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IOT Based Smart Shopping Cart for Automated Retail Checkout Using RFID and Arduino

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Abstract - By combining automation and real-time monitoring for increased convenience and safety, the Internet of Things-powered Smart Shopping Cart improves the in-store shopping experience. The device uses an Arduino-based controller and RFID technology for product tracking. Customers are alerted by a buzzer. When expired products are discovered, a siren and LCD display are also used by an expiry date detecting device to alert users. A NodeMCU (ESP8266) module installed in the cart allows cloud access using UBIDOTS for real-time alerts, such as notifications, special offers, and information on product expiration. By calculating the bill automatically and enabling digital payments, the system also expedites the checkout procedure. Here touch sensor is used as switch. If the customer decides to remove/add the product from the cart can use the Touch Sensor switch and remove the product from the cart. Through the integration of various technologies, the smart shopping cart increases shopping efficiency, improves customer safety, and offers a smooth, intelligent retail experience via email alerts and real- time notifications.

***Key Words*:** RFID technology, Arduino, NodeMCU (ESP8266), Internet of Things (IoT), smart shopping carts, real- time monitoring etc**.**

1. INTRODUCTION

The use of IoT-based technologies to improve the shopping experience has significantly changed the retail sector. Long lines, ineffective billing procedures, and difficulties managing inventories are common features of traditional shopping systems. By combining technologies like RFID, artificial intelligence (AI), and cloud computing, smart shopping carts have been introduced with the goal of streamlining these procedures (Rajasekar et al., 2022; Kavitha et al., 2022). More consumer happiness and more operational efficiency result from the automated billing, real-time inventory management, and individualized shopping help made possible by smart shopping trolleys (Raj et al., 2022). Despite the progress, there are still a number of obstacles to overcome when implementing smart shopping carts. Prior research has emphasized problems like:

- IoT transactions with low security: Many systems have weak encryption and data security measures, which could expose them to vulnerabilities (Muppalaneni & Prathima, 2021).
- Errors in RFID product detection: Signal interference, misreads, or tag collisions can cause errors in RFID- based tracking (Jaishree et al., 2021).
- High implementation costs: According to Rajkanna et al. (2021), integrating smart retail technology necessitates a large infrastructure and maintenance expenditure.
- Adaptability and user acceptance: Users may find it difficult to adjust to automated shopping systems, hence user-friendly interfaces are essential (Pangasa & Aggarwal, 2022).

The necessity to solve these issues and improve the operation of smart shopping carts is what inspired this effort. A more effective and safe purchasing experience can be attained by strengthening security protocols, maximizing RFID tracking, cutting expenses, and improving

user engagement. Retail management efficiency can also be increased by using AI-driven recommendations and predictive stock monitoring (Kothavale et al., 2021). The following are the main goals of this paper:

1. To evaluate the present issues with IoT-based smart shopping cart systems and suggest workable fixes.
2. To develop authentication and encryption techniques in order to increase the security of IoT transactions.
3. To reduce product detection mistakes and maximize RFID tracking accuracy.
4. To create economical plans for putting smart shopping systems into place.
5. To enhance user engagement and flexibility through AI-driven suggestions and user-friendly interfaces.

The following are the main contributions of this paper:

- Improved IoT security: Suggests better encryption methods to guarantee safe transactions.
- Enhanced RFID-based tracking: Accurate product identification is made possible by error reduction techniques.
- Cost-effective system design: Offers ways to reduce the price of smart retail solutions.
- AI-driven recommendations: Combines machine learning methods to forecast inventory and provide individualized shopping assistance.

The rest of the paper is organized as follows: Section 2 provides an in-depth review of related works, analyzing existing methodologies and their limitations. Section 3 details the proposed methodology, highlighting improvements in IoT security, RFID tracking, and AI integration. Section 4 discusses the implementation and experimental results, comparing the proposed system with existing approaches. Section 5 concludes the paper with future research directions.

2. RELATED WORKS

For predictive stock monitoring, T. Rajasekar, S. Y. Ritika, and G. Ruthra (2022) suggested a smart trolley system with machine learning integrated. The technology optimizes supermarket inventory management by using IoT sensors to track inventory in real time and machine learning algorithms to forecast the need for product replenishment.[1]

In 2022, M. Kavitha, R. Kavitha, R. Srinivasan, and Kumar M. Krish presented an intelligent mart system for smart cities that makes use of natural language processing (NLP). The technology integrates IoT and artificial intelligence to enable efficient shopping and uses voice commands for a better user experience.[2]

In order to expedite the shopping process, Tejashwi Raj, Yaksh Cheema, Vishal Kumar Singh, Anshu Kumar, and Shiv Narain Gupta (2022) created an automated shopping cart using the Internet of Things. RFID readers on the cart can identify when products are added or removed, cutting down on checkout times.[3]

In order to improve the checkout process, Himani Pangasa and Shipra Aggarwal (2022) developed an automated invoicing system for shopping centers. Their study concentrated on creating an IoT and RFID-enabled intelligent billing transactions.

[4] system for smooth, contactless Digambar Rane, Pratik Lavhate, Nikhil Shinde, and Ravindra Kankate (2022) created a "Follow Me" smart shopping cart that uses artificial intelligence and Internet of Things sensors to follow the user on its own, eliminating the need for manual management.[5]

In their thorough assessment of smart shopping trolley systems, Fiza Mariam, Gowrishankar B.S., Niharika, S.P. Nandi, and B.S. Ganavi (2021) examined a number of current solutions and their effects on improving retail administration and customer convenience.[6]

Using RFID and the Internet of Things, Naresh Babu Muppalaneni and Ch. Prathima (2021) suggested a safe smart shopping cart. By incorporating encryption techniques, this solution guarantees safe transactions and improves data privacy in intelligent retail settings.[7]

Prakash Ganesan, M. Mathankumar, and U. Rajkanna (2021) looked into how effective smart trolley systems are in supermarkets. Their research concentrated on using automated billing and product tracking to enhance customer satisfaction and cut down on wait times.[8]

An AI-based smart shopping assistant for interior navigation, product recommendations, and queue-less paying was created by Shreya Kothavale, Shivam Pawar, machine Sanket Kankarej, Sonali Patil, and Roshani Raut (2021) using vision and artificial intelligence approaches.[9]

An IoT-based smart shopping trolley was presented by M. Jaishree, Prabha K.R., Lakshmi S. Jeyaprabha, and K. Mohan (2021). It integrated RFID, sensors, and cloud computing for real-time inventory and invoicing administration, guaranteeing a productive shopping experience.[10]

In order to improve shopping convenience through automation and data-driven analytics, Talreja Sahil, Pendharkar Arjun, Madur Srushti, Mohammad Saad Nalband, and Pragati Mahale (2021) suggested the "Smart Basket" IoT application for contemporary retail.[11]

The supermarket shopping cart system was improved by Subhanvali Shaik, Mohammad Jabirullah, Anish Kumar Vishwakarma, and Rakesh Ranjan (2020) by including IoT for automatic product recognition, billing, and customer assistance.[12]

3. PROPOSED METHOD

The IoT-driven Smart Shopping Cart incorporates a combination of RFID technology, ultrasonic sensors, and cloud-based monitoring to enhance safety and convenience in retail environments. Each product in the store is tagged with an RFID tag, which is detected by an RFID reader integrated into the cart. When a customer adds or removes an item, the system automatically updates the cart' s inventory and displays the product details on an LCD screen. Additionally, an expiry date detection system verifies the freshness of products and alerts customers via both the buzzer and LCD display if an expired item is detected. For cloud-based functionality, the system is connected to the NodeMCU (ESP8266), enabling seamless communication with the UBIDOTS IoT platform. This allows real-time synchronization of shopping data, remote notifications via email, and alerts about product expiry, promotional offers. Furthermore, the cart features an automated billing system that calculates the total cost of items in real time, minimizing checkout delays and reducing the need for manual scanning. By integrating these technologies, the proposed method ensures a safer, more efficient, and user-friendly shopping experience.

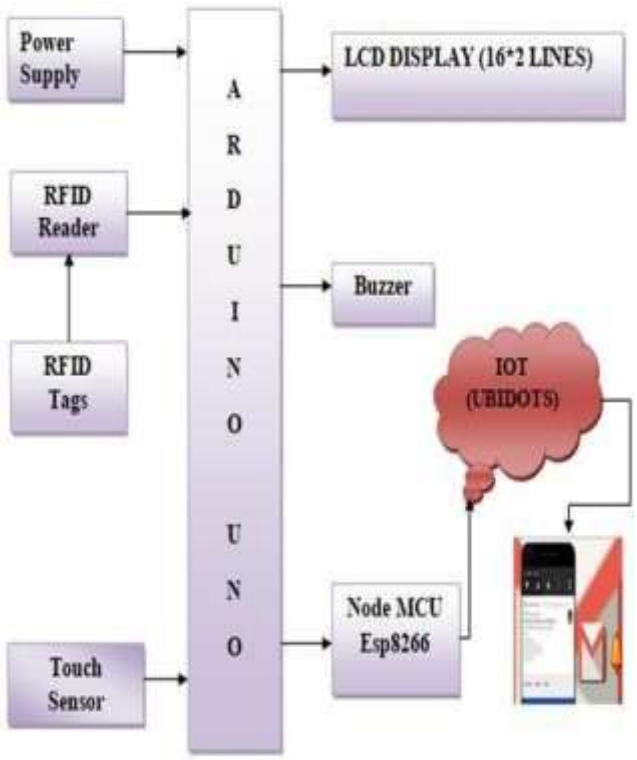

Fig. 1. Proposed Method Architecture

The implementation of the IoT-driven Smart Shopping Cart follows a structured approach, integrating various hardware and software components to ensure real-time product Step 3: Expiry Date Verification tracking, safety monitoring, and automated billing. The methodology consists of the following key steps:

1) Hardware Setup

• RFID-Based Product Detection:

o Each product is embedded with an RFID tag.

o An RFID reader mounted on the cart scans tags when items are added or removed, updating the cart' s inventory.

o The product details (name, price, expiry date) are displayed on an LCD screen.

• Expiry Date Detection:

o The system verifies the expiry date of scanned products.

o If an expired product is detected, an alert is displayed on the LCD and a buzzer notification is activated.

2) Cloud Connectivity & IoT Integration

• The NodeMCU (ESP8266) module connects the cart to the UBIDOTS IoT platform, enabling:

o Real-time data synchronization for product tracking and billing.

o Cloud-based alerts and notifications sent via email regarding expired products, offers. o Remote monitoring and analytics, helping store management optimize inventory and improve customer service.

3) Automated Billing System

• The cart automatically calculates the total bill based on the items scanned.

• The bill is displayed on the LCD screen, and customers can choose to make payments digitally through an integrated payment system, reducing checkout time and human intervention.

4) Notification & Alert System

• Customers receive real-time alerts via the LCD screen and expired products.

• Email notifications are sent for product expiry alerts, promotional offers, and billing details through the UBIDOTS platform

B. Algorithm

Step 1: System Initialization

1. Start the system.
2. Initialize RFID reader, ultrasonic sensor, LCD display, buzzer, and NodeMCU (ESP8266).
3. Connect to the UBIDOTS IoT platform for real-time data communication.

Step 2: Product Detection and Tracking

1. Scan RFID tags of products when added or removed from the cart.
2. If a new product is detected:

a. Retrieve product details (name, price, expiry date) from the database.

b. Display product details on the LCD screen.

c. Add product price to the total bill.

3. If a product is removed:

o Update the cart inventory.

o Subtract product price from the total bill.

1. Compare the product' s expiry date with the current date.
2. If the product is expired:

o Trigger buzzer alert.

o Display an "Expired Product Detected" message on the LCD.

o Send an expiry notification via UBIDOTS.

Step 4: Cloud Communication & Notifications

2. Send real-time updates to the UBIDOTS IoT platform:

o Updated cart inventory.

o Expiry alerts and promotional offers.

o Social distancing alerts.

3. If an offer is available, notify the customer via LCD and email notification.

Step 5: Automated Billing and Checkout

4. Display the total bill amount on the LCD screen.
5. Provide a payment option (manual/digital payment).
6. Upon successful payment:

o Send email confirmation of the purchase.

o Reset the cart' s inventory for the next user.

Step 6: System Termination

If shopping is complete, disconnect from the cloud and shut down the system.

C. Implementation

1) System Initialization

• Power ON the system

. • Initialize RFID reader, ultrasonic sensor, LCD, buzzer, and NodeMCU (ESP8266).

• Establish connection with the UBIDOTS IoT platform.

2) Product Detection & Tracking

• RFID reader scans product RFID tags when added/removed.

• Retrieves product name, price, expiry date from the database.

• Updates cart inventory and displays details on LCD screen.

3) Expiry Date Verification

- Compares expiry date with the current date.
- If expired:
  - o Triggers buzzer alert.
  - o Displays a warning on LCD.
  - o Sends an alert notification via UBIDOTS.

4) Cloud Communication & Notifications

- NodeMCU (ESP8266) updates real-time data to UBIDOTS
- . • Sends email alerts for:
  - o Product expiry warnings.
  - o Special offers/promotions.
  - o Social distancing violations.

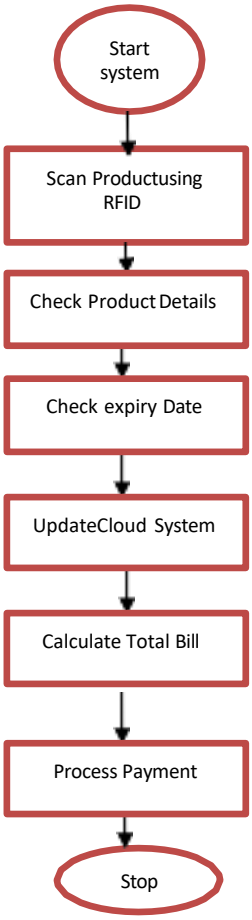

Fig. 2. Implimentation of the flow chart at Vehicle

5) Automated Billing & Checkout

- The system calculates the total bill automatically.
- Displays bill amount on LCD screen.
- Provides manual/digital payment options.
- After successful payment
  - o Sends email confirmation.
  - o Resets the cart for the next customer

6) System Termination

- Disconnects from UBIDOTS IoT cloud.
- Resets and shuts down the system

4. EXPERIMENTAL RESULTS

This figure 3 showcases the integration of RFID technology in the smart shopping cart, enabling automatic product scanning and tracking. The RFID reader identifies items placed in the cart, ensuring a seamless shopping experience.

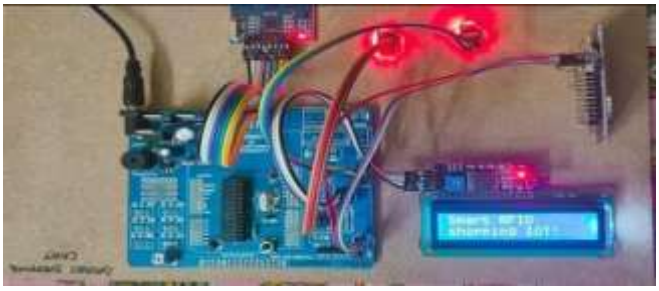

Fig. 3. Showing Smart RFID shopping IOT

Figure 4 showing the LCD screen on the smart cart confirms the store name, "DMART, Puttur," ensuring that the cart is correctly initialized within the store' s network.

Fig. 4. Display the Shopping cart name that DMART, Puttur

Figure 5 showing Upon adding 1 kg of Undhal to the cart, the system detects and displays the item's details, including the weight and price, ensuring accurate billing.

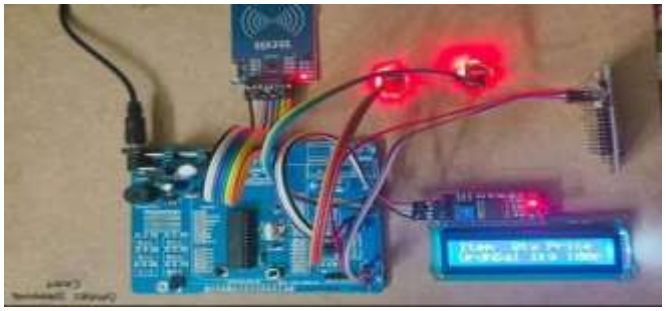

Fig. 5. Showing Undhal 1Kg for 100 Rs

Figure 6 showing When a 1-liter bottle of palm oil is added, the RFID scanner updates the cart display with the product name and price, verifying successful item recognition.

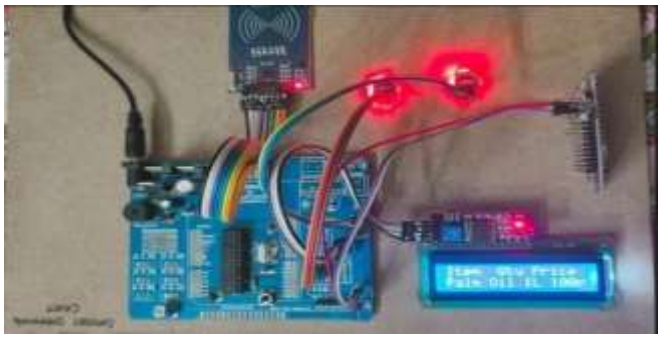

Fig. 6. Showing Palm oil 1 ltr item price 100 rs

Figure 7 Showing The cart' s system recognizes 1 kg of carrots and updates the digital display with the corresponding price, adding it to the total bill.

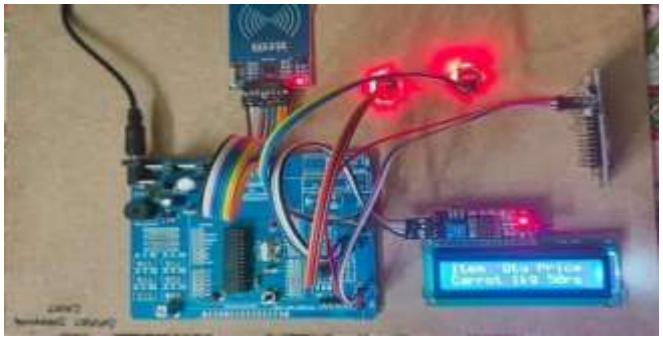

Fig. 7. Showing Carrot item 1 kg 50rs

Figure 8 Showing The system successfully detects a 25 kg bag of rice and logs it into the bill, confirming the correct price.

Fig. 8. Showing Rice item 25 kg price 1000 rs

Figure 9 Showing As a non-grocery item, the book is scanned and added to the cart, demonstrating the versatility of the RFID-based tracking system

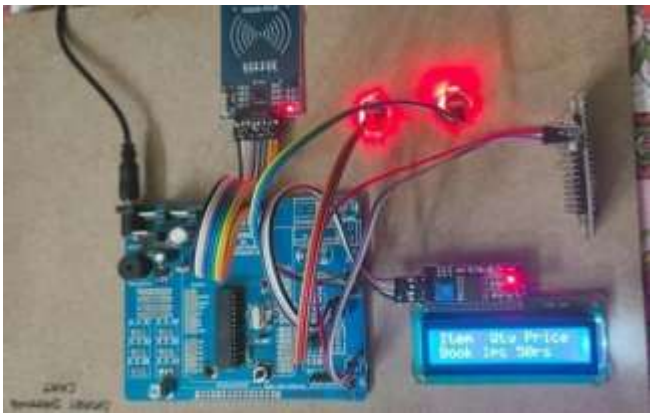

Fig. 9. Showing Book item price 50rs

This figure 10 confirms that a sports bat is scanned and displayed correctly on the system, highlighting the cart's capability to track various product categories.

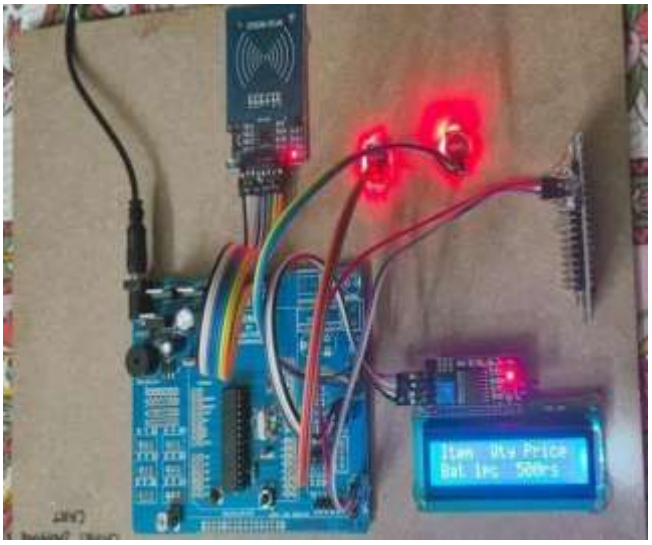

Fig. 10. Showing bat item price 500 rs

This figure 11 shwoing The smart cart scanner detects a biscuit packet, displaying the product details on the screen.

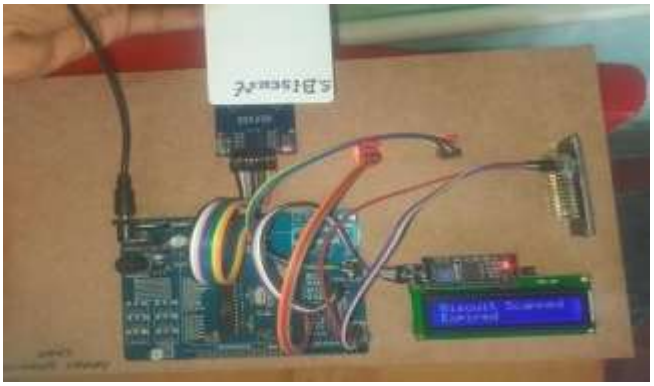

Fig.11.showing Biscuit scanned on scanner

Ths figure 12 showing A ball is scanned, and its details are reflected in the cart's system, showing that the RFID scanner efficiently detects different product types

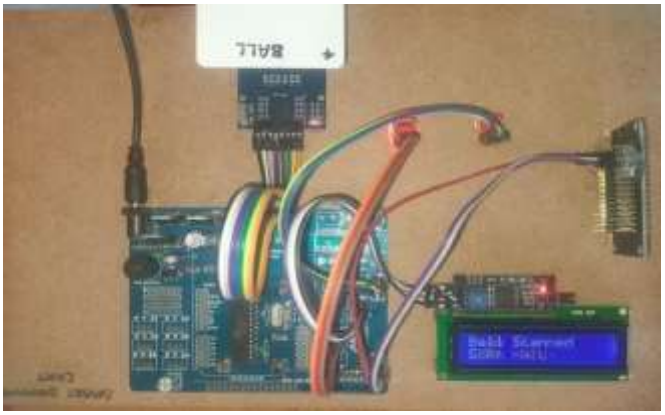

Fig. 12. Showing Ball item on Scanner

This figure 13 showing A second scan of carrots verifies that the system consistently identifies and processes previously scanned products

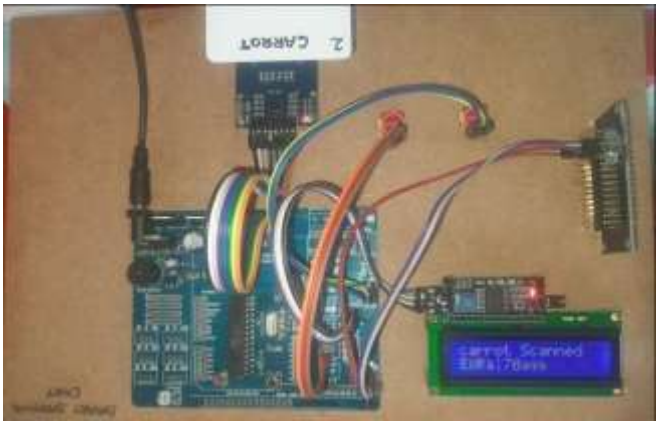

Fig. 13. Showing Carrot item on scanner

Figure 14 shwoing After all selected items are scanned, the system automatically generates a bill, ensuring a hassle-free checkout experience.

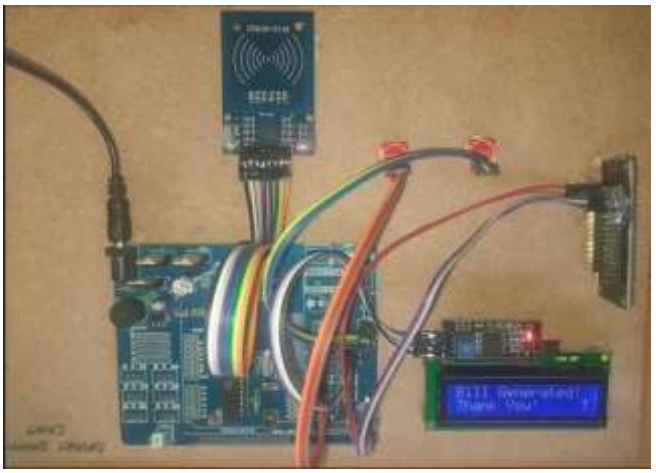

Fig. 14. Showing that bill generated

This figure 15 shwoing After digital payment or adjustments, the remaining bill balance of ₹140 is displayed, helping customers track their spending.

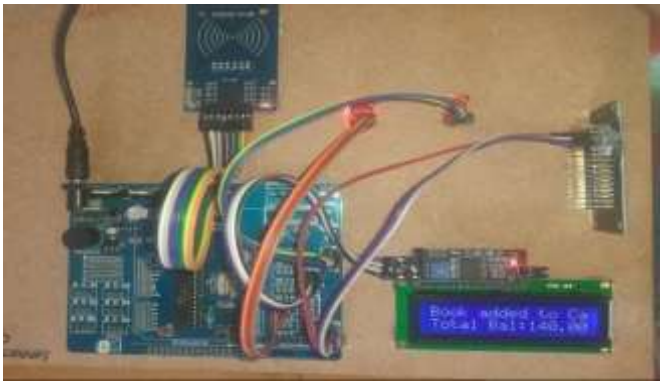

Fig. 15. Shwoing Bill Balance on 140 rs

The bill summary shown in fig.16, including itemized details and final balance, is uploaded to the IoT cloud (UBIDOTS). Customers receive real-time billing information through notifications, enabling easy payment and record-keeping.

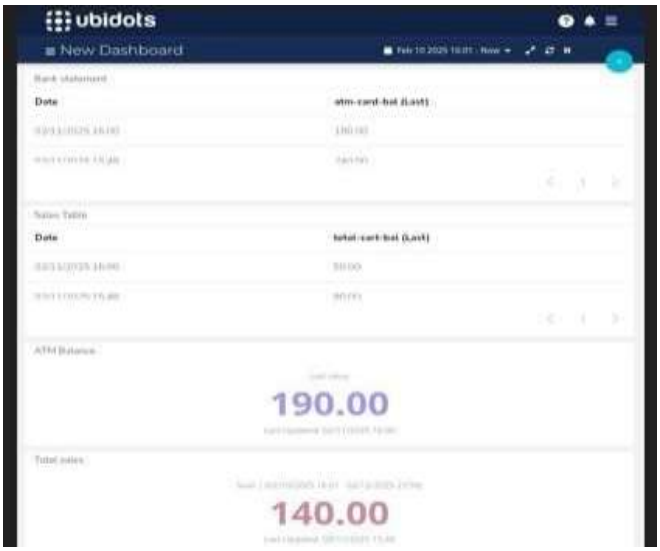

Fig. 16. Showing Bill Balance details in IOT

5. CONCLUSION AND FUTURE SCOPE

The implementation of IoT-driven smart shopping carts has revolutionized the retail experience by integrating automation, real-time monitoring, and intelligent billing systems. This literature survey highlights various advancements in smart shopping trolley systems, including RFID-based product tracking, AI-driven recommendations, automated billing, and real-time inventory management. These innovations have significantly enhanced shopping efficiency, customer convenience, and security. Additionally expiry date detection, and mobile application integration have further improved user safety and the overall retail experience. Despite these advancements, challenges such as scalability, cybersecurity risks, and system reliability remain key areas for improvement. In future Implementing AI- powered image recognition for seamless product identification and billing, reducing dependency on RFID tags.

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