

Development of a Smart Scanner Trolley System for Intelligent Billing Solutions using RFID and IoT System

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ABSTRACT

Shopping at hypermarkets, which offer an enormous array of household goods and food, has become a part of everyday life. Customers typically place all intended purchases into a shopping cart or trolley, then queue at a billing counter for each item to be scanned and bagged. This process is often hectic and time-consuming. These problems are often exacerbated during peak times, such as the weekend or holiday periods. Typical wait times may reach 15 to 20 minutes or longer. However, the ubiquity of wireless communications has enabled the development of e-commerce smart products which could simplify this process. The objective of this project is to develop a smart scanner trolley system using Radio Frequency Identification (RFID) and an Arduino microcontroller. The user simply scans each item using an RFID reader. After finishing his shopping, the user can pay for his purchases using a loyalty card linked to a debit card. The Smart Trolley terminal will automatically send a receipt via text message using the Internet of Things (IoT). Registered customers are not required to provide personal information other than a scan of their loyalty cards. The aim of this system is to facilitate in-store shopping with a system which is scalable, inexpensive, and durable.

Key words : RFID, scanner trolley system, bar code, internet of thing IoT.

1. INTRODUCTION

Supermarkets have become a common destination for the purchase of food products, clothing, and appliances. Consumers increasingly desire a safer, more convenient shopping experience. Conventional checkout counters are inconvenient for consumers, especially during peak times, and are labor-intensive, leading to higher costs. Long wait times contribute to customer dissatisfaction [1-3]. This is often due to the use of slower traditional methods for invoice generation [4-6]. Surveys have shown that a

majority of customers are not willing to wait in a long queue to buy a few products, and may even abandon their trolley without completing the transaction.

Supermarkets must make improvements to their billing systems to ensure that their customers remain satisfied with their shopping experience [4] [6]. Several attempts have been made in the past few decades to address the problem of long queues in checkout lines. For example, self-checkouts have improved the shopping experience and remain popular among retailers due to decreased overhead costs [5] [7]. Additionally, smart shopping carts have been deployed which can display the total price of all items in a shopping cart, increasing convenience and customer confidence [6].

The ubiquity of advanced technology has increased consumer acceptance of electronic gadgets such as barcode scanners and RFID readers, as encountered in the context of the shopping mall [2- 3]. For example, Maulana, et al. [8] examined the effectiveness of the Zigbee shopping trolley application. The system relays information concerning purchased goods to a central server. Zheng, et al. [8] investigated a smart checkout system using Radio Frequency Identifier (RFID) tags which allows buyers to protect their privacy by disabling the tags [9-11]. These technologies serve as an important opportunity for retailers to provide increasingly personal service to an increased number of customers, while reducing costs and wait times [12] [10].

Chen, et al. [13] [9- 10] developed a novel way to toggle an RFID tag off and re-enable it when needed. Their system allows for an RFID tag attached to a customer's membership card to be detected by an RFID reader attached to a shopping trolley. A smartphone application acts as a barcode scanner. A barcode is generated which is sent to the Arduino through a Bluetooth module. The Arduino interfaces with a Memory Unit, which contains information such as a product description, price, and stock count [10]. The results are then displayed on an LCD screen attached to the trolley [1][9][14-15].

RFID technology has become increasingly popular as an alternative to barcode systems [5][16-18]. Panasonic introduced a cashier-free convenience store concept using an RFID-enabled basket and UHF RFID tags on times. The technology has rapidly entered the mainstream in Malaysia

in industries as diverse as logistics, transport, and manufacturing. In Sri Lanka and most South Asian countries, RFID technologies in retail have reduced labor requirements and customer purchase times and led to higher customer satisfaction [5][19-20].

RFID systems use transponders attached to individual items to store and retrieve information about the items [10]. RFID implementations can be broadly distinguished as active or passive [11]. Activated tags require an external power source and can be read from a further distance than passive tags, which are powered by the reader itself. For example, the ‘Smart Tag’ used on toll booths in Malaysia is an active tag, whereas passive tags are often incorporated into product packaging.

Smart Trolley Systems which incorporate these technologies offer numerous benefits to customers and retailers alike. While customers avoid long queues at the billing counter and thus enjoy faster and more convenient shopping, the retailer can achieve increased traffic with decreased labor requirements [1] [6][21][12]. In this paper, we have developed a Smart Trolley System which produces a list of items placed in a trolley for presentation at the billing counter for payment. The system also allows payment through a smartphone application.

The system works as follows. The user initiates the system by pressing a green button. Then, RFID tags for each item to be purchased are scanned using an RFID reader. The scanned items are displayed on an LCD screen. To cancel a scan, the user can press a red button on the device. When the user is finished shopping, she presses a yellow button to generate a display of the total price for all scanned items on the LCD screen. A receipt is also sent through a linked smartphone application. Payment can then be made via a loyalty card linked to a debit card.

2. METHODOLOGY

2.1 Block Diagram

The microcontroller used for this ‘RFID Scanner Trolley System’ is the Arduino Mega, as shown in Figure-1. It has two inputs, namely the RFID RC522 reader and a push button system. System outputs include a 20 X 4 liquid crystal display (LCD), buzzer and light emitting diode (LED). A Wi-Fi Node MCU is used to send the total spent to the user’s smartphone. The Smart Trolley System also incorporates a loyalty card which is scanned by the RFID reader for payment. A diagram of the system is provided in Figure 1 below.

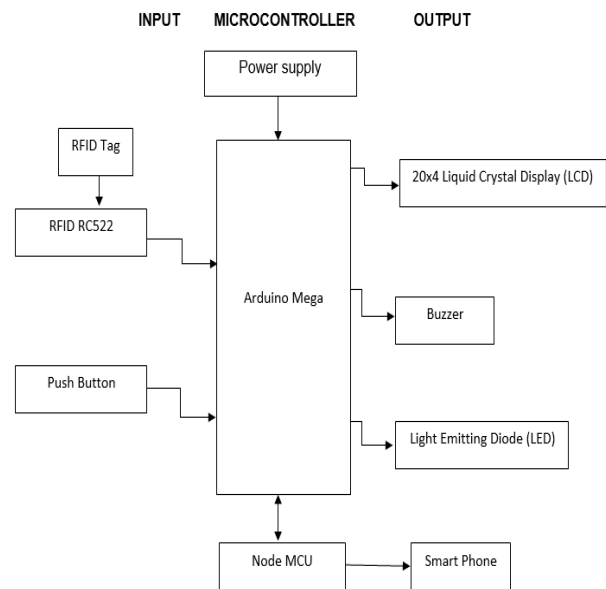


Figure 1:Block diagram of the RFID Scanner Trolley System

2.2 System Flowchart

Figure2 contains a flowchart detailing how the system functions. When the start button is pressed, the system displays, “Welcome to VIXX Supermarket”. The user must push an green button to continue. The user may then begin to scan items. To cancel an item, the user presses the red button, which resets the system to the first stage. To view a total of the prices of all scanned items on the LCD screen, the user presses the yellow button.

After the total price of all items is displayed, the user may scan an RFID-enabled loyalty card. The LCD then displays the name of the user and the current balance of the loyalty card. The system will then deduct the total amount and display the remaining balance. The user will also receive a receipt through the linked smartphone application.

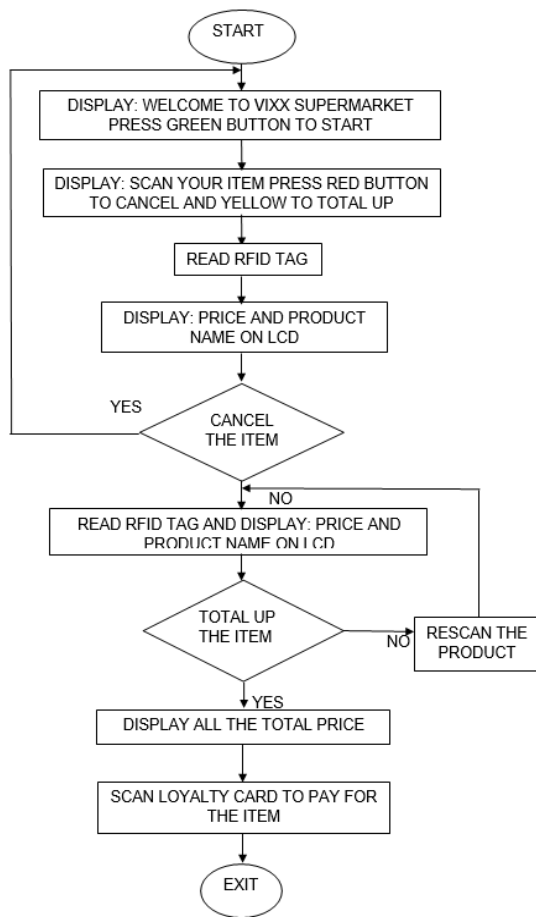


Figure 2: Flowchart of the RFID Scanner Trolley System

```
#include <SPI.h>
#include <MFRC522.h>

#define SS_PIN 53
#define RST_PIN 5
MFRC522 mfrc522(SS_PIN, RST_PIN); // Create MFRC522
#include <LiquidCrystal.h> // we need this library
const int rs = 44, en = 42, d4 = 40, d5 = 38, d6 = 41, d7 = 43;
LiquidCrystal lcd(rs, en, d4, d5, d6, d7); // pins :

int price1 = 8.00;
int price2 = 5.00;
int price3 = 3.00;
int price4 = 2.00;
int sum4, sum5, sum6;
int a, b, c, d, e, f;
int debit1 = 200;
int debit2 = 100;
const int PBG = 28, PBY = 26, PBR = 24;
int ledPin = 30;
int buzzer = 49;
int total1, total2, total3, total4, total5, total6;
```

Figure 3 : Coding for VIXX Supermarket

This project consists of five major parts: block diagram, flowchart, schematic diagram, hardware design, testing and debugging.

Figure 3 shows an example of the coding for RFID scanner trolley using Arduino programming. Libraries are included for the RFID system and the LCD. Additionally, the pin for each component is declared. Int price refers to the price of a scanned item. The int sum is declared for use in the void loop. Int debit is refers to the value stored on the loyalty card. Const int values PBG, PBY and PBR refer to the push buttons. The int led pin refers to the LED and int buzzer refers to the buzzer.

```
void cancel() {
  if (digitalRead(24) == HIGH) {
    lcd.begin(20, 4);
    lcd.setCursor(2, 0);
    lcd.print("CANCEL ITEM");
    lcd.setCursor(4, 2);
    lcd.print("BACK TO SCREEN");
    digitalWrite(ledPin, HIGH);
    tone(buzzer, 1000);
    delay(1000);
    digitalWrite(ledPin, LOW);
    noTone(buzzer);
    delay(3000);
    setup();
  }
}
```

Figure 4: Coding for void cancel

‘Void cancel’ refers to canceling an item. When the red push button is pressed, the LCD will display ‘cancel item’ and return to the first screen. The LED will light and the buzzer will sound. The cancel is put at the end of the void loop.

2.3 Schematic Diagram

Figure 5 shows a schematic diagram for this RFID Scanner Trolley System using Proteus software. The schematic depicts the LCD, RFID, three push buttons, LED, and the buzzer. The system has two input types, namely the RFID scanner and three push buttons. The first button is the start button; the second button is the cancel button; and the final button is the ‘total’ button. The outputs include an LCD, LED and buzzer. The LED and buzzer will turn on when any buttons are pressed. The LCD will show a display when the push button is pushed or when an RFID tag or RFID card is scanned. The microcontroller that controls the overall system is the Arduino Mega.

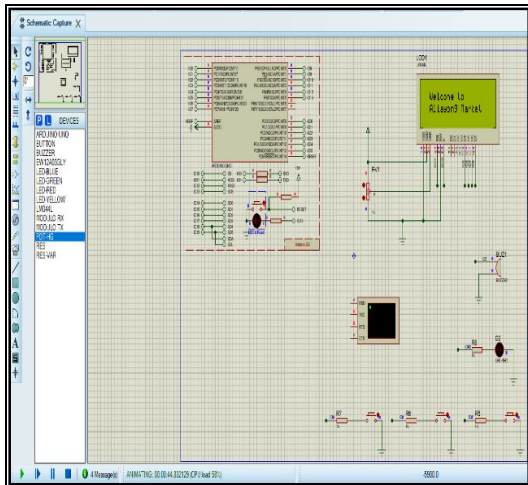


Figure 8: Simulation Result I

ii. The LCD displays, "Please scan your item"

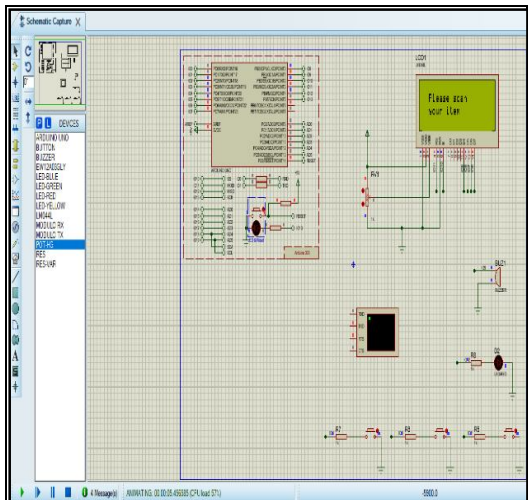


Figure 9: Simulation Result II

iii. The LCD displays, "THANK YOU"

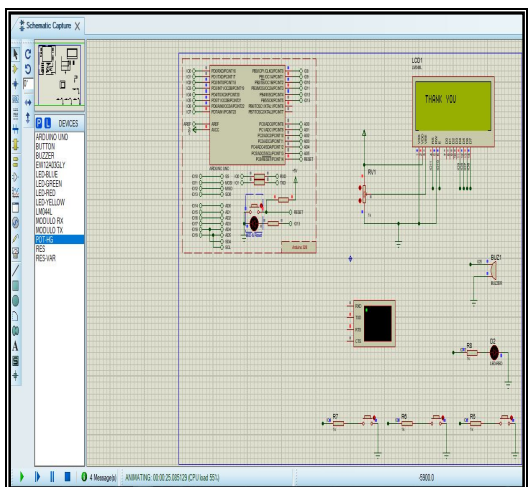


Figure 10: Simulation Result I

3.2 Prototype Result

Figure 11 shows a prototype of the RFID Scanner Trolley System. The system starts by displaying, "Welcome to VVIX Supermarket". The user presses the green button to proceed to the next step. The user scans each item's RFID tag in the RFID reader. These data are transferred to the Arduino Mega microcontroller, which displays the name and price for each scanned item on the LCD. The user is given a choice whether to cancel an item or to total the prices of all items scanned.



Figure 11: Prototype



Figure 12



Figure 12 & 13: Output for VVIX Supermarket

4. CONCLUSION

RFID Scanner Trolley System is a revolutionary mobile self-checkout system which provides users flexibility in their shopping transactions. It is designed to be highly efficient and fully synchronized with retailers' current systems. Users will appreciate its speed and convenience, especially during busy periods such as weekends and holidays. The system is fun and user-friendly. The system allows constant monitoring to ensure that stock counts are up-to-date, improving decision making by management. This project can be further improved by reducing the size of the prototype and simplifying the system. Retailers can incorporate this inexpensive, efficient technology into their systems to improve customer retention. In the academic context, the output from this study will help in improving engineering efforts to bring existing technologies to end users. The efficiency of the proposed IoT concept will spur development in manufacturing as well. An affordable RFID Smart Trolley System allows less human intervention in processing data and will boost operational efficiency. Naturally, all findings in this research will be disseminated to the public.

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