a unique order token, which the customer needs to present when collecting the food. The generated token is shown on the customer application, billing screen and kitchen dashboard for synchronised order management.

The kitchen sync module continuously listens to Firebase DB for the new orders being placed. The kitchen staff receive the order details in real time on a digital display and update the order status as it progresses through different stages like Order Received, Preparing and Ready for Pickup. These updates are instantly displayed on the customer interface, so users can see the status of their orders without having to contact you verbally.

The proposed system also supports optional modules like RFID authentication, QR-code login, thermal token printing, buzzer and LED notifications and digital order confirmation alerts to improve flexibility. These extra features provide user convenience and operational efficiency and are compatible with the existing architecture.

Finally, the system is tested and validated for functionality, communication reliability, billing accuracy, token uniqueness, cloud synchronisation, and overall system performance. Experiments have shown that the proposed system successfully reduces customer waiting time, eliminates manual billing errors, improves communication between customers and kitchen staff and provides secure cloud-based data management. The modular architecture also enables future features like Artificial Intelligence (AI) based food recommendations, automated inventory management, voice-assisted ordering, and robotic food delivery, making the system scalable for next-generation Smart Campus applications.

VI. SYSTEM ARCHITECTURE

The proposed End-to-End Canteen Automation Robot: Order Taking, Billing and Delivery system is designed with a modular and cloud based architecture, integrating the customer interface, cloud database, billing system, kitchen display and notification module into a single platform. The architecture enables all components to communicate seamlessly through the Firebase Realtime Database, keeping the order information and system status synchronised in real-time. The system is accessed by customers through a mobile application or web-based interface where they can browse the digital menu, select food items, specify quantities, and place orders conveniently without the need to wait in physical queues. Secure and contactless user identification can be provided by integrating optional authentication mechanisms such as RFID cards or QR-code login.

Once the order is placed, it is sent to Firebase Realtime Database which is the primary cloud backend used to store menu details, customer details, order details, billing details, payment status, token number, timestamp and order history. The cloud database instantly syncs information across all connected devices, giving administrators, billing counters and kitchen staff access to updated order details in real time. This centralisation approach removes manual communication and ensures data availability across the entire system.

The billing module automatically calculates the total cost of the selected food items on the basis of the predefined prices stored in the database. The payment through UPI or QR based digital payment methods on successful completion will generate a unique token number for each order. The generated token is displayed at the customer interface, billing counter and kitchen dashboard at the same time, thus allowing an organised and efficient food collection process. Alternatively, a physical receipt or token can be printed on a thermal printer for the customer

to refer to if required.

The kitchen unit is connected to the cloud with ESP32 or ESP8266 Wi-Fi-enabled microcontrollers that constantly monitor the Firebase database for new orders. As soon as a customer places an order, the kitchen dashboard instantly shows the ordered items, quantities, billing details and token number. They will also change the status of the order as the order goes through the different stages such as Order Received, Preparing, Ready for Pickup. The cloud database automatically syncs these updates to the customer application. Thus, the customer can track his order status without any verbal communication.

The notification module improves the overall efficiency of the system by informing the customers when their orders are ready for pickup. The mobile app, digital signage, LED lights, buzzers or optional text messages can be used for notifications. This reduces unnecessary crowding around the serving counter and allows for a smooth token-based distribution of food. The modular design also facilitates additional features in future like Artificial Intelligence based food recommendations, automatic inventory management, voice-assisted ordering, facial recognition, robotic food delivery etc. without making major changes to the current system. Overall, the proposed architecture provides a scalable, secure and efficient platform that improves service quality, reduces manual intervention, increases operational transparency and supports the implementation of Smart Campus initiatives.

A. Overview

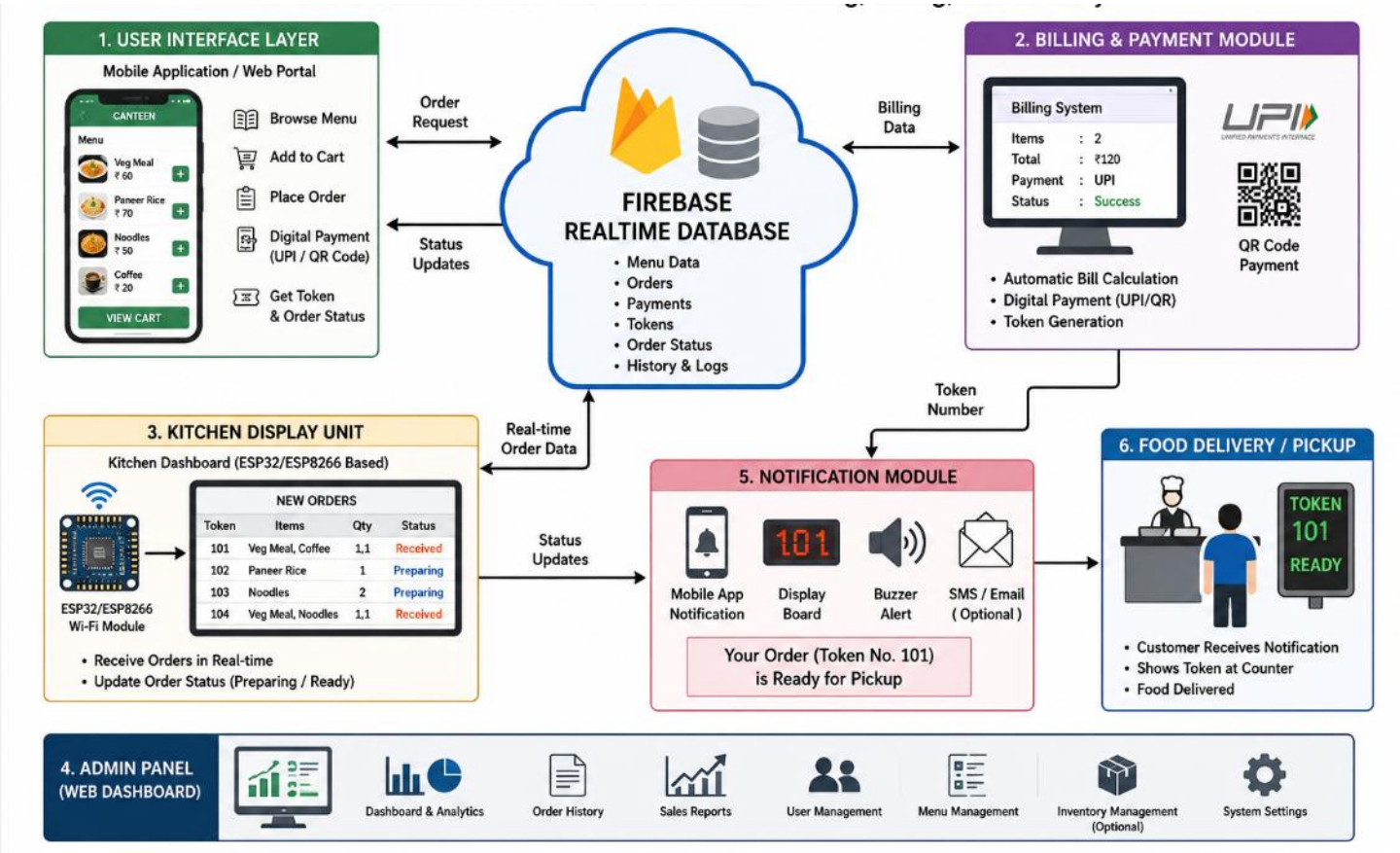
The system architecture illustrates the complete working of End-to-End Canteen Automation Robot: Order Taking, Billing and Delivery system. It shows how the clients, cloud services, the billing module, the kitchen unit and the notification system work together to automate the whole food ordering process. The main cloud platform is the Firebase Realtime Database, which provides real-time communication and synchronisation for all modules. Customers browse the menu, order food, pay digitally and receive order status updates via a mobile app or web portal. Once the order is placed, the billing module automatically calculates the total amount, processes UPI or QR-code payments and generates a unique token number.

The order details are immediately sent to the Kitchen Display Unit, connected via ESP32/ESP8266 Wi-Fi microcontrollers. Kitchen staff can see incoming orders, prepare the food and update the status of the order i.e. Received, Preparing and Ready for Pickup. These updates are synchronised with the cloud database and are instantly reflected to the customer application through the Notification Module which can send mobile notifications, alert messages, buzzer notification or optional SMS/email messages.

The customer then uses the generated token number to collect the food.

There is also an Admin Panel in the architecture for the admin to control menus, track orders, generate sales reports, analyse customer data, manage inventory, and configure system settings. The proposed architecture integrates cloud computing, IoT devices, automated billing, digital payments, and real-time notifications to offer a scalable, secure, and efficient solution that reduces waiting time, minimises manual intervention, enhances order accuracy, and streamlines the overall canteen management process.

B. Architecture Diagram



VII. EXPERIMENTAL SETUP

The experimental setup of the proposed End-to-End Canteen Automation Robot: Order Taking, Billing and Delivery system was designed to evaluate the functionality, reliability and real-time performance of the whole canteen automation platform. The configuration integrates cloud computing, Internet of Things (IoT) devices, web/mobile interfaces, digital payment facilities and kitchen display systems to emulate the operation of a smart institutional canteen.

The hardware configuration is ESP32/ESP8266 Wi-Fi enabled microcontrollers which act as the communication interface between the cloud database and the kitchen display unit. Microcontrollers keep an eye on the Firebase Realtime Database for new customer orders and instantly display order details on the kitchen dashboard. The administrator system for menu management, order monitoring, billing verification and report generation is a personal computer or laptop. Customers place food orders through a web application or mobile interface and can track their order via smartphone or desktop browsers. To ensure uninterrupted communication between all connected devices, stable Wi-Fi connectivity is maintained throughout the experiment.

The software environment comprises the customer interaction via a mobile application based on Flutter or a responsive web interface and Python with Flask as the backend framework to process the requests and manage the application logic. Firebase Realtime Database is a cloud platform that stores menu information, customer records, order details, payment status, token numbers, and order history. The administrator dashboard is linked to the same cloud database, allowing for centralised monitoring and real-time synchronisation of all system activities. The digital payments are simulated using UPI/QR-code payment methods and on successful payment confirmation, a unique token number is auto generated.

The experimental procedure starts with customer authentication, browsing of menu, selection of food and submission of order through the application. The selected order is sent to Firebase, where the billing module automatically generates the total amount based on the predefined menu prices. After confirmation of payment, the generated token number and order details are synchronised to the kitchen display system through the ESP32 / ESP8266 module. The order is immediately sent to the kitchen staff who prepares the food and updates the order status as Order Received, Preparing, and Ready for Pickup. These status updates are synchronised on the customer application in real-time with Firebase. Once the order is ready, the customer collects the food using the generated token.

The proposed system is tested with the help of several performance parameters such as order processing time, billing accuracy, cloud synchronisation delay, payment confirmation time, token generation accuracy, communication reliability and order delivery efficiency. Functional testing is done to test menu display, order placement, payment processing, kitchen synchronisation, and notification delivery. The integration testing tests the communication between customer interface, cloud database, billing module and kitchen display whereas the system testing tests the overall performance under multiple user requests.

The experimental results demonstrate that the proposed system can operate efficiently, offering accurate billing, reliable real-time synchronisation, low communication latency, and secure digital transaction processing. The cloud based architecture has been successful in minimising manual intervention, reducing customer waiting time, preventing order mismatches and improving operational transparency. The modular experimental setup also offers flexibility to upgrade in the future with AI-based food recommendation, automated inventory monitoring, robotic food delivery, and voice-assisted ordering, making it suitable for next-generation Smart Campus canteen automation.

VIII. RESULT ANALYSIS

We successfully developed and tested the proposed system End-to-End Canteen Automation Robot: Order Taking, Billing and Delivery to evaluate its performance under different operational conditions. The experimental results show that the system is able to automate the whole canteen workflow effectively, such as food ordering, billing, digital payment, communication with the kitchen and notification to customers. All the modules of the system were successfully integrated with the Firebase Realtime Database which enabled the reliable synchronisation in real-time between the customer interface, billing module, kitchen dashboard, and administrator panel.

The customer application correctly displayed the digital menu, accepted food orders and sent the order information to the cloud database without any perceivable delay. The total bill was calculated correctly based on the chosen menu items with the automated billing module and a unique token number was generated immediately after successful UPI/QR-based payment confirmation. The generated token was synchronised across all connected modules, so that the order tracking was consistent throughout the system.

The kitchen display unit built on the ESP32/ESP8266 was able to get customer orders in real time from the Firebase Realtime Database. The kitchen staff could see the orders coming in and see their progress through stages like Order Received, Preparing, Ready for Pickup etc. These changes were reflected instantly on the customer application, allowing customers to monitor the status of their orders without the need to verbally communicate with the kitchen staff. The notification module was successful in informing customers when their orders were ready for collection, thereby reducing crowding around the service counter.

The administrator dashboard worked well in managing menu items, tracking customer orders, keeping track of transactions and generating sales reports. The cloud-based architecture provided centralised data storage, secure record management, and reliable synchronisation across all connected devices. During the testing phase, the system was capable of establishing stable communication over Wi-Fi network and no significant data loss or failure in synchronisation was observed. Firebase gave good handling for multiple customer requests. It

maintained data consistency and communication latency was low.

The performance evaluation showed that the proposed system significantly reduced the customer waiting time compared to the conventional manual canteen operations. Automation of billing eliminated errors in calculations, and the integration of digital payment shortened transaction time and increased financial transparency. The token-based order management mechanism reduced the order mismatches and provided an organised food distribution process. The real-time communication between the customer application and kitchen dashboard enhanced the coordination and overall operational efficiency of the canteen. .

In general, the experimental results prove the reliability, scalability and user-friendliness of the proposed system for modern canteen automation. The quality of service is improved, the manual intervention is reduced, the order accuracy and customer satisfaction are increased with the integration of IoT devices, cloud computing, automated billing and digital payment technologies. Moreover, the modular design offers scope for future expansion of AI-based food recommendation system, automated inventory management, voice assisted ordering and robotic food delivery system making it suitable for deployment in colleges, universities, corporate cafeterias, hospitals and other institutional food service environments.

Summary of Results

Performance Parameter	Result
Food Order Placement	Successfully completed
Automated Billing	Accurate bill generation
UPI/QR Payment	Successfully processed
Token Generation	Unique token generated for every order
Firebase Synchronization	Real-time data synchronization achieved
Kitchen Dashboard	Orders received instantly
Order Status Tracking	Updated in real time
Customer Notifications	Successfully delivered
Order Accuracy	High
Waiting Time	Significantly reduced
Overall System Performance	Efficient and reliable

IX. CONCLUSION

The proposed End-to-End Canteen Automation Robot: Order Taking, Billing and Delivery system provides an intelligent and efficient way to update canteen operations by using cloud computing, Internet of Things (IoT) and digital payment technologies. The system automates the whole process of menu browsing, food ordering, automatic billing, digital payment, kitchen communication, order tracking and customer notification, thus removing the limitations of traditional manual canteen management.

Firebase Realtime Database allows for the secure synchronisation of order details in real-time with the customer app, billing module, kitchen display and administrator dashboard. The kitchen unit is in permanent contact with Wi-Fi enabled microcontrollers, ESP32/ESP8266, which process the commands at lightning speed and display them efficiently. Upon successful completion of the digital payment, the automated billing module calculates the correct total amount and generates unique order tokens to ensure a transparent and organised food collection process.

Experimental evaluation shows that the proposed system significantly reduces customer waiting time, billing errors, order mismatches and improves customer and kitchen staff coordination. The cloud-based architecture enables centralised management of data, secure storage of records, and real-time monitoring of canteen operations, thus leading to improved operational efficiency and overall service quality. The modular design of the system makes it scalable and adaptable for deployment in educational institutions, corporate cafeterias, hospitals and other food service environments.

The proposed solution not only brings operational efficiency but also helps in building Smart Campus infrastructure by promoting digital transformation, contactless service and optimal use of resources. It provides an easy-to-use interface for customers and powerful tools for administrators to manage menus, monitor orders, analyse sales, and generate reports.

Further improvements can be added to the proposed system in future to include the AI based food recommendation systems, machine learning algorithms for demand prediction, automated inventory management, voice-assisted ordering, facial recognition based authentication, robotic food delivery and advanced analytics for customer behaviour analysis. These enhancements will create a smarter system, optimise resource management and provide a more personalised and efficient dining experience.

To sum up, the End-to-End Canteen Automation Robot: Order Taking, Billing, and Delivery system provides a reliable, scalable, secure, and cost-effective solution for next-generation canteen management. The successful implementation and evaluation of the proposed system demonstrates its potential to improve the service quality, increase the operational productivity, enhance the customer satisfaction and support the growing demand for smart and automated institutional food service systems.

X. REFERENCES

[1] A. Bahga and V. Madisetti, Internet of Things: A Hands-on Approach. Atlanta, GA, USA: Universities Press, 2015.

[2] O. Hersent, D. Boswarthick, and O. Elloumi, The Internet of Things: Key Applications and Protocols. 2nd ed. Hoboken, NJ, USA: John Wiley & Sons, 2012.

[3] P. S. Gill, Cloud Computing: Principles and Paradigms. New York, NY, USA: Springer, 2011.

[4] Google, "Firebase Realtime Database Documentation," Google Developers. [Online]. Available: https://firebase.google.com/docs/database. [Accessed: Jun. 2026].

[5] Espressif Systems, "ESP32 Series Datasheet," Espressif Systems, Shanghai, China, 2024. [Online]. Available: https://www.espressif.com/en/products/socs/esp32.

[6] Espressif Systems, "ESP8266EX Datasheet," Espressif Systems, Shanghai, China, 2023. [Online]. Available: https://www.espressif.com/.

[7] Google, "Flutter Documentation," Google Developers. [Online]. Available: https://docs.flutter.dev. [Accessed: Jun. 2026].

[8] M. Grinberg, Flask Web Development: Developing Web Applications with Python. 2nd ed. Sebastopol, CA, USA: O'Reilly Media, 2018.

[9] National Payments Corporation of India (NPCI), "Unified Payments Interface (UPI)," [Online]. Available: https://www.npci.org.in/what-we-do/upi/product-overview. [Accessed: Jun. 2026].

[10] S. K. Dash, S. Mohapatra, and P. K. Pattnaik, "A Survey on Applications of Wireless Sensor Network Using Internet of Things," International Journal of Computer Science and Engineering Technologies, vol. 1, no. 4, pp. 50–55, 2010.

[11] A. Banks and R. Gupta, MQTT Version 3.1.1, OASIS Standard, 2014.

[12] V. K. Jain and R. Gupta, "Smart Restaurant Ordering System Using IoT and Cloud Computing," International Journal of Engineering Research & Technology (IJERT), vol. 9, no. 6, pp. 850–855, 2020.

[13] S. Malik and A. Verma, "Cloud-Based Food Ordering and Restaurant Management System," International Journal of Scientific Research in Computer Science, Engineering and Information Technology, vol. 6, no. 4, pp. 210–216, 2021.

[14] R. Buyya, J. Broberg, and A. Goscinski, Cloud Computing: Principles and Paradigms. Hoboken, NJ, USA: Wiley, 2011.

[15] K. Ashton, "That 'Internet of Things' Thing," RFID Journal, June 2009.