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Smart Trolley with Real-Time Billing and Inventory Management Using Arduino and IoT

Tanuja Nandam[1] | Dr B.Mahesh babu[2] | Anusha Nandam[3] | Gireesh Nandam[3]

[1]Department of ECE, Seshadri Rao Gudlavalleru Engineering College, Gudlavalleru, Andhra Pradesh, India
[2]Department of EEE, Seshadri Rao Gudlavalleru Engineering College, Gudlavalleru, Andhra Pradesh, India
[3]Department of Computer Science, East Texas A&M University, commerce, USA

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ABSTRACT

The Smart Trolley system is a complete innovation in the conventional manual billing and inventory management systems that are used in supermarkets. This system uses an Arduino Uno microcontroller, RFID technology, and IoT for real-time billing and efficient inventory management. The traditional method of billing, which depends on barcode scanning, involves manual intervention and is prone to human errors, making it time-consuming. This proposed Smart Trolley system aims to automate these processes, enabling seamless shopping experiences. The system integrates RFID tags and a reader with an Arduino board to automatically detect and add or remove items from the trolley, compute the total cost, and display it in real time on an LCD screen. It also enhances inventory tracking, reducing the manual labor involved in inventory control.

KEYWORDS: Smart Trolley, Arduino Uno, RFID, IoT, Real-Time Billing, Inventory Management, Automation, Retail Systems

1.INTRODUCTION

In modern retail, supermarkets and shopping malls use manual inventory and invoicing. The cashier or staff scans each product, checks its pricing, and manually enters it into the billing system using barcodes. Additional manual inventory updates occur following sales transactions or stock audits. Traditional approaches have worked effectively in the past, but they are sluggish, error-prone, and dependent on humans. Staff scanning and inputting product information causes delays, errors, and inaccurate inventory records, which may hurt operations and customer satisfaction.

Retail automation may solve some of these issues. Automating billing and inventory management would boost efficiency, eliminate human error, and improve customer service. Automation lets retailers update stocks in real time, improving product availability tracking. This prevents stock-outs and helps retailers

better manage stock levels, eliminating the time-consuming task of manual stock-taking and simplifying the entire process from check out to inventory replenishment.

Smart Trolleys solve these issues in novel ways. RFID and IoT-enabled Smart Trolleys can monitor and bill things automatically [1]. RFID tags on items and an RFID reader in the trolley will allow the system to scan things in real time without operator involvement. RFID reader data will be processed by the Arduino Uno microcontroller to update trolley item prices. Checkout is faster and billing problems are less likely with this automation.

Smart Trolley reduces human interaction in invoicing and inventory management. RFID technology immediately reads each product's unique identity as it enters the trolley, allowing real-time tracking. Customers see the running total on an LCD screen while they shop since the technology calculates the total cost dynamically. This function reduces barcode scanning, streamlines checkout, and improves user experience. Our real-time technology updates the store's inventory system instantly, improving stock management and minimizing human inventory audits.

This article will discuss the idea, design, implementation, and advantages of an RFID/IoT [2] Smart Trolley system. Product monitoring, invoicing, and inventory management will be real-time. Shopping in a Smart Trolley is faster, more precise, and more welcoming due to automated streamlining. Real-time stock levels in the system simplify inventory management. IoT enables the trolley to directly communicate with the central shop system, which automatically changes product inventory, pricing, and stock availability [4]. This technology boosts operational efficiency and changes shopping to be quicker, more convenient, and less error-prone.

a. Objective

The objective of the Smart Trolley system is to revolutionize conventional supermarket operations by automating the billing and inventory management processes. It aims to enhance the shopping experience by leveraging modern technologies like RFID, Arduino Uno, and IoT for real-time, efficient, and error-free billing. The system aspires to provide a seamless shopping experience by automating item detection, cost computation, and inventory tracking, reducing the need for manual intervention.

b. Problem Statement

Traditional supermarket billing systems rely heavily on barcode scanning, which requires manual intervention, making the process prone to human errors and time-consuming. This approach not only slows down the checkout process but also creates inefficiencies in inventory management, as it involves significant manual labor. The lack of automation in these processes limits the overall efficiency of supermarket operations. Therefore, there is a need for a smart solution to automate billing and inventory management, reducing errors and improving operational efficiency.

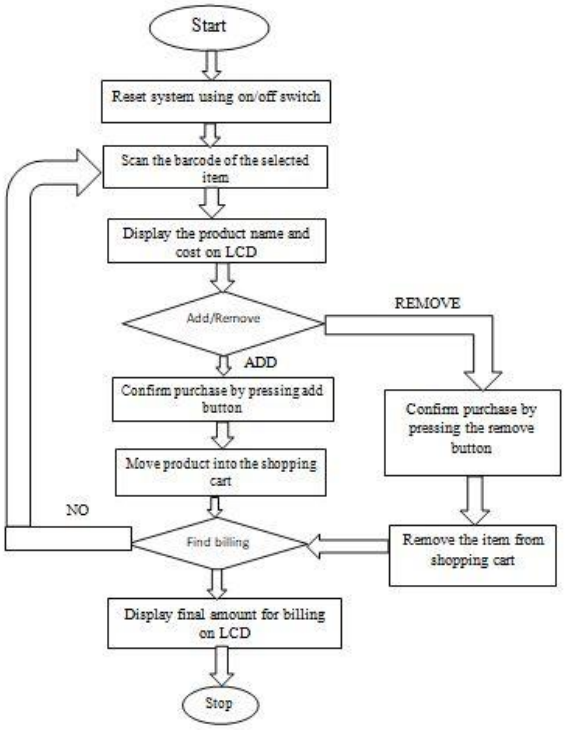

Fig 1: Flow Chart Diagram

The Fig 1 illustrates the process of managing a digital shopping cart system. Here's a simplified explanation:

Step 1: Turn on the system using the on/off switch.

Step 2: Scan the barcode of the product, which displays its name and cost on the LCD.

Step 3: Choose whether to add or remove the item.

Step 4: Confirm the addition, and the item moves to the cart.

Step 5: Confirm the removal, and the item is taken out of

the cart.

Step 6: If done, proceed to billing.

Step 7: Display the total amount on the LCD.

Step 8: Complete the process.

2. Literature Survey

A. Gupta et al. [1]: A. Gupta and colleagues' study on RFID-based smart shopping carts explores using RFID tags to automate item tracking in retail. The system detects products placed in carts, improving inventory accuracy and minimizing human errors. Automation eliminates manual barcode scanning, speeding up checkout and enhancing customer satisfaction. Their research highlights benefits such as streamlined inventory management, reduced costs, and a seamless shopping experience.

S. R. Patel et al. [2]: This paper explores Arduino-based systems for automating retail processes with smart shopping carts. An Arduino microcontroller integrated with RFID technology tracks items and calculates costs in real-time, eliminating manual scanning at checkout. The system is cost-effective, ensures accurate item tracking, and minimizes human errors. Benefits include faster checkout, efficient inventory management, and reduced labor costs.

M. R. Khan et al. [3]: This paper presents a smart shopping trolley solution using Arduino, RFID, and cloud-based data processing. The system enables real-time inventory management, seamless checkout, and remote stock monitoring with automatic updates. IoT integration ensures real-time data transmission between the trolley and inventory systems. Benefits include faster billing, improved operational efficiency, and reduced overstocking or stock outs.

V. J. Murugan et al. [4]: Murugan et al. propose a Smart Shopping Trolley prototype using IoT to communicate with the supermarket's central system for billing and inventory updates. RFID tags track items in the cart, and data is transmitted in real time to manage stock levels. The trolley calculates the total cost and displays it on an LCD screen, enhancing speed and accuracy. This system improves the shopping experience while reducing human error and streamlining inventory management.

N. A. R. Ibrahim et al. [5]: Ibrahim and colleagues present an intelligent shopping cart using Arduino, RFID, and sensors to automate billing and inventory management. The system dynamically updates the total cost in real-time on a screen while communicating with the central database to update stock levels. Sensors enhance detection accuracy, ensuring all items are properly scanned and tracked. This system offers a seamless shopping experience, improves inventory accuracy, and reduces operational costs for retailers.

3. Overview of Existing System

The current inventory management and billing system of a supermarket mainly follows manual processes like scanning of a barcode and pricing by a human cashier. It hampers customers to stand in line and scan each product barcoded in a scanner held by the cashier. This will add to delays, and also prone to human error. Even management of the stock is cumbersome in the current method as the entire stock needs to be audited periodically to verify the existence of products.

The current system has a speed and accuracy limitation with regard to the customer experience. The process of manually adding or removing items from the cart and updating the inventory can be time-consuming and prone to mistakes. Moreover, the system does not track in real time, so it may show some inaccuracies in the record of inventory. The manual billing process is labor-bound and inefficient and offers an opportunity to improve this process by making these tasks automatic. The process of introducing the RFID and microcontroller-based system can eliminate the inefficiencies with more accurate and faster and customer-friendly solutions.

4. Proposed Approach

The proposed Smart Trolley system will introduce automation into the billing and inventory management processes. Using an Arduino Uno microcontroller, RFID tags, RFID reader, and IoT technology, it offers customers and retailer's easy smooth running. All items within the supermarket have been tagged with RFID

tags; this contains the name and price of the product.

The smart trolley is equipped with an RFID reader that scans tags on the items inserted into the trolley. When an item is added to or removed from the trolley, the system updates the contents in real time and shows the overall cost on the LCD screen. It further communicates with the central inventory management system to track out the stock level. The trolley has three switches: one is for adding the article, another for removing the article, and the third for refreshing the trolley that will update the bill or remove all articles.

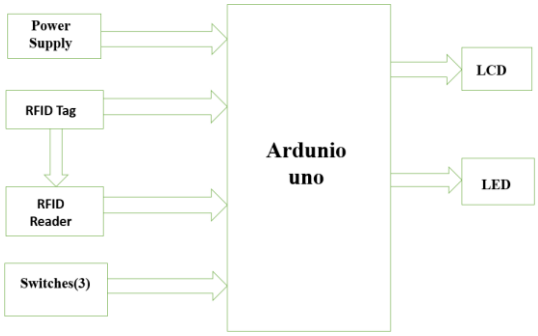

Fig 2: Proposed Block Diagram

The implementation of the Smart Trolley system involves several key components:

1. Arduino Uno: The microcontroller acts as the brain of the system, controlling the RFID reader, managing user input through switches, and displaying data on the LCD screen.

2. RFID Technology: Each product is embedded with an RFID tag that holds the product details. The Arduino uses an RFID reader to detect the tags and retrieve the product information.

3. LCD Screen: The LCD screen displays the current items in the trolley, the total price, and real-time updates as items are added or removed.

4. LED Indicators: LEDs provide feedback for successful item scanning, and they also indicate whether the trolley is ready for checkout.

5. IoT Connectivity: The system communicates with a central server to update inventory levels and billing information. The cloud-based system ensures real-time stock management and reduces manual errors.

6. User Interface: The system includes three buttons: add an item, remove an item, and refresh the trolley, making the interaction straightforward for the user.

5. Experimental Results

Implementations of the Smart Trolley system greatly improved efficiency, accuracy, and customer satisfaction. Using RFID technology, products were monitored in real time, and automatic item recognition was accomplished through items placed in the trolley. The integration of an Arduino microcontroller facilitated communication between the RFID reader and the central database for dynamic updates of the total cost. The LCD would reflect the updating total cost during adding or dropping items, for example, on a more direct and interactive transparent display. To that extent, a high level of automation reduced much manual intervention time and accelerated checkouts while further enhancing the usability experience by automatically providing instant feedback about purchases.

In addition to simplifying the billing process, Smart Trolley streamlined inventory management. It automatically updated stock levels each time an item was purchased or returned. Inventory audits required less manual labor, freeing up valuable resources for other tasks. The accuracy of inventory records increased dramatically, because real-time updates ensured that the stock information was current. This shift towards the automated system minimized human error during billing and management of stock within both retail firms and customers' firms, giving enormous time saving in both scenarios. Overall, Smart Trolley exhibited its prospects toward optimizing the performance of a store, offering efficiency and accuracy within this modern shop setup.

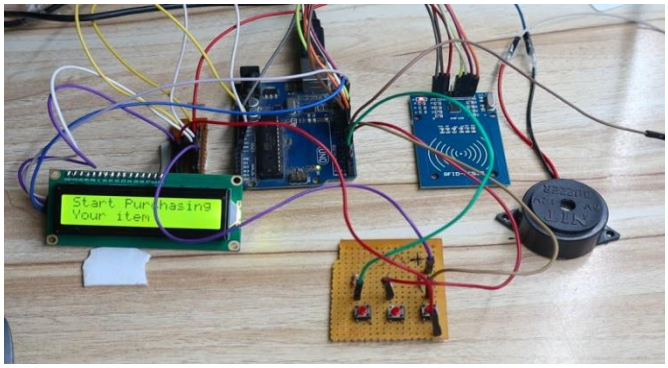

Fig 3: Hardware Connections of the Circuit

The above figure is the hardware connection of the smart trolley system using Arduino

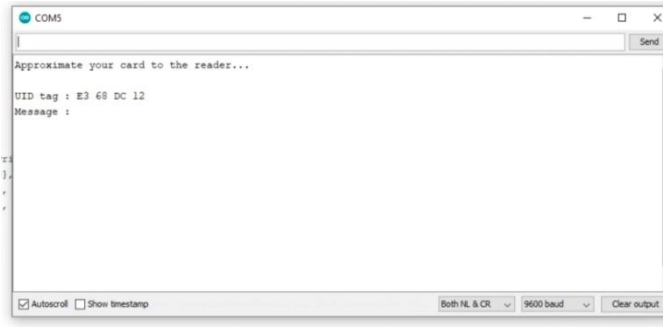

Fig 4: Reading the RFID tag number

The serial monitor in the Arduino IDE software is displaying the RFID tag number while scanning the RFID tag

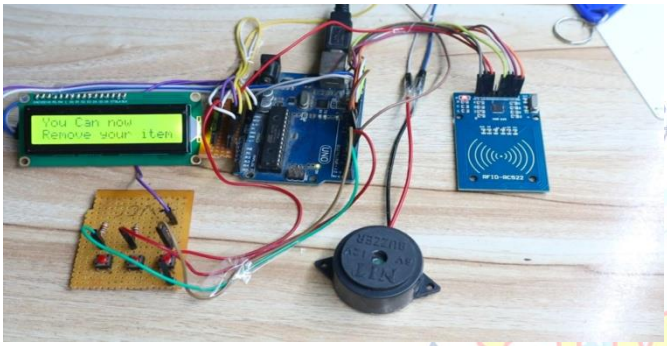

Fig 5: Removing an item from the trolley

When we press the remove button then LCD will display you can remove your item on LCD screen and after displaying the message on LCD screen then it will displaying the name of the item and it will display the total cost of the items.

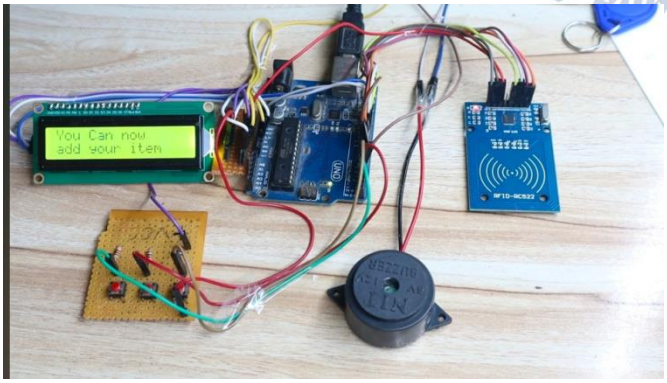

Fig 6: Adding an item into the trolley

When we press the add button then LCD will display you can now add your item on LCD screen and after displaying the message on LCD screen then it will displaying the name of the item and it will display the total cost of the items.

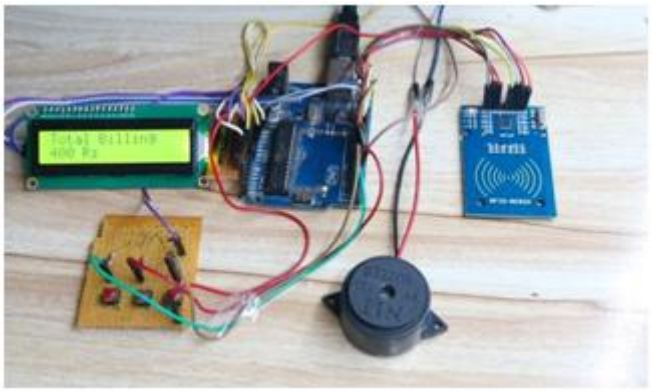

Fig 7: Displaying total billing on LCD

The total billing of the items in the shopping cart is displaying on the LCD display

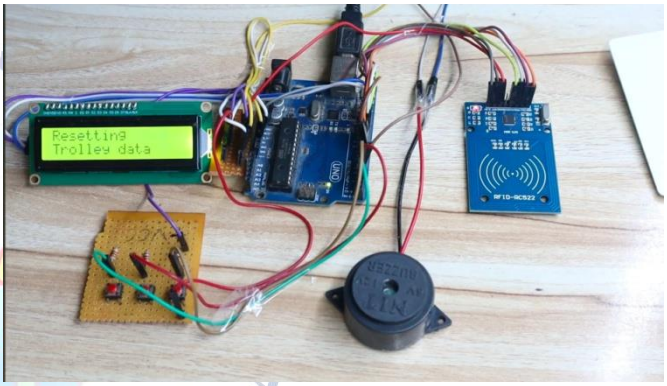

Fig 8: Resetting the trolley data

The smart trolley is displaying the resetting trolley message on LCD when we press the rest button and total system will be reset.

6. CONCLUSION

The Smart Trolley system revolutionizes retail by integrating Arduino, RFID, and IoT to optimize the shopping experience. Arduino acts as the core controller, managing communication between RFID-tagged products and a central inventory system. RFID enables automatic product identification, eliminating manual checkout scans, while real-time updates on an LCD display show the total cost, enhancing customer convenience. IoT connectivity ensures seamless communication between the trolley and the store's database, automating inventory and billing updates. This system accelerates checkout, reduces billing errors, and provides retailers with accurate stock insights, preventing overstocking or shortages. The Smart Trolley exemplifies how smart technologies enhance retail

efficiency, accuracy, and customer satisfaction, paving the way for fully automated shopping. The Smart Trolley system is a strong example of how smart technologies can be integrated into the normal operation of retail business, offering efficiency, accuracy, and convenience. Therefore, it has the potential to revolutionize the retail industry by offering operational benefits for retailers but also an improved and more efficient shopping experience for customers. By integrating those technologies, it would be a beginning toward the intelligent future of completely automated retail applications.

7. Future Enhancement

The Smart Trolley system has significant potential for expansion and improvement. Future developments could include:

1. Mobile App Integration: A smartphone app could be developed for customers to track their trolley's contents and total bill in real time, enhancing user experience.

2. Automatic Checkout: The system could be further developed to include automatic checkout, allowing customers to pay via mobile or NFC-enabled cards without standing in line.

3. Advanced Inventory Management: Integrating advanced data analytics for real-time demand forecasting and stock replenishment could optimize inventory management further.

4. Sustainability Features: The inclusion of energy-efficient components and biodegradable RFID tags would make the system more environmentally friendly.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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