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Smart Shopping Trolley with Automated Billing and Theft Prevention

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Abstract: *In modern retail stores and supermarkets, customers often face long billing queues, disorganized trolley storage, and increased chances of theft or unpaid product removal. Conventional shopping trolleys do not provide any automated billing mechanism or security control, which results in time wastage at checkout counters and poor shopping experience. To overcome these issues, this paper presents the design and implementation of a Smart Shopping Trolley with Automated Billing and Theft Prevention.*

The proposed system consists of a trolley with four secure compartments that remain locked until the user scans an item. Once an item barcode is scanned, the corresponding compartment unlocks automatically using a servo motor mechanism. All scanned items are simultaneously updated to a cloud-based billing system (Firebase), enabling real-time bill calculation. The customer can view cart details and total bill on a mobile application and complete payment using a QR code. Additionally, the trolley provides theft prevention using a buzzer alert system that activates if any compartment is forcefully opened or if the trolley attempts to exit without completing payment.

This system improves shopping efficiency by reducing billing time, ensures organized item placement, and enhances store security. The Smart Shopping Trolley provides a practical and scalable solution for modern retail automation using IoT and embedded systems..

Keywords: Smart Shopping Trolley, Automated Billing, Barcode Scanner, IoT, ESP32, Firebase, Theft Prevention, Cloud Billing

I. INTRODUCTION

Supermarkets and retail stores have become a major part of daily life. However, the traditional shopping process still includes challenges such as long queues at billing counters, manual scanning by cashiers, and difficulty in managing different types of items inside the trolley. Customers often waste time waiting for checkout, especially during weekends and festivals. Along with this, theft and unpaid product removal is also a serious issue for retail stores.

To improve the shopping experience, automation in billing and security is required. IoT-based smart shopping solutions can help reduce checkout time and provide a more efficient shopping method. Many smart cart systems focus only on billing automation, but they lack proper theft prevention and secure storage.

The Smart Shopping Trolley with Automated Billing and Theft Prevention aims to solve these problems by introducing secure compartment unlocking after scanning, real-time cloud billing, QR payment support, and buzzer-based theft detection.

II. SYSTEM ARCHITECTURE

The proposed system is designed as an IoT-based automated shopping trolley that integrates hardware components with cloud services for billing and monitoring. The system ensures that each item is scanned before it is stored, which prevents theft and ensures accurate billing.

The platform allows users to:

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- Scan product barcodes using a scanner
- Automatically unlock the correct compartment for storage
- View running bill in real time through cloud integration
- Make payment using QR code via mobile application
- Trigger buzzer alert during suspicious activities

2.1 System Architecture

The system follows a modular architecture consisting of four main layers:

Input Layer: The input layer includes a barcode scanner module used to scan product barcodes. The scanned code is sent to the ESP32 microcontroller for processing.

Control Layer (ESP32 Microcontroller): ESP32 acts as the main controller responsible for reading barcode values, controlling servo motors for locking/unlocking, updating cloud database (Firebase) using Wi-Fi, and managing LED indicators and buzzer alerts.

Cloud Layer (Firebase): Firebase stores scanned item data such as item name and ID, quantity and price, and total bill amount. This enables real-time billing and transparent tracking for both customers and store management.

Output Layer (Mobile App + Indicators): The output layer provides mobile app display for cart details and bill, QR code generation for payment, LED indicators showing lock/unlock status, and buzzer alerts for theft detection.

2.2 Functional Modules

Barcode Scanning Module: Scans product barcode and sends data to ESP32.

Compartment Locking/Unlocking Module: Four compartments unlock automatically after scanning using servo motors.

Cloud Billing Module: Every scanned item is updated to Firebase and bill is calculated in real time.

Theft Detection Module: Activates buzzer alert for forced opening or unpaid exit.

Mobile Application Module: Displays scanned items, total bill, QR code payment, and payment status.

III. TECHNOLOGY USED

3.1 Software Requirements

Programming Language: Embedded C/C++

IDE: Arduino IDE

Cloud Platform: Firebase

Mobile Application: Android (Java/Kotlin) / Flutter

Database: Firebase Realtime Database / Firestore

3.2 Hardware Requirements

ESP32 Microcontroller

Barcode Scanner Module

Servo Motors (for locks)

LED Indicators

Buzzer

Rechargeable Battery Pack

Trolley Frame with 4 compartments

Mobile Holder / Display unit

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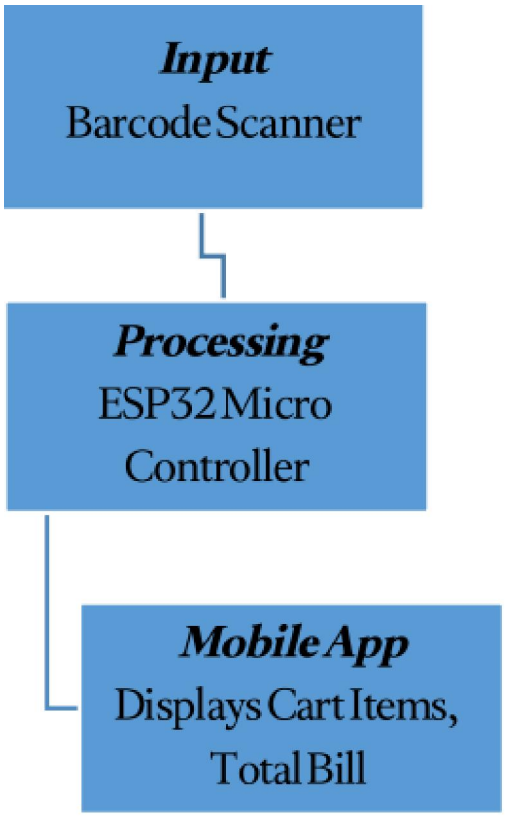

IV. WORKING METHODOLOGY

The working of the Smart Shopping Trolley begins when the customer scans a product barcode. The barcode scanner reads the item code and sends it to the ESP32 microcontroller. ESP32 verifies the item and identifies the correct compartment category.

After successful scanning:

1. The related compartment unlocks using servo motor
2. LED indicator shows unlocked status
3. Item details are uploaded to Firebase cloud
4. The mobile app updates the running bill in real time
5. Customer can continue shopping and scan more items

At the end of shopping, the customer completes payment using the QR code generated in the mobile app. Once payment is successful, the trolley becomes authorized to exit. If the trolley exits without payment or if any compartment is opened forcefully, the buzzer alarm is triggered, ensuring theft prevention.

V. PERFORMANCE EVALUATION

The system performance can be evaluated using parameters such as:

- Time saved compared to traditional checkout billing
- Accuracy of scanned items and billing
- Response time of compartment unlocking
- Cloud update speed and real-time synchronization
- Theft alert detection accuracy

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The proposed trolley significantly reduces billing queue time and improves the overall shopping experience. The compartment-based locking mechanism provides an additional security layer, preventing unpaid item removal and increasing customer trust.

VI. APPLICATION

The Smart Shopping Trolley system can be used in:
- Supermarkets and malls
- Retail stores and shopping centers
- Wholesale grocery markets
- Automated self-service stores
- Smart retail and IoT-enabled shopping environments

VII. FUTURE SCOPE

The system can be improved further by:
- Adding RFID support for faster scanning
- Integrating weight sensors to validate item placement
- Supporting multiple payment gateways (UPI, card, wallet)
- Implementing AI-based product recognition using camera
- Adding GPS or exit gate verification for better theft prevention
- Enhancing mobile app with customer history and offers

VIII. CONCLUSION

The Smart Shopping Trolley with Automated Billing and Theft Prevention provides an efficient and secure solution for modern retail shopping. By integrating barcode scanning, compartment locking, cloud-based billing, and buzzer-based theft detection, the system reduces billing time, improves storage organization, and prevents unpaid item removal. This project demonstrates how IoT and automation can transform traditional retail systems into smarter, faster, and safer shopping experiences.

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