Smart Cart for Easy Shopping Using RFID Technology

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Abstract – **This paper targeted to reduce queue at billing counter in a shopping complex. The main objective of the system is to provide a technology oriented, low-cost, easily scalable and rugged system for assisting shopping in person. The RFID powered electronic shopping cart is built to enhance the overall shopping experience for customers in shopping mall. Upon placing the item in the cart, the customer can access an array of product information like its price and expiry date. If the product date is expired the buzzer will beep. After the completion of the process, the customer presses the finish key, the total bill is sent to the mobile application through the GSM and the customer can pay the bill through online or can also pay the bill in the cash counter. The person can also plan his shopping by buying the essential commodities as the total bill is being displayed on the screen resulting in enhanced savings. This system also has the feature to delete the scanned products by scanning it again to further optimize the shopping experience of the customer. The RFID mounted trolley is defined as "Smart Cart" and the shopping items are tagged using RFID Tags.**

Keywords - Smart Cart, RFID Technology, ESP8266, Buzzer, Firebase cloud, Arduino, Android Studio.

1. INTRODUCTION

In the world of Internet of Things (IoT), interactions among physical objects have become a reality. Day to day items would now be able to be outfitted with computing power and communication functionalities, permitting objects everywhere to be associated with one another. This has bought a new revolution in industrial, financial and environmental systems and triggered great challenges in data management, wireless communications and real-time decision making. There are many researches of IoT on different applications. One of the biggest IoT applications is the Smart shopping cart. The Smart Shopping system comes with the smart which is an embedded device with RFID reader for scanning the RFID tag of products, an LCD display for displaying the bill, a ESP8266 wi-fi module for manipulation and sending data to server and a GSM module for wireless communication. People tend to overshoot their budget when they are shopping at a big shopping center. Moreover, they end up in long queues at the end of their shopping waiting for the products to be scanned and billed. The Smart Shopping Cart addresses the above problems with ease. I helps the customer in ensuring that he does not overshoot his pre decided budget and only buys the essential commodities actually needed by him, also the system aids in eliminating the long queues at the billing counter .It also aids in eliminating long queues at the billing counter as the items are already scanned and the customer has to just pay the bill through the mobile application.

The Smart Shopping Cart has RFID reader to scan the product where the product details are stored in the Firebase Cloud. And LCD which displays the total bill, Then the customer pays the bill through the different modes provided. The System not only displays the total cost of the commodities in the cart it also has a feature to remove any product if the customer wishes to do so. The Smart cart also eliminates the tedious process of scanning the products at the counter as this process is already done by the customer during the shopping itself. The product is also beneficial for the shopping centers as it helps them in optimizing the total workforce at their place resulting in profits in the long run.

The traditional shopping carts which are available in shopping markets are nothing but carts with a steel frame moving on wheels. Till now there has been no incorporation of electronics in order to aid the customers and enhance their shopping experience. Though there have been a lot of attempts to modernize the shopping carts all of these attempts are aimed at finding the products in the shopping market in lesser time using web servers and other utilities.

This system is aimed at doing the above in a cost effective manner so that it is feasible to implement it in real-time. There are lot of changes that have been incorporated into the traditional shopping system.

2. RELATED WORKS

A paper entitled "Arduino based smart cart" here group of people designed the smart cart in interesting way; they also implemented the feature of security in it. The design of smart cart was like mail box when item is dropped in it the door used to get closed automatically they will open only when the mount of the product was paid, but this system had many drawbacks such as once the item is dropped and if the customer do not want to purchase it the will not unless payment is done. This system did not gain much popularity because of this drawback[1]. A paper entitled "RFID technology for IOT-

based healthcare systems in smart spaces, "The group of authors has explained about the use of RFID for personal healthcare, the device is used for personal healthcare, the device is used for monitoring the users health and gives remote assistances, the users can interact through any wireless communication medium, the sensors are able to detect the physical parameter of environment such as humidity, temperature and presence of toxic agent[2].

In the world of Internet of Things (IoT), interactions among physical objects have become a reality. Day to day items would now be able to be outfitted with computing power and communication functionalities, permitting objects everywhere to be associated with one another. This has brought a new revolution in industrial, financial and environmental systems and triggered great challenges in data management, wireless communications and real-time decision making[3]. There have been various attempts which were carried out in the past to eliminate lengthy shopping lines in retail stores. One of the famous approaches is the introduction of self-checkouts where customer convenience has been improved drastically[4].

A paper entitled "Future internet, the internet of things application, key challenges and architecture". The author in this paper talked about the existing development trends, the generic architecture of IoT, its distinguish features and future application they also explained about key challenge associated with future IoT such as naming and standardization, information privacy, object security, data encryption and network security. The author also discussed about ubiquitous computing where processing of information is linked with each object that is encountered and IoT Security [5]. There are multiple attempts made in 2003. Shanmuqaprivan et al.proposed a basic design using RFID and a barcode reader for product identification, while using ZigBee for communication [6].

Their design was similar to a mail receptacle: a chute where items are inserted and scanned, then dropped into a closed chamber. The chamber had a door on the top which can only be opened if the user has paid for the items. The design indirectly guarded against wireless communication security threats by not allowing any wireless communication - the cart was physically wired up to a point-of-sales system to pay when the user was done shopping. Ali et al. designs a smart cart system with navigation[7]. In [8] the authors have presented a their work in which each commodity in the Mall will be attached with a RFID tag, and each trolley will be attached with RFID Reader which would be working on the ZigBee. A centralized system would be there for any help and queries and for the billing transaction of the products by the customers. Even the exit gates of the mall will be laced up with the RFID readers for detecting any theft. There is no user interface and hence it is not a user friendly system. Vrinda et al in [9] have featured a cart equipped with an RFID reader, a ZigBee transceiver and an LCD display. This smart shopping cart keeps an account of the bill made by keeping running total of their purchases. LCD screen will show the total bill of the items present in the cart. System does not have a user interface and ZigBee is used instead of WiFi module.

In 2009, the University of Arkansas Information Technology Research Institute completed a study to determine the business value of RFID item-level tagging for day-to-day operations at a major luxury retailer. The chain's management evaluated the use of RFID tags in the denim category. The results demonstrated that overall inventory accuracy improved by more than 27 percent, under stocks decreased by 21 percent, and overstocks decreased by 6 percent. The study also compared how long it took to count items using RFID vs. a barcode reader. With RFID, scanning 10,000 items took two hours; scanning with a barcode reader took 53 hours. This translated into an average of 4,767 counted items per hour using RFID, and 209 items per hour using a barcode system—a 96 percent reduction in cycle-counting time [10]. Public awareness of RFID was heightened in recent years when the U.S. Department of Defense (DoD) and retail giant Wal-Mart required their suppliers to use RFID technology. In January of 2005 Wal-Mart's CIO stated that using RFID has resulted in a 26 percent reduction in out of stocks in the stores with RFID capabilities, and out of stock items that are replenished three times faster than those items not RFID tagged [11]. There are earlier work done on modernizing shopping carts. These works mainly focused on autonomous movement of the cart and finding the location of the desired product inside the shopping complex. Though these features are useful and help in reducing the time for shopping, there is a fundamental flaw that they are very expensive to implement[12].

A paper entitled "Intelligent shopping cart" here the shopping cart for speeding the billing process and used the Arduino microcontroller, and RFID tag and reader for selecting the items. Practical usage of these tag in shopping mall is expensive and requires lots of maintains [13]. A paper entitled "Integration of wearable devices in a wireless sensor network for an e-health monitoring" The author in this paper discussed about use of WSN in IoT based application, the use of WSN ine-health or human physiological monitoring, this application was used in fire fighting and sports, the user is provided with interface to suggest a series of exercise to improve a sports man's/women's condition depending upon their context and profile, the user can interact using different interface [14].

3. PRODUCT DESCRIPTION

The paper is to design a smart shopping cart which helps users with their shopping. The microcontroller used to achieve the functions required is an ESP8266 Wi-Fi module. It has been divided into five broad areas to achieve the targeted functionality:

A. ESP8266 configuration

This involves writing the code in embedded C which will enable the microcontroller to perform the various functionalities of the smart shopping cart. Figure 1 shows the development board of ESP8266.

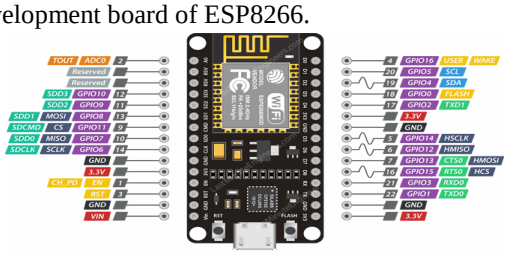

Figure 1: ESP8266 Wi-Fi Module

B. LCD Interfacing

A Liquid Crystal Display is included to display the total cost continuously. It also displays the name of the product and its price.

C. RFID Interfacing

A RFID card reader is interfaced with the Arduino Uno present on the shopping cart so that the customer is able to scan the products he/she intends to buy. The card reader is also equipped with a buzzer which indicates if a product is expired.

D. GSM Interfacing

The GSM module establishes the communication between the mobile device and the ESP8266. After the customer completes shopping the link to the payment gateway is sent as a SMS through GSM.

E. Firebase Cloud

Firebase is a Google's database platform which is used to store the data of the products in the shopping complex. It also enables to send messages to the customer. All the details of the products are stored in Firebase cloud and after the customer completes the shopping, the bill is being generated and a link to pay the bill is sent through a SMS. The customer can pay the bill by clicking on the link which redirects to the payment gateway

With the above mentioned goals in mind, the Smart Shopping Cart will have the following functions-

- The cart is initialized automatically once it is powered on. The ESP8266 microcontroller starts all the devices interfaced with it.
- The LCD starts displaying the welcome message with the initial cost as "Rs.0".
- The customer can now start his/her shopping by scanning the RFID cards attached to the products against the RFID reader one at a time.
- The system triggers a buzzer whenever it detects a product which is being expired.
- Once the product is detected by the RFID reader the ESP8266 sends the card details to the central database(Firebase cloud)
- The ESP8266 compares the information with the database and then returns the cost of the product which is transmitted wirelessly back to the cart.
- The LCD shows the name of the product scanned and adds its cost to the total cost counter.
- In case a product has been scanned multiple times accidentally or the customer changes his mind he/she can delete the product from the Total cost counter by scanning the same product twice.

4. METHODOLOGY

An ESP8266 wifi module has been used in this system. It is interfaced with an RFID reader, LCD display, GSM and buzzer. The Google's Firebase cloud is used as a database to store all the product information. Through the GSM an SMS is sent as a payment link and list of the products and the total bill is displayed in the mobile application

1. ESP8266 Wi-Fi Module

The ESP8266 is used to transfer the information from the RFID reader to the cloud as the product information is to be compared with the product list in database and the corresponding data is to be displayed on the LCD. The ESP8266 can be controlled from the local wifi network. The code for the above task is written in the Arduino IDE and is being uploaded to ESP8266.

2. RFID Reader

The RFID reader is attached to the shopping cart which detects any tag which comes in its vicinity. The tag has a unique number assigned to it. Once the reader reads the number it passes it to the ESP8266 which further communicates it for further processing. The RFID reader is connected to the serial rxd(pin 0) of the ESP8266.

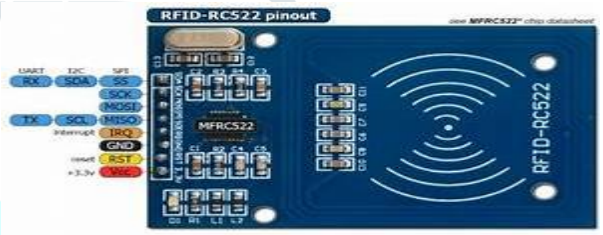

Fig. 2. RFID Card Reader

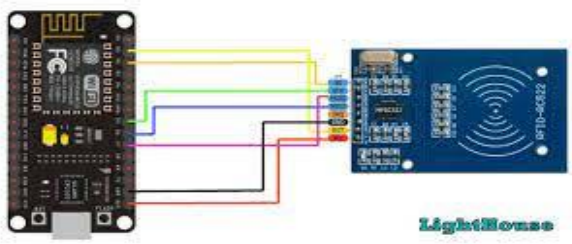

Figure 3: .RFID reader interfaced with the ESP8266

3. Arduino IDE

Arduino IDE is used to push the code into the ESP8266 for computations.

4. Liquid Crystal Display (LCD)

The conventional 16 × 2 character LCD is used. This type of LCD is the most ideal display device which is used popularly with the Arduino microcontrollers. These modules are preferred over seven segments and other multi segment LEDs. The reasons being: LCDs are economical; easily programmable; have no limitation of displaying special & even custom characters (unlike in seven segments), animations and so on. This LCD has two registers namely Command and Data. The command register stores the command instructions given to the LCD. A command is an instruction given to LCD to do a predefined task like initializing it, clearing its screen, setting the cursor position, controlling display etc. The data register

stores the data to be displayed on the LCD. The data is the ASCII value of the character to be displayed on the LCD. The library name for LCD is "Liquidcrystal.h". The library incorporates a host of functions like clear screen, scroll select, special character display, auto scroll, serial display and text direction. The contrast of the LCD can be adjusted with the help of a potentiometer. The LCD displays the initial "Smart Cart "message when the system is powered on along with the "total cost". When the customer begins shopping the LCD displays the name of the product and the cost whenever an item is scanned. The data to display is sent to the LCD using the pins D4, D5, D6 and D7. Pins 15 and 16 are used for the backlight while pins 1 and 2 are the ground and supply respectively. Pin 6 acts as an enable necessary to actuate the LCD. Fig. 4 shows the LCD interface.

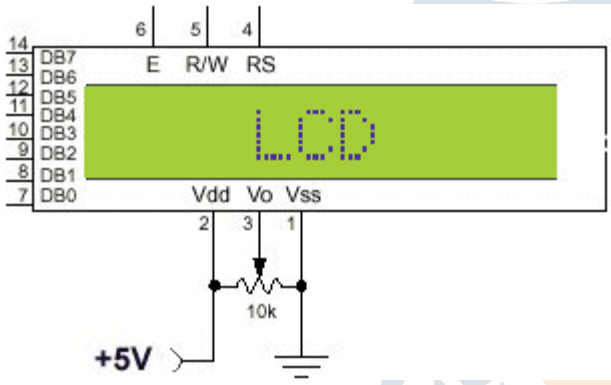

Fig.4. LCD Display

5. Firebase cloud

Cloud storage for the Firebase is a powerful, simple and cost-effective object storage services built for Google scale. All the information about the products is stored in database in the cloud.

6. Mobile Application

The mobile application is created using MIT App Inventor. It is a web application integrated development environment originally provide by Google and now maintained by the Massachusetts institute of technology. It allows newcomers in computer programming to create application software(apps) for android and iot.It is free and open-source software related under multi-licensing. It uses GUI very similar to programming languages it is written in java. Kawa and scheme. It also supports the use of cloud data via an experimental Firebase Database component. The screen view of the "smart cart" app created using MIT app inventor.The data from the firebase cloud is transferred to the variables assigned in the app and the list of items is displayed on the mobile screen.

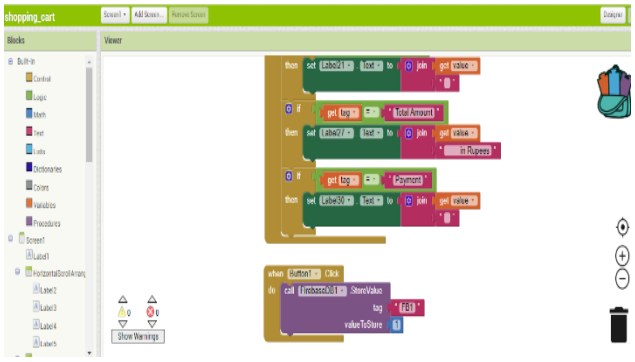

Figure 5: Making app Responsive for button press

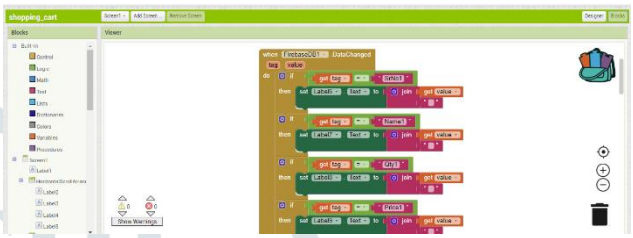

Figure 6: Making app Responsive for button press

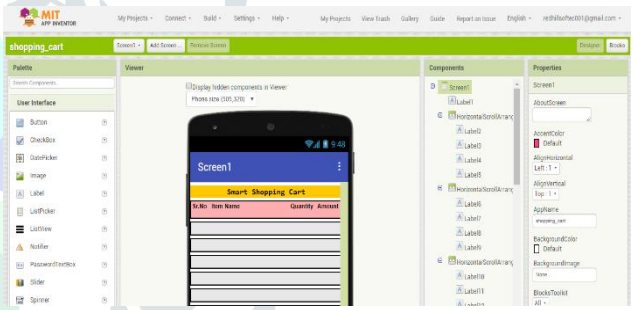

Figure 7: Layout of the app created

5.RESULTS AND DISCUSSIONS

Being a portable device, this product can be demonstrated live. All the functions described are demonstrated as follows:

A)The connections are shown in the following figure where both the cart module and the database are visible. The figure clearly depicts the ESP8266 microcontroller. The cart module is interfaced with the LCD, Buzzer and the RFID reader while the ESP8266 microcontroller is interfaced with the GSM.

B) When the product is powered on a welcome message is displayed on the LCD along with the total, which is zero at the beginning.

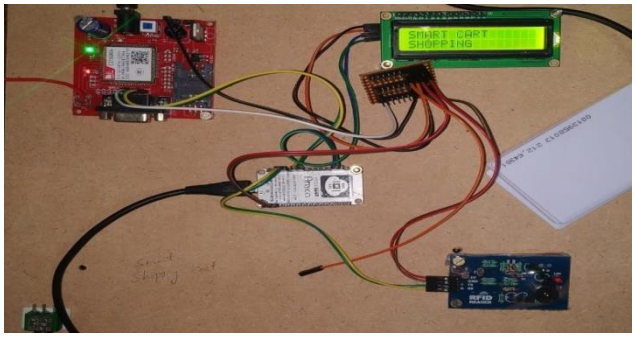

Figure 8: Initializing and welcome screen display

C) Once it is powered on it is ready for scanning of products. The following figures will show the scanning process. Fig. 9 shows the initializing screen of the product.

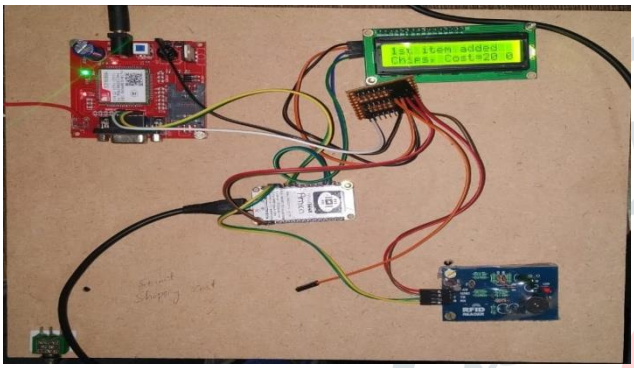

Figure 9: Item is being added

D) If the customer changes his mind and want to delete the product, he can do it by scanning the unwanted product twice, the cost of the item will be reduced from the total bill.

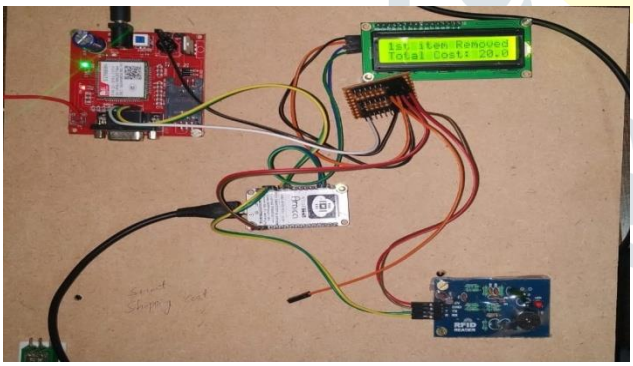

Figure 10: Deleting the item

E) Total list of items is being sent as an SMS and the list of items and the total bill is displayed in the mobile application.

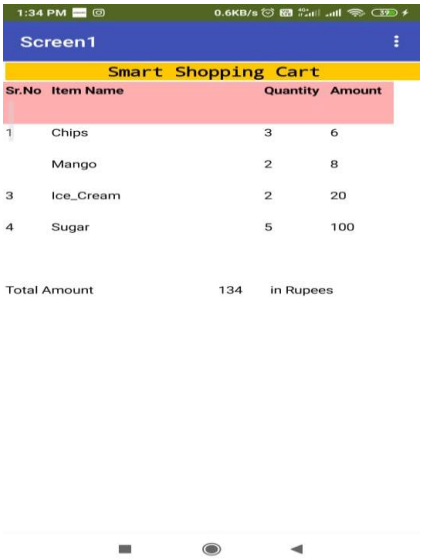

Figure 10: Snapshot of the mobile application

6. RESULTS

This product has been designed and completed. Both the programming and the hardware design have been completed successfully and we have been successful in making all the functions work. The cart consisting of all the components has been successfully developed. There is also a scope of improvement, a feature where a customer can feed in the shopping list which will enable the customer not to miss out on any item. In the current market, this shopping cart stands apart from the existing designs due to a variety of features. One reason is that it stands apart from the conventional method of bar code scanning where an item has to be in the line of sight whereas using RFID reader it just has to be in the vicinity and it would be detected. The cart will enable the customer to scan the items and get the total bill instantly. This would reduce the checkout time of a customer from the billing counter. An added advantage for the shop owner is that there is reduced amount of man power required at the billing counter. Hence, the Smart Shopping Cart stands apart from existing designs.

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