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RFID Technology in Retail: A Study on IoT-Based Shopping Cart System

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Abstract: *The emergence of the Internet of Things (IoT) technology has revolutionized various industries, and the retail industry is no exception. The application of IoT technology in the retail sector has led to the development of smart and connected devices that enhance the customer experience and streamline operations. One such application is the IoT-based shopping cart, which uses sensors and microcontrollers to automate inventory management and real-time monitoring. The proposed IoT-based shopping cart is designed to automate and optimize the shopping experience. The RC522 sensor enables accurate and fast RFID scanning of products, which ensures real-time inventory management and tracking. The NodeMCU microcontroller handles data processing and wireless communication with the cloud server, ensuring seamless communication between the shopping cart and the backend system. The system is designed to provide personalized recommendations to customers based on their shopping history, which can enhance the customer experience and increase sales.*

Keywords: NodeMCU microcontroller, RC522 RFID sensor module, Wireless Sensor Networks(WSNs), Real-time Data Acquisition, IoT, inventory management, smart cart, cloud, data processing, Wifi Connectivity

I. INTRODUCTION

Mobile commerce is the buying and selling of goods and services through mobile phones and tablets. It has become the new generation's e-commerce. M-commerce enables doing transactions via digital means with security anywhere and anytime. The intimidating task of daily life can now be perpetrated by a few clicks on our smartphones. In the traditional system shopping of goods is a time-consuming job. Sometimes the mode of payment is not accepted in the traditional system and also customers have to wait in long queues for payment purposes at the cash counter. This consumes a lot of time and energy of both the cashier and the customer. Online shopping seems to provide extra convenience while traditional shopping provides a greater comfort factor. But in online shopping, it is not always safe to make an order online since you have to expose personal data and credit card information. Hackers can access personal information easily through online transaction and steal it for unauthorized deals. The project aims at removing the inadequacy of both traditional and online shopping. The customer can scan the NFC Stickers on the products while purchasing and generate bill by themselves. Waiting in a long queue at the cash counter will also be avoided as the customer can make payment using NFC Membership Card. Hence the user can make quick payment and leave the shop early. The owner or the sales executive can verify the payment by looking at the indicators connected to the cart. Hence the process is made easy for both customer as well as shop owners and staff.

II. LITERATURE REVIEW

[1].Mohamed Ali and Ahmed Ramadan's paper presents a smart shopping trolley that utilizes IoT to enhance the shopping experience. The system consists of an RFID sensor that detects the products added to the cart and a mobile application that manages the user's shopping list and payment. The mobile app provides product recommendations based on the user's purchase history and allows them to pay through the app. The authors conducted experiments to evaluate the performance of the system, and the results showed that their system can provide a personalized and efficient shopping experience. In [2] authors propose an IoT-based smart shopping cart system that uses RFID

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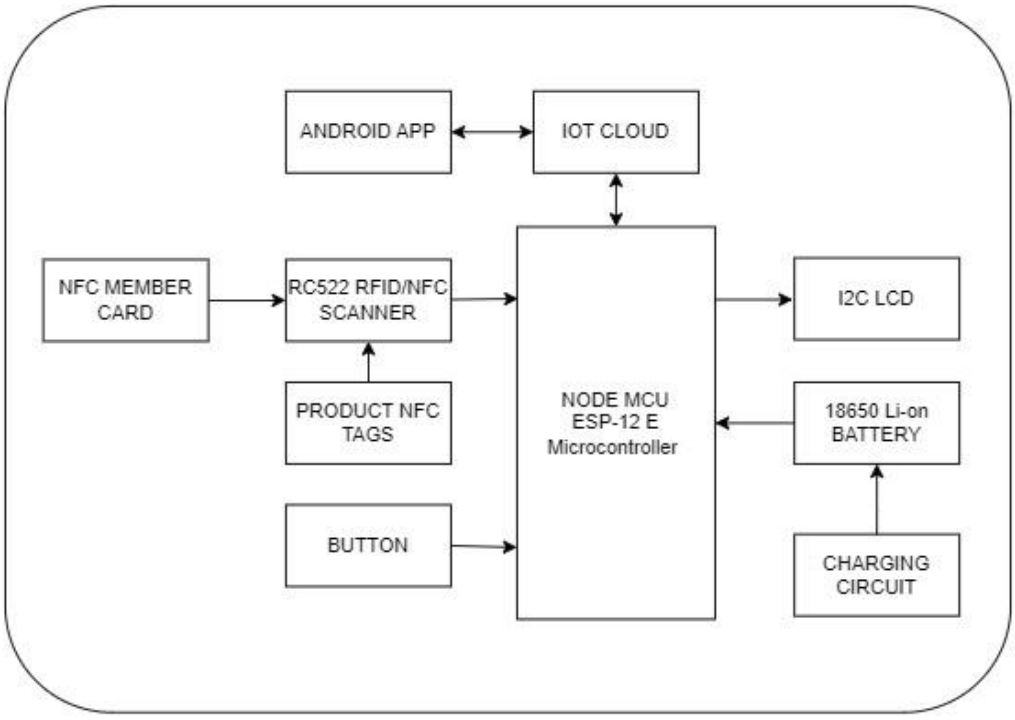
technology to enhance the shopping experience. The system provides real-time product information and personalized recommendations based on the user's purchasing history. The system also includes a feature that allows customers to receive notifications when they are near a product on their shopping list. The authors conducted experiments to evaluate the performance of the system, and the results showed that their system can provide an efficient and personalized shopping experience.[3].Shivendra Singh and Mudit Kumar's paper presents a mobile app for an eCommerce platform using PrestaShop. The app allows users to browse products, add items to their cart, and make purchases directly from their mobile device. The app also includes a feature that allows users to track their orders and provides notifications when the order is dispatched or delivered. The authors conducted experiments to evaluate the performance of the app, and the results showed that their app can provide an efficient and convenient shopping experience..In [4] the subject addressed in this paper, is proposing a smart shopping cart application for Android that uses barcode scanning and voice recognition to assist shoppers in finding products and making purchases. The app provides a shopping list, product recommendations, and payment options. The authors conducted experiments to evaluate the performance of the app, and the results showed that their app can provide an efficient and convenient shopping experience. The app also received positive feedback from the users.

III. BLOCK DIAGRAM AND CIRCUIT DIAGRAM

Block Diagram:



Block Diagram Description:

An IoT-based shopping cart system utilizing RFID technology includes several key components.

- The first component is an RFID reader, which is used to read RFID tags attached to products. When a tag is read, the unique ID of the tag is transmitted to a microcontroller.
- The microcontroller is responsible for processing the data received from the RFID reader and sending it to a cloud server via either Wi-Fi or Ethernet. Additionally, the microcontroller manages communication between the different modules of the system.

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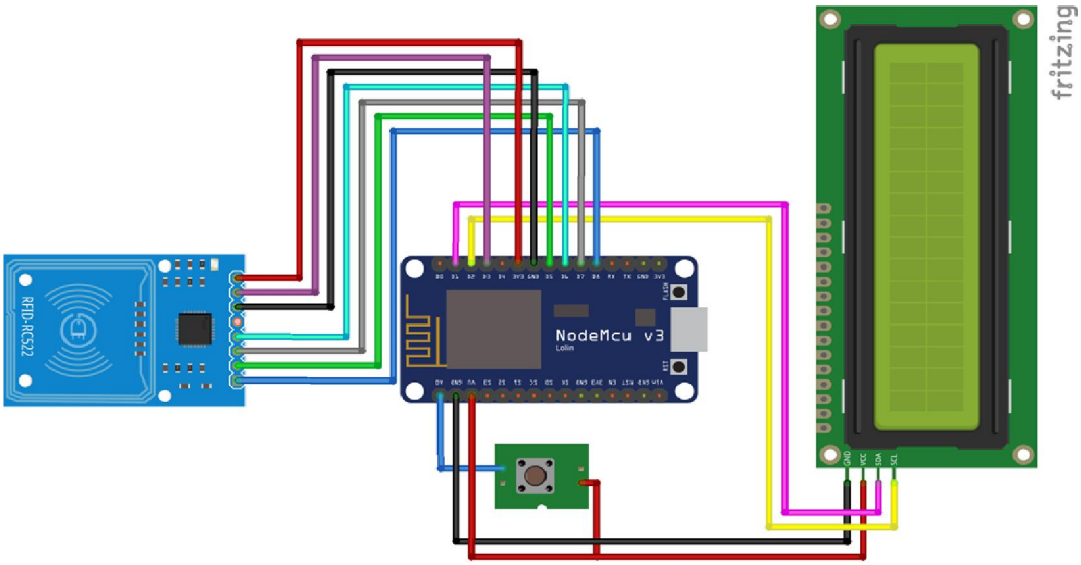
- Cloud Server: The cloud server receives the data from the microcontroller and processes it to keep track of the products in the cart. It also calculates the total cost of the products in the cart and sends this information back to the microcontroller.
- User Interface: The user interface allows customers to interact with the system. It includes a screen that displays the list of items in the cart, their prices, and the total cost.
- Security System: The security system ensures that only authorized customers can use the shopping cart. It includes an authentication module that verifies the identity of the customer using a unique identifier, such as a card or a mobile app.
- Power Supply: The power supply provides the necessary voltage and current to the modules. It includes a battery that can be recharged.

Circuit Diagram:



IV. PROPOSED METHODOLOGY

4.1 Design Considerations

The system uses a NodeMCU Microcontroller which acts as the main processing system for the shopping cart.

- RC522 rfid sensor is used in order to sense the rfid tags which works on the HF frequency range.
- The system gets the supply from a single 18650 Li-ion battery.
- The complete system can be monitored remotely.
- Thing Speak Cloud Server is used for this purpose.
- Product details such as the price and weight of the product will be displayed on the LCD screen.

4.2 Description of the Proposed design working

The aim of the proposed design is to create a smart shopping cart that can help the customer get a better shopping experience with the help of an automated system integrated into the cart. The algorithm followed for the process is given as follows.

Step 1: Initialize NodeMcu:

The first step is to initialize theNodeMcu, for that purpose we power the NodeMcu with a 18650 Li-ion cell and feed the code in it. Appropriate connections are made as per the circuit diagram where we connect the Rfid sensor, LCD Display, and a pushbutton to the NodeMcu.

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The system first tries to connect with the wifi network mentioned in the code in order to establish a connection with the database as well as the Android app of the customer.
A message “Scan a Product” will appear on the LCD display once the wifi connection is established.

Step 2: User Login:
The QR code attached to the cart can be scanned to download the Android app through which the user can login to view all the products added to the cart. The setup is a one-time process for the user and the app will be applicable at multiple stores.

Step 3:Addition of the product:
Every product in the mall/ shop is equipped with an RFID sticker which has a unique id assigned to it. We have an RC522 RFID sensor attached to each cart which is connected to the NodeMCU through an SPI interface.When a product to be added is brought near the cart, the RFID reader will detect the unique tag ID of the product.TheNodeMcu microcontroller will read the ID and send it to the cloud server, which will match the ID with the product information in the database.The server will then update the cart with the product details and the updated total cost.This updated list of products and there price can be viewed on the Android app by the user. Also the added item will be displayed on the LCD display.

Step 4:Removal of the product:
If a customer decides to remove a product, they can press a push button located on the shopping cart and simultaneously scan the product that is to be removed. NodeMcu will detect the push button input and will send this ID to the cloud server, which will remove the product from the cart and update the total cost accordingly. The product removal message can be viewed by the customer on the LCD display.

Step 5:Final Billing:
Once the user is done shopping, they can initiate the billing process by tapping their Master key.TheNodeMcu microcontroller will send the final product information like weight, unit cost, quantity and the total price to the cloud server. The server will generate the bill and send it back to the NodeMcu microcontroller. Microcontroller will then check for the available balance with the user, if the balance in the user account is sufficient the payment will be successful. If an insufficient amount is found, a message saying “Low Balance” is displayed on the LCD screen and the user needs to add the required amount to the account for proceeding with the payment.

Step 6:Admin Login and Verification: This step involves implementing a secure login system for authorized personnel to monitor all generated bills and verify the system's functioning. The login system ensures that only authorized personnel can access the system, providing a layer of security. The admin can view the generated bills, check for any errors or discrepancies, and ensure the smooth functioning of the system. This helps in identifying and resolving any issues that may arise, improving the overall efficiency of the system.

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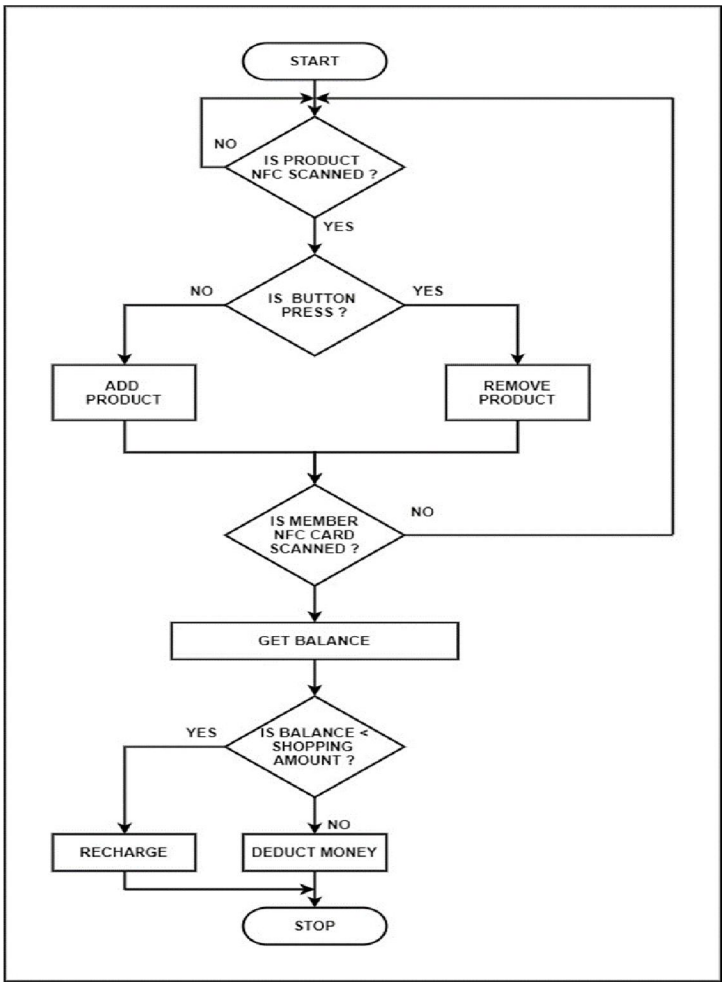
V. FLOWCHART

The process flowchart can be given as follows.



VI. RESULTS AND CONCLUSION

6.1 Hardware Results

The following figures show the shopping process for a customer using the cart

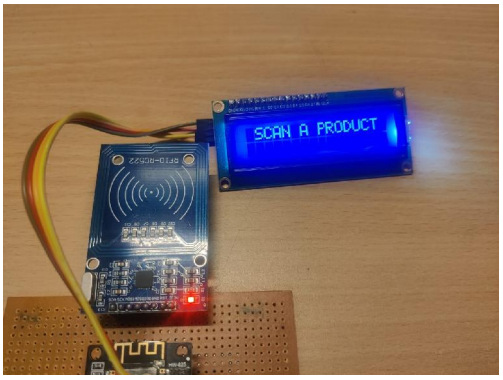


Figure 1: Initialised system message

Figure 2: Product addition message

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Figure 3: Product removal message

Figure 4: Final bill

Figure 5: Low balance error

Figure 6: Payment Successful if balance is enough

The following figures show the App interface that the customer will see while using the cart

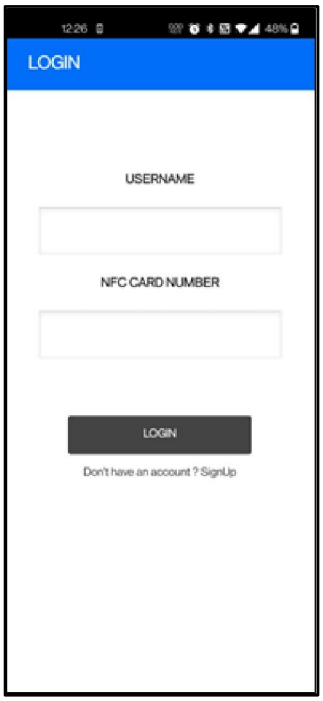

Figure 1: Login

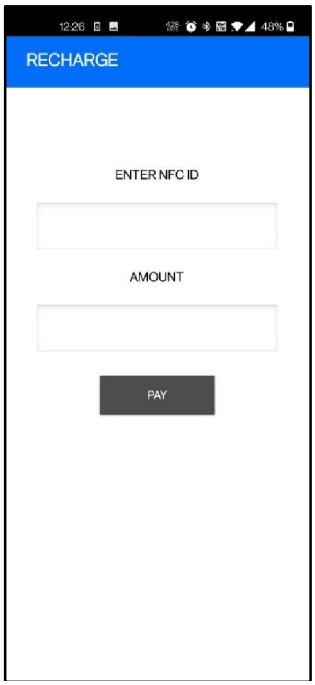

Figure 2: Recharge

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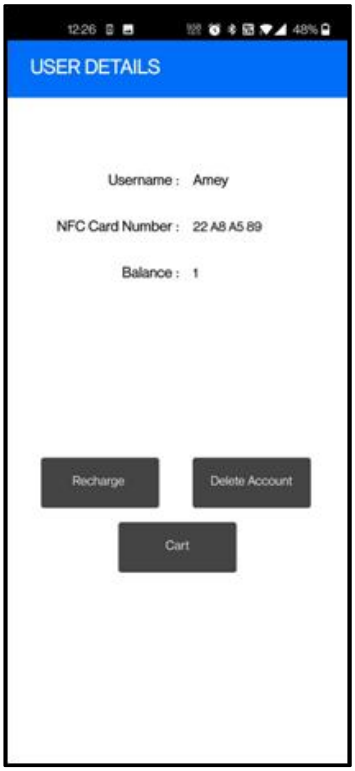

Figure 3:User Details

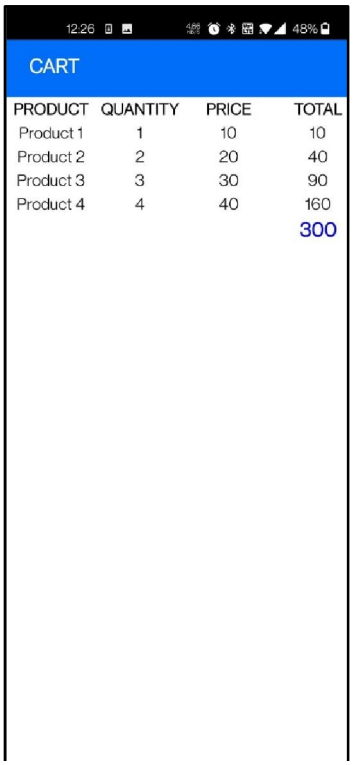

Figure 4: Product List

VII. CONCLUSION AND FUTURE SCOPE

In conclusion, the IoT-based shopping cart system using RFID technology has the potential to revolutionize the way we shop in physical retail stores. By integrating RFID tags with shopping carts, retailers can gain real-time insights into the shopping behavior of their customers, enabling them to provide personalized recommendations and optimize store layouts for better customer flow. Furthermore, the IoT-based shopping cart system can also help retailers reduce theft and prevent loss of inventory, as the RFID tags can track the movement of products throughout the store.

However, the implementation of an IoT-based shopping cart system using RFID technology is not without its challenges. For instance, retailers would need to invest in expensive hardware and software to implement the system, and they would also need to address customer concerns regarding privacy and data security. Nevertheless, with proper planning and execution, the IoT-based shopping cart system using RFID has the potential to enhance the customer shopping experience, increase store efficiency, and drive business growth for retailers.

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Book • 2014
Edited by:Arshdeep Bahga and Vijay Madisetti
The book is a practical guide that provides an in-depth understanding of IoT concepts, architectures, and applications, along with hands-on exercises using popular IoT platforms and technologies. The book covers topics such as sensors, actuators, communication protocols, cloud computing, and security, making it a valuable resource for students, researchers, and practitioners in the field of IoT.

"RFID Handbook: Fundamentals and Applications in Contactless Smart Cards, Radio Frequency Identification and Near-Field Communication"
Book • 1999
Edited by: Klaus Finkenzeller
It is a comprehensive guide to the fundamental principles, technologies, and applications of RFID. The book provides an overview of the history and development of RFID, as well as the different types of RFID systems and their components.