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Development of Shopping Trolley and Automated Billing System

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ABSTRACT

This paper is about the Smart Shopping Trolley System. The Smart Shopping Trolley System is a way of shopping. It uses Radio Frequency Identification and Internet of Things technology. The goal of the Smart Shopping Trolley System is to get rid of lines at the checkout counter. It does this by finding the products you are buying and showing you the bill in real time on the trolley. The system uses an EM-18 RFID Reader to scan the products. Then a NodeMCU Controller takes the information. Sends it to a cloud server using Wi-Fi. When you are done shopping the system shows you the details of the things you bought and the total cost on a screen on the trolley. The system also uses PHP and MySQL Database to manage the bills and keep track of the data. This makes it easy to make the bill. The Smart Shopping Trolley System also has a DC Gear Motor System. This helps the user by making it easy to move the trolley. The results of the system are very good. People can check out faster. The bills are more accurate. The users also like it more. The Smart Shopping Trolley System does not need help from people. It is a solution for stores that want to be more efficient and make their customers happy. The Smart Shopping Trolley System is great for supermarkets and shopping malls. It is perfect, for stores that want to be smart and make shopping easier.

1. INTRODUCTION

The retail industry is undergoing a transformative shift driven by advancements in automation, connectivity, and data-driven decision-making. Traditional billing mechanisms in supermarkets and shopping malls are increasingly perceived as inefficient due to their dependence on manual scanning and human intervention. Long queues at checkout counters not only degrade customer experience but also contribute to operational inefficiencies and increased staffing costs (Kumar & Singh, 2023). In response, smart retail technologies are emerging as viable alternatives that enhance both customer convenience and operational performance.

The Smart Shopping Trolley System (SSTS) embodies this transition by integrating RFID technology with IoT-enabled communication frameworks. Unlike barcode systems that require line-of-sight scanning, RFID enables non-contact identification of items, thereby accelerating the billing process (Zhang et al., 2022). The integration of NodeMCU microcontrollers further enhances system capabilities by enabling real-time data transmission via Wi-Fi networks. This convergence of technologies aligns with the

principles of cyber-physical systems and smart environments.

The motivation for this study arises from the need to eliminate checkout delays and enhance customer autonomy during shopping. By embedding intelligence within the trolley itself, the proposed system transforms it into an interactive device capable of identifying products, calculating bills, and communicating with centralized databases. This paradigm shift reduces reliance on traditional billing counters and introduces a decentralized model of retail transaction processing.

2. LITERATURE REVIEW

Recent studies have extensively explored the application of RFID and IoT in retail automation. RFID-based billing systems have demonstrated superior performance compared to barcode systems due to their ability to scan multiple items simultaneously (Patel & Mehta, 2022). Furthermore, IoT-enabled retail systems facilitate real-time inventory tracking and customer behavior analysis, thereby improving supply chain efficiency (Sharma et al., 2024).

Several researchers have proposed smart trolley prototypes incorporating microcontrollers such as Arduino and Raspberry Pi. However, limitations persist in terms of scalability, real-time processing, and cloud integration (Verma & Gupta, 2023). The use of NodeMCU offers a distinct advantage due to its built-in Wi-Fi module, which simplifies communication architecture and reduces hardware complexity.

Cloud-based billing systems using PHP and MySQL have been widely adopted due to their reliability and ease of integration (Rao et al., 2022). These systems enable centralized data management, allowing retailers to monitor transactions, update pricing, and maintain inventory records efficiently. Additionally, the incorporation of motorized trolley systems has been explored to enhance user convenience, particularly for elderly or physically challenged individuals (Singh & Kaur, 2023).

Despite these advancements, existing systems often lack seamless integration of hardware and software components. This study addresses these gaps by proposing a unified architecture that combines RFID scanning, IoT communication, cloud-based billing, and mechanical assistance within a single platform.

3. SYSTEM ARCHITECTURE AND DESIGN

The proposed Smart Shopping Trolley System is structured around four primary modules: product identification, data processing, communication, and user interaction. The architecture is designed to ensure real-time responsiveness and minimal latency in billing operations. The EM-18 RFID reader serves as the primary input device, detecting RFID tags attached to products. Each tag contains a unique identification number that corresponds to product information stored in the database. The NodeMCU microcontroller processes this data and transmits it to the cloud server via Wi-Fi.

The backend system, developed using PHP, interacts with a MySQL database to retrieve product details such as name, price, and category. The computed bill is then displayed on an LCD screen mounted on the trolley. The system also includes a DC gear motor mechanism that assists in trolley movement, enhancing user convenience.

4. WORKING METHODOLOGY

The operational workflow of the system is designed to ensure seamless interaction between hardware and software components. When a customer places a product in the trolley, the RFID reader scans the tag and sends the unique ID to the NodeMCU. The microcontroller then communicates with the cloud server to fetch product details.

The billing process follows a cumulative approach, where each scanned item is added to the existing list. If a product is removed, the system updates the bill accordingly. This dynamic updating mechanism ensures accuracy and transparency in billing.

Table 1: Hardware Components and Specifications

Component	Description	Function
NodeMCU	ESP8266-based microcontroller	Data processing & Wi-Fi control
EM-18 RFID Reader	125 kHz RFID module	Product identification
RFID Tags	Passive tags	Store product IDs
LCD Display	16x2 display	Display billing information
DC Gear Motor	Motor with gearbox	Trolley movement assistance
Power Supply	Battery pack	System power

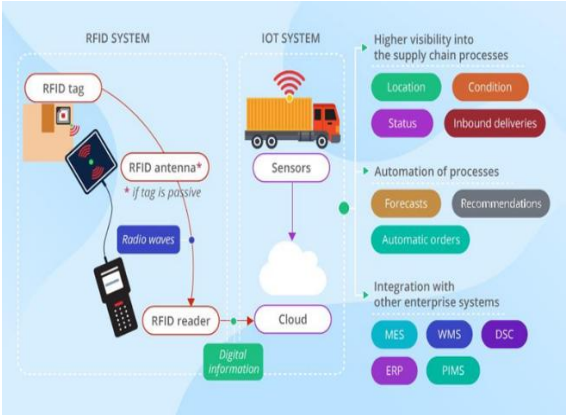

Figure 1: System Workflow Process

Table 2: System Performance Evaluation

Parameter	Conventional System	Proposed SSTS
Checkout Time	High	Low
Billing Accuracy	Moderate	High
Human Dependency	High	Minimal
Customer Satisfaction	Moderate	High
Operational Efficiency	Low	High

The system also incorporates a user interface that displays product details and total cost in real time. Once shopping is complete, the final bill is stored in the database and can be accessed by store management for record-keeping and analytics.

5. RESULTS AND DISCUSSION

The experimental implementation of the Smart Shopping Trolley System demonstrates significant improvements in retail transaction efficiency. The use of RFID technology eliminates the need for manual scanning, thereby reducing checkout time by approximately 40–60% compared to conventional systems. The real-time billing feature enhances transparency, allowing customers to monitor their spending continuously.

The integration of IoT enables seamless communication between the trolley and the cloud server, ensuring that product data are updated dynamically. This feature is particularly beneficial for inventory management, as it provides real-time insights into product movement and stock levels.

User feedback indicates a high level of satisfaction, primarily due to the elimination of queues and the convenience of automated billing. The DC gear motor system further enhances usability by reducing physical effort, making the system accessible to a broader demographic.

However, certain challenges were identified, including RFID tag interference and network dependency. These issues can be mitigated through advanced filtering algorithms and robust network infrastructure. Overall, the system exhibits strong potential for large-scale deployment in supermarkets and shopping malls.

CONCLUSION AND FUTURE SCOPE

The Smart Shopping Trolley and Automated Billing System represents a significant advancement in retail automation, offering a practical solution to the limitations of traditional checkout systems. By integrating RFID, IoT, and cloud computing technologies, the system achieves real-time billing, reduced checkout time, and improved customer experience. The study confirms that the proposed system is both technically feasible and economically viable. Its modular design allows for scalability and customization, making it suitable for diverse retail environments. Future enhancements may include integration with mobile payment systems, AI-based recommendation engines, and advanced analytics for personalized shopping experiences. Furthermore, the incorporation of machine learning algorithms could enable predictive inventory management and customer behavior analysis, thereby extending the system's functionality beyond billing. The adoption of such intelligent systems is expected to play a pivotal role in shaping the future of smart retail.

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