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Smart Medical Procurement Trolley With Budget Control And Expense Tracking

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Abstract: A smart medical trolley system that uses RFID technology and built-in budget tracking to streamline inventory and purchasing processes in healthcare settings. By scanning RFID-tagged medical items, the system instantly displays details such as item name, price, and quantity on an LCD screen and a connected online platform. It also includes a budget control feature that prevents adding items once a set spending limit is reached. If adjustments are needed, a button allows users to remove items. This system helps minimize human error, ensures greater transparency, and supports more efficient and cost-effective supply management, making it a practical solution for hospitals and clinics.

Index Terms - Budget tracking, cost control, inventory management, RFID.

I. INTRODUCTION

The increasing complexity of healthcare delivery has amplified the need for efficient, transparent, and reliable management of medical resources. Among the most pressing operational challenges in hospitals and clinics is the procurement and tracking of essential medical supplies. Traditional methods, often based on manual record-keeping, periodic audits, and disconnected billing, tend to be error-prone and inefficient, leading to inventory mismatches, delays in restocking, and unplanned financial overheads. To address these inefficiencies, there is a growing shift toward intelligent, technology-driven solutions that enhance visibility, accountability, and cost control. This paper presents a smart inventory management approach utilizing an automated medical trolley system aimed at streamlining procurement workflows in healthcare settings. The system integrates technologies for real-time item tracking and budget monitoring, enabling more accurate, timely, and cost-effective inventory handling.

The system enhances decision-making and optimizes resource allocation by reducing manual interventions and incorporating automated checks on expenditure and stock levels. This proactive approach enables healthcare staff to identify potential shortages or overstocking issues before they become critical. Furthermore, the system's ability to enforce budget limits in real time strengthens financial control while also ensuring that procurement decisions are transparent and accountable. Ultimately, this leads to improved operational efficiency, cost savings, and more reliable, consistent patient care by minimizing delays and ensuring essential medical supplies are always available when needed.

2. RESEARCH METHODOLOGY

2.1 Hardware Connections:

The Smart Medical Procurement Trolley system is built around the ESP32 WROOM-32 microcontroller, which acts as the central unit controlling all the components. The RFID reader is used to scan the RFID tags attached to medical products, and the LCD display is used to show product names, costs, quantities, and billing details in real-time. A buzzer is connected to provide audio alerts for important actions like exceeding the budget limit or successful scanning. A push button is included for the removal of products from the trolley.

LEDs are used for status indications, while resistors and capacitors are used to stabilize and protect the circuit. The BC337 transistor helps drive the buzzer efficiently.

2.2 Web Platform Development:

A simple and interactive web application was developed using HTML, CSS, and PHP for the frontend and MySQL for the backend database. This website allows users to set the shopping budget, view scanned items, monitor quantities, check the total cost, and manage the procurement process easily. Whenever a product is scanned through the RFID reader, its details are immediately updated and displayed both on the LCD and on the website, providing a seamless, real-time tracking experience.

2.3 Product Addition and Removal Logic:

When an RFID tag is scanned, the ESP32 identifies the unique ID, maps it to the corresponding product, and updates the item list and cost on both the LCD and the web platform. If the same tag is scanned again, the quantity of that product increases. To remove a product, the user must first press the push button and then scan the RFID tag of the product to be removed. If the scanned product is not already in the trolley during removal, the system displays a "No stocks left" message, preventing accidental errors.

2.4 Budget Control Mechanism:

Before starting shopping, a budget limit must be set on the website. The system keeps track of the total cost as products are added or removed. If the total cost matches or exceeds the set budget, further product addition or removal is restricted. At this point, users have the option to either increase the budget manually or proceed to the payment stage. This budget control feature ensures efficient and cost-effective procurement without overspending.

3. PROPOSED SYSTEM

The Proposed Smart medical trolley addresses the limitations, like a lack of budget control, delays, and errors in the existing system. Additionally, this system allows users to switch to product removal by using a push button

3.1 Hardware components

The system has four important hardware modules that are integrated with the web application interface. Which are,

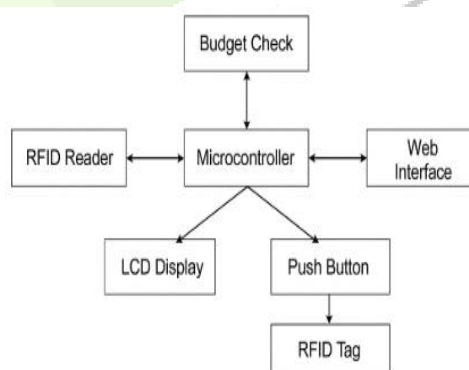


Fig.3.1 Architecture

ESP32 WROOM 32

It is a compact, powerful Wi-Fi and Bluetooth-enabled microcontroller module developed by Espressif Systems. In this project, it acts as the central processing unit, managing communication between the RFID module, push button, LCD, and the web interface. It handles real-time product scanning, budget tracking logic, database updates, and user interaction through display and inputs. Its wireless capability allows syncing data to an online web interface or cloud in real-time. It is built around the ESP32-D0WDQ6 chip, featuring

dual-core processors and a rich set of peripherals. It supports both Wi-Fi (802.11 b/g/n) and Bluetooth (v4.2 BR/EDR + BLE), making it suitable for a wide range of applications such as smart home devices, wearable electronics, industrial automation, and sensor networks.

RC522 RFID Module

It is used for wireless identification and authentication through RFID tags and smart cards. The RC522 RFID module is a contactless identification system that operates at 13.56 MHz. It enables wireless reading and writing of RFID tags/cards and is used in secure authentication, access control, and smart shopping trolley applications.

LCD Display

It is a widely used character display module that can show 16 characters per row for two rows. It provides a simple interface for displaying real-time data, such as scanned items and budget updates, in the smart trolley system.

Push Button

It is a simple electromechanical switch used to control the item removal process in this proposed System. It is connected to a digital GPIO pin of the ESP32 microcontroller. When pressed, it activates the removal mode, allowing scanned items to be subtracted from the system's inventory and total budget. This provides an intuitive user interaction method for correcting mistakes or adjusting the selected items within the budget.

3.2 Software platforms

In the proposed system, Arduino IDE is used to program and control the hardware components. Visual Studio Code is used to develop the web application interface. Together, they integrate hardware operations with a user-friendly online platform.

Arduino IDE

It is an open-source platform designed for writing, compiling, and uploading programs, primarily in embedded C/C++, to microcontrollers such as the ESP32. It streamlines the process of embedded system development by offering a user-friendly interface, built-in support for a wide range of boards, and a rich collection of pre-built libraries. This makes it easier for developers, hobbyists, and engineers to quickly prototype and deploy embedded applications without needing extensive knowledge of low-level hardware programming.

Visual Studio Code

It is a powerful, lightweight, and highly extensible code editor developed by Microsoft. It is extensively used for both frontend development (HTML, CSS, JavaScript) and backend development (Node.js, PHP, Python, and more). In this project, VS Code serves as the primary development environment for creating a web application that displays scanned products along with their quantities and billing amounts. Additionally, it enables users to set budget limits and execute payment functionalities, providing an interactive and seamless shopping experience.

3.3 Integration

In the proposed system for software interfacing, the ESP32 uses its built-in Wi-Fi module to connect to a custom-developed website. The seamless integration between hardware modules (RFID, LCD, buzzer, LED, push button, ESP32) and software components (website interface, server, database) ensures efficient procurement and expense tracking in a hospital environment.

4. WORKING

The core working principle of the proposed Smart Medical Trolley system is as follows:

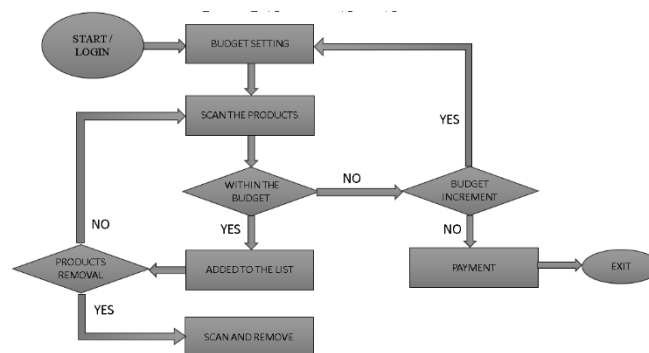


Fig.4.1 Workflow

The below Fig. 5.1 below shows the workflow of the proposed system

4.1 RFID Tagging

Each medical product is equipped with an RFID chip containing its unique identification, which holds essential details such as the product name, cost, and quantity.

4.2 RFID Scanning & Data Retrieval

When the RFID scanner reads a tag, the system's microcontroller retrieves the associated product details (name, cost, quantity) from the database.

4.3 Real-time Updates

The LCD and web interface are updated in real-time to reflect the added items and the cumulative total cost as products are scanned.

4.4 Budget Monitoring

The microcontroller continuously compares the cumulative cost of items in the trolley to the user-defined budget. If the total cost exceeds the set budget, the system prevents any further item additions.

4.5 User Alerts & Actions

If the budget is exceeded, the system prompts the user to either adjust the budget or remove items to stay within the financial limits.

4.4 Item Removal Mode

A push button on the trolley activates the item removal mode, allowing the user to re-scan items and remove them from the list to adjust the total cost.

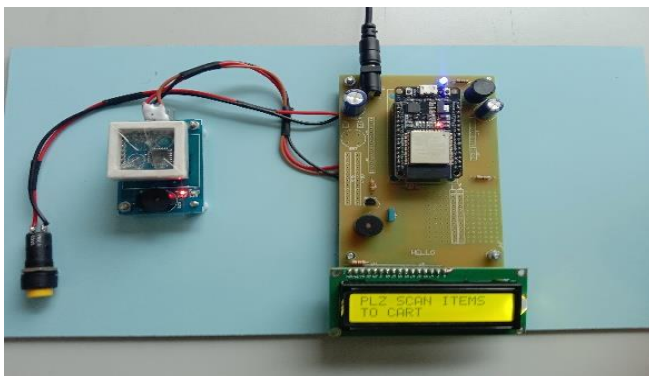
4.6 Payment Process

Once the user is satisfied with the selected items and total cost, they can proceed to payment, completing the procurement process. This system automates and streamlines the product selection, budget management, and purchasing process, ensuring accuracy and financial control in hospital procurement.

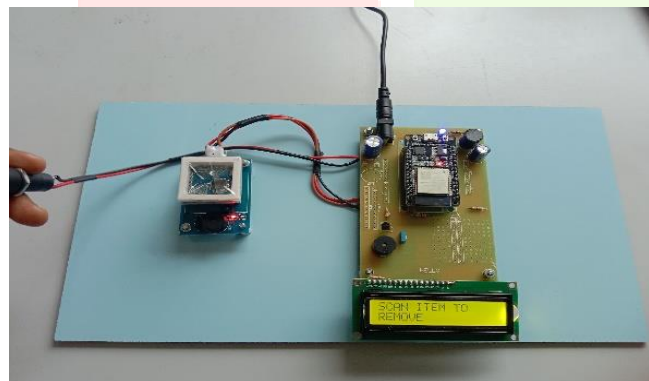
5. RESULTS AND DISCUSSION

5.1 Results of the Working Principle

The analysis and discussion were based on the integration of RFID technology, embedded systems, and web development to automate the medical procurement process. The system was evaluated through functional testing to assess efficiency, accuracy, and usability across various operational scenarios. RFID (Radio Frequency Identification) enables real-time tracking of inventory, while the embedded system coordinates hardware control, and the web interface allows for streamlined data access and management. Due to its automation, the system reduces reliance on manual labor and minimizes human error, thus improving overall pharmacy workflow. The proposed work aims to evaluate the effectiveness of this integrated approach in terms of inventory tracking accuracy, reduction in procurement time, and budget control. Key performance indicators such as stock update latency, error rate in item recognition, and system responsiveness were recorded. This analysis provides insights into the current system's capability and highlights areas for enhancement to further improve automation in medical inventory management.



(a) Adding Items



(b) Removing Items

Customer Billing Amount

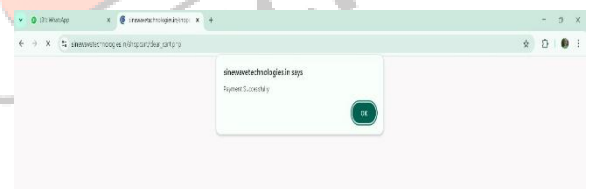
Product Name	Quantity	Billing Amount (₹)
paracetamol	5	50.00
Aspirin	3	45.00
ORS	3	150.00
Antacid	4	100.00
wocin	2	34.00
Dolo 650	1	23.00
Total Amount		₹402.00

Enter the limit Amount

Set Limit

Payment

(c) Web interface billing



(d) Interface Of Payment

Fig 4.1 Sample Outputs

Fig 5.1 represents a setup uses an ESP32 microcontroller, an RFID reader, and an LCD screen to simulate an automated checkout system and an online transaction system's complete customer billing and payment workflow. Fig 5.1 (a) displays a idle state of the system, prompting "PLZ SCAN ITEMS TO CART". Fig 5.1 (b) shows that the system is in removal mode, prompting "SCAN ITEM TO REMOVE". Fig 5.1 (c) displays a billing table listing the purchased products: Paracetamol (₹50.00), Aspirin (₹45.00), ORS (₹150.00), Antacid (₹100.00), Wocin (₹34.00), and Dolo 650 (₹23.00), with quantities varying from 1 to 5 units. The total billing amount sums up to ₹402.00. Users are given the functionality to set a payment limit before proceeding. Fig 5.1 (d) captures the successful payment confirmation prompt, indicating that the transaction was processed seamlessly. Together, these results represent stable network behavior during the transaction, ensuring a smooth and reliable user experience crucial for e-commerce operations and validate

that the proposed system is functional, reliable, and fulfills the objective of automating pharmacy procurement with budget control.

1. CONCLUSION

This paper demonstrates the effectiveness of the Smart Medical Trolley system in improving medical supply procurement and inventory management in healthcare environments. The system addresses key challenges in traditional procurement methods by integrating RFID technology, budget tracking, and real-time monitoring, including inventory discrepancies, delayed restocking, and unplanned expenses. The findings confirm that the system significantly reduces manual errors, enhances budget compliance, and improves operational efficiency. Furthermore, the ability to track medical supplies in real-time, coupled with automated budget enforcement, promotes transparency and accountability in the procurement process. Future developments could focus on integrating predictive analytics for demand forecasting, enhancing user interface features, and expanding the system's scalability to accommodate larger healthcare facilities. Overall, the Smart Medical Trolley offers a cost-effective and reliable solution for streamlining procurement, optimizing resource allocation, and ultimately supporting improved patient care outcomes

II. FUTURE WORK

The system can be enhanced by enabling dynamic product management, where users can add or update product information directly through the web platform without needing to modify the code. Cloud integration can also be introduced, allowing all procurement data to be stored and accessed online for better tracking, reporting, and remote monitoring. Additionally, incorporating an automatic stock refill notification system would help pharmacies maintain inventory levels efficiently by sending alerts when critical items are running low, thereby preventing shortages.

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