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Smart Cart using Automation

Prof. Sachin Shinde[1], Gauri Gupta[2], Sakshi Kapare[3], Diya Agrawal[2],Yogita Jadhav[5]
Department of Computer Engineering
PDEA'S College of Engineering, Manjari, Pune

Abstract - The rapid growth of retail automation has increased the demand for efficient and intelligent billing systems to reduce checkout time and improve customer experience. Traditional shopping systems rely on manual barcode scanning, leading to long queues, increased operational costs, and human errors. To address these challenges, this paper proposes an IoT-based Smart Cart system that enables automatic product identification and real-time billing using Near Field Communication (NFC) technology and an ESP32-S3 microcontroller. In the proposed system, each product is embedded with an NFC tag containing a unique identifier, which is detected by a PN532 NFC reader integrated into the cart. The ESP32-S3 controller processes the tag data and communicates with a cloud-based backend server over Wi-Fi using HTTP protocol to retrieve product details. The system dynamically updates the cart information and total bill, which is displayed on an OLED screen, providing real-time feedback to the user. The proposed approach minimizes human intervention, reduces billing time, and enhances shopping efficiency. Experimental observations indicate that the system significantly decreases checkout delays and improves accuracy in billing compared to traditional methods. Additionally, the integration of cloud services enables scalable data management and supports future enhancements such as personalized recommendations and secure payment integration.

I. INTRODUCTION

With the rapid advancement of embedded systems and Internet of Things (IoT) technologies, the retail industry is undergoing significant digital transformation. Traditional shopping systems often involve long billing queues, manual product scanning, and higher operational costs. To overcome these limitations, the concept of a Smart Cart has emerged as an efficient and automated solution to enhance the in-store shopping experience.

A Smart Cart is an intelligent shopping trolley integrated with embedded hardware and sensing technologies that enables real-time product identification, automatic billing, and user interaction. In this proposed system, the Smart Cart is designed using an ESP32-S3 microcontroller as the core processing unit due to its high performance, low power consumption, and support for wireless communication. NFC (Near Field Communication) technology is used for product identification, where each product is associated with an NFC tag that stores unique product information. The PN532 NFC reader/writer module is employed to read and write data from NFC tags accurately.

To improve user interaction and feedback, an OLED display is used to show product details, total cost, and system messages in real time. A buzzer provides audio alerts for successful scans or error conditions. Additionally, a camera module is integrated to enhance security and monitoring, helping to prevent theft or unauthorized product handling. Supporting components such as a breadboard and jumper wires are used for circuit prototyping and connectivity.

The proposed Smart Cart system aims to reduce billing time, minimize human intervention, and improve overall shopping efficiency. By automating the product scanning and billing process, the system benefits both customers and retailers, making it a promising solution for modern smart retail environments.

II. LITERATURE SURVEY

1. Design of Smart Basket Cart Using Near Field Communication

Building on these studies, the present project replaces RFID with NFC, a cheaper and short-range technology that minimizes tag-collision errors. The Smart Basket Cart (SBC) integrates Arduino UNO, NFC tags/readers, OLED display, and ESP8266 Wi-Fi module to detect items automatically, update totals in real time, and send data to a central server for instant billing.

2. Smart Shopping Cart

Previous research aimed to reduce supermarket checkout time using automation and IoT. Early systems used RFID and barcode scanning, but these were costly or manual. Later, studies used image processing and Raspberry Pi to recognize products and automate billing. Recent works adopted deep learning (YOLO) for real-time object detection, removing the need for RFID tags and improving accuracy.

3. A new automated smart cart system for modern shopping

Earlier research on smart carts focused on reducing customer effort and automating billing. Many systems used line-following robots or ultrasonic sensors to track customers, but these limited flexibility. Some approaches added Android-controlled carts or image-processing techniques for user tracking, while others integrated RFID readers for automatic billing. Project shows a trend toward fully automated, camera-based smart carts that integrate mobility, billing, and database management, offering greater flexibility and reduced human intervention in modern retail environments.

4. Smart Shopping Cart Using QR Code

The paper highlights a shift from RFID and manual barcode systems toward QR and vision-based smart carts,

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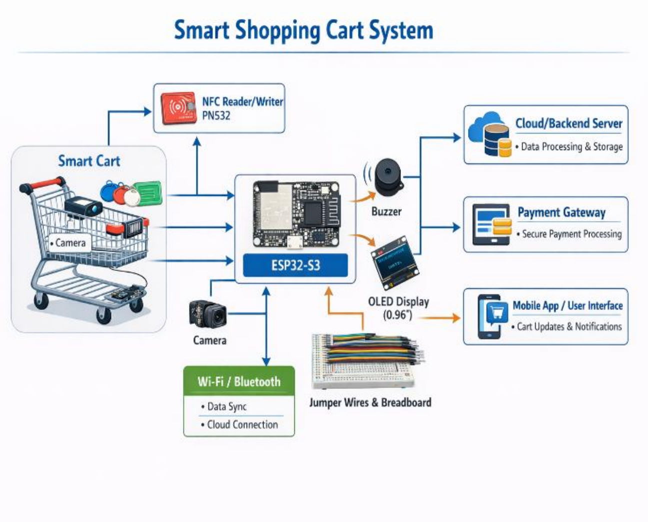
emphasizing affordability, automation, and user convenience in modern retail environments.

III. PROBLEM STATEMENT

In traditional retail systems, several challenges hinder efficiency and customer satisfaction. The manual product scanning process often leads to long queues, making checkout slow and inconvenient. This further results in delayed inventory tracking, reducing stock visibility and hampering supply chain management. Additionally, retailers face limited customer interaction insights, preventing them from analyzing shopping patterns effectively. The tedious and time-consuming payment process creates frustration for customers, while high operational costs burden retailers due to dependency on manpower. Moreover, human errors in billing or stock management decrease accuracy and trust. Current systems lack personalization and automation, offering little innovation in shopping experiences. The poor real-time data availability restricts decision-making, and existing solutions expose a gap in technology, especially in integrating AI with IoT devices. Furthermore, security and misuse challenges such as product theft remain unresolved. Hence, an automated, intelligent smart cart system is essential to overcome these limitations.

IV. SYSTEM ARCHITECTURE

Fig. 1: System Architecture



The proposed Smart Cart system follows a layered architecture consisting of hardware components, communication modules, and cloud-based services. The architecture is designed to enable real-time product identification, automated billing, and seamless data synchronization.
The overall system is divided into three main layers:

1. Data Acquisition Layer
2. Processing and Communication Layer
3. Cloud and Application Layer

A. Data Acquisition Layer

This layer consists of NFC-enabled products and the PN532 NFC reader module. Each product is embedded with a unique NFC tag containing a product identifier (UID). When a product is placed inside the cart, the NFC reader detects the tag and captures the UID.The reader communicates with the ESP32-S3 microcontroller using serial communication protocols such as SPI or I2C. This layer is responsible for accurate and fast data collection from physical objects.

B. Processing and Communication Layer

The ESP32-S3 microcontroller acts as the central processing unit of the system. It receives the UID from the NFC reader and processes the request. The controller establishes a wireless connection with the backend server using Wi-Fi.The communication is performed using HTTP protocol, where the ESP32 sends a request containing the product ID and receives corresponding product details. The controller maintains a local cart list, updates the total bill, and manages user interaction.An OLED display is used to show product information and total cost in real time, while a buzzer provides feedback for successful operations.

C. Cloud and Application Layer

The cloud layer consists of a backend server and a database that stores product details, user information, and transaction records. Upon receiving a request from the ESP32, the server processes the product ID and retrieves relevant information from the database.The server also handles cart synchronization, billing, and payment processing. Each cart is associated with a unique cart ID linked to a user account, enabling multi-cart management and real-time updates.

D. Data Flow Description

The system operates in a sequential data flow manner. When a product is added to the cart, the NFC reader scans the tag and sends the UID to the ESP32 controller. The controller forwards this data to the backend server via Wi-Fi. The server processes the request and returns product details such as name and price.The ESP32 updates the cart data and displays the information on the OLED screen. This process continues dynamically for all items, ensuring real-time billing. During checkout, the final bill is retrieved from the server and used for payment processing.

E. Key Features of Architecture

Real-time product identification using NFC

Wireless communication using Wi-Fi

Cloud-based data storage and synchronization

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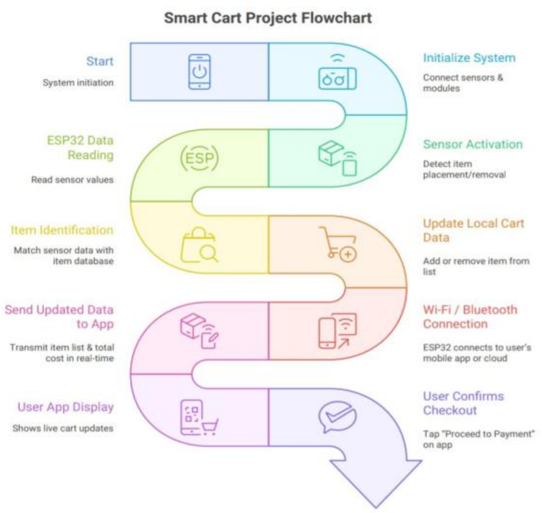
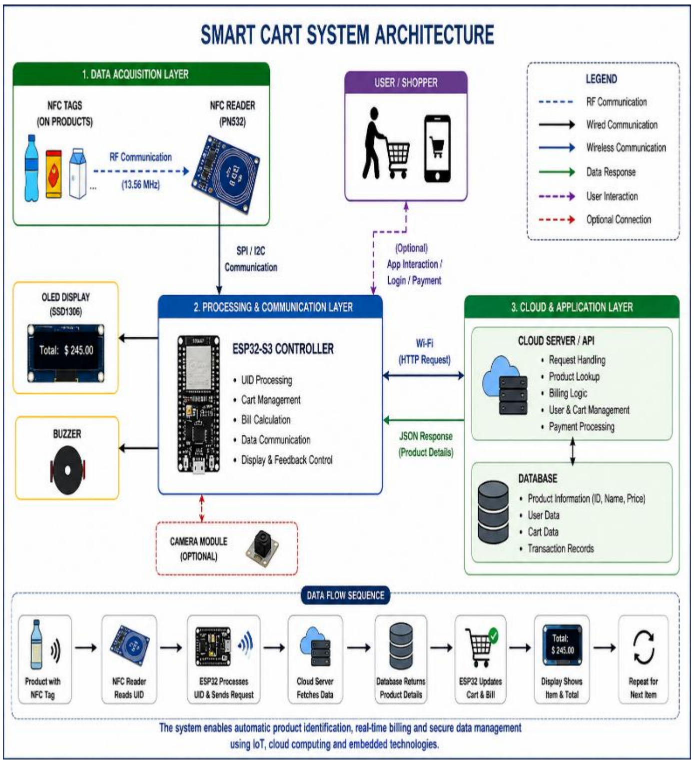
Automated billing and reduced human intervention

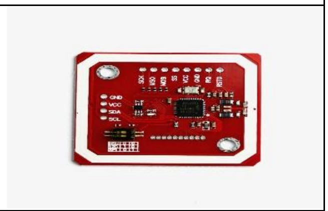
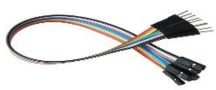
Scalable design for large retail environments

Fig. 2: Process Flow Diagram





V. HARDWARE COMPONENTS

Component name	Purpose	Image
ESP32 Microcontroller	Main controller	
NFC Tags	Product identification	
NFC Reader/Writer (PN532)	Reads NFC tags	
OLED Display	Visual output	
Breadboard	Circuit prototyping	
Jumper Wires	Electrical connections	
Buzzer	Audio Alert	
Camera	Product Analysis	

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VI. METHODOLOGY

The proposed Smart Cart system is designed to automate the product identification and billing process using Internet of Things (IoT) and embedded system technologies. The methodology focuses on integrating Near Field Communication (NFC), wireless communication, and cloud-based data processing to achieve real-time billing and enhanced shopping efficiency.

A. System Overview

The system consists of four major components: NFC-enabled products, NFC reader module, ESP32-S3 microcontroller, and a cloud-based backend server. Each product is embedded with a unique NFC tag containing a product identifier (UID). When a product is placed in the cart, the NFC reader detects the tag and transmits the UID to the ESP32-S3 controller for further processing.

The ESP32-S3 acts as the central processing unit, responsible for communication with the backend server, data processing, and user interaction through the OLED display.

B. Data Acquisition and Processing

When a product is added to the cart, the PN532 NFC reader scans the tag and extracts the unique identifier. This UID is transmitted to the ESP32-S3 via serial communication (SPI/I2C/UART). The controller processes the UID and sends a request to the backend server using Wi-Fi.

The communication between the ESP32-S3 and the server is performed using HTTP protocol. The request is formatted in JSON as follows:

```
{
  "product_id": "UID12345",
  "cart_id": "CART001"
}
```

The server queries the database and returns product details such as name, price, and category. The ESP32-S3 updates the cart data and calculates the total bill dynamically.

C. Real-Time Billing Mechanism

The billing process is performed incrementally as products are added or removed from the cart. The total bill is updated using the following relation:

$$Total = \sum_{i=1}^{n} Pric\, e_i$$

where $Price_i$ represents the cost of each scanned product.

The updated product list and total cost are displayed on the OLED screen in real time. A buzzer provides audio feedback to confirm successful scanning.

D. Product Removal Detection

To handle product removal, the system maintains a local list of scanned product IDs. When a product is removed, the system re-scans the cart or detects absence of the tag and updates the bill accordingly by subtracting the respective product price.

This ensures accuracy in billing and prevents duplication or mismatch of items.

E. Cloud Integration and Data Synchronization

The backend server maintains a centralized database of products, users, and transactions. Each cart is associated with a unique cart ID linked to a user account. The system continuously synchronizes cart data with the server to ensure consistency across multiple devices.

The backend system performs:

- Product information retrieval
- Cart data storage
- Final bill generation
- Payment processing integration

F. Security and Validation Mechanism

To enhance system security, basic validation mechanisms are implemented. Each NFC tag contains a unique identifier that is verified with the database to prevent unauthorized product addition.Additionally, a camera module can be integrated for visual verification of items to reduce fraud and improve system reliability.

G. Algorithm for Smart Cart Operation

1. Initialize ESP32-S3, NFC reader, and display module
2. Wait for NFC tag detection
3. Read unique product ID (UID)
4. Send UID to backend server via Wi-Fi
5. Retrieve product details from database
6. Update cart list and total bill
7. Display product information on OLED
8. Generate audio feedback using buzzer
9. If product removed, update total bill accordingly
10. Repeat until checkout

VII. RESULTS AND DISCUSSION

The proposed Smart Cart system was tested under a controlled environment to evaluate its performance and efficiency. The system successfully identified products using NFC technology and updated the billing information in real time.

The system was tested with multiple products under real-time conditions

Parameter	Observed Value
NFC Scan Time	1–2 seconds
System Response Time	< 2 seconds
Billing Accuracy	~95%
Checkout Time Reduction	~60%

VIII. FUTURE SCOPE

One of the key advancements in the smart cart system is the integration of AI-driven recommendation systems. These systems analyze a customer’s purchase history, preferences, and shopping behavior to suggest relevant products in real time. By

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offering personalized recommendations, the system enhances user engagement and improves the overall shopping experience. Additionally, it helps retailers increase sales through targeted and personalized marketing strategies.

Another important feature of the smart cart is real-time location tracking within the store. This is achieved using technologies such as Bluetooth Low Energy (BLE) or indoor positioning systems. With this capability, the system can track the movement of carts throughout the supermarket, assist customers in easily locating products, and help store management understand customer navigation patterns. As a result, it contributes to better store layout optimization and improves customer convenience.

The system also includes cart identification and user mapping to ensure personalization and security. Each cart is uniquely identified and linked to a specific user through methods such as mobile application login, QR code scanning, or NFC authentication. Once connected, the customer's name can be displayed on the cart interface, creating a personalized experience and reducing the chances of misuse or confusion between carts.

In addition, the smart cart incorporates an automatic cart locking mechanism after the shopping process is completed. This is implemented using an electronic locking system that is triggered by the software once payment is confirmed. This feature prevents unauthorized removal of products and ensures that there are no mismatches between selected items and billing, thereby improving security and trust in the system.

Finally, the system addresses the multi-cart handling problem, which occurs when a customer uses multiple carts or baskets during shopping. To solve this, all carts are linked to a single user account, allowing their data to be synchronized in real time. Through cloud-based integration, items from multiple carts are combined into one final bill. This ensures a seamless and efficient checkout process, even in complex shopping scenarios

Finally, the system introduces a simple product clustering feature to make shopping faster and easier. Similar or related items are grouped together into clusters, such as daily essentials or personal care products. Instead of searching for each item one by one, the user can open a cluster and quickly choose the product they want with a single action. This saves time and reduces effort, especially when there are many products in the store. The clusters can also be updated based on common shopping habits, so users see more useful and relevant groups. Overall, this feature makes the shopping experience smoother, more organized, and user-friendly.

IX. CHALLENGES

The proposed Smart Cart system faces several technical challenges that affect its efficiency and scalability. One major limitation of NFC-based technology is its restricted scanning range and susceptibility to signal interference when multiple tagged items are placed in close proximity. Furthermore, tag collision may result in incorrect item detection, while the requirement of tagging each product increases the overall system cost, making large-scale deployment more challenging.

Another key challenge lies in selecting an appropriate machine learning algorithm for applications such as recommendation systems and customer behavior analysis. The effectiveness of these algorithms depends on the availability of quality data, model accuracy, and the ability to process data in real time. Ensuring a balance between performance and computational efficiency is essential for system reliability.

Database design is a critical component of the system, requiring an efficient Entity-Relationship (ER) model to manage entities such as customers, products, carts, and transactions. Proper relationships between these entities ensure smooth data flow, efficient storage, and quick retrieval. The system also supports multiple customer types, including manual, permanent, and temporary users, to provide flexibility and personalized experiences.

Inventory management is integrated with the database to enable real-time stock updates, track product availability, and prevent out-of-stock situations. This improves both operational efficiency and customer satisfaction.

The system must also address risks related to failures and security. Possible failures include network issues, sensor malfunctions, and payment gateway errors, which can be mitigated using offline modes, local caching, and redundant system design. Security risks such as data leakage, unauthorized access, and payment fraud require strong encryption and authentication mechanisms.

Finally, the system incorporates section-based product organization, where items are categorized into sections such as grocery, electronics, and dairy. This enhances store.

X. CONCLUSION

The proposed Smart Cart system presents an efficient and automated solution to modern retail challenges by integrating Internet of Things (IoT) and embedded system technologies. By utilizing NFC-based product identification, real-time data processing through the ESP32-S3 microcontroller, and cloud-based communication, the system successfully eliminates the need for manual barcode scanning and significantly reduces checkout time. The implementation demonstrates improved billing accuracy, reduced human intervention, and enhanced user experience through real-time cart updates and automated cost calculation. The experimental observations indicate that the system effectively minimizes delays in the billing process and provides a scalable framework for smart retail environments. Although certain challenges such as NFC limitations, tag collision, and system scalability exist, the proposed solution lays a strong foundation for future enhancements. Overall, the Smart Cart system highlights the

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potential of IoT-driven automation in transforming traditional shopping systems into intelligent and efficient retail solutions.

XI. REFERENCES

[1] Design of Smart Basket Cart Using Near Field Communication Year 2021 October HBRP Publication

[2] Smart Shopping Cart. Year 2 Febuary 2021
INTERNATIONAL JOURNAL OF SCIENTIFIC RESEARCH IN ENGINEERING AND MANAGEMENT (IJSREM)

[3] A new automated smart cart system for modern shopping centres. Year 4 August 2021 Bulletin of Electr Eng & Inf

[4] Automated Billing System using Smart Shopping Cart. June 2019 International Journal of Trend in Scientific Research and Development (IJTSRD**)**

[5] Smart Shopping Application using NFC. Year 3 March 2018 International Research Journal of Engineering and Technology (IRJET)

[6] Smart Shopping Trolley. Year 6 April 2025 International Journal of Advanced Research in Science, Communication and Technology.

[7] IoT-Based Smart Shopping Cart Using Radio
Frequency Identification. Year 5 April 2020. IEEE Acess

[8] Design and implementation of a human following smart cart. Year 19 October 2020 IEEE Xplore.

[9] An Intelligent and Automated Approach for Smart Minimarkets. International Journal of Computational Journal System.

[10] Smart Shopping Application using NFC. Year 3 March 2018. International Research Journal of Engineering and Technology (IRJET)

[11] Design And Development Of E-Retail Cart Using Iot And Robotic Technology For Supermarket. Year 5 May 2025 International Research Journal of Engineering and Technology (IRJET)

[12] RFID-Cloud Smart Cart System
Nazarbayev University

[13] Design and development of full self-service smart
shopping system for unmanned supermarket. Year 14 July 2025 Springer

[14] Smart Shopping Trolley. Year 6 April 2025 International Journal of Advanced Research in Science, Communication and Technology

[15] A Survey on Smart Trolley/Shopping System Based on Mobile Application

[16] An IOT Based Smart Shopping Cart for Smart Shopping.

[17] H. S. Wabale, ``Automatic menu ordering system using ZigBee and arm processor,'' *J. Elect. Electron. Syst.*, vol. 4, May 2017.

[18] M. I. Niranjana, K. Lakshmi, G. Priyadharsini, and K. Saravanapriya, ``Smart trolley_A novel innovation to super market,'' *Int. J. Electron., Elect. Comput. Syst.*, vol. 7, no. 3, pp. 414_418, 2018.

[19] A. Lele, ``Internet of Things (IoT),'' in *Disruptive Technologies for the Militaries and Security* (Smart Innovation, Systems and Technologies). 2019.

[20] H. Toral-Cruz, ``A survey on wireless sensor networks,'' in *Next Generation Wireless Network Security and Privacy*. 2015