# RFID-Based Shopping Cart for Automated Billing

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*Abstract*—Shopping at retail stores often leads to long waiting times at billing counters. Traditional barcode scanning requires manual effort and causes delays, leading to customer dissatisfaction. This Report presents an RFID-based Smart Shopping Cart system that automates the billing process by detecting RFID-tagged products in real time. The system consists of an RFID reader, microcontroller(ESP32 and Arduino),display unit(16x2 LCD).By eliminating barcode scanning, this approach reduces waiting times and improves the shopping experience.Additionally, the system enhances customer satisfaction, store efficiency, and inventory management. This technology not only enhances efficiency but also improves hygiene by minimizing human interference. Future implementations include integration with AI for personalized recommendations,cloud-based data management, and enhanced security features.

*Index Terms*—RFID, Smart Shopping Cart, Embedded Systems, Retail Automation, IoT, Contactless Payment.

## I. INTRODUCTION

Supermarkets and retail stores often face problems like long queues at checkout counters and slow billing processes. This happens because barcode-based scanning requires cashiers to manually scan each item one by one, which takes a lot of time. Sometimes, mistakes happen while scanning, leading to incorrect prices and billing errors, causing inconvenience for both customers and store owners.

To solve these problems, RFID (Radio Frequency Identification) technology can be used. RFID is a contactless system that allows items to be detected automatically without the need for manual scanning. Each product has a small RFID tag that stores details like its name and price. When a customer places an item in the shopping cart, an RFID reader instantly detects it, and the system updates the bill automatically.

This system offers many advantages:

- Fast and automatic item detection – No need for barcode scanning, saving time.
- Automated billing – Reduces cashier workload and prevents human errors.
- Better inventory management – Store owners can track stock levels in real time.
- Contactless payment – Customers can pay without physical contact, making shopping more hygienic and secure.

The RFID-based Smart Shopping Cart helps in making shopping more efficient, secure, and convenient. It bridges the gap between traditional shopping and modern automation, making the entire process smoother for both customers and store owners.

## II. LITERATURE REVIEW

Many researchers have explored the use of RFID technology in retail automation, some of them are listed below:

- **Smith et al. (2019)** developed an RFID-enabled supermarket that cuts the checkout times by nearly 50%. Their system utilized RFID readers at checkout points to automatically scan multiple items simultaneously, eliminating the need for manual barcode scanning. Customers could place their shopping carts near the reader, and all items were detected instantly. This approach significantly reduced waiting times, improved billing accuracy, and enhanced the overall shopping experience [1].
- **Patel and Mehta (2021)** combined RFID and mobile payments to enhance security and efficiency. Their research integrated RFID technology with digital wallets, allowing customers to link their bank accounts with RFID-enabled shopping carts. As items were placed into the cart, their prices were added to a virtual bill, and payment was automatically deducted upon exiting the store. This system minimized human intervention, reduced fraud risks, and streamlined the checkout process [2].
- **Zhang et al. (2022)** focused on RFID interference issues and optimized tag placement to improve signal detection. They addressed challenges like tag collision, signal attenuation, and misreads in crowded retail environments. By experimenting with different tag orientations and reader configurations, they developed an optimized placement strategy that enhanced RFID readability and ensured seamless product tracking with minimal errors [3].

Despite its advantages, RFID technology still faces challenges such as cost, security risks, detection issues, and interference with metallic objects. The integration of IoT and machine learning can further optimize RFID-based retail automation.
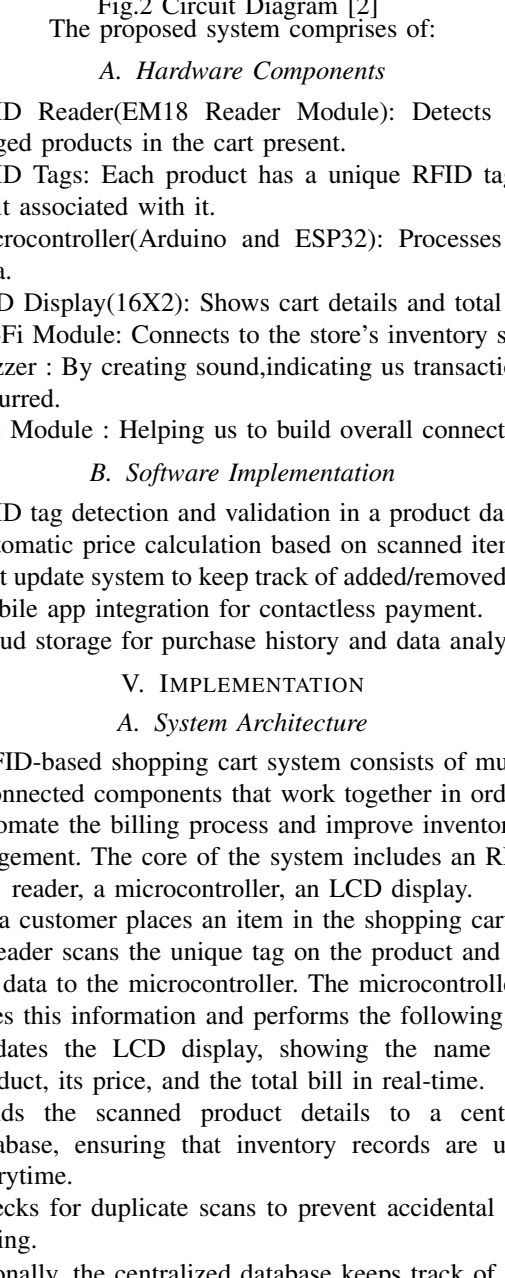
## III. PROBLEM STATEMENT

Retail stores currently face several challenges:

- Frequent billing errors caused by human mistakes..
- Theft and fraud, as barcodes can be swapped.
- Inefficient inventory management, leading to stock mismanagement.
- Lack of personalized shopping experiences for customers.

To address these challenges, an RFID-based Smart Shopping Cart is proposed to automate billing, enhance security, and improve customer convenience.

## IV. METHODOLOGY



Fig.1 Flowchart of Circuit [1]



Fig.2 Circuit Diagram [2]

The proposed system comprises of:

### A. Hardware Components

- RFID Reader(EM18 Reader Module): Detects RFID-tagged products in the cart present.
- RFID Tags: Each product has a unique RFID tag a 12 digit associated with it.
- Microcontroller(Arduino and ESP32): Processes RFID data.
- LCD Display(16X2): Shows cart details and total price.
- Wi-Fi Module: Connects to the store's inventory system.
- Buzzer : By creating sound,indicating us transaction had occurred.
- I2C Module : Helping us to build overall connection.

### B. Software Implementation

- RFID tag detection and validation in a product database.
- Automatic price calculation based on scanned items.
- Cart update system to keep track of added/removed items.
- Mobile app integration for contactless payment.
- Cloud storage for purchase history and data analytics.

## V. IMPLEMENTATION

### A. System Architecture

The RFID-based shopping cart system consists of multiple interconnected components that work together in order to automate the billing process and improve inventory management. The core of the system includes an RFID reader, a microcontroller, an LCD display.

When a customer places an item in the shopping cart, the RFID reader scans the unique tag on the product and sends the data to the microcontroller. The microcontroller processes this information and performs the following tasks:

- Updates the LCD display, showing the name of the product, its price, and the total bill in real-time.
- Sends the scanned product details to a centralized database, ensuring that inventory records are updated everytime.
- Checks for duplicate scans to prevent accidental double billing.

Additionally, the centralized database keeps track of stock levels in real time, reducing errors in inventory management.

## B. Working Mechanism

The working process of the RFID-based shopping cart is simple, efficient, and user-friendly. The system operates in the following steps:

1) Adding Items to the Cart: - When a customer picks an item and places it in the shopping cart, the RFID reader detects the unique RFID tag attached to the item. - Unlike traditional barcode scanning, which requires line-of-sight scanning, RFID allows for seamless detection without direct visibility.

2) Scanning and Billing: - The microcontroller updates the LCD display inside the shopping cart, showing the newly added item, its price, and the total cost of all items in the cart. - If a customer removes an item from the cart, the system detects this and automatically removes it from the bill.

3) Real-Time Display of Cart Contents: - The LCD screen continuously updates as more items are added or removed. - This real-time tracking ensures transparency for the customer, preventing billing disputes.

4) Automated Checkout and Payment - When the customer is ready to pay, they can proceed to the checkout section, where the final bill is automatically processed. - The system supports contactless payment methods such as mobile wallets, credit/debit cards, or pre-linked accounts, reducing the need for manual cashier interactions. - Once payment is completed, the system generates a digital receipt, which can be sent to the customer via email or SMS.

5) Inventory Management and Data Update: - After payment, the purchased items are automatically deducted from the store's inventory system. - This prevents problems like stock shortages or overstocking, helping store managers make better restocking decisions.

This automated process reduces billing errors, enhances the shopping experience, and ensures smooth store operations.

By eliminating the need for long checkout lines and paper-based receipts, this RFID-based shopping cart system represents a significant step toward a modern, efficient, and customer-friendly retail environment**.

## VI. LIMITATIONS

Although the RFID-based shopping cart system offers many advantages, there are certain challenges that need to be considered. These limitations can affect its widespread adoption and require improvements for better efficiency.

- Higher Initial Cost Compared to Barcode Systems: - Implementing RFID technology requires special hardware such as RFID readers, tags, and microcontrollers, which are more expensive than traditional barcode scanners. - Stores also need to invest in updating their existing systems to integrate RFID, which increases the upfront cost.

- Interference with Metal Objects, Affecting Accuracy: - RFID signals can be disrupted by metal surfaces, making it difficult to scan products that have metal packaging. - This can lead to inaccurate readings, requiring additional adjustments to improve system reliability.

- Security Risks Like Unauthorized RFID Tag Reading: - Since RFID tags can be read from a distance, there is a risk that unauthorized scanners might try to steal information. - This raises concerns about data privacy and security, requiring encryption or protective measures to prevent misuse.

- Difficulty in Replacing Barcodes with RFID in All Stores: - Many retail stores still rely on barcodes, and switching completely to RFID technology requires significant investment and time. - Small businesses may find it challenging to adopt RFID due to cost and compatibility issues with their existing systems.

- Battery Life Limitations in Carts: - The RFID-enabled shopping carts require power for the microcontroller, display, and RFID reader, meaning they need regular battery charging or replacement. - If the battery runs out, the system may stop functioning properly, causing inconvenience to customers and store staff.

Despite these challenges, continued advancements in RFID technology are expected to reduce costs, improve reliability, and enhance security, making the system more practical for widespread use in the future.

## VII. ADVANTAGES

The RFID-based shopping cart system offers many benefits that make shopping easier, faster, and more efficient for both customers and store owners. Below are the key advantages explained in simple terms:

- Faster Checkout – No Need for Barcode Scanning: - Traditional barcode scanning requires each item to be scanned one by one, which takes time. - With RFID, all items in the cart are automatically detected at once, making checkout much quicker.

- Error-Free Billing – Reduces Human Mistakes: - Cashiers can sometimes miss scanning an item or enter the wrong price. - RFID automatically records each product, ensuring accurate billing without mistakes.

- Better Hygiene – Contactless Scanning Reduces Touch-points: - In traditional shopping, cashiers handle products and payment devices, increasing the spread of germs. - RFID allows for fully contactless shopping, improving hygiene and safety, especially during health crises.

- Real-Time Tracking – Customers Can See Expenses Instantly: - The RFID system updates the total cost as customers add or remove items from the cart. - This helps customers keep track of their spending and avoid surprises at checkout.

- Reduced Labor Costs – Less Need for Checkout Staff: - Since the RFID system automates billing, fewer cashiers are needed at the counters. - This helps stores reduce labor costs and focus staff on other important tasks like customer assistance and inventory management.

Overall, this system improves shopping convenience, speeds up checkout, and ensures smooth store operations, making it a modern and efficient solution for retail businesses.

## VIII. Applications

The RFID-based shopping cart system is not limited to supermarkets; it has a wide range of applications across different industries. By automating tracking and billing processes, RFID technology improves efficiency, reduces human effort, and enhances user experience in various fields. Below are some key applications explained in detail:

- Retail Stores – Improves Inventory Management: - RFID helps store managers keep track of stock levels in real time. - This prevents overstocking or stock shortages, ensuring that popular items are always available.
- Libraries – Enables Self-Checkout for Books: - Traditional library systems require a librarian to manually scan books for check-in and check-out. - With RFID, readers can simply pass their book through an RFID scanner, and the system will automatically update the database. - This makes borrowing and returning books much faster and more efficient.
- Pharmacies – Helps Track Medicines Efficiently: - RFID is used in pharmacies to manage medicine inventory and prevent stock shortages. - It ensures that expired medicines are easily identified and removed, reducing the risk of dispensing outdated drugs. - Pharmacists can quickly check medicine availability without searching through shelves manually.
- Airports – Manages Luggage Tracking: - RFID is widely used in airports to track baggage from check-in to arrival. - Each suitcase is tagged with an RFID chip, allowing airport staff to monitor its location in real time. - This reduces the chances of lost luggage and ensures that bags reach the correct destination.

These applications demonstrate the versatility of RFID technology in improving efficiency, reducing human effort, and enhancing accuracy in various industries. As RFID technology continues to advance, its adoption in more sectors is expected to grow.

## IX. Conclusion

The RFID-based Smart Shopping Cart is a modern solution that makes shopping easier, faster, and more efficient. By using RFID technology, this system automates the checkout process, reduces billing errors, and removes the need for long queues at payment counters. Customers can simply add items to their cart, and the system automatically updates the bill, making shopping smooth and hassle-free.

This system not only benefits customers but also helps store owners by improving inventory management, reducing labor costs, and preventing theft, With real-time tracking of products, stores can maintain accurate stock levels and provide a better shopping experience.

Looking ahead, this system can be further improved by integrating AI-powered recommendations to suggest products based on customer preferences. Cloud-based data management can help stores analyze shopping patterns and optimize stock availability. Additionally, enhanced security features can be added to prevent unauthorized RFID scanning and protect customer data.

Overall, this smart shopping cart system is a step toward the future of retail, making shopping more convenient, efficient, and enjoyable for everyone.

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## X. Obtained Output

The following images represent the real-time working of the RFID-based shopping cart system:

[4]

Fig. 3. Sugar added [3]



Fig. 4. Milk added [4]



Fig. 5. Total Price [5]



Fig. 6. Biscuits removed [6]
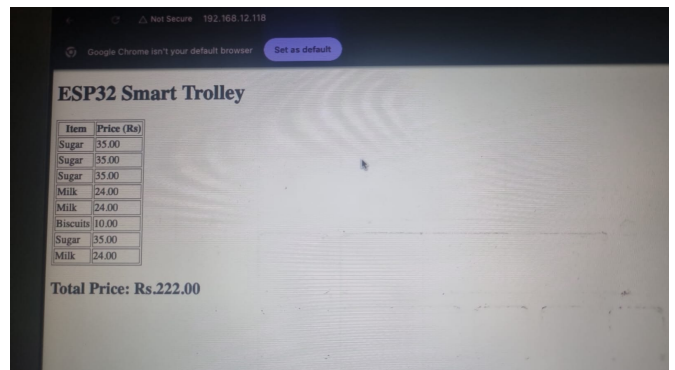


Fig. 7. Biscuits added [7]



Fig. 8. Final bill display (Webpage Based Result) [8]

Fig. 9. LCD Display Showing Various Stages of Item Scanning and Billing