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FASTBAG: AN RFID-BASED IOT DEVICE FOR SEAMLESS QUICK EVERYDAY SHOPPING

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ABSTRACT

With the increasing demand for faster and more efficient retail experiences, conventional billing systems continue to pose challenges such as long queues and delays, particularly for customers purchasing a small number of items. This paper proposes a novel RFID-based smart shopping solution specifically designed for daily buyers and quick shoppers who require rapid check-in and checkout processes. The system introduces a compact, clip-on device, similar in concept to electronic toll collection systems such as FASTag, which can be attached to a customer's shopping bag. The proposed device integrates an RFID reader to automatically detect products added to or removed from the bag, maintaining a real-time virtual cart through seamless synchronization with a mobile application. Each product is equipped with a unique RFID tag to ensure accurate identification and tracking. Unlike traditional smart cart systems aimed at bulk or monthly shopping, this solution is optimized for low-item, high-frequency purchases, enabling minimal interaction and significantly reduced transaction time. The system employs geofencing to detect store entry and exit points, facilitating automatic billing upon exit. The total purchase amount is deducted directly from the user's digital wallet, eliminating the need for manual checkout. Digital receipts are generated and shared with both customers and retailers. Additionally, a dual-application framework is implemented, comprising a customer interface for expense tracking and wallet management, and a retailer interface for monitoring sales and transaction analytics. To ensure security, an anti-theft mechanism is incorporated wherein unpaid or unregistered items retain active RFID status and are detected at the exit gate, triggering an alert system. The proposed

solution aims to deliver a frictionless, fast, and secure shopping experience tailored for modern consumers seeking convenience in everyday retail transactions.

KEY WORDS: RFID, Smart Shopping, Quick Checkout, FASTag-like System, Geofencing, IoT, Retail Automation, Digital Wallet, Anti-theft System.

1.INTRODUCTION

Checkout inefficiency remains a persistent challenge in large-scale retail environments. Barcode-based point-of-sale systems, which necessitate the sequential manual scanning of each purchased item, create bottlenecks that diminish both customer satisfaction and store throughput. RFID technology offers a compelling alternative, enabling the simultaneous, contactless identification of multiple tagged items and dramatically reducing the time required for transaction processing. A growing body of research has explored the integration of RFID and IoT frameworks into shopping environments. The predominant approach embeds readers and processing units within shopping carts or purpose-built bags. While functional, this model introduces hardware dependency, restricts scalability, and fails to accommodate shoppers who prefer using their own accessories. To address these shortcomings, this paper presents a compact clip-on device designed to operate with any personal bag, offering a flexible and cost-efficient billing alternative.

2. LITERATURE SURVEY

1. Rfid and zigbee-integrated smart cart billing

One category of smart cart systems employs rfid readers in conjunction with zigbee wireless communication to Facilitate automated item detection and billing. Each cart Is outfitted with a microcontroller, reader unit, and local Display module. When products bearing rfid tags enter The cart, their details are transmitted to a central billing Server. Although this configuration effectively reduces. Queue formation at checkout counters, it is fundamentally Dependent on a managed fleet of equipped carts and Supporting network infrastructure, limiting its Applicability in resource-constrained or decentralised Retail settings [1]X

2. Lcd-based smart cart with RFID

An alternative approach involves rfid-enabled carts that Compute and display the running bill on an onboard lcd Screen. As customers add items to the cart, the system Retrieves product details and updates the total in real time. This design improves transactional transparency for Shoppers; however, the requirement for a specially Manufactured cart restricts its adoption.

Portability Remains a fundamental limitation, as users cannot replicate This experience outside the designated cart environment. [2]

3. Dynamic billing with item removal detection

A more sophisticated iteration of rfid-based cart systems Incorporates bidirectional item monitoring, enabling the Bill to update dynamically when products are both added To and removed from the cart. Integration with digital Payment gateways further enhances the checkout Workflow. Despite these improvements, this system still Mandates the use of vendor-specific smart carts, creating An accessibility barrier for shoppers who do not have or Wish to use such equipment.

4. Iot-augmented smart shopping platforms

A broader class of solutions integrates iot connectivity Into retail billing frameworks, enabling cloud-based data Aggregation, remote monitoring, and multi-device Synchronisation. These platforms enhance operational Scalability and allow store managers to track inventory and Transaction data in real time. Nevertheless, the increased Architectural complexity raises both deployment costs and Maintenance requirements, making such systems less Practical for mid-scale retailers or emerging markets.

5. Comparative analysis

Table i summarises the key features and limitations of the Reviewed systems alongside the conventional barcode Approach.

COMPARISON OF EXISTING SYSTEMS WITH PROPOSED SYSTEM (FASTBAG)

System	Primary Feature	Key Limitation	Infrastructure Requirement	Portability
RFID + ZigBee Cart	Wireless auto-billing	Requires dedicated cart fleet	High (Needs smart carts)	Not Portable
LCD-Based RFID Cart	Real-time cost display	No portability	High (Needs LCD carts)	Not Portable
Dynamic Billing Cart	Add/remove item detection	Cart-dependent operation	High (Needs smart carts)	Not Portable
IoT Cloud System	Scalable remote monitoring	High cost and complexity	Very High (Cloud + IoT Infrastructure)	Not Portable
Barcode POS System	Low infrastructure cost	Manual and time-intensive	Low (Barcodes + POS Terminal)	Not Portable
Proposed FastBag System (Clip-on Device)	Clip-on, portable smart billing with real-time updates	RFID cost and signal challenges (needs optimization)	Low to Medium (RFID tags + Readers)	Highly Portable

Note: Infrastructure Requirement indicates overall deployment complexity and hardware investment.

FIG I. COMPARISON OF EXISTING SMART SHOPPING SYSTEMS.

3. RESEARCH GAPS IDENTIFIED

A review of the existing literature reveals several recurring constraints that limit the broader

applicability of current smart shopping systems:

- The overwhelming majority of implementations are architected around dedicated shopping carts or purpose-engineered bags, creating an inherent dependency on vendor-supplied hardware and excluding shoppers who use personal accessories.
- Existing systems lack portability; they are confined to the specific store environments in which they are deployed and cannot be extended to other retail contexts without significant hardware re-investment.
- Security mechanisms for preventing unauthorized item removal or tag manipulation remain insufficiently addressed in the literature.
- There is a noticeable absence of solutions that prioritise the user's own accessories as the primary interface, an approach that could substantially reduce system cost while improving adoption

IV. PROPOSED SYSTEM: CLIP-ON SMART BILLING DEVICE

A. Concept Overview

The proposed system introduces a compact, lightweight clip-on module designed to attach to any personal bag—whether a handbag, backpack, or tote—there by decoupling the billing functionality from any specific shopping accessory. By embedding the necessary hardware within a portable, self-contained unit, the system eliminates the need for retailers to maintain dedicated cart infrastructure while providing shoppers with a consistent and seamless billing experience regardless of the bag they carry.

B. Working Principle

The working principle of the proposed system is based on RFID-enabled automatic item detection, real-time processing, and wireless data synchronization. Products available in participating stores are affixed with passive RFID tags encoded with unique item identifiers, pricing information, and product descriptions. When a shopper clips the device onto their bag and begins selecting items, the onboard RFID reader continuously scans and detects nearby tag signals.The detected item data is processed locally by an embedded microcontroller, which maintains a dynamic list of selected items and computes the running total in real time. This information is transmitted to a companion mobile application through short-range wireless communication protocols such as Bluetooth Low Energy (BLE) or Wi-Fi. Simultaneously, transaction data is forwarded to a cloud-based server for secure storage, inventory updates, and payment validation. The

mobile application displays real-time cart updates, total cost, and payment status, enabling the user to monitor their purchases continuously. Upon completion of shopping, the billing process is finalized digitally through the mobile application using supported payment methods such as UPI, debit/credit cards, or wallet balance. Once the payment is successfully verified, a digital receipt is generated and shared with both the customer and the retailer, eliminating the need for traditional checkout counters and manual billing procedures [7].

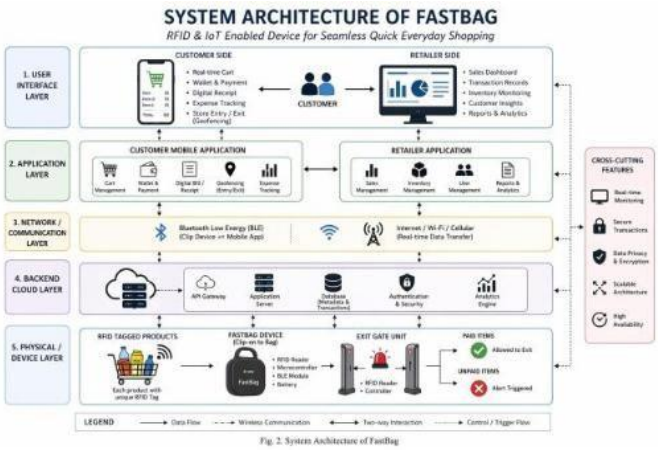


Fig. 2. System Architecture of FastBag

FIG 2. SYSTEM ARCHITECTURE OF FASTBAG.

C. Key Features

The proposed clip-on smart billing device offers several distinctive features: Clip-on Form Factor: Universally compatible with different types of personal bags, ensuring flexibility and ease of use. Real-Time Billing: Continuous visibility of total cost as items are added or removed from the bag. Wireless Connectivity: Seamless communication between the device, mobile application, and cloud backend. Cart Independence: Eliminates reliance on shopping carts, making it suitable for compact stores and open retail environments. Low Hardware Footprint: Cost- effective solution compared to infrastructure-heavy smart cart systems. Fast Checkout Experience: Enables quick entry and exit without manual billing, ideal for daily and low-item shoppers.[7]

3. ADVANTAGES OF THE PROPOSED SYSTEM

The proposed clip-on smart billing device offers several significant advantages over conventional and cart-based smart shopping systems, particularly for daily buyers and quick shoppers. One of the primary advantages is its device portability and independence from store infrastructure. Unlike cart- centric solutions, the proposed system operates independently of store-provided equipment, allowing customers to use the device with any personal bag. This

eliminates dependency on shopping carts and enables a consistent shopping experience across different retail environments. The system is specifically optimized for fast and low-item shopping scenarios, where customers prioritize speed and minimal interaction. By enabling real-time product detection and automatic billing, the system significantly reduces checkout time and eliminates the need for standing in queues, thereby enhancing overall customer convenience. From an economic perspective, the proposed solution offers a cost-effective alternative to existing smart cart systems. Implementing clip-on devices requires significantly lower investment compared to retrofitting shopping carts with embedded electronics and sensors. This makes the system more feasible for small and medium-scale retailers. Another key advantage is seamless and flexible shopping experience. Customers are not restricted by cart-based movement or predefined shopping paths within the store. They can shop freely using their own bags while the system continuously tracks items in the background.

4. CHALLENGES AND LIMITATIONS

Despite its conceptual advantages, several technical and operational challenges must be addressed before wide- scale deployment:

A. Signal attenuation and reading accuracy

Rfid performance may be affected by signal attenuation, especially when items are densely packed inside a bag. Materials such as metals and liquids can interfere with radio frequency signals, leading to missed or inaccurate readings. Ensuring consistent detection accuracy within enclosed and variable bag environments remains a critical challenge.

B. Tag collision and data reliability

When multiple rfid tags are present within the reader's range, simultaneous responses may lead to tag collision.This can result in incomplete or incorrect item detection if not properly managed. Implementing robust anti-collision algorithms and efficient tag-reading protocols is essential to maintain billing accuracy.

C. Security and fraud prevention

The system is vulnerable to scenarios such as intentional removal of items without proper deregistration or attempts to bypass detection. To mitigate such risks, additional mechanisms such as exit-gate rfid validation, weight sensors, or camera-based verification systems may be required to enhance security and ensure transaction Integrity [4]

D. Onboarding and deployment cost

The initial setup cost associated with tagging all products using rfid technology can be

significant, particularly for large inventories. This includes the cost of tags, readers, and system integration. Such investment may pose a barrier for small and medium-sized retailers.

E. Power and device constraints:

The clip-on device must maintain continuous operation for real-time scanning and communication while being Compact and lightweight. Balancing power consumption,battery life, and performance is a key hardware design challenge

5. FUTURE SCOPE

The proposed clip-on smart billing system presents significant potential for further enhancement through the integration of advanced technologies and expanded functionalities. Future developments can incorporate machine learning algorithms to analyze customer purchase history and shopping patterns, enabling personalized product recommendations in real time. Such intelligent features can enhance user engagement and improve the overall shopping experience. Integration with retailer inventory management systems can enable real-time stock updates based on customer interactions. This would allow automatic inventory tracking and efficient supply chain management, reducing the chances of stockouts and overstocking. The system can also be extended to support voice-enabled interaction using embedded smart assistant modules. This would improve accessibility, allowing users to interact with the system through voice commands for tasks such as checking total cost, searching for products, or confirming payments [9]. To address existing security limitations, future enhancements may include advanced anti-theft mechanisms such as Computer vision-based monitoring and multi-sensor fusion techniques combining RFID, weight sensors, and cameras. These additions can significantly improve detection accuracy and system reliability. Furthermore, as the cost of RFID technology continues to decline, the economic feasibility of large- scale deployment is expected to improve. This will make the system more accessible to a wider range of retailers, including small and medium-sized businesses. Overall, the integration of intelligent analytics, enhanced security, improved user interaction, and scalable infrastructure will further strengthen the proposed system, making it a robust and future-ready solution for modern retail environments

5. CONCLUSION

While existing rfid- and iot-based smart shopping systems have demonstrated improvements in checkout efficiency, their dependence on dedicated carts and fixed infrastructure limits their portability, flexibility, and scalability. These constraints reduce their suitability for

modern retail environments, particularly for quick and low-item shopping scenarios.

The clip-on smart billing device proposed in this paper presents a structurally distinct and user-centric approach. By functioning as an independent, portable module that can be attached to any personal bag, the system eliminates the reliance on store-specific hardware such as smart carts. This design significantly reduces infrastructure requirements while providing a consistent and seamless shopping experience across different retail environments. The proposed system emphasizes real-time item detection, automated billing, and minimal user interaction, making it highly suitable for daily buyers and fast-paced shoppers. In addition, its cost-effective deployment model makes it accessible to a wider range of retailers, including small and medium-scale businesses. Although certain challenges such as rfid accuracy, signal interference, and security mechanisms remain, these can be addressed through further technological enhancements and system optimization. With continued advancements in rfid technology and iot integration, the proposed solution holds strong potential to enhance automated retail systems and contribute to the evolution of frictionless shopping experiences.

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