

RFID-Based Smart Shopping Trolley

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Abstract: *A design case of prototyping an intelligent shopping cart system for retail environments is designed to overcome the inconvenience of long queues and manual billing processes in traditional shopping methods. This prototype aims to enhance the shopping experience by integrating automation and real-time tracking of purchased items. The system uses RFID technology to detect products as they are added to the cart. Each item tagged with an RFID label is automatically scanned when placed in the cart, and the corresponding amount is added to the total bill. This real-time billing process ensures transparency, efficiency, and a user-friendly experience for customers. Unlike traditional billing systems that require manual scanning at the counter, this smart cart offers a seamless self-checkout experience. The integration of a microcontroller, RFID reader, and display unit enables automatic calculation and display of the total amount. At the end of the shopping session, the customer can directly view and pay the final bill without the need to wait in queues. This project addresses the automation of shopping processes and aims to minimize waiting time, improve billing accuracy, and reduce human effort. The main perspective of the project is to create a smart retail solution that enhances convenience while promoting a modern and efficient shopping environment.*

Keywords: Smart shopping cart, RFID, automation, self-checkout

I. INTRODUCTION

The “RFID-Based Smart Shopping Trolley” is an innovative embedded system designed to enhance the retail shopping experience by automating product scanning, billing, and payment. It integrates STM32 microcontroller technology with RFID, servo motor control, and wireless communication to provide customers with a seamless and efficient shopping process. The system eliminates the need for manual billing queues, allowing customers to scan and pay for products directly through the trolley itself.

This smart trolley employs an RC522 RFID reader that identifies each product using unique RFID tags. The STM32 Blue Pill microcontroller serves as the central control unit, processing the scanned data and displaying product information such as name and price on the LCD. A servo motor mechanism controls the trolley door — opening only when the payment is successfully completed — thereby ensuring security and preventing unbilled products from leaving the trolley.

For power management, the system utilizes a lithium-ion battery with a buck converter to provide stable voltage to all components. The HC-05 Bluetooth module enables wireless communication between the trolley and a smartphone application. Through the Virtuino 6 app, the customer can view the total bill amount, initiate payment, and receive confirmation in real time. Once payment is done, the STM32 triggers the servo motor to unlock the trolley door, allowing the customer to exit.

The system demonstrates a strong integration of embedded hardware, wireless communication, and automation principles. Each product added to the trolley is automatically recognized and billed, while all purchase data is updated live on the user’s mobile interface. This approach simplifies the checkout process, reduces waiting time, and enhances user convenience.



By leveraging RFID and Bluetooth technologies, the “*RFID-Based Smart Shopping Trolley*” transforms the traditional shopping experience into a smart, connected, and automated process. It minimizes manual intervention, improves billing accuracy, and ensures a secure payment mechanism. Overall, this system represents a modern retail innovation combining embedded systems, automation, and IoT-based communication for smarter, faster, and more efficient shopping.

II. LITERATURE SURVEY

[1] S. C. Chaudhari and N. J. Janwe, “Intelligent Smart Shopping Cart System Using RFID and ZigBee,” in Proc. IEEE Int. Conf. on *Smart Technologies and Management for Computing, Communication, Controls, Energy and Materials (ICSTM)*, Chennai, India, 2015, pp. 1–4.

This paper proposes a smart shopping cart using RFID and ZigBee technology to automate product identification and wireless billing. The system scans RFID tags and displays product information on an LCD, transmitting billing data wirelessly to a central server, thereby reducing human effort and checkout time.

[2] V. Padole, A. Patil, R. Gajjalwar, and P. Raut, “Smart Shopping Trolley using IoT,” in Proc. IEEE Int. Conf. on *Communication and Signal Processing (ICCSP)*, Chennai, India, 2016, pp. 1–5.

The study presents an IoT-enabled shopping cart utilizing NodeMCU, RFID, and load cells to automate billing and verify product weight. The data is uploaded to a cloud server, enabling real-time monitoring through a mobile application. This approach enhances billing accuracy and prevents fraud.

[3] K. Suryawanshi, S. Doijad, and D. Gopnarayan, “Smart Trolley Using RFID,” in Proc. IEEE Int. Conf. on *Electrical, Electronics, and Optimization Techniques (ICEEOT)*, Chennai, India, 2016, pp. 1–4.

This work introduces a smart trolley system using RFID tags, an RFID reader, Arduino, and an LCD. The user scans each product’s tag to display name and price, while a push-button allows quantity control. The system simplifies billing but lacks wireless communication for centralized tracking.

[4] V. Chavan, A. Magdum, A. Patil, and A. Bhosale, “IoT Based Smart Shopping Cart,” in Proc. IEEE Int. Conf. on *Inventive Communication and Computational Technologies (ICICCT)*, Coimbatore, India, 2017, pp. 1–5.

The paper proposes an IoT-based smart cart using ESP32 and RFID with Firebase integration. It updates billing details on the cloud and enables users to monitor their cart in real time through an Android app, thus offering convenience and transparency in shopping.

[5] Y. Patil, P. Rajput, P. Patil, and S. Pawar, “Smart Shopping Cart with Automated Billing System,” in Proc. IEEE Int. Conf. on *Computing, Communication, Control and Automation (ICCUBEA)*, Pune, India, 2017, pp. 1–4.

This paper develops a smart shopping cart using Arduino Uno, RFID, Bluetooth, and an LCD. The system scans items, calculates the bill, and transmits data to a smartphone via Bluetooth. While it improves in-cart billing, it is limited by short-range communication and lacks scalability.

[6] S. G. Rajput and S. S. Sonawane, “IoT Based Intelligent Trolley for Shopping Mall,” in Proc. IEEE Int. Conf. on *Intelligent Computing and Control Systems (ICICCS)*, Madurai, India, 2018, pp. 1–5.

This research introduces an IoT-enabled smart trolley using RFID and Wi-Fi for automated billing. The cart updates data to a central server and allows users to pay directly without standing in queues. The system aims to improve user experience and reduce labor costs in retail environments.

[7] A. Jadhav, P. Agrawal, A. Gawande, and S. Nanaware, “Automated Shopping Trolley for Super Market Billing System,” in Proc. IEEE Int. Conf. on *Power, Control, Signals and Instrumentation Engineering (ICPCSI)*, Chennai, India, 2018, pp. 1–4.

The paper proposes an automated trolley using Arduino, RFID, and IR sensors. Products are identified using RFID, while IR detects unauthorized item removal. The system ensures accurate billing and prevents theft, offering a secure solution for supermarket applications.

[8] V. Dhavale, M. Chopde, A. Gabhane, and S. Kanhe, “Smart Trolley for Supermarket Billing Using IoT,” in Proc. IEEE Int. Conf. on *Smart Structures and Systems (ICSSS)*, Chennai, India, 2019, pp. 1–5.



This study develops a smart trolley using Raspberry Pi, RFID, and cloud storage. The billing is performed in real time and uploaded to the cloud. Customers receive updates on their smartphone, which helps eliminate checkout lines and provides efficient billing management.

[9] D. Dhamal, A. Gharate, and K. Gite, "Smart Trolley Using RFID and GSM," in Proc. IEEE Int. Conf. on Intelligent Computing and Control Systems (ICICCS), Madurai, India, 2019, pp. 1–4.

The system uses RFID for product identification and GSM for bill communication. The Arduino-based system sends the final bill via SMS after shopping. It offers a low-cost alternative for small-scale stores where internet access may not be consistently available.

[10] P. Mishra, R. Bhutada, M. Patil, and A. Jagtap, "IoT Based Smart Shopping Trolley Using RFID," in Proc. IEEE Int. Conf. on *Communication and Signal Processing (ICCSP)*, Chennai, India, 2020, pp. 1–5.

This paper presents a smart trolley using RFID and NodeMCU to automate billing. It connects to a cloud database, and billing information is displayed on an app. The system reduces human effort and improves shopping efficiency through real-time item tracking and automatic billing.

III. EXISTING SYSTEM

The evolution of the retail shopping system has been limited by traditional methods that rely heavily on manual billing and cashier-based checkouts. These conventional setups are time-consuming, prone to human errors, and often result in long queues, reducing customer satisfaction. Although barcode scanners have introduced partial automation, they still require human involvement for scanning and billing, offering little improvement in efficiency or real-time data tracking. Existing systems also lack features such as automated item detection, instant billing updates, and digital payment integration. Without technologies like RFID, IoT connectivity, and wireless data exchange, customers cannot monitor their purchases in real time, and retailers struggle with labor costs, slow checkout processes, and inaccurate billing records.

Moreover, the absence of smart connectivity between the cart and central systems prevents seamless synchronization of billing data and payment confirmation. This gap highlights the need for an intelligent shopping trolley that integrates RFID-based item recognition, microcontroller-based automation, wireless communication, and secure payment access. Such a system can provide real-time billing, reduce manual effort, and enhance shopping convenience—transforming traditional retail into a faster, smarter, and more user-friendly experience.



Fig. 1. Manual Billing Process in Traditional System

IV. PROPOSED SYSTEM

The proposed system introduces an RFID-Based Smart Shopping Trolley that automates the process of product identification and billing to provide a faster and more efficient shopping experience. Each product in the store is embedded with an RFID tag, and the trolley is equipped with an RC522 RFID reader that scans the tag when a product



is placed inside the trolley. The STM32 Blue Pill microcontroller acts as the central control unit, processing the tag data to retrieve and display the product's name, price, and total amount on the LCD screen.

When a product is scanned successfully, an MG995 servo motor operates the trolley gate, it opens automatically to allow product placement and closes immediately after scanning. This controlled opening and closing mechanism prevents unscanned items from being added to the trolley, ensuring secure and accurate billing. Additionally, a Bluetooth module (HC-05) connects the system to the Virtuino 6 mobile application, which displays billing details in real time. Customers can monitor their total bill and manage payments conveniently through the app.

The system is powered by a lithium-ion battery, and a buck converter ensures a stable voltage supply to all components. By integrating STM32 Blue Pill, RC522 RFID reader, MG995 servo motor, Bluetooth module, and LCD, this proposed system achieves automation, accuracy, and convenience, revolutionizing the traditional shopping process and reducing manual effort at billing counters.

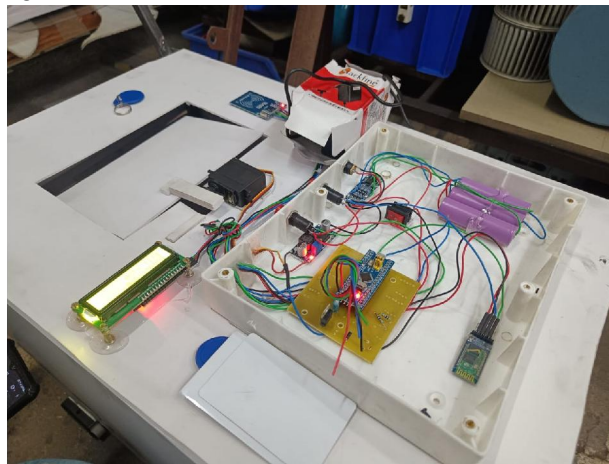


Fig. 2. Experimental setup

V. SYSTEM ARCHITECTURE

The system architecture of the **Smart Shopping Trolley** consists of an **STM32 Blue Pill microcontroller** as the main control unit, connected to an **RC522 RFID tag reader**, **MG995 servo motor**, **LCD display**, **Bluetooth module (HC-05)**, and a **battery power supply**. When a **product with an RFID tag** is brought near the reader, the **RFID module** sends the tag information to the **STM32 controller**, which processes and identifies the product details such as name and price. The **MG995 servo motor** is then activated to **open the trolley gate**, allowing the customer to place the item inside, and automatically **closes** it after scanning to prevent unauthorized addition of items.

The **LCD display** shows the scanned product's name, price, and total bill amount in real time. The **Bluetooth module** provides wireless connectivity between the trolley and the **Virtuino mobile application**, enabling live monitoring of billing details and total cost on a smartphone. A **battery unit** powers all components, with charging supported through an external **charger**. The **buck converter** ensures stable voltage regulation for all modules. This architecture ensures **automation, transparency, and user convenience** by integrating smart identification, controlled access, and wireless communication within a single embedded system.



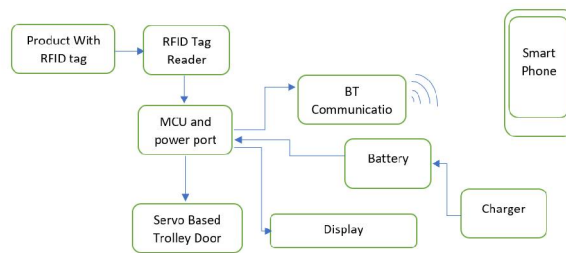


Fig.3.Block Diagram

VI. RESULTS AND DISCUSSION

The prototype of the RFID-Based Smart Shopping Trolley was successfully designed and implemented using the STM32 Blue Pill microcontroller, RC522 RFID reader, MG995 servo motor, and HC-05 Bluetooth module. The system performed as expected, with smooth communication between all components and accurate real-time billing and display functions. When a product with an RFID tag is placed near the reader, the RC522 module detects the tag and sends its unique ID to the STM32 controller. The microcontroller then retrieves the product details such as name and price and displays them on the 16×2 LCD. The total bill is updated instantly as each item is scanned.



Fig. 4: Virtuino app showing real-time Bill and Budget display.

Fig.4 shows the Virtuino mobile application interface, where the Bill and Budget values are displayed in real time via Bluetooth communication.



Fig.5: LCD showing scanned Product name and price details.

Fig.5 demonstrates the detection of a specific product, displaying its name and price on the LCD.



Fig.6: LCD displaying total Budget and Bill values.

Fig.6 depicts the LCD output showing the customer's budget and the total bill amount after scanning multiple products.



After completing the billing process, the payment is carried out through the linked mobile app (e.g., PhonePe). Once the payment is confirmed, the MG995 servo motor automatically opens the trolley door, allowing the customer to exit securely. This ensures that only billed items can leave the trolley, enhancing both convenience and security.

The overall system functioned reliably, verifying that the designed prototype effectively achieves automated billing, accurate item detection, and user-friendly payment integration. This approach significantly reduces checkout time, improves billing accuracy, and minimizes manual intervention in retail environments.

VII. CONCLUSION AND FUTURE WORK

The **RFID-Based Smart Shopping Trolley** successfully demonstrates an automated shopping and billing system that integrates embedded control, RFID technology, and wireless communication within a single platform. The prototype effectively automates product identification, billing, and trolley access, thereby reducing checkout time and enhancing the overall shopping experience. The system, built around the **STM32 Blue Pill microcontroller**, ensures reliable operation of all modules including the **RC522 RFID reader**, **MG995 servo motor**, and **HC-05 Bluetooth module**. Real-time product details and total billing amounts are displayed on the LCD and synchronized with the mobile app, providing customers a transparent and efficient self-checkout process. By eliminating manual billing and enabling automatic trolley control, the system reduces human dependency, prevents billing errors, and promotes a seamless shopping environment. The combination of automation and communication technologies highlights the potential for integrating embedded systems into retail operations. Future improvements may include adding **cloud-based connectivity** through Wi-Fi or GSM for real-time data storage and analytics, as well as **integration with online payment gateways** for fully contactless transactions. Incorporating **weight sensors or image recognition** could further enhance product verification and security. Additionally, upgrading the system with **IoT-based dashboards** would enable store managers to monitor trolley usage and inventory more effectively. With these enhancements, the RFID-Based Smart Shopping Trolley can evolve into a fully smart retail automation system, ensuring faster, smarter, and more customer-friendly shopping in the future.

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