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Research Article

Smart Cart For Automatic Billing With Integrated Rfid System

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Abstract: Visiting a supermarket is something we all do at some point or another. It offers so many options under a single roof that it only makes it relevant and convenient. It however comes with its own drawbacks much like anything does. Currently, the billing in supermarket is done only at the billing counters with a barcode scanner. This system not only may cause bottlenecks at the counters but if any system experiences any technical issues or a customer engages the worker, it can cause major lapse of productivity. To tackle this issue, an automated smart shopping system is proposed, introducing the concept of readable passive RFID tags. In this system, an inexpensive RFID tag is embedded within each product. When the product is placed into a smart cart, the product detail is automatically read by the cart equipped with an RFID reader. Hence, billing is made from the shopping cart itself preventing customers from waiting in a long queue at checkout. Also, price of the product is displayed along with other additional details. Moreover, it helps with social distancing norms by preventing crowded billing areas. Finally, the checkout points can validate the purchased items by the client.

Keywords: RFID reader, RFID tag, Automatic Billing, Database, ESP8266

1. Introduction

A supermarket is a place where customers come to purchase their daily used products and pay for that. So, there is a need to calculate how many products are sold and generate the bill for the customer. It however gets too crowded very often in the billing department; hence the billing counter becomes the bottleneck [1-3]. When we go for shopping, we have to work for selecting the right product and for this some crucial product details are required. Also, choosing the products that fits the budget is major requirement. After the shopping is done, the product has to be billed and the customer has to wait at the billing stations resulting in long queues.

A smart shopping cart system is proposed that will keep the track of purchased products for billing using RFID. Every product in Mart will have a passive RFID tag, and every cart will be having RFID Reader and Wi-Fi module attached to it. There will be a centralized system for the recommendation that will be automated using an AI based bot. Moreover, also there will be RFID reader at the exit door for anti-theft. This system will not only reduce the human force required at the billing stations, but will also eliminate the bottlenecks at the counters. Especially during the time when social distancing is a necessity due to the global pandemic we are facing in from the year 2020. The customers will also be able to view details about the item they are interested in, along with the price. This provides the user, the ability to decide if they want to carry on with their current product list or want to change it. This gives the user the autonomy to decide before they go to the final billing counter. The proposed system can be embedded easily to an existing normal cart usually used in super markets at a mere cost less than 800 rupees.

2. Problem definition

Supermarket is place which provides a plethora of product types. It is feasible and this is the reason it attracts a lot of crowd quite often. Much to its disadvantage, the billing counters suffer and get overcrowded for most part. Waiting in long queues not only wastes time but is also stressing at times. In addition, people might be unaware of how much are they actually about to spend in a shopping session before the billing is done, and this might be an issue to worry for many. Also, the need of manpower at the billing stations is significantly high. We usually use barcode for scanning the product. Since a barcode scanner is not cheap, we can only have a certain amount of scanners for it to practically make sense.

3. Previous work

While surveying, it was observed that similar smart shopping carts have been developed to aid the shopping experiences and reduce the inconvenience caused by bottlenecks at the billing counters.

In [1], the authors "Galande Jayshree, Rutuja Gholap, Preeti Yada" proposed automatic billing trolley based on RFID. In this model, the system consists of RFID reader, and RFID tags embedded on the products in the malls. When the user puts any product in the trolley, the RFID tag code will be detected by RFID reader and the price of the product will be stored in the memory. At the billing counter the total bill data gets transferred to the system via wireless RF modules. This project uses ZigBee which is slower and costlier than Node MCU.

In [2], the authors "S.Sainath, K.Surender, V.Vikram Arvind" proposed an Automated Shopping Trolley with billing system. In this, the automated shopping trolley is a smart trolley integrating a raspberry pie embedded chip with two barcode scanners and a battery kit, allowing customers to self checkout at supermarkets. However, the use of raspberry pi and barcode scanners makes it overkill and also cost heavy which is not the best for practical use.

In [3], the authors "Mr. Yathisha L, Abhishek A, Harshit R, Darshan Koundinaya" proposed an automation of shopping cart to ease queue in mall by using RFID kit and ZigBee module. In this system RFID tags are used instead of bar codes. Whenever a customer puts a product into a trolley, RFID reader will scan the product, and the price displayed on the LCD panel. ZigBee transmitter is used to transfer the data to the main pc. The system isn't complex but it can however be simplified further by using say, a NodeMCU.

In [4], the authors "Jadhav Rahul, Pradeep, Nandkumar, Tarali ShivkumarJ" proposed an RFID based automated billing trolley. In this, the communication is in between RFID tag and reader. Each tag has magnetic strip with specific code and tag which is recognized by an RFID reader module. The automated billing system based on the passive RFID tags that provide fair solution to the current manual billing method in shopping mall. The system uses a microcontroller and a ZigBee module because of which the cost is moderately high than actually required.

In [5], the authors "Udita Gangwal, Sanchita Roy, Jyotsna Bapat" proposed a system of smart shopping cart having the purpose of automated billing. They used a wireless sensor networks. In this, authors describing the implementation of a reliable, fair and cost efficient shopping card using wireless sensor networks.

4. Proposed work

The shopping and billing protocol that is currently in use in most shopping complexes has room for improvement. The barcode scanners are only available at the billing counters only and cannot be provided in a shopping cart because of the high price. Also, the customers have to look into the price of each product manually to have a rough estimate of how much is they are about to spend. This could be a pain point for budget oriented people. To tackle this issue we will be installing cheap passive RFID tag on each product. This tag does not require a battery to stay alive. However, the registered number of the tag can hold a lot of information once we assign it to a database. Now for the other part of the system, we will install an RFID reader on each cart. Now the user can manually scan the product on his card itself. He does not necessarily require going to the billing counter for the entire process. A comparison between a barcode reader and an RFID reader is given in Table 1.1. This solves the issue of bottlenecks that are formed over the building counters, especially when the shopping complex is crowded, which is very common in India.

The scanner that is installed in the cart also has a processing and connection unit. This unit is always connected to the central system and the database. This provides fast and smooth transfer of data among the smart carts and the central database. We will be using a Wi-Fi module for this purpose. This is not only cheap and effective but it is also fast since we are using a database. Also, the customer will have a chance in deciding whether he wants to keep a product as the bill is reflected on the LCD screen in the cart in real time.

TABLE 1: Comparison between Barcode and RFID

Barcode Reader	RFID Reader
Requires line of sight	Requires close proximity only
Reading distance is less	Reading distance is more
Reading rate is slow	Reading rate is faster

The proposed system will give the customer a hassle free shopping experience. When the customer takes a product and places it in the cart, the RFID reader reads the product details and shows it on the screen. As in when

a product is added, the total bill will be displayed and if a customer wishes to remove a product from the cart, the customer can scan the product again and it will be removed. The Wi-Fi module is used to communicate between the smart cart and the central database.

5. Hardware description

The block diagram of the proposed work is given in FIG 1. It consists of the components listed as follows.

- Passive RFID Tag - Passive RFID tags have no internal power source and instead are powered by the electromagnetic energy transmitted from an RFID reader.
- RFID Reader - MFRC522 is a device that uses radio-frequency waves to transfer data between itself and a RFID tag/label in order to identify, categorize and track assets.
- Wi-Fi module - ESP 8266 is a low-cost, low-power, wireless mesh is access point that allows the station or client to connect to any router.
- LCD Screen - The LCD screen displays the product info.
- Processing Unit - ESP8266 will serve as the processing unit as well along with being the communication unit.

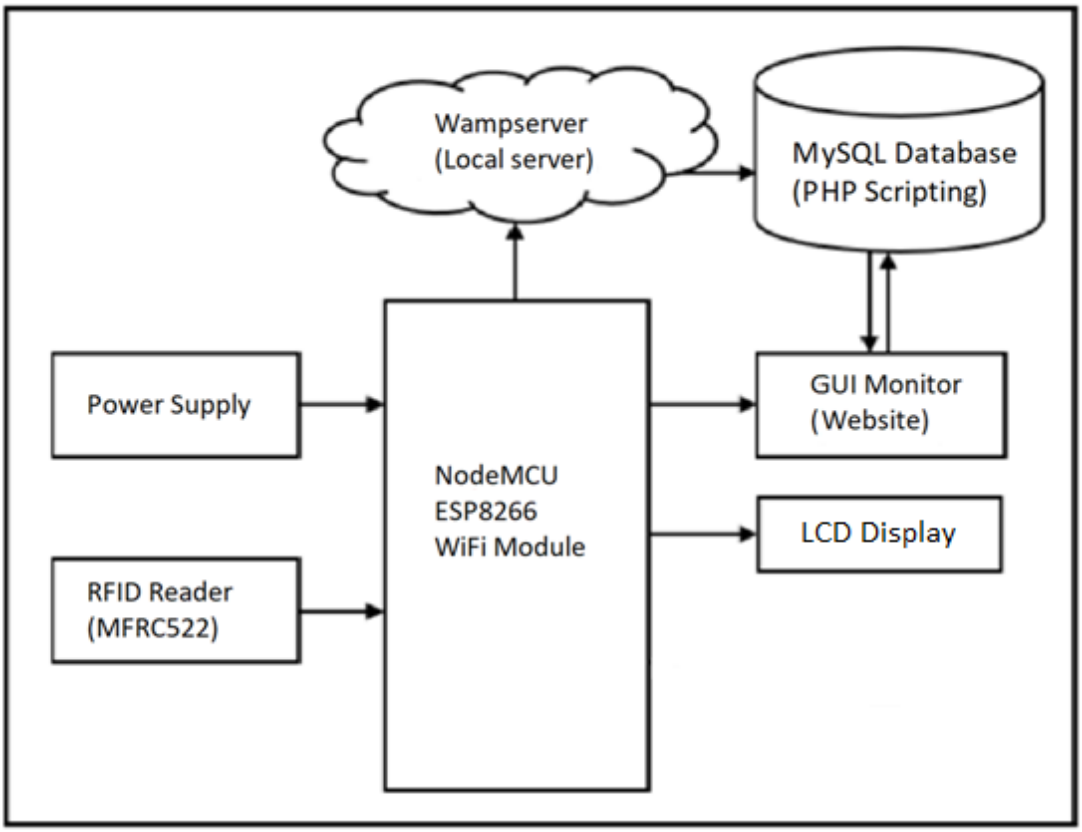

FIG 1: Block diagram of the proposed system

5.1 PROCESSING UNIT/ COMMUNICATION UNIT

This system is predominantly designed to fetch information from a database. The unit has a Wi-Fi module attached to it. We will be using an ESP8266 for this purpose. This will not only serve as the communication unit, but also as a processing unit. It is a low cost Wi-Fi module that works on IEEE standard 802.11bgn. We can handle up to 32 devices on a single network. Since Wi-Fi I is available at very cheap rates these days it is a better and cheaper option than installing ZigBee modules. These models can stay connected to a range of up to 100 meters.

5.2 DETECTION UNIT

RFID tags and reader are used for this project. A passive RFID tag will be embedded on each product. This RF ID tags do not require a battery to stay alive. Every RFID tag has a unique identification number. List

number can be read by the RFID scanner. The RFID scanner emits a low frequency wave. As a passive RFID tag comes in close proximity, the RFID reader is able to read the passive RFID tag that is embedded in the product. The system uses the concept of magnetic induction and electromagnetic wave capture. Once the passive RFID tag captures sufficient power from the RFID reader, the tag transmits the information to the reader. We'll be using RC522 module as the reader which is a cheap and effective RFID scanner.

5.3 DISPLAY UNIT

The name and the cost of the product will be displayed on an LCD screen that is embedded on every smart cart. We have used a basic 16×2 LCD panel for this project. The LCD displays the name and the cost of the product in real time. This LCD panel is very low cost and has high power efficiency and hence suitable for this project.

5.4 DATABASE UNIT

An offline server bundle known as Wampserver is used. It bundles Windows, Apache, MySQL and PHP under one roof. PHP is used as the API. The database is created using MySQL, and the webapp is hosted over Apache.

6. Methodology

The smart shopping cart will have a RFID scanner system attached to it. The system can be switched on when required. As soon the system is switched on, the ESP8266, LCD, and the RFID Scanner is switched on. A flowchart of the system is given in FIG 2.

Each product in the store will have a passive RFID tag. The passive tags are inexpensive and do not require any energy to stay alive. When they are in range of radio waves of certain frequency, the tag becomes active and starts working.

The RFID scanner emits radio waves which triggers the tag when in range depending upon the frequency range. As the passive tag of any product is brought close to the RFID scanner, the tag catches radio waves that are emitted by the scanner and becomes active. Each tag has its own ID. The scanner reads the tag and identifies the ID. This data then goes to the controller which is thereafter sent to the Wi-Fi module of the smart cart.

The product details are stored in a centralized system. The Wi-Fi module of the smart cart and the centralized system communicate with each other and the product details are fetched from the central server. The details are then flashed on the LCD screen for the user to see. The price of the product gets added.

If the client wishes to return any of the products, the tag of the product that is supposed to be returned can be scanned for the second time, and the product will be removed. The prize of that product is then automatically deducted from the billing list of the client. Once done, the final bill can be paid at the counter.

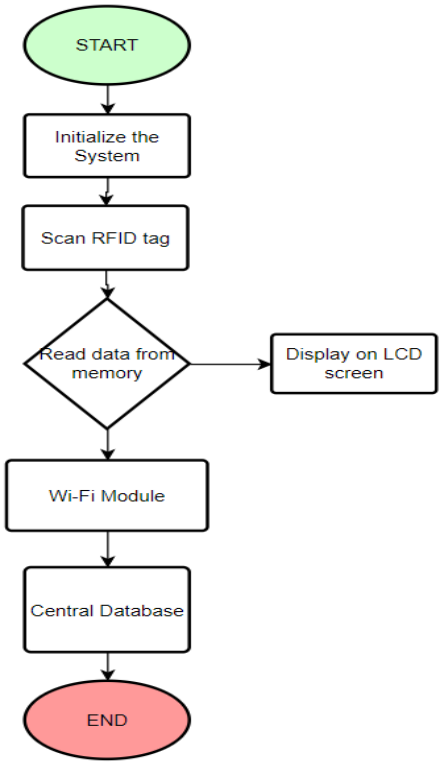

FIG 2: Flowchart of the system

Since every product has RFID tags attached, any product which is not paid for can be read at the exit gate to prevent theft.

7. Result and discussion

The prototype of the system is depicted in the figures.

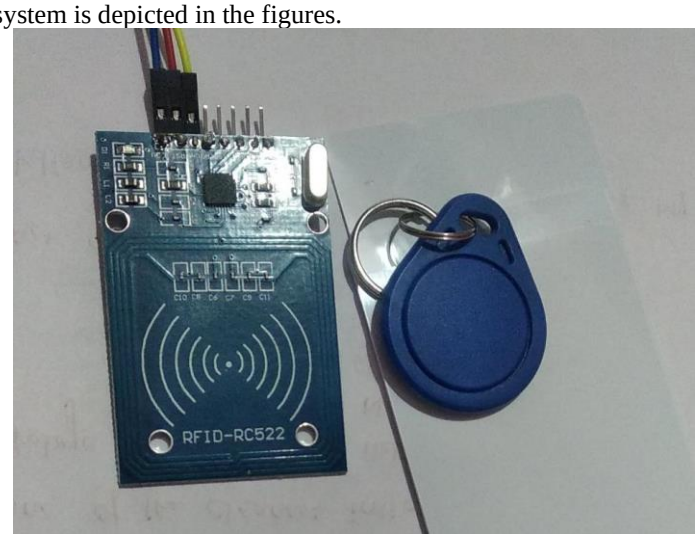

FIG 3: MFRC522 and passive RFID tag cards

The RF reader module and passive RFID tags used in the project are shown in FIG 3. The product details that'll be displayed on the LDC panel screen as shown in FIG 4. When one product is added as shown in FIG 5, the LCD will show the total price of the cart. The PP represents the product price, and TP represents the total price.

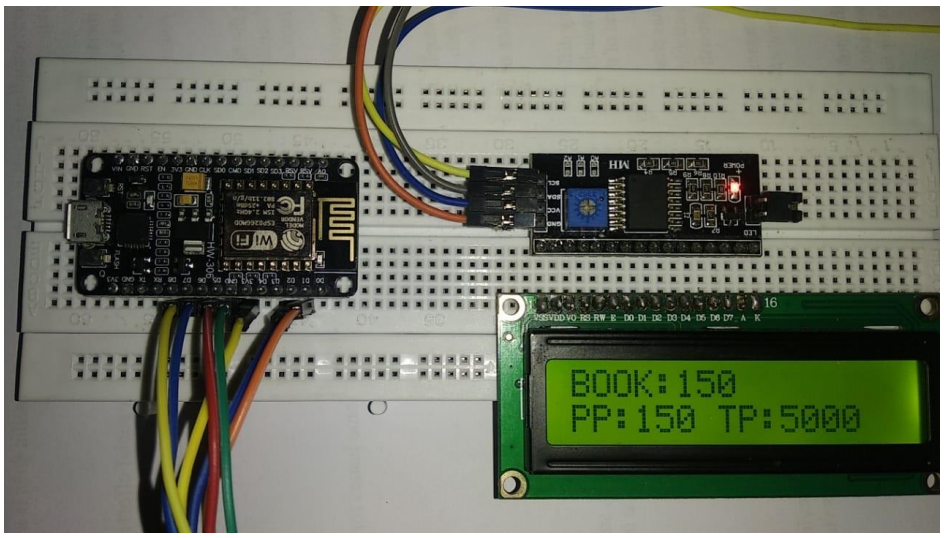

FIG 4: Product name and price displayed on the LCD Screen

The proposed objective was successfully accomplished. The system can be used by any person who has any basic understanding of how gadgets work. The total payable amount of the shopping session and displayed at the end screen, shown in FIG 5.

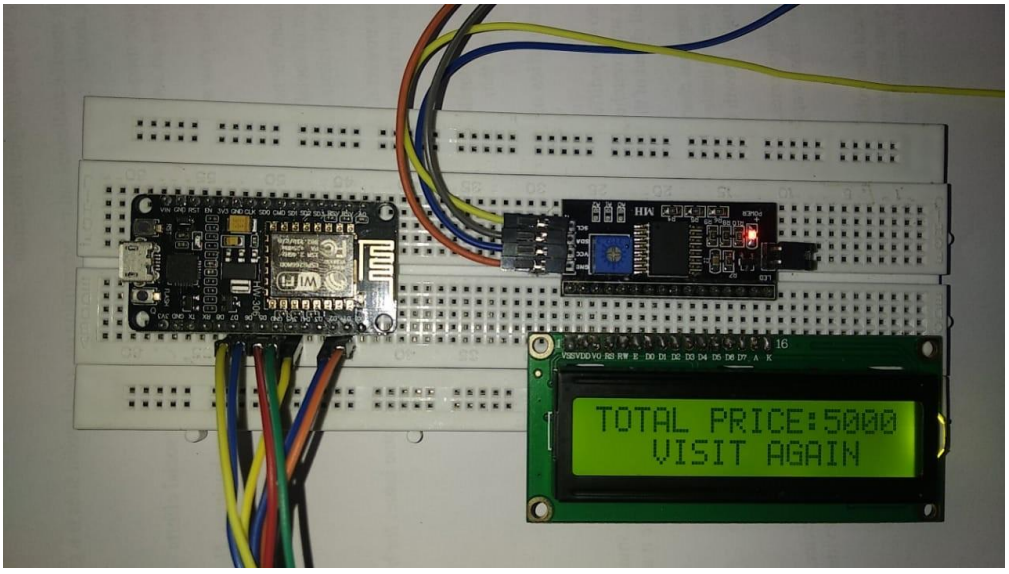

FIG 5: Total payable amount on the exit screen

A brief comparative analysis table of the cost efficiency of the research models referred here is given in Table 2.

Table 2: Comparative cost analysis of projects

Ref. No.	**Design**	**Approximate Cost**
[1]	Lpc2148 Microcontroller IC Arm7, CC2500 Module, MAX232 TTL + Thermal Printer + LCD Panel + RFID Reader	400 + 440 + 25 + 2000 +200 + 150 = 3215
[2]	ESP8266 + Arduino UNO R3 + OLED Display + NFC Reader	320 + 800 + 450 + 1000 = 2570
[3]	ESP8266 + Arduino UNO + LCD Display + RFID Reader	320 + 800 + 200 + 150 = 1470
[4]	ESP8266 + LCD Display + MFRC522+ Misc.	320 + 200 + 150+130 = 800

8. Conclusion

The proposed project tackles with the issue of overcrowded supermarkets. Moreover, it is significantly cost effective as compared to some of the other projects. The proposed project here uses a passive RFID tag which actually is costlier than printing a bar code, but the scanner is significantly cheaper. A Wi-Fi module is being used that eliminates the need of a ZigBee module which is also drops the cost of the system by a lot.

It was observed that on an average, in a semi crowded shopping complex, one new customer would join the billing queue after every two minutes. If on an average, the billing of one customer takes about three to four minutes, then the time lag starts to compound. The automatic billing system will tackle this problem of long waiting queues that not only requires man power to operate but also will save the customers time and reduce the crowd bottlenecks in the shopping complexes.

9. Future work

The current project is not only cost effective but can also be extended in many ways. The database is updated in real time and the web application is hosted over Apache so an AI based Chabot can be added to the existing project making it very handy for the customers. A phone based optional app can be created for the users as well.

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