Grenze International Journal of Engineering and Technology, June Issue

RFID based Self Billing Supermarket with Payment Android App

Dheeraj P Raj[1], Jasira P P[2], Joslin Elizabath Thomas[3], Vishnu Prakash K G[4] and Adarsh Dilip Kumar T P[5]
[1-5]Department of Computer Science and Engineering, Vimal Jyothi Engineering College, Chemperi, Kannur, Kerala, India
Email: dheerajdhyan@gmail.com, jasira097@gmail.com, joslinelizabaththomas@gmail.com, vishnu2004prakash@gmail.com, adarshdilipkumar@vjec.ac.in

***Abstract*— In order to improve customer satisfaction and cutdown on checkout times, automated and effective billing systems are becoming more and more necessary as retail firms expand quickly. Long lines and billing problems are the results of traditional barcode based billing systems, which need manual scanning and human intervention. In order to automate product recognition, billing, and theft prevention, this article proposes an RFID based self billing supermarket system that is coupled with an Android payment application. Every product has a unique RFID tag implanted in it, and as things are added or removed, an RC522 RFID reader installed on a smart cart instantly recognizes them. Through Wi-Fi, an ESP32 microcontroller synchronizes cart data with the Firebase Realtime Database and processes tag data. Digital payment capabilities and realtime bill presentation are offered by a mobile application. To further improve security, an exit gate RFID verification system makes sure that unpaid items cause an alarm. The suggested system exhibits an economical, expandable, and effective solution that may be implemented in contemporary smart retail settings.**

***Index Terms*— RFID, ESP32, Firebase, IoT, Retail Automation, Theft Detection.**

I. INTRODUCTION

The growing need for efficiency, automation, and improved customer experience is driving the retail sector's rapid digital transformation. Large volumes of consumers are served everyday in modern supermarkets, and barcode scanning based traditional billing systems can lead to lengthy checkout lines, longer wait times, and unhappy customers. Manual billing counters generate bottlenecks during peak hours, resulting in lost income and operational inefficiencies. For each product, barcode based systems need human intervention and line of sight scanning. In addition to taking time, this procedure raises the possibility of billing problems. Furthermore, inventory management is less effective with traditional systems since they do not offer real time synchronization between cart contents, billing counters, and inventory databases. One potential remedy for these restrictions is Radio Frequency Identification (RFID) technology [1]. RFID uses radio waves to automatically detect tagged objects, unlike barcodes,which need direct line of sight scanning. An intelligent and fully automated billing ecosystem can be created by combining RFID with cloud based databases and IoT enabled microcontrollers. Scalable smart retail solutions have been made possible by recent developments in embedded systems, inexpensive microcontrollers like the ESP32, and real time cloud platforms like Firebase. Through Wi-Fi networks, these technologies enable smooth communication between mobile applications and hardware devices.

Grenze ID: 01.GIJET.12.2.171_24

In this research, we present an Android application for payments that is connected with an RFID based self billing supermarket system. RFID tags placed in every item are used by the suggested method to automatically detect products. Products are identified as they are added or withdrawn using an ESP32 microcontroller and an RC522 RFID reader in a smart shopping cart. The billing data is shown on a mobile application and immediately synchronized with the Firebase Realtime Database. To further improve security and reduce theft, an RFID enabled exit gate verification system makes sure that only paid items are taken out of the store. Reducing checkout time, minimizing manual involvement, improving consumer convenience, and enhancing store security are the goals of the suggested solution. The prototype's efficacy in delivering automated transaction processing and dependable real time billing is demonstrated via experimental validation.

II. System Architecture

An edge layer, cloud layer, application layer, and security layer make up the system architecture's structure. The smart shopping cart hardware, which is part of the edge layer, is where RFID based product detection takes place. As the central processing unit, the ESP32 microcontroller controls network connection, billing logic, and RFID readings.Firebase Realtime Database is used to implement the cloud layer, allowing real time synchronization of transaction records, inventory updates, and cart data. Firebase guarantees scalability over numerous carts and users as well as low latency data access. An Android mobile application with an interactive user interface makes up the application layer. Consumers can safely complete payments, view the items in their carts, and monitor the entire bill. The exit gate RFID verification system, which is part of the security layer, prevents theft by comparing detected objects with authorized billing records.

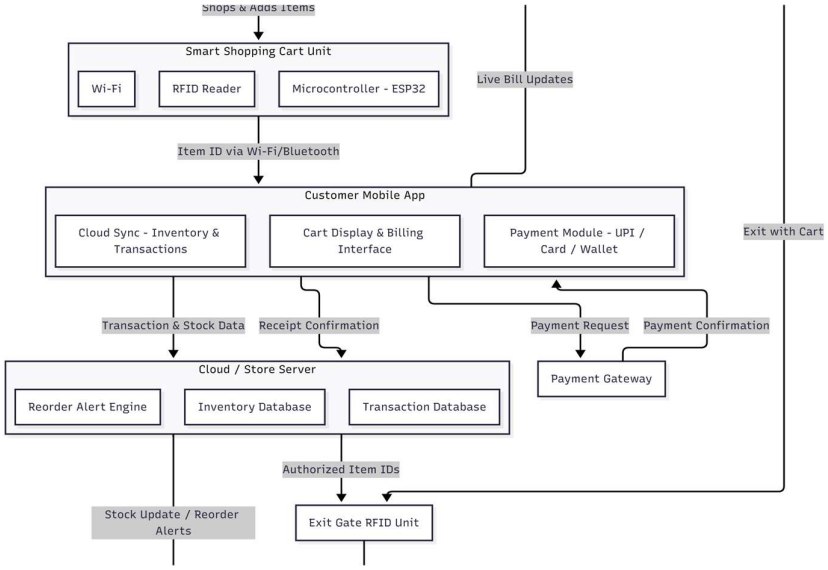

Figure 1. Architecture Diagram

III. Implementation

An ESP32 microcontroller coupled with an MFRC522 RFID reader is used to implement the system. The Arduino IDE is used to create the ESP32 firmware, which has logic for RFID detection, billing calculation, Firebase connection, andLED and buzzer based system feedback. The backend is Firebase Realtime Database, which holds transaction records, product details, and cart data. Multiple user sessions and real-time updates are supported by the database structure. A rapid application development framework is used to create the Android application, and Firebase's SDK is used to connect to it. Reliable billing performance and seamless user engagement are ensured by the system's real time operation with low latency.

IV. Results and Discussions

The prototype's experimental evaluation shows a notable improvement over conventional checkout systems. The technology instantly updates billing information and accurately recognizes the addition and removal of items.

Customers use the mobile application to pay directly, which significantly cuts down on checkout time. By efficiently identifying unpaid items, the exit gate RFID verification method improves store security. Because low cost components like ESP32 and RC522 are used, the system is affordable and suitable for real world implementation. Comparing the suggested solution to traditional barcode based billing, the average checkout time was lowered by about 50–60%.

V. Conclusion

This paper presented an RFID based smart self billing supermarket system integrated with an Android payment application and cloud backend. By automating product detection, billing, and payment processes, the system significantly reduces checkout time and human effort while improving accuracy and security. The proposed solution demonstrates a low cost, scalable, and efficient approach to modern retail automation and smart shopping environments.

Acknowledgement

The authors would like to express their sincere gratitude to the Department of Computer Science and Engineering, Vimal Jyothi Engineering College, for providing the necessary facilities and academic support to carry out this work. We extend our heartfelt thanks to our project guide for valuable guidance, constructive suggestions, and continuous encouragement throughout the development of this Shopping cart Application. We also acknowledge the support and motivation provided by our faculty members, peers, and families, which greatly contributed to the successful completion of this project.

References

[1] A. Q. Abd Alhasan, M. F. Rohani, and M. S. Abu-Ali, "Ultra-lightweight mutual authentication protocol to prevent replay attacks for low-cost rfid tags," IEEE Access, vol. 12, pp. 50 925–50 934, 2024.

[2] A. Khalid, M. I. Zulfiqar, A. Siddig, M. J. Nawaz, and S. Saay, "Ai-driven smart shopping carts with real-time tracking and inventory forecasting for enhanced retail efficiency," IEEE Access, 2025.

[3] J. Wang, "Enhancing the e-commerce shopping experience with iot enabled smart carts in smart stores," Discover Internet of Things, vol. 5, no. 1, p. 35, 2025.

[4] S. Lopez-Soriano, J. Meli ´ a-Segu ` ´ı, and J. P. Granados, "Uhf rfid wristbands: A long-range, durable, flexible, and low-cost tag antenna design," IEEE Journal of Radio Frequency Identification, vol. 8, pp. 125–133, 2024.

[5] S.-R. Yan, S. Pirooznia, A. Heidari, N. J. Navimipour, and M. Unal, "Implementation of a product recommender system in an iot-based smart shopping using fuzzy logic and apriori algorithm," IEEE Transactions on Engineering Management, vol. 71, pp. 4940–4954, 2022.

[6] C. Heuer, V. Jung, and S. Brell-Cokcan, "A hardware-based rfid identification and tracking system for components in digitalised construction logistics," Developments in the Built Environment, p. 100726, 2025.

[7] L. Li, P. Tian, J. Dai, and F. Miao, "Design of agricultural product traceability system based on blockchain and rfid," Scientific Reports, vol. 14, no. 1, p. 23599, 2024.

[8] Z. Wang, B. Guo, Q. Wang, D. Zhang, and Z. Yu, "Mobieye: An efficient shopping-assistance system for the visually impaired with mobile phone sensing," IEEE Transactions on Human-Machine Systems, vol. 53, no. 5, pp. 865–874, 2023.

[9] A. Galdelli, R. Pietrini, A. Mancini, and P. Zingaretti, "Retail robot navigation: A shopper behavior-centric approach to path planning," IEEE Access, vol. 12, pp. 50 154–50 164, 2024.

[10] C. Sharma, S. Ghosh, K. A. Shenoy, and G. Poornalatha, "A novel multiclass object detection dataset enriched with frequency data," IEEE Access, vol. 12, pp. 85 551–85 564, 2024.

[11] M. Jeong, D. Kim, and J. Paik, "Practical abandoned object detection in real-world scenarios: Enhancements using background matting with dense aspp, " IEEE Access, vol. 12, pp. 60 808–60 825, 2024.