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RFID Based Smart Trolley for Theft Detection

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ABSTRACT: In recent years, automation in retail environments has become increasingly essential to enhance customer experience and operational efficiency. This project presents the design and development of an RFID-based Smart Trolley system with Theft Detection, aimed at streamlining the shopping process and reducing the risk of theft in supermarkets. The smart trolley is equipped with an RFID reader, which scans the RFID tags attached to each product as it is added to the cart. The product information is simultaneously displayed on an LCD screen and updated in a centralized billing system, enabling real-time monitoring and reducing the need for traditional checkout lines. A load cell is integrated to measure the total weight of items in the trolley, ensuring consistency between the scanned products and the physical contents, thereby enabling a basic form of theft detection. Additionally, a Wi-Fi module is used to send billing information to a cloud service or mobile application, providing transparency and convenience to both customers and store management. This system minimizes human intervention, increases billing accuracy, and improves security against shoplifting, thereby offering a comprehensive solution for smart retail environments.

I. INTRODUCTION

In modern retail, automation is key to improving efficiency and customer convenience. A major challenge is theft and billing accuracy, which traditional trolleys can't address. This project proposes an **RFID-based Smart Trolley** that scans RFID-tagged products in real time using an embedded reader. At checkout, it compares scanned items with the bill, flagging discrepancies to prevent theft. Security features like alarms, smart locks, and Telegram alerts can notify staff instantly. The system also speeds up checkout, reduces manual scanning, and enhances inventory accuracy. Powered by cost-effective Arduino microcontrollers and optional load cells for weight verification, it offers a smart, secure solution for modern supermarkets.

II. LITERATURE SURVEY

Smart Shopping Cart Using RFID by Valte, Pathan, and Tonage (2022) proposes an IoT-based system to streamline shopping. RFID tags on products are read by an RFID reader connected to an Arduino, with data sent via Bluetooth to a mobile app. The app displays item details and total cost in real time, reducing manual billing and checkout delays. While focused on convenience and efficiency, the system lacks theft detection features. This study showcases the potential of combining RFID and IoT for smarter, faster retail experiences.

Smart Shopping Trolley Using RFID and IoT by Kollu et al. (2021) introduces an Arduino-based system with NodeMCU ESP8266, RFID, and an LCD display to automate billing and reduce checkout times. As customers scan RFID-tagged items, the total cost updates in real time on the screen. The system allows easy addition/removal of items and uses IoT for wireless data handling, with potential for cloud integration. While it enhances shopping convenience and reduces queues, it lacks theft detection or security features, leaving room for future improvements.

ISA: An Intelligent Shopping Assistant by Lai, Bui, and Lipka (2020) presents a mobile-based assistant that enhances in-store shopping using computer vision, speech processing, and NLP. Customers can scan barcodes or take pictures to identify products, engage in conversations for info, and receive personalized recommendations. Unlike RFID systems focused on tracking and billing, ISA prioritizes customer interaction and support, offering a personalized, AI-driven shopping experience without theft detection features.

Grab: Fast and Accurate Sensor Processing for Cashier-Free Shopping by Liu et al. (2020) presents a multi-sensor system enabling cashier-free retail. It uses pose tracking, face recognition, and arm movement detection to link shoppers with selected items. By fusing data from cameras, weight sensors, and RFID tags, Grab ensures high accuracy even in crowded settings. Unlike typical RFID-based smart carts, Grab focuses on precise customer-item association and theft prevention, offering a seamless and secure shopping experience.

III. METHODOLOGY

The Smart RFID and Anti-Theft Security System uses an ESP32 microcontroller to integrate RFID-based authentication, theft detection via a load cell, and real-time IoT communication. When a user scans an RFID tag, the ESP32 verifies its authenticity and displays the result on an LCD. Simultaneously, a load cell monitors the weight of a protected object, and any unauthorized removal triggers a buzzer alarm. The system connects to Wi-Fi and uses platforms like Arduino IoT Cloud or Blynk to enable remote monitoring, while critical alerts—such as theft or invalid access—are instantly sent to the user via Telegram. Powered by a 12V supply, this system offers a compact, real-time, and remotely accessible solution for secure asset management.

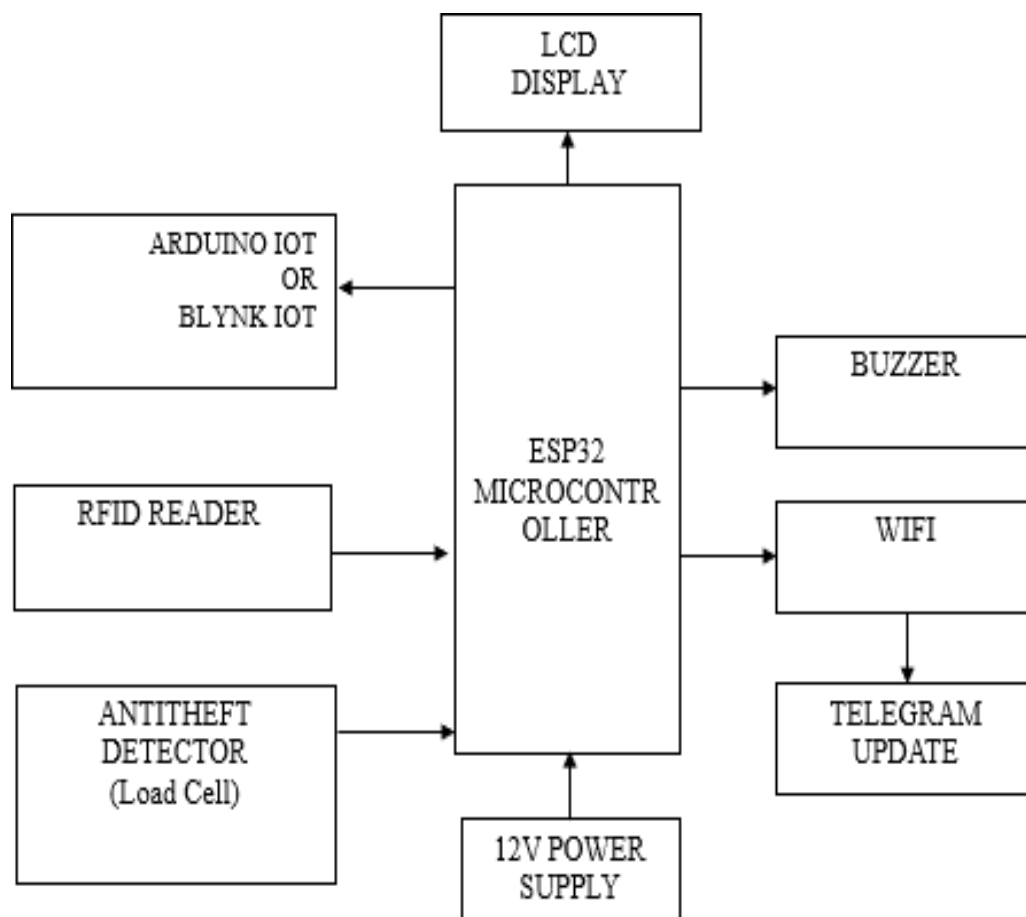


Fig: Block Diagram

The RFID module ensures only authorized users can access or interact with protected assets, making it ideal for secure zones such as lockers, storage shelves, or museum displays. The load cell, typically paired with an HX711 amplifier, continuously senses weight changes, acting as the anti-theft sensor. The buzzer provides an immediate local alert when a threat is detected, while the LCD shows real-time system feedback.

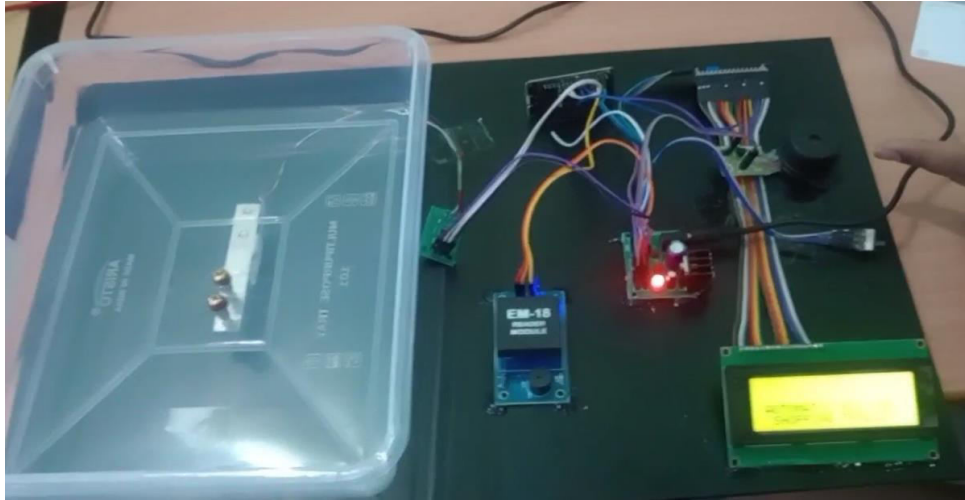


Fig: RFID Based Trolley

IV. EXPERIMENTAL RESULTS

The result of an RFID-based smart trolley for theft detection project demonstrates improved security and efficiency in retail environments. Each product is tagged with an RFID, and as customers add items to the trolley, the system automatically updates the cart inventory. If a customer tries to exit the store without proper billing, the RFID readers at the exit detect unpaid items and trigger an alert. This reduces shoplifting and ensures accurate billing. The system also helps reduce queue time at billing counters, enhancing the shopping experience. Overall, it offers a practical solution for loss prevention and customer convenience.

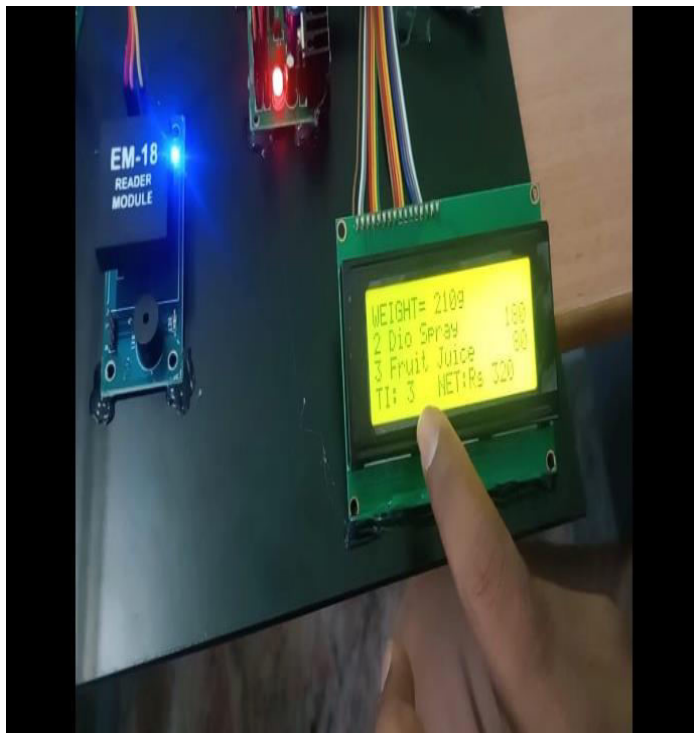


Fig: Product Billing in LCD

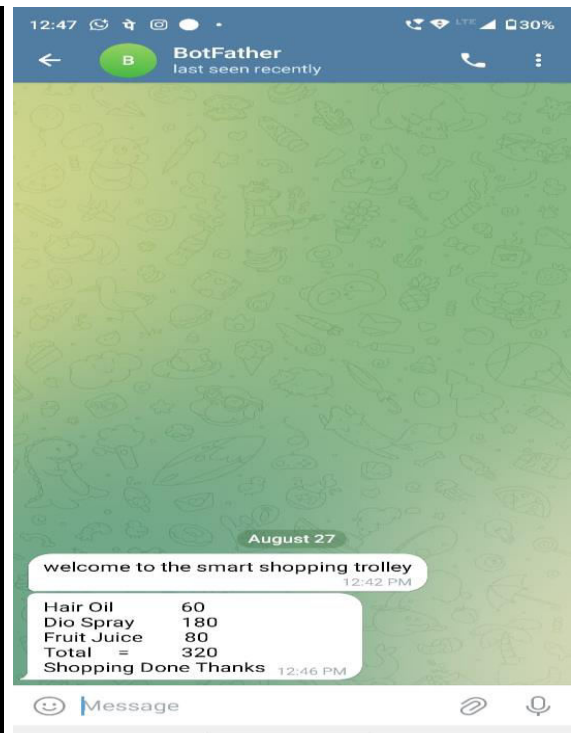


Fig: Product Billing in Telegram

V. CONCLUSION

The **Smart Cart system using ESP32 WROOM** integrates RFID, IoT, and cloud automation to enhance shopping efficiency, security, and convenience. It enables real-time billing, theft prevention, and digital monitoring, reducing checkout time and manual errors. By automatically scanning items, it streamlines the shopping process while ensuring all products are accounted for, acting as a theft deterrent. Though promising, its success relies on robust design, quality hardware, and effective integration. As RFID technology advances and costs drop, such smart systems are set to become more scalable and widespread in modern retail.

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