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IOT-BASED INTELLIGENT TROLLEY

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Abstract: IoT-Based Intelligent Trolley System enhances shopping by integrating IoT and embedded systems to automate product selection and billing. It eliminates long checkout lines by enabling real-time billing within the trolley. The system includes an Arduino Uno, Radio Frequency Identification based product scanning, and a display for product details. New customers enter their mobile numbers via a keypad to receive offers through Short Message Service, while regular customers use Radio Frequency Identification membership cards for personalized recommendations. Products are added or removed using Radio Frequency Identification taps. After shopping, the customer presses a finish button to trigger billing. The total bill is sent via Bluetooth to a thermal printer for receipt generation and via Wireless Fidelity through Node Mirco Controller Unit to the store owner's Personal Computer. A Quick Response code inside the store provides access to a website for browsing products, viewing discounts, and tracking expenses. This system improves efficiency, reduces manual errors, and enhances the shopping experience.

Index Terms - IoT, Radio Frequency Identification, Real-time Billing, Bluetooth, Wireless Fidelity, Automated Checkout.

I. INTRODUCTION

Traditional supermarket billing systems require customers to wait in long queues for manual barcode scanning, causing delays and inconvenience. Additionally, customers often struggle to track their expenses while shopping, leading to budget mismanagement. Manual billing also increases the chances of human error, mispricing, and inefficiencies in inventory tracking. To overcome these challenges, an automated and efficient billing system is essential. The IoT-Based Intelligent Trolley System streamlines the shopping process by integrating RFID technology, Bluetooth, Wi-Fi communication, and embedded systems. The system consists of a customer module and a product module connected via a relay. New customers enter their mobile number on a keypad to receive promotional offers via SMS. Regular customers tap their RFID membership card to receive personalized product recommendations based on previous purchases.

Each product is tagged with an RFID chip, allowing seamless product addition and removal from the cart with a single or double tap. The system dynamically updates the total bill, which is sent to the store owner's PC via Node MCU. After shopping, the Finish Button triggers receipt generation via a Bluetooth-enabled thermal printer. Additionally, customers can access a store website via QR code to browse products, check discounts, and track expenses.

II. LITERATURE SURVEY

In recent years, automation in shopping environments has gained significant attention with the integration of IoT and embedded technologies. Traditional billing systems involve manual scanning of barcodes, resulting in increased wait times, human error, and reduced customer satisfaction. To address these limitations, researchers have proposed various smart trolley systems that aim to automate the shopping and billing processes using technologies like RFID, GSM, Bluetooth, and microcontrollers such as Arduino and ESP8266. In [1], Thalor et al. (2024) presented an IoT-based smart billing system using

RFID and a mobile application to reduce manual effort during checkout. Their system emphasized RFID scanning but lacked in-cart billing and real-time product removal capabilities. In contrast, our system offers single-tap addition and double-tap removal of products using RFID technology directly from the trolley, enhancing user control. Radhakrishna et al. (2023) [2] developed an IoT-based smart trolley using RFID to automate billing. While their system simplified product identification, it did not provide features such as SMS-based promotional offers or personalized recommendations based on shopping history. Our project introduces GSM functionality to send promotional offers via SMS to new customers and uses RFID-based customer identification for personalized engagement with regular customers. Tirumala et al. (2023) [3] proposed an IoT-enabled shopping cart focused on maintaining social distancing during the pandemic by limiting cashier interactions. Although their design incorporated embedded systems and automation, it did not include printed receipts or data transfer to store records. In our system, receipt generation is automated through a Bluetooth-connected thermal printer, and final bill details are sent to the store owner's PC via Wi-Fi using NodeMCU.

Garg et al. (2022) [4] designed an RFID-based smart shopping cart using Arduino to simplify the shopping process. However, it lacked modular separation for customer identification and product scanning. Our system uses two structured modules: the customer module and the product module, connected through a relay to ensure sequential operation. Chavan et al. (2022) [5] proposed an RFID trolley with custom PCB design, focusing on compact hardware layout but without advanced communication features. Our project extends this by incorporating multi-modal communication, including GSM, Bluetooth, and Wi-Fi, allowing both customer notification and backend record management. Valte et al. (2022) [6] focused on smart carts with RFID billing but did not include support for dynamic product addition/removal or website-based item tracking. In our system, products can be added or removed using tap-based interaction, and customers can access a QR-linked website inside the store to browse products, view offers, and track their budget in real time. From these studies, it is evident that while previous work focused on basic automation of shopping carts, limitations such as lack of real-time billing, customer-specific engagement, flexible product handling, and centralized record transmission remained unaddressed. The proposed system in this project bridges these gaps by providing a complete smart trolley experience with real-time product management, SMS integration, Bluetooth-enabled receipt printing, NodeMCU-based billing transmission, and a QR-linked digital product catalog.

III. PROPOSED SYSTEM

The IoT-Based Intelligent Trolley System aims to enhance the retail shopping experience by automating product selection, billing, and customer interaction. The system is divided into two main modules: the customer module and the product module, which are interconnected through a relay to ensure an orderly sequence of operation. The core objective is to eliminate long queues at billing counters, minimize manual errors, and provide a smart, efficient shopping process using components like RFID, Arduino Uno, GSM module, Node MCU, Bluetooth, LCD, and a thermal printer.

The process begins with the customer module. New customers enter their mobile numbers using a keypad, and the GSM module sends them promotional offers via SMS. This keeps them informed about ongoing discounts while shopping. Regular customers use an RFID membership card, which retrieves their stored mobile number from the database and offers product recommendations based on past purchases. These personalized suggestions enhance the customer experience without requiring manual assistance. Once customer identification is complete, the product module is activated. Each item in the store is embedded with an RFID tag containing product details such as name, price, and category. When a customer taps the RFID tag of a product on the reader, the item is added to the cart and its details appear on the LCD display. The total bill is updated in real time. A double tap removes the product from the cart, allowing for flexible and user-friendly operation. This eliminates the need for barcode scanning, reducing errors and saving time. After shopping is completed, the customer presses the Finish Button, which triggers the billing process. The Arduino sends the total bill amount via Bluetooth to a thermal printer, which then generates a printed receipt. Simultaneously, the Node MCU module transmits the total bill wirelessly to the store owner's PC, enabling real-time record-keeping and analytics without manual entry. This dual-mode communication improves efficiency and accuracy. A key enhancement of the system is a user-friendly website, accessible through a QR code placed inside the store. Shoppers can scan this QR code to open the website on their mobile phones, where they can browse available products, check ongoing offers, and monitor their spending during shopping. This additional feature gives customers more control over their purchases and helps with better budgeting and decision-making. The relay ensures that the product module becomes active only after customer verification, preventing unauthorized access. This approach not only

secures the system but also maintains operational order. Overall, the IoT-Based Intelligent Trolley uses embedded systems and wireless technologies to automate shopping, offering faster checkout, fewer billing errors, real-time tracking, and a personalized digital experience. It is well-suited for supermarkets and retail stores aiming to modernize operations and improve customer satisfaction.

3.1 WEBSITE

The system identifies customers via mobile numbers or RFID cards, offering personalized recommendations. As shown in Fig.1, products are added or removed by tapping RFID tags, with the LCD displaying the updated bill in real time. A relay ensures the product module activates only after customer verification, preventing unauthorized access. Pressing the finish button triggers billing, sending the total via Bluetooth to a thermal printer and via Wi-Fi to the store owner's PC for record-keeping. Additionally, a website accessible through a QR code (Fig.1) allows customers to check product details, discounts, and expenses, enhancing convenience and informed purchasing. This system streamlines checkout, reduces errors, and modernizes the shopping experience.

Fig.1. Website's Product Page

Fig.2. Website's Cart Page

IV. SYSTEM ARCHITECTURE

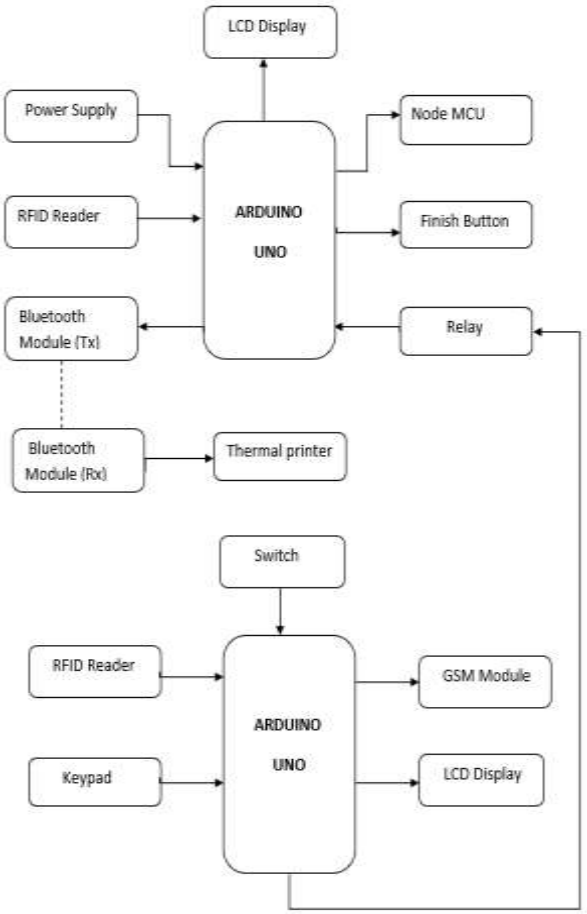

Fig.3. System Architecture

The architecture of the IoT-Based Intelligent Trolley System ensures a smooth and automated shopping experience by integrating two main modules: the customer module and the product module. The customer module, powered by an Arduino Uno, includes a GSM module, LCD display, keypad, RFID reader, and a button. New customers enter their mobile numbers via the keypad, while regular users are identified through RFID membership cards. Promotional offers or product recommendations are sent to the customer's mobile via SMS using the GSM module. The LCD only displays instructions and billing prompts.

Once customer verification is complete, the product module activates. It includes another Arduino Uno, an RFID reader for product scanning, NodeMCU for Wi-Fi communication, an LCD, a relay, and a power supply. Each store item has a unique RFID tag. A single tap adds an item to the cart, and a double tap removes it. The Arduino manages these actions and updates the cart in real time. The relay mechanism ensures smooth switching between the customer and product modules without power conflicts, contributing to energy efficiency and operational control.

After shopping, the customer presses a button to finalize the session. The Arduino calculates the total bill, which is sent via Bluetooth to a thermal printer for receipt printing. Simultaneously, the NodeMCU transmits the billing data to the store owner's PC for digital record-keeping. This dual-mode communication ensures both the customer and store have access to purchase information.

The system significantly reduces manual effort, errors, and checkout delays, making it ideal for busy retail environments. Additionally, the modular design allows for scalability, so features like mobile payment, inventory management, or app integration can be added in the future. By combining automation, wireless communication, and real-time processing, this intelligent trolley system presents a practical step toward smarter, tech-enabled retail shopping.

V. FLOW DIAGRAM

Fig.4. Process Flow

Fig. 4 shows the workflow of the IoT-Based Intelligent Trolley System. A new customer enters their mobile number, while a regular customer taps their RFID membership card. Offers and product recommendations are sent via SMS, and instructions are shown on the LCD.

Products are added to the cart with a single RFID tag tap and removed with a double tap. After shopping, the customer presses a button to end the session. The bill is generated, printed via a thermal printer, and sent to the store owner's PC. The system ensures fast, automated billing and real-time updates.

VI. SYSTEM FUNCTIONALITY

The functionality of the IoT-Based Intelligent Trolley System revolves around improving the shopping experience by automating the process of item selection and billing. As shown in Figure 4, the system workflow begins with customer identification. A new customer is asked to enter their mobile number using the keypad, while a returning customer can identify themselves by tapping their RFID-based membership card. The system either stores the new customer's data or retrieves existing data accordingly. Once the identification is complete, the system sends promotional offers or product suggestions via SMS using the GSM module. It is important to note that the offers and recommendations are not displayed on the LCD; instead, the LCD is used for internal prompts such as notifying the customer when to scan or when billing is complete.

Customers can then begin scanning products. Each product has an RFID tag. A single tap of the product's RFID tag on the reader adds the item to the cart, while a double tap removes it. These actions are recognized and processed by the product module's microcontroller, which keeps an updated list of items in the cart. When shopping is completed, the customer presses the finish button, which triggers the billing process. The Arduino calculates the total amount based on the cart contents and sends the billing data via Bluetooth to a thermal printer that generates the receipt. Simultaneously, the NodeMCU transmits the bill details to the store owner's PC for record keeping. It is essential to clarify that this system is not involved in payment processing. Customers are expected to make payments at the cashier counter using conventional methods such as cash, card, or mobile payment. The main advantage of the system lies in minimizing the time spent

during checkout, especially by removing the need for cashiers to manually scan or enter product details. This contributes to a smoother, quicker, and smarter shopping experience.

VII. RESULTS AND DISCUSSION

The IoT-Based Intelligent Trolley System effectively addresses the inefficiencies of traditional billing methods by replacing manual barcode scanning with RFID-based automation.

Fig.5.1 Total Items displayed in LCD

As demonstrated in Figure 5.1, the system accurately detects both product tags and customer membership cards, immediately updating product details and total billing on the LCD screen in real time. Compared to earlier systems [1][2], which required cashier-led barcode scanning or manual product selection, this system eliminates the need for manual intervention at the checkout phase, drastically reducing queue times and improving user satisfaction.

The Bluetooth-based communication module reliably transfers the total bill to a thermal printer for receipt generation, while the NodeMCU ensures that the same billing data is transmitted wirelessly to the store owner's PC for accounting purposes. This dual-path communication improves on previous models [4][6], which often focused solely on customer-side convenience but lacked real-time backend synchronization.

Fig.5.2 Customer module

For new customers, the system offers a unique GSM-based SMS feature, where promotional messages are sent to their mobile number immediately after input through the keypad, as seen in Figure 5.2. Unlike earlier smart trolley systems which required apps or displayed generic offers on screens [3][5], this approach directly engages the customer with personalized SMS communication. This feature not only promotes ongoing offers but also encourages customer retention.

The product module (refer Figure 5.5) allows users to add or remove products from their cart using simple single or double RFID tag taps. This function improves usability compared to prior systems where once an item was added, it could not be easily removed. Display of product details and updated billing on the LCD screen ensures transparency and real-time awareness, which systems like [2] lacked due to offline processing or delayed updates.

Fig.5.3. Regular customer

As shown in Figure 5.3, regular customers, identified through RFID membership cards, receive tailored product recommendations based on their past purchases. This level of personalization is absent in earlier designs that did not differentiate between customer types. The data-driven recommendation system increases customer engagement by promoting frequently purchased or related items, thus potentially increasing sales and satisfaction.

Fig.5.4. New customer

Additionally, Figure 5.4 illustrates how the system sends promotional offers via SMS to new users, ensuring they are immediately aware of discounts. This real-time engagement is not only more effective than static displays but also supports targeted marketing strategies. A user-friendly website, accessible through a QR code inside the store, further enhances the system's reach by enabling users to browse items, check discounts, and track expenses from their smartphone. This digital extension provides a modern interface that aligns with the ongoing shift toward contactless and app-based retail.

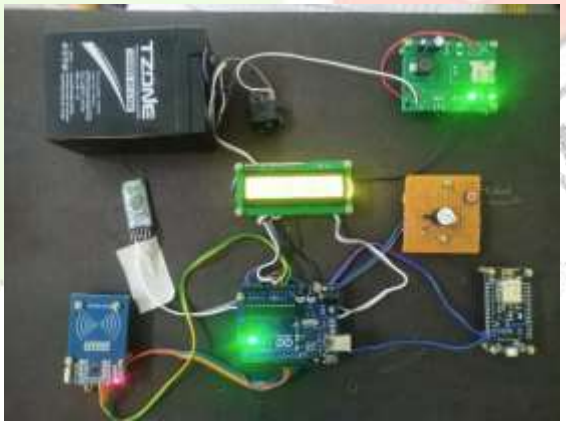

Fig.5.5. Product module

Overall, the experimental outcomes demonstrate (in fig.5.5) a comprehensive improvement over existing solutions. By merging RFID, GSM, Bluetooth, and Wi-Fi technologies, the system bridges multiple gaps present in previous research: lack of real-time data sharing, absence of customer categorization, and limited billing control. The implementation proves that integrating multi-channel communication and modular design not only enhances operational efficiency but also delivers a more intuitive and customized shopping experience.

VIII. CONCLUSION

The IoT-Based Intelligent Trolley System presented in this project offers a practical, efficient, and scalable solution to overcome the limitations of traditional shopping and billing processes. By integrating embedded systems, RFID technology, Bluetooth, GSM, and Wi-Fi communication, the system automates product identification and billing within the trolley itself, eliminating the need for manual barcode scanning and reducing customer wait times at checkout counters. The design also supports customer segmentation by offering new customers promotional SMS and recognizing regular shoppers through RFID membership

cards. Additionally, the inclusion of a QR-accessible website enhances transparency and allows customers to browse products and monitor their spending, adding a digital layer to the in-store experience.

Beyond its technical execution, the broader impact of this system lies in its potential to transform the retail industry. It promotes smart shopping, reduces dependency on store staff, minimizes billing errors, and encourages data-driven store management. This intelligent trolley framework aligns with current trends in digital transformation and smart retail, offering a sustainable, customer-centric solution adaptable to future enhancements like inventory control and mobile payment integration.

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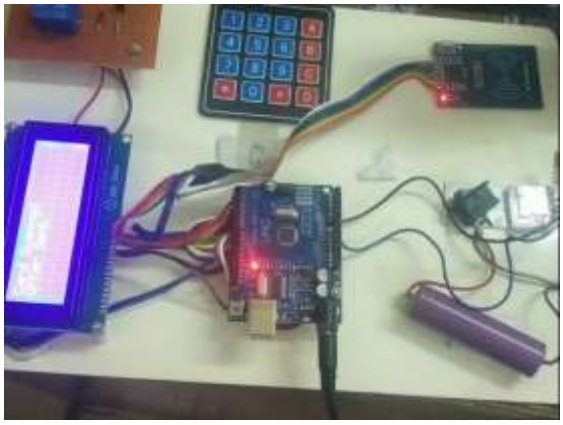

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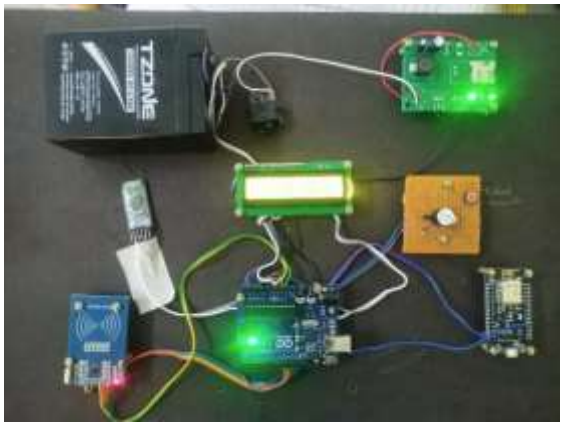

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