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CARTMATE: RFID DRIVEN SMART CART FOR EFFICIENT SHOPPING

Deeksha S[1], Harshitha B S[2], Bhavana B[3], Ms. Eesha poonja A[4]

Department Of Electronics And Communication Engineering, AIET, Moodbidri, Mijar[1-4]

Abstract: In the modern era, where time efficiency and customer satisfaction are paramount, traditional shopping methods often lead to delays, particularly during billing in crowded supermarkets. To address these challenges, this project introduces Cart Mate, an RFID-driven smart cart designed to revolutionize the shopping experience. The system automates product scanning using RFID technology, displaying the total bill dynamically on a customer's smartphone via a mobile application. Customers can seamlessly make payments through online or offline modes, eliminating the need to wait in checkout queues. Cart Mate also features budget alerts, enabling shoppers to manage expenses proactively, and tracking product location to streamline the search for items in the store. The system leverages microcontrollers, such as Arduino, integrated with cloud connectivity for real-time stock monitoring and efficient inventory management. By combining IoT-enabled technology with advanced data analytics, Cart Mate ensures accurate billing, reduces shopping times, and enhances customer satisfaction, offering a highly flexible and efficient retail experience.

Keywords: Smart Shopping Cart, RFID Technology, Automated Product Identification, Wi-Fi Module, Mobile Updates, Keypad Budget Management , Buzzer Alert, Location Tracking, Arduino Node MCU, LCD Display, Real-Time Updates, Expense Monitoring , Automated Billing, IoT Applications, Retail Technology ,Customer Convenience Scalability ,Cost-Effectiveness ,Seamless Integration

I. INTRODUCTION

The traditional shopping experience, involving manual item selection, queuing for billing, and expense management, is often time-consuming and inefficient. These challenges are exacerbated in crowded retail environments, frustrating shoppers and complicating store operations. To address these issues, the Cart Mate project proposed a smart shopping cart leveraging IoT and RFID technologies, aiming to streamline the shopping process and enhance customer satisfaction. The core of this system is RFID technology, which enables the automatic detection of items placed in the cart. This eliminates manual scanning during checkout, significantly reducing wait times and improving efficiency [1]. The cart also features a real-time billing system that dynamically updates the total as items are either added or removed. Shoppers can complete payments directly through the cart, bypassing traditional checkout queues and ensuring a seamless shopping experience [3]. To enhance navigation, the system includes a location-tracking feature that helps customers quickly locate the desired products. This saves time and improves overall convenience, especially in large stores. An intuitive interface displays product details, pricing, and total costs, whereas budget alerts help shoppers stay within financial limits [2]. The integration of IoT enhances both customer and retailer experience. Store shelves equipped with RFID sensors communicate with a central server to monitor stock levels and notify staff of timely restocking. Retailers can also analyse real-time data to optimize inventory and adjust marketing strategies [4]. Furthermore, customers receive electronic bills via SMS or app notifications, which adds transparency and convenience to the process. The proposed smart cart not only reduces reliance on manpower but also improves operational efficiency for retailers. It combines automated billing, real-time inventory management, and seamless payment processes to modernize retail shopping. By building upon prior research [5], the Cart Mate project aims to redefine retail experiences and create smarter, more efficient, and customer-centric shopping ecosystems.

II. PROBLEM STATEMENT

Traditional shopping practices frequently result in delays and inefficiency, particularly during the checkout phase in busy supermarkets. Shoppers encounter lengthy lines, manual scanning of items, and difficulties in finding products, rendering the experience both time consuming and frustrating. Retailers, in turn, face challenges such as billing inaccuracies, ineffective inventory management, and a lack of comprehensive insights into customer behaviour, all of which adversely affect operational efficiency and customer satisfaction. The Cart Mate initiative seeks to resolve these challenges by implementing a smart shopping cart system that automates item scanning, enhances navigation within stores, facilitates real-time expense tracking, and optimizes inventory management. This innovation aimed to create a quicker, more efficient, and customer-centric shopping experience.

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III. PROPOSED METHOD

The proposed system utilizes RFID (Radio Frequency Identification) technology in conjunction with microcontrollers to develop an advanced shopping cart system that optimizes the shopping experience and improves customer satisfaction. Each shopping cart is fitted with an RFID reader, a microcontroller, and a display screen. Products within the store are affixed with RFID tags that contain vital information such as product ID, price, and quantity. As customers place items into their carts, the RFID reader scans the tags and automatically updates the total cost on the display. The entire system is driven by an Arduino microcontroller, which serves as the central processing unit. The flexibility of Arduino facilitates smooth integration with the RFID reader, display units, and communication modules, ensuring precise functionality and an intuitive user experience. This cutting-edge system effectively tackles significant issues associated with conventional shopping practices, enhancing both efficiency and convenience for customers and store operators.

IV. SYSTEM ARCHITECTURE

The proposed system architecture integrated various hardware and software components to create an efficient smart shopping cart system. At the heart of the architecture is the Arduino Node MCU, which acts as the central processing unit, managing the communication and data flow between all connected components. This microcontroller ensures seamless integration of modules, such as the RFID reader, LCD display, Wi-Fi module, keypad, and buzzer, enabling the system to automate product identification, budget management, and expense tracking.

RFID technology is central to system functionality. Each product is tagged with a passive RFID tag containing unique details such as product ID, name, and price. An EM-18 RFID reader operating at 125 kHz was mounted on the cart to scan the tags wirelessly. When a product is scanned, the reader communicates its data to the Arduino, which processes the data and updates the total amount. This approach eliminates manual entry errors and improves accuracy, as demonstrated in previous research on RFID-based systems [9].

The system features a 16×2 LCD display that is connected to the microcontroller to provide real-time updates. This display shows the product name, price, and total cost to customers while shopping. The use of LCDs is well documented for their efficiency ,cost-effectiveness, and capability to display custom characteristics [7].

A Wi-Fi module (ESP8266) was incorporated to enable wireless communication with the mobile application. This connectivity allows customers to receive detailed shopping updates and monitor expenses directly on their smartphones, extending the functionality of the cart and aligning with IoT applications in retail environments [6].

In addition, the system includes a keypad for customers to input budget constraints. When the total expenditure exceeds the set limit, the buzzer provides an audio alert, ensuring that customers remain within their defined spending limits.

This budget management feature is a practical addition to the system that enhances its usability in real-world scenarios. The system also incorporated a portable battery power unit to ensure operational mobility throughout the shopping experience.

For location tracking, the architecture uses an Arduino Node MCU to efficiently manage data processing, addressing the need for a lightweight and cost-effective solution.

Finally ,the designated checkout button enables customers to complete their shopping. Pressing this button triggers the system to calculate the final bill and display it on the LCD ready for payment. This streamlined approach reduces the time spent at traditional checkout counters and improves the overall shopping experience [8]. The integration of these components ensures that the smart shopping cart system is robust, user friendly, and efficient. By leveraging RFID for automated scanning, IoT for real-time data sharing, and modular components for enhanced functionality, the architecture is well suited for implementation in modern retail environments.

V. IMPLEMENTATION

This system uses RFID technology for automated product scanning. Passive RFID tags containing details such as product ID, name, and price were attached to the items. When a product is added to the cart, an RFID reader (EM-18) reads the tag wirelessly, and the data are processed by the Node MCU , which is the system's central controller. This ensures efficient and accurate product identification while reducing manual errors [2]. A 16×2 LCD display was used to provide real-time feedback to the customers. It displays details such as the product name, price, and updated total cost, improving

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transparency and assisting customers during their shopping experience. This display technology is widely preferred because of its ability to render custom characters and its cost-effectiveness [6]. For wireless connectivity, the system included a Wi-Fi module (ESP8266) to send shopping data to a mobile application. This enables customers to monitor their shopping expenses on their smartphones, enhance usability, and align themselves with IoT-enabled shopping systems [2]. The cart incorporates a keypad that allows customers to set up a budget before shopping. If the total cost exceeds the predefined budget, a buzzer is triggered to alert the user, ensuring that they remain within their spending limits [6]. This budget management feature adds practical value to a system. Node MCU also facilitates location tracking and efficient data processing across components [2]. This system integrates RFID for automated product identification, IoT for real-time data sharing, and various user-friendly features to streamline shopping experiences. By leveraging these technologies, the proposed solution is effective, accurate, and well suited for modern retail environments. The block diagram is shown in below Fig. 1.

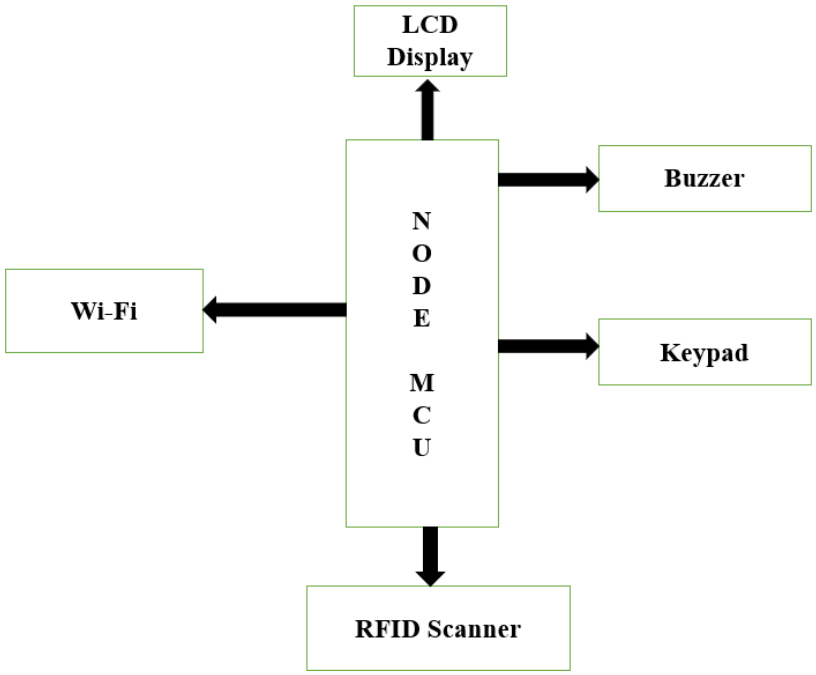

Fig. 1. Block Diagram

VI. CONCLUSION

The smart shopping cart system represents a paradigm shift in retail, integrating state-of-the-art technologies to enhance the consumer experience. By incorporating RFID technology for automatic product detection, Wi-Fi connectivity for real-time mobile updates, and a keypad-buzzer interface for budget management, this system offers unparalleled convenience. The addition of location tracking capabilities and an LCD display further augments transparency and user-friendliness during the shopping process. Through the elimination of traditional checkout procedures and the implementation of features such as automated billing and expense monitoring, this innovative solution not only streamlines the shopping experience but also demonstrates adaptability and cost-effectiveness. This forward-thinking approach establishes a new standard in contemporary retail, harmonizing convenience, efficiency, and versatility to address the dynamic requirements of modern consumers.

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