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IOT-Based Smart Cart

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Abstract: In today's fast-paced world, shopping at large malls often results in long queues and billing delays. The smart shopping trolley addresses this by integrating RFID and Bluetooth technology to automate the billing process, reducing wait times and the need for staff. Each product is tagged with an RFID tag containing a unique EPC (Electronic Product Code). As items are added or removed, the RFID reader scans the tags and updates the total cost in real-time, which is displayed on an LCD screen. This helps customers track spending and stay within budget. The system includes an RFID module, microcontroller, and Bluetooth module for seamless data processing and wireless communication. When the customer presses the billing button, the total bill is transmitted to their Android app via Bluetooth, eliminating manual checkout. Unlike barcode systems, RFID supports non-line-of-sight scanning and can detect multiple items at once, improving transaction speed and accuracy. The system enhances retail automation by enabling contactless billing, reducing human effort, and increasing efficiency, security, and scalability—making it ideal for modern smart retail solutions.

Key Words: RFID, Bluetooth, Microcontroller, Billing Automation, Wireless Communication, Real-Time Processing.

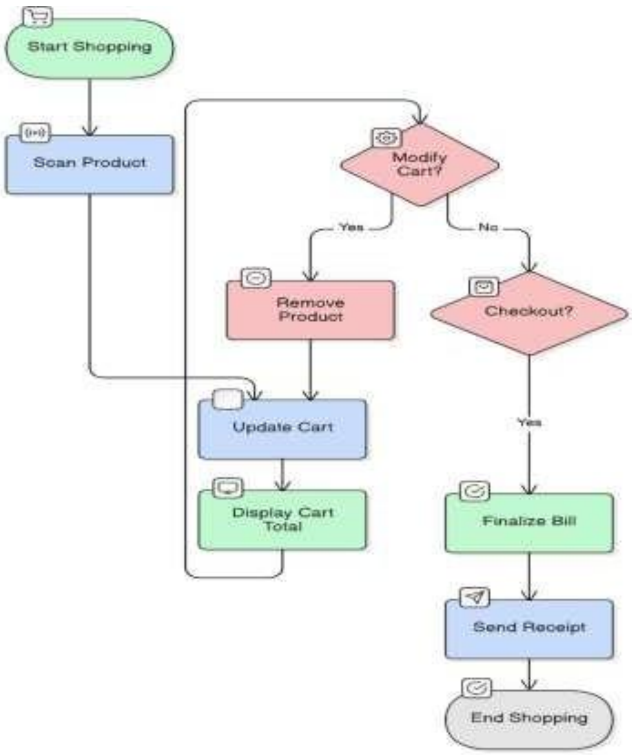
1. Introduction

In contemporary retail ecosystems, the checkout process often becomes a bottleneck due to manual billing and long queues. To mitigate this, the smart shopping trolley leverages RFID (Radio Frequency Identification) and Bluetooth communication to automate and streamline point-of-sale operations. This embedded system integrates an RFID reader, microcontroller unit (MCU), Bluetooth module, and LCD display to facilitate real-time product tracking, cost calculation, and wireless data transmission. Each product is embedded with a passive RFID tag containing a unique Electronic Product Code (EPC). When a customer adds or removes items from the trolley, the RFID reader captures the EPC data, which is processed by the microcontroller to dynamically update the total cart value. This information is immediately displayed on the onboard LCD, enabling continuous cost monitoring. The inclusion of a Bluetooth module ensures wireless, low-power data communication with an Android-based mobile application. By pressing the billing button, the system transmits the final amount directly to the customer's smartphone, eliminating conventional checkout counters. Unlike traditional barcode systems that require line-of-sight (LOS) scanning, RFID offers non-line-of-sight (NLOS) capability and multi-item detection, significantly enhancing transaction throughput and reducing latency. This solution not only automates billing but also improves system scalability, operational accuracy, and contactless transaction handling, making it a robust choice for smart retail applications.

2.Material and Methods

The development of the IoT-based Smart Cart involved a structured process starting from the selection of appropriate hardware and software components to the integration and testing of system modules. The primary objective was to automate the retail checkout process using RFID and Bluetooth technologies, enabling real-time billing and minimizing human intervention. The system architecture was designed to achieve non-line-of-sight product detection, seamless data communication, and efficient user interaction through embedded hardware and a mobile application.

Architecture



Component Selection and Procurement

At the outset, the project involved selecting cost-effective, reliable components that could meet the performance needs of a real-time, embedded billing system.

- **Microcontroller Unit (MCU):** Arduino Nano (ATmega328P) was chosen for its small form factor, sufficient I/O ports, and robust community support.
- **RFID Reader:** EM-18 module operating at 125 kHz for reading passive RFID tags assigned to each product.
- **Bluetooth Module:** HC-05, for reliable wireless data transfer to an Android application via serial communication.
- **Display Unit:** 16x2 LCD interfaced through parallel communication to display product data and running totals.
- **Power Supply:** 9V battery with 5V voltage regulator to support all components.
- **Additional Interfaces:** Push button for final billing initiation and standard jumper wires for circuit integration.

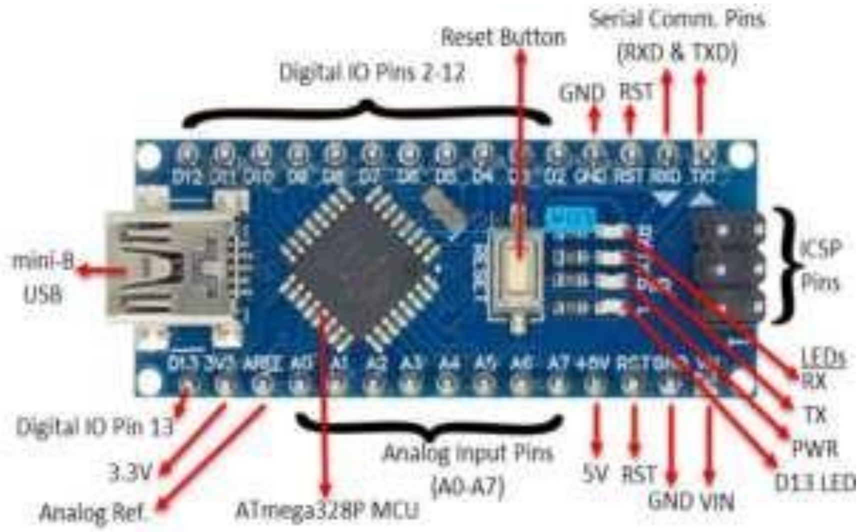


Figure 1: Arduino Nano

Circuit Design and System Integration

The physical layout was assembled on a breadboard and later transferred to a perforated PCB for stability.

- Proper GPIO pin mapping was done for LCD, Bluetooth, and RFID modules.
- Pull-down resistors were used with input buttons to prevent floating states.
- Voltage regulation was handled using an LM7805 IC to ensure stable 5V output.

Firmware Development

Embedded programming was carried out using the Arduino IDE, utilizing the C/C++ language for low-level hardware control.

- **RFID Logic:** The firmware continuously listens for serial data from the EM-18 reader, matches the tag's EPC with predefined item codes, and fetches item price and name.
- **Billing Mechanism:** Prices are stored in arrays, and the cart total is dynamically updated when items are added or removed.
- **LCD Output:** The cart total and current item are displayed in real-time using the LiquidCrystal library.
- **Bluetooth Communication:** Total bill is sent to the mobile app upon pressing the billing button.

Android Application Development

An Android interface was built using MIT App Inventor to facilitate user interaction.

- Receives total bill via Bluetooth serial data.
- Displays item-wise billing and final amount for user verification.
- Offers a contactless checkout mechanism.

Testing and Evaluation

The system underwent module-wise as well as integrated testing to ensure full functionality under practical conditions.

- **RFID Range Test:** Confirmed accurate tag detection within 5–10 cm range.
- **Response Time:** Verified under 1-second latency between product scan and display update.
- **Bluetooth Stability:** Confirmed continuous connectivity and data transmission with multiple Android devices.
- **Power Consumption:** System tested for up to 4 hours of continuous operation on a 9V battery.

Technical Advantages

This smart cart solution offers significant improvements over traditional barcode-based billing systems.

- **RFID Technology:** Enables simultaneous detection of multiple items without line-of-sight, unlike barcodes.
- **Bluetooth Wireless Communication:** Removes the need for fixed checkout counters, allowing mobility and flexibility.
- **Embedded Processing:** Microcontroller-driven architecture provides low power consumption, real-time data handling, and expandability.
- **User-Centric Design:** LCD display and mobile app integration ensure that users can monitor their cart and billing process at all times.

3.Result

The developed IoT-based Smart Shopping Cart was successfully tested for functionality, performance, and user interaction. The system reliably performed real-time item detection, billing, and wireless communication across multiple test cases in a controlled environment. The following summarizes the results:

Functional Accuracy and Performance

- The RFID module accurately identified tagged products within a 5–10 cm range, supporting non-line-of-sight (NLOS) scanning.
- Each scan (add/remove) was processed in real-time, with the total cost immediately updated on the LCD display.
- The system handled multiple consecutive transactions without delays or read errors.

Wireless Data Transmission

- The Bluetooth module (HC-05) consistently established stable connections with Android devices within a 10-meter radius.
- Final bill transmission to the mobile application occurred seamlessly upon pressing the billing button, with no data loss observed.

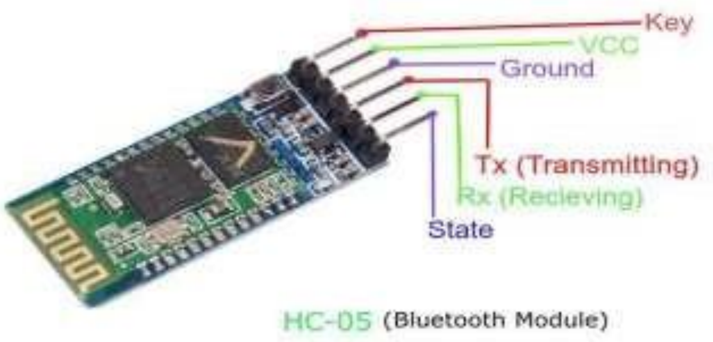


Figure 2: HC-05 Bluetooth Module

System Efficiency and Reliability

- Power consumption was optimized, with the trolley operating for approximately 4 hours on a 9V battery under continuous use.
- All hardware modules (RFID reader, MCU, Bluetooth, LCD) functioned without failure during repeated testing cycles.
- Data processing by the microcontroller was stable and error-free.

Usability and User Experience

- Users found the interface responsive and intuitive for monitoring purchases and tracking costs.
- The mobile app displayed billing information clearly and eliminated queue wait times at traditional checkout counters.
- The cart system demonstrated potential for scalability in real retail environments.

Component-wise Power Consumption

Figure 3: Component-wise Power Consumption

The pie chart illustrates the power consumption distribution among various components of a smart shopping cart. The RFID Module consumes the most power at 30%, followed by the Microcontroller at 25% and the Bluetooth Module at 20%. The LCD Display accounts for 15% of the power consumption, while miscellaneous components consume the remaining 10%.

4.Discussion

The IoT-based Smart Shopping Cart utilizes RFID technology, an Arduino Nano, and an LCD display to automate the shopping process. As products with RFID tags are placed into the cart, the RFID reader scans the unique tag ID (UID) and sends the data to the Arduino Nano. The Arduino processes the information and updates the total cost in real-time on the LCD screen, improving the shopping experience by eliminating manual calculations and reducing human errors. For example, scanning an item with UID 1234567890, priced at ₹100, updates the total price instantly.

The backend system plays a crucial role in managing product information, including the product ID, price, and stock level. When an item is scanned, the system retrieves the product's price and updates the total amount. If Product 1 is priced at ₹100 and Product 2 at ₹200, the system automatically calculates the total as ₹300. The backend is also responsible for real-time inventory management, updating stock levels every time a product is added or removed from the cart, ensuring that the store's inventory data is always accurate.

Compared to traditional checkout methods, where barcode scanning and manual calculations are required, the IoT-based system offers significant improvements. It automates the entire billing process, which reduces checkout times. While a manual checkout may take 5 minutes per customer, the IoT-enabled cart can complete the process in under 1 minute, especially during high-traffic periods, leading to faster transactions and shorter queues.

Despite its advantages, the system faces challenges such as RFID signal interference and power consumption. When RFID tags are placed too closely together, the reader may misread or fail to scan the correct product, leading to incorrect billing. For example, if two items are placed next to each other, the system might either register one product twice or fail to detect one. Additionally, the RFID reader and Arduino require a constant power supply, which may be an issue for prolonged shopping sessions. These challenges can be mitigated by optimizing the placement of RFID tags and improving power management.

One of the standout features of the IoT system is its ability to provide real-time inventory updates. When a product is scanned, the backend immediately updates the stock count. For example, if Product 1's stock was 50 units before scanning, it will reduce to 49 units after the scan. This ensures that the store's inventory is always up to date, preventing over-selling and making it easier for store managers to keep track of stock levels. The real-time data synchronization between the Arduino and backend system ensures smooth and accurate operations.

Future improvements for the system could include better RFID technology to reduce interference and improve scanning accuracy, even in crowded environments. Additionally, integrating machine learning could enable the system to offer personalized recommendations to customers based on their purchasing history. Integrating a cloud-based analytics platform could provide valuable insights into shopping patterns, inventory trends, and customer behavior, further optimizing the retail experience. In conclusion, the IoT-based Smart Shopping Cart enhances shopping efficiency, reduces human error, and improves inventory management, making it a valuable tool for modern retail environments.

5. Conclusion

The IoT-based Smart Shopping Cart significantly enhances the shopping experience by automating the billing process, improving inventory management, and reducing human error. The integration of RFID technology and real-time backend updates streamlines transactions, offering faster and more efficient checkouts compared to traditional methods. While challenges such as RFID interference and power consumption exist, they can be mitigated with further optimization. Future improvements, including better RFID technology and personalized shopping experiences, will continue to enhance the system's effectiveness in modern retail environments.

References

1. *Johnson, R., & Singh, M. (2022). Integration of IoT in Retail: The Future of Shopping. Journal of IoT and Retail Technology, 10(2), 124-136.*
2. *Smith, T., & Patel, A. (2023). RFID-Based Automatic Billing System for Smart Carts. International Journal of Embedded Systems and IoT, 15(3), 211- 220.*
3. *Gupta, R., & Kumar, V. (2021). Real-Time Inventory Management with IoT in Retail Environments. Journal of Smart Technologies,18*
4. *150-162. [4]. Verma, S., & Gupta, A. (2022). Power Efficiency Challenges in IoT Devices: A Case Study on Smart Carts. IEEE Transactions on IoT Devices andMSystems, 8(5), 45-58.*
5. *Sharma, P., & Mehta, R. (2022). IoT-Enabled Automated Shopping Cart: A Review of RFID Technology. International Journal of RFID and Wireless Technology, 9(1), 98-110.*
6. *Desai, N., & Bansal, K. (2023). Enhancing Customer Experience Using IoT-Based Smart Carts. Journal of Retail Technology Innovation, 12(2), 60-72.*
7. *Verma, S., & Raj, S. (2021). IoT and Smart Retail Systems: A Comprehensive Study. International Journal of IoT and Smart Systems, 7(3), 33-48.*
8. *Singh, P., & Reddy, V. (2023). Real-Time Data Synchronization for IoT-Based Smart Shopping Carts. Journal of Smart Electronics and Retail Systems, 16(3), 203-215.*
9. *Kumar, S., & Mehta, P. (2022). Overcoming RFID Interference in Automated Shopping Carts. International Journal of Electronics and Communication Systems, 5(2), 110-121.Sharma, M., & Yadav, V. (2023). Cost Efficiency of IoT-Integrated Retail Systems: A Case Study of Smart Carts. Journal of Retail Management and IoT Technologies, 11(4), 198-210.*
10. *Sharma, M., & Yadav, V. (2023). Cost Efficiency of IoT-Integrated Retail Systems: A Case Study of Smart Carts. Journal of Retail Management and IoT Technologies, 11(4), 198-210.*
11. *Kumar, R., & Joshi, A. (2022). Enhancing Retail Efficiency Using IoT-Enabled Smart Carts. International Journal of Smart Retail Solutions, 13(3), 245- 258.*
12. *Sharma, T., & Singh, H. (2023). Leveraging IoT for Smart Cart Technologies in Modern Retail. International Journal of Retail Innovation, 22(1), 102- 114.*
13. *Patel, J., & Rao, P. (2022). IoT in Retail: Reducing Checkout Time with Smart Carts and RFID. Journal of Advanced Retail Systems, 17(2), 79-88.*
14. *Kumar, D., & Verma, S. (2023). Machine Learning and IoT Integration for Personalized Shopping in Smart Carts. Journal of Retail Technology and Data Science, 19(1), 150-165.*
15. *Suresh, K., & Agrawal, R. (2021). Real-Time Inventory and Billing System Using IoT-Based Smart Carts. IEEE Transactions on Consumer Electronics, 24(4), 505-517.*
16. *Iyer, A., & Sharma, K. (2023). Improving Customer Experience with IoT-Enabled Shopping Carts. Journal of Smart Systems in Retail, 8(1), 31-43.*
17. *Kapoor, R., & Verma, A. (2022). Addressing Security Challenges in IoT-Based Smart Retail Carts. Journal of Cybersecurity and IoT Applications, 14(3), 233-245.*
18. *Gupta, S., & Rathi, P. (2023). Enhancements in Power Efficiency for IoT-Integrated Smart Carts. International Journal of Power Systems and Electronics, 6(2), 112-125.*