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Smart Trolley with Automated Billing System

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Abstract: *This paper talks about an innovative approach in enhancing the shopping experience through the introduction of smart technology in traditional shopping carts. The project highlights the development of a Smart Trolley with an Automated Billing System that utilizes ESP32 microcontroller and PN532 NFC/RFID scanner. Both NFC and RFID technologies are incorporated in the project to streamline the shopping process by allowing automatic item detection and initiating the billing process as items are placed in the cart. For the bill to be accessed by the user, the bill not only gets displayed on the LCD screen attached to the trolley but is also sent to the user's Telegram account since a Telegram bot is created for sending the bill to the user directly on their phones. The main objective here is to reduce checkout times and enhance the overall efficiency in retail environments. The addition of Telegram bot to the project makes it even more user friendly and innovative in the market*

Keywords: Smart Trolley System, RFID/NFC Tag Scanning, Seamless Shopping Experience, Retail Innovation, Telegram Bot.

I. INTRODUCTION

It is the age of technology and everyone seems to enjoy and indulge in such an automated world of systems. In the fast-evolving world of shopping, the combination of consumer preferences and festive occasions often results in higher grocery expenses and crowded shopping venues. To address these challenges, a progressive system is proposed that would scan the items and let the customer create their bill whilst shopping through their individual trolley. This inventive shopping system not only simplifies the shopping experience but also offers instant spending updates, and enables customers to adhere to their budgets. By enabling seamless item scanning, automatic bill generation, and convenient payment methods, this system enhances efficiency. The system uses the two most essential seamless technologies – RFID and NFC. The customers would not have to line in queues to get their bills generated, the proposed system would do it for them and display the bill on the LCD screen attached to the trolley.

Every product in the shopping venue is equipped with either an RFID tag or an adhesive NFC tag which contains the price of the product and once scanned against PN532 scanner, the price of it is read and displayed on the LCD screen. Not only can customers add new items to the bill but can also remove an existed item from the bill but scanning the item even number of times against the NFC/RFID scanner attached to the trolley. When scanned an odd number of times, the product cost is added, whereas it is removed when scanned an even number of times. Another interesting feature of the proposed setup is that the list of items and the final bill is also sent to the customer's Telegram Chat ID's. With this bill, customers have the flexibility to make payments according to their preferences, as offered by the shopping venue.

RFID technology is used because it is very accurate, and NFC (Near Field Communication) NFC is incorporated into the project to enable effortless communication between the smart trolley and the products it holds. NFC tags are adhesive and hence are stuck on the product for ease of scanning process.Shopping using the traditional method can take a significant amount of time, especially during busy hours, and often doesn't offer real-time updates on product availability or pricing. The system calculates the total cost of all scanned items during the shopping process and the total bill is sent to their Telegram's id and hence the customer can proceed with the payment method as per their choice. This eliminates the waiting time for customers during the product scanning process, as payment is scheduled directly thereafter.

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As we move forward in this exploration, the following sections will uncover the different aspects of this innovation. We will discuss the progress made, the results and the overall potential of this technology in improving the face of retail in the future.

II. METHODOLOGY

Hardware Requirement Specification

The project primarily requires hardware components to integrate RFID technology into the smart shopping system. The hardware components that are used in the project are listed as follows:

PN532 RFID/NFC scanner:- This is a compact transmission module that is used for contactless communication at 13.56 MHz. It has 40 Kbytes of ROM and 1 Kbytes of RAM memory. It supports different modes and interfaces with host controllers, ensuring an easy integration and operation. The scanner can integrate RFID and NFC capabilities into electronic projects, enabling a diversified applications, including access control, inventory control and payment systems. Its versatility and ease of use popularizes it among professional developers.

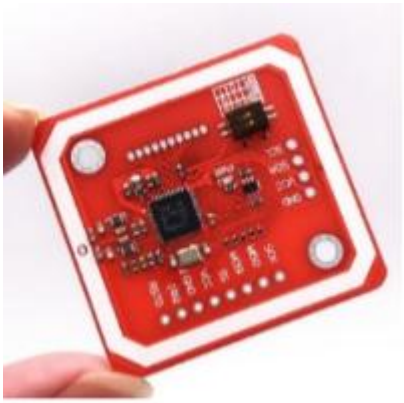

Fig. 1. PN532 RFID/NFC scanner

Its functions are like other RFID (Radio Frequency Identification) or NFC modules. RFID/NFC cards and tags also contain antennas and chips inside them. They are powered by and communicate with the RFID/NFC module using these components. When a card is brought close enough to the module, it is activated (the chip receives power through the antenna), allowing the RFID/NFC module to communicate with it. The PN532 module supports reading RFID and NFC cards, as well as reading and writing messages on NFC cards.

RFID & NFC tags and their functioning: - RFID is a wireless technology that employs electromagnetic waves technology to extract information from RFID tags. RFID tagsfeature a microchip and an antenna to transmit their unique identification number to an RFID reader when attached to an item. As the tagged object moves within the reader's range, it triggers the reader to emit a radio signal, powering the tag and prompting it to relay its ID back to the reader. This captured ID is then forwarded to a computer or system for item identification and tracking. The data stored in the RFID such as item details and price can be accessed easily, this enhances efficiency and accuracy across various domains, including inventory management, supply chain operations and retail transactions.

Fig. 2. RFID tags

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NFC (Near Field Communication) technology is used for short-range wireless communication, enabling data exchange between devices. It works on the same principleas RFID and allows devices to communicate when brought within a distance of 4 cm or less. It helps in the seamless and secure connections between objects. This contactless communication is widely used in smartphones these days.

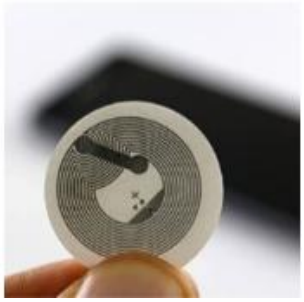

Fig. 3. NFC Tags.

ESP32 Microcontroller:- It is developed by Espressif Systems and is widely-used microcontroller. It is system-on-chip (SoC) integrated with Wi-Fi and Bluetooth functionalities. It integrates essential components like Wi-Fi, Bluetooth onto a single platform enabling seamless internet connectivity and facilitates in IoT applications. The ESP32 is energy-efficient, making it suitable for projects requiring long-term operation. It offers a wide range of peripheral interfaces, including SPI, DAC, PWM, I2C, UART, ADC, and more, for integration with various sensors, displays, and external devices.It is compatible with popular development platforms such as Arduino IDE making it a perfect choice of access for developers.

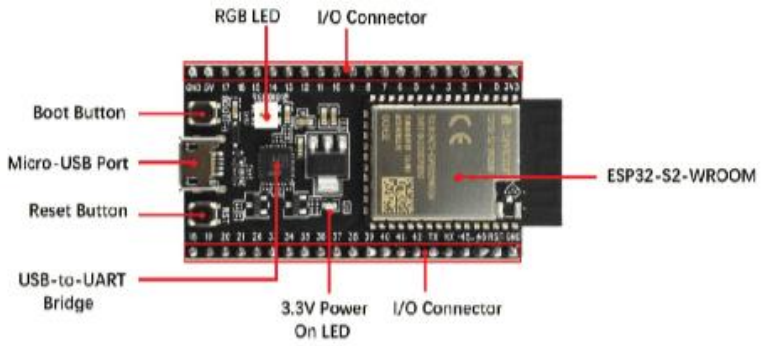

Fig. 4. ESP32 microcontroller

16*2 LCD display with I2C interface:- An LCD (Liquid Crystal Display) with I2C interfacing refers to an LCD module with an I2C (Inter-Integrated Circuit) interface that communicates with a microcontroller or other devices. I2C is a serial communication protocol. It uses only two wires: SDA (Serial Data) and SCL (Serial Clock) for communication of multiple devices with each other. LCD module with I2C interface means that the module includes a built-in I2C controller and circuitry, that helps it to communicate with a microcontroller or other devices using the I2C protocol. The I2C interface reduces the number of wires required for interfacing the LCD module with the microcontroller since it needs only two wires for communication, thus simplifying the wiring and reducing the risk of errors.

Fig. 5. 16*2 LCD with I2C display

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Buzzer: - It is an electromechanical device that converts audio signal to sound signal. It is used in timers, alarm devices, printers, computers, etc where it can generate different sounds like alarm, music, bell & siren. It includes two pins namely positive and negative. The longer terminal represents the positive terminal and is powered through 6Volts whereas the short terminal represents the negative terminal which is connected to the GND terminal. Its operating voltage ranges from 3V to 24V DC. This buzzer can be used by connecting it to a DC power source with a voltage ranging from 4V to 9V. The pin configuration of the buzzer is shown below:

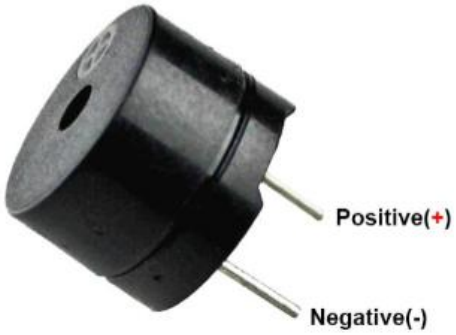

Fig. 6. Buzzer pin configuration

LEDs: - LED stands for light-emitting diode which is a semiconductor device whose function is to radiate light if there is a flow of an electric current through it. It works on the principle of electroluminescence, where the recombination of electrons and holes generates photons of lightwithin the semiconductor material. LEDs are energy-efficient and durable, hence are a popular choice for various applications such as lighting, displays and indicators. LEDs have lower power consumption, longer lifespan, and can produce a wide range of colors. Their construction includes heavily doped p-n junctions, where doping levels determine theefficiencyand color of the radiated light. LEDs are encapsulated with a transparent cover to allow the emitted light to be visible. LEDs directly convert electrical energy into light, this direct conversion process results in efficient light generation with minimal electricity wasted.

Here in the project, two LEDs are used, one green colored and the other is a red LED. The green and the red LED demonstrate the two different processes in the project. One shows the addition of a product into the system by glowing green while the other shows that an invalid card is scanned and that it has no records in the system by glowing red.

Fig. 7. Green and Red LEDs

Software Requirement Specification:

Arduino IDE: In our project, we employed the Arduino IDE software to code for our system. This user-friendly platform facilitated writing, compiling, and uploading code to the Arduino microcontroller. With its intuitive interface and extensive library of functions and examples, the Arduino IDE streamlined the development process, allowing for rapid prototyping and iteration of our designs. Overall, the Arduino IDE was instrumental in the successful implementation of our system, enabling efficient coding and seamless integration of hardware and software components.

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Block Diagram of the system

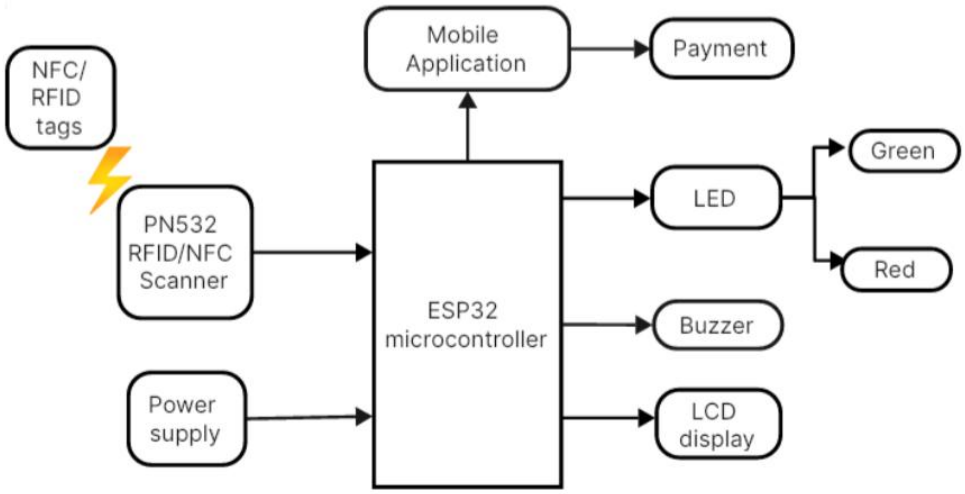

Fig. 8. Block Diagram of the system

III. IMPLEMENTATION

Working of the system

The shopping process begins as customers pick up trolleys equipped with ESP32 boards featuring PN532 NFC/RFID readers. Each product in the mall's racks is tagged with NFC/RFID tags. Since the NFC tags are cheaper and lighter in weight, they are stuck upon all sorts of daily necessity products that do not have high MRP like kitchen essentials or stationaries. The RFID tags are used for items that have comparatively higher MRP like clothes, jewellery, electronic gadgets, or heavier products like blankets etc. Customers select items and scan their NFC/RFID tags using the trolley's PN532 reader. The microcontroller within the trolley recognizes the product information, including name, quantity, cost, and total cost, stored in the internal EEPROM. An LCD display on the trolley presents this information along with the total cost. If a customer scans the product and its cost is summed up to the bill, green LED glows along with the message “Product added” on the LCD screen. If the customer no longer wishes to buy a certain item, he can re-scan the item to get it removed from the total bill and if a product is removed from the list of scanned items, buzzer beeps for the customer’s awareness. If an item is not known to the system’s memory and it is scanned, red LED glows and the message “Invalid card” is displayed on the LCD. After selecting all desired items, customers proceed to the billing counter to complete payment. They can pay directly without waiting, as the trolley's system stores the product list and total cost. Additionally, the product list is transferred to the customer's Telegram mobile application via an ESP8266 Wi-Fi module for verification. Each trolley is labelled with a unique number (e.g., trolley1, trolley2) to match it with the corresponding customer, preventing confusion during the billing process and ensuring a secure shopping experience.

Once the desired items are added to the cart, to get the final bill with total items list we use user’s Telegram account to get the final bill. We have created a Telegram Bot named “Pintu11_bot” and as soon as the bot is created it generates an API (Application Programming Interface). The bot's API is integrated into the code to establish a connection with the prototype, allowing seamless communication between the system and users via Telegram.

Each trolley is equipped with a Mastercard that serves as the key to initiate the process of sending the bill to the app once the shopping is completed. After the user finishes shopping, they scan the Mastercard on the NFC scanner. This action triggers the system to send a message titled "Receipt" to the designated chat ID. Immediately following this message, the system sends the list of items purchased by the user and the total bill as well.

It's important to note that users can access the bill only twice by scanning the Mastercard twice. Upon the third scan of the Mastercard, the trolley is automatically reset, clearing the previous user's data, and making it available for the next user. This process ensures efficient utilization of the trolleys and prevents unnecessary data accumulation.

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Circuit Diagram

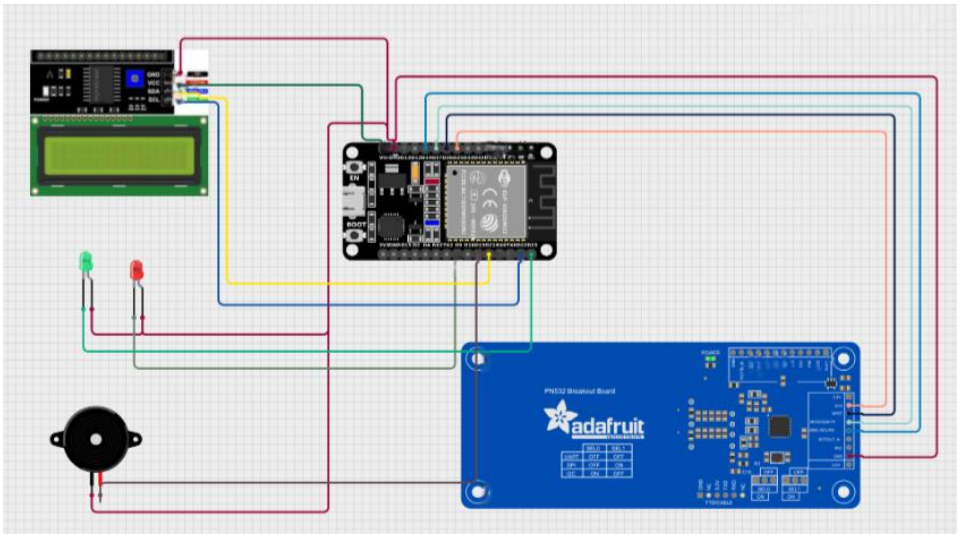

Fig. 9. Circuit Diagram of the proposed system

IV. ADVANTAGES

- Integration with Mobile App enhances convenience and accessibility.
- Real-Time Feedback
- Energy-Efficient and Eco-Friendly
- Time saving shopping experience.

V. RESULT AND DISCUSSION

The system was devised with the aim of automating billing procedures, minimizing lengthy queues, and delivering a shopping experience tailored to the individual preferences of customers. The system accurately detected when a product was added to the trolley, as indicated by the green LED indicator lighting up. On the other hand, when a product was removed from the trolley, it was detected through scanning the product twice, and the buzzer buzzed to notify the user. The implementation of the Telegram bot for billing communication was a crucial aspect of the project. The system efficiently sent item lists to users' Telegram chat IDs, offering personalized accessibility to bills. Resource management was optimized as the trolley reset after the third scan, ensuring availability for subsequent users. The NFC scanner effectively engaged customers by first sending a "Receipt" message before transmitting item lists to their chat IDs.

Project findings indicate that the smart trolley system notably enhances the shopping experience by automating billing processes. Efficient resource management and effective communication with customers further underscore its user-friendly nature for both malls and customers. Moreover, the utilization of Telegram bots and APIs showcases the potential of chatbots and messaging platforms for billing and communication, presenting promising prospects for future research and development.

In summary, the project demonstrates that integrating NFC scanners and Mastercard billing significantly elevates the shopping journey, providing convenience, personalization, and security. The exploration of NFC technology, Mastercard integration, and chatbot applications for billing and communication suggests promising avenues for future innovation.

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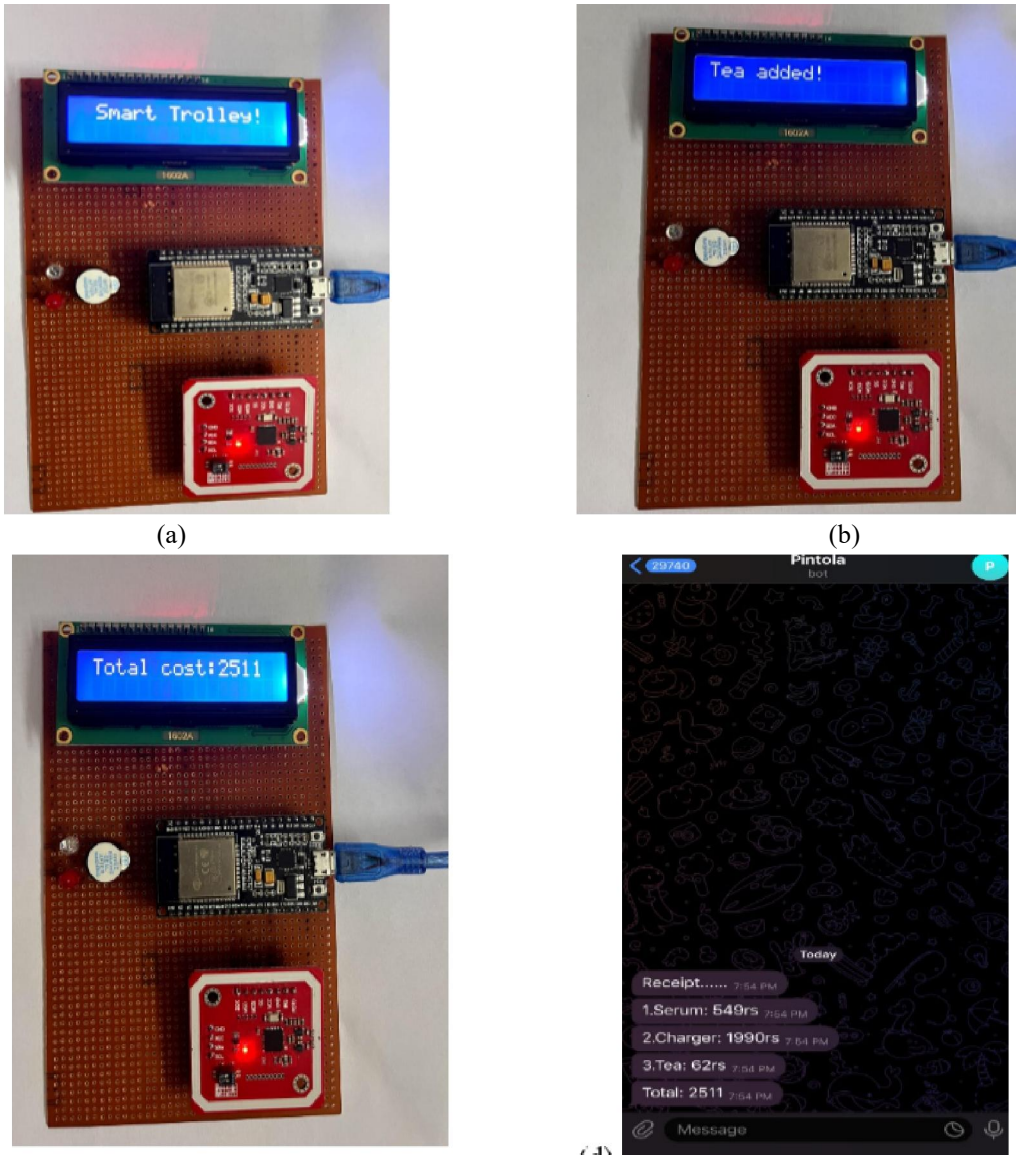

(a) (b)

(c) (d)

Fig. 10 Results of the project

Fig 10(a) displays our circuit for the project. Fig (b) shows the LCD display when an item is added to the cart. Fig(c) displays the total bill when all the wanted items are added in the cart and Fig(d) displays the Telegram bot interface when the total bill is sent to the user with the sequence of added items along with the total bill.

VI. COMPARISON OF PROPOSED SYSTEM AND EXISTING SYSTEM

In the existing retail world, Barcode scanners are used to scan the products while the customers wait in line for their turn. This paper has eliminated the need for both, the Barcode scanner, and the long queues to get your product scanned. Paper [1], [5] speaks about using Barcode scanners in the smart trolley but RFID/NFC technology is more versatile than barcodes and is more secure since each tag has a UID that is difficult to tamper with. Paper [6] proposed a system where the bill of each trolley goes to the main server and user must access the bill by standing in lines at the counter. This has been eliminated in our research paper via the integration of mobile application, Telegram where the user can access their bill which is sent to them directly on their mobile phones just by searching the username of the Telegram bot, without having the access to user's sensitive information like mobile numbers [8].

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VII. CONCLUSION

In the present study, we have thoroughly examined the utilization of a smart trolley system incorporating RFID and NFC scanners and Telegram integration. In this paper, we have highlighted the efficiency and convenience offered by smart trolleys in automating billing processes and optimizing resource management. Furthermore, our investigation has shed light on the promising prospects of utilizing Telegram bots for enhanced communication and data management in retail settings. Overall, we have underscored the significance of smart trolley systems in meeting the evolving needs of consumers and driving innovation in the retail industry.

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