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RFID Based Smart Trolley Using IOT

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Abstract: ***Even though E Commerce has grown exponentially in the past few years, sales made from retail still account for around 85% of the total sales made. Among the difficulties faced by customers, one difficulty is to line up in a queue to follow through with the billing process. Though their intent is just to buy one or two products, waiting to bill products consumes time and also inconvenient these days as people live in a busy environment. The goal is to develop technology that can meet all the needs of the customer while simplifying the billing process and saving the time of the customer. The proposed method is to have the customer directly process products and bill them in the trolley instead of waiting in a queue for long periods of time. The customers have to add the products after a short scan in the trolley and when they're done, the amount will be displayed in the trolley. The customer can also log in to the app which will display the list of all the products added and their amount. Once done, the customer can pay digitally through the app; thus, cutting down on the time that would be otherwise spent in long queues and relieve them from the tediousness of scanning barcodes.***

Keywords: RFID, trolley, ESP8266, ATMEGA328P, ionic framework

1. Introduction

The dynamic growth and the advent of new and exciting development in the field of IoT (Internet of Things) have paved the way for unique ways of using technology in a lot of fields. Wireless communication combined with radio and frequency sensing gives a whole new dimension to the way people interact with devices and use them in their daily routine.

Nowadays, supermarkets and shopping complexes have become so commonplace, that they are no longer a luxury afforded only by urban cities. They have expanded beyond the domain of big cities and ventured into rural areas as well. Anybody can go to these stores and buy products that they need, but they are not entirely convenient, especially when a customer has to wait for hours in queues on busy days.

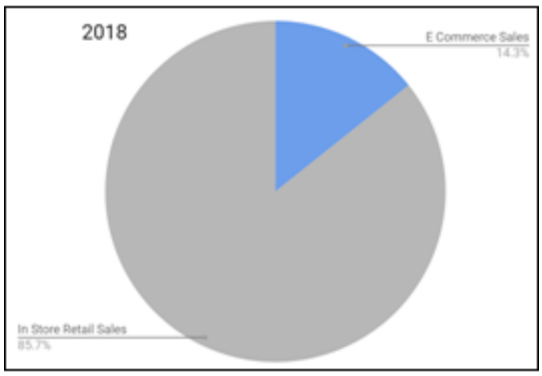

Figure 1: The proportion of total sales occupied by in-store sales

In recent times, the RFID technology has been developing rapidly and we're seeing its applications in a variety of industries, from employee ID cards being scanned in the office to the issuing of books in libraries. RFID stands for Radio-Frequency Identification, where information is digitally encoded into tags which can be used to uniquely identify a product. The RFID tags are generally captured using radio waves and the captured data is stored into a database.

The RFID tags are somewhat similar to the traditional barcodes in their purpose and functionality, as they are used for data processing. However, there are a few key differences between the two. Barcode usually requires a barcode reader to visually register the code in order to obtain information, while in the case of RFID, the use of radio waves as a means of recording data means that no line of sight is required. RFID has automatic tracking enabled and allows new information to be updated from time to time while the barcode scanning requires one to manually track the data and has no provision for updating records. RFID overcomes the drawbacks posed by barcode system which also include durability issues.

The aim here is to create a system that combines the convenience of RFID tags and wireless sensing with a simple and easy tracking system that allows customers to purchase products without the hassle of waiting in queues. The customer simply has to put a product in the trolley and let the reader scan the product for information. By fitting the trolley with a touch-enabled LCD that can display product information, it also gives us a feasible system of providing the customer with all the information like manufacturing date, expiry date, price, etc. which proves to be useful when making the decision to buy an article.

The system allows a customer to scan the items and the trolley automatically updates the total cost and bills the customer. It also has the provision of setting a budget, which when exceeded, sounds an alarm, as well as the removal of products and their cost from the total bill if a person deems it unnecessary. The system is built such that billing information is sent to a central server in real-time using the ESP8266 wifi module which tracks all the shopping trolleys and allows the client to log into the integrated app to track purchase and make payments digitally on the spot. The ease of functionality, versatility, and adaptability of the RFID enabled shopping cart makes it a state of the art system for shopping. On completion of the customer's shopping, he/she will press the button present on the trolley, which will lock it through the help of a servo motor installed on the trolley to provide security and prevent theft and the final bill will be generated.

2. Literature Survey

In [1], the authors have developed a smart shopping cart fitted with facial recognition and information retrieval

features. They have also used an automated billing system to avoid queues during checkouts to provide a comfortable shopping experience with the integration of the Internet of Things into the cart for a smart system that assists the customers.

In [2], the authors succeeded in implementing a low budget, smart and fully functional system to make the experience of shopping convenient and comfortable for customers. They made use of RFID technology because of its efficient tracking capabilities and security features. The system deployed features like setting a budget, product addition, and removal, recommendation, as well as addition and deduction of the cost of the product depending upon its presence in the cart.

The authors of [3] devised a smart shopping trolley by installing RFID readers on the trolley which were connected to a centralized server using a mode of wireless communication known as ZigBee. It facilitated automatic bill generation on scanning the products, which was transmitted to a central department for billing. The drawback of this system was that it only allowed payments over the counter which compromised on user experience.

In [4], the authors created a concept model which made use of RFID tags fitted on the products as well as ZigBee to transmit bills to a central server. The drawback here is again, the lack of alternative options for payment of bill as opposed to the traditional counter payments. The worker is supposed to collect the bill once the customer is identified, which leads to the customer waiting in queues.

In [5], the authors conceptualized an advanced shopping trolley, wherein each trolley had an RFID reader and RFID tags were present for each product. Once the product is scanned, the information is displayed on the LCD screen to show all product related information to the consumer. The aim was to help customer evade long queues but it also posed the disadvantage of possible thefts as well as collisions.

The authors of [6] accomplished in creating a centralized system for automatic billing. Every trolley was fitted with a Product Identification Device(PID) containing an RFID reader, LCD, EEPROM, a microcontroller and ZigBee Module for wireless transmission. The biggest advantage of this system was that enabled the customer to go cashless, thus, successfully implementing a method to avoid queues.

3. Approach

a) Problem Statement

The current system involves a large amount of manual handling on the part of the customer. It helps in tracking and identification of trolleys, which is useful for the management of the shop but does nothing for the customer. It does not provide a feasible solution to reduce the time spent by the customer in the store, mainly while standing in line for billing and payment. This is because of a lack of alternative mode of payments and collision issues as signals are easily intercepted. The main drawback is the lack of satisfaction and ease of use on the part of the customer.

b) Proposed Framework

Our proposed method of billing is simple, stable as well as reliable. Customers don't have to wait in queues for getting billed. They can easily pay online through our app, thus saving them time. Also, we provide our trolley with security by locking it with the help of servo motor once the shopping is completed. As RFID tags don't work on the line of sight technology, no product can be put inside the trolley without being scanned. Also, as a backup, a security check is done at the door. Another advantage of our project is that we have used ionic framework to develop our app, which enabled us to provide users with app compatibility with all three formats i.e, Android, Ios and Windows. Hence, our customers won't just be limited to Android users.

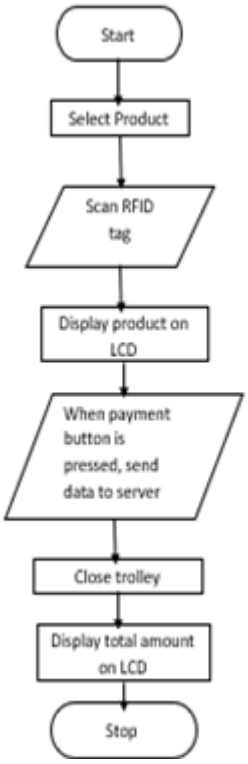

Figure 2: Flow of control of the proposed framework

4. Methodology

a) Trolley Cart Design

The methodology that we propose is based on the idea of creating an automatic billing system while shopping made possible using RFID assisted by other IOT based technologies. All the products in the shopping malls or supermarkets are provided a unique RFID tag instead of a barcode. Each shopping trolley has its own setup which contains an RFID reader, a servo motor along with a door, ESP module, a push button to make payments or cancel orders, and an LCD screen to display all information related to the item.

- **Micro-controller:** ATMEGA is an 8-bit microcontroller chip that delivers high performance at a low cost. Based on AVR-RISC core for microprocessors, it combines its read-while-write ability with a flash memory that clocks in at 32KB, giving users complete control over the versatile applications of the chip in multiple areas. The RISC architecture ensures a quick execution of programs and the

ability of the chip to be used in extreme temperatures makes it one of the most popular controllers. It can be easily operated at 1-1.5 Volts.

- **RFID Tags:** Each tag is fitted with a microchip that is used for storing the number as well as a coil which is used as an antenna for the radiation of information through radio-frequency waves. Depending on whether the kind is active or passive, it may or may not be equipped with a power source. Active tags have their own battery which they use to operate the circuitry and emit electromagnetic ways to generate a current in the antenna. Passive tags have no battery of their own and function by drawing power from the RFID reader and have a lower cost when compared to active tags. When the tag makes contact with the coverage range of RFID reader, the reader transmits radio-frequency waves to the tag which emits the waves back to the reader for the identification of an article.
- **RFID Reader:** Each trolley is reinforced with an RFID reader, and the type of reader that is used is RFID-RC522. It is a low-cost RFID reader which can also write data into the tags if required and can be directly loaded into the reader module for modulation and demodulation of signals. It operates at 13.6 MHz frequency and can operate wirelessly and handsfree in any environment making it a suitable choice as an RFID reader for a supermarket trolley. It also supports encryption techniques and algorithms and error detection in modules for a reliable experience.
- **LCD Display:** A 16X2 LCD touch-enabled LCD screen is used for displaying the information. The LCD screen can display a multitude of alphanumeric characters and graphics on its screen. It is connected to the I/O port of ATMEGA328P chip and can display information in real time.
- **ESP8266**: A low cost and highly integrated solution to connect wirelessly, this microcontroller is powered by a 32-bit Tensilica Microprocessor, which makes it possible for it to consume minimum battery resources. The WiFi stack, as well as the Real Time Operating System, allow the user to use 80% of the power for program processing and application development. It is a highly durable, compact and is able to operate for long hours on a single battery, making it suitable for a portable device like a smart supermarket trolley.
- **Servo Motor:** The servo motor here functions as a part of a mechanism to secure the products once a purchase is made, to prevent the case of thefts and enable a security feature. It is a simple device used to precisely control the angular rotation, acceleration, velocity, or linear position. The sensors are used to measure the rotation at every point and control its motion.
- **Push Button**: It functions as a simple switch that performs a function like payment and cancellation when it is pressed upon. It sends high voltage electrical signals on feedback generated from the user to set a task in motion. The Payment button is used to display the total cost of all the items in the trolley, that were scanned using either the screen or the app. The Cancel button resets the total value to default i.e. NIL.

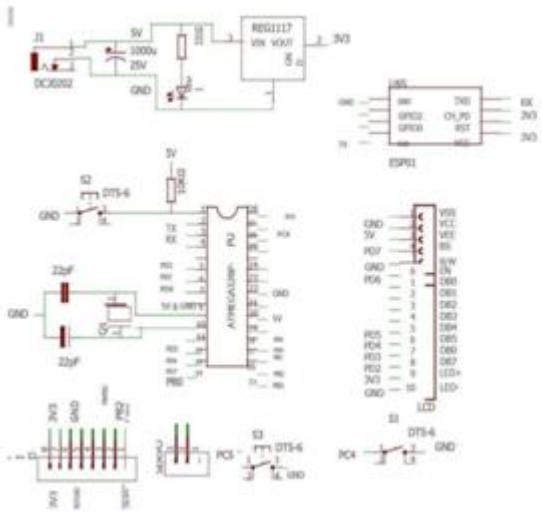

Figure 4: Circuit Diagram

b) Mobile App Design

The app functions as a smart way of integrating the manual system of RFID enabled shopping cart with the seamless user experience offered by an integrated app. All the product related information that can be displayed on the touch-enabled LCD screen fixed in the smart shopping cart can be accessed on the app as well with a simple tap. The home screen of the app is designed to be as accessible and simple to use as possible. At the first prompt, it asks whether the person logging in is a user or an admin. Both the options redirect to vastly different pages embedded inside the app, one for admin and the other for user, each offering features specific to the category.

Figure 5: Home page of the integrated app.

The admin login page consists of a simple login that asks one to enter the User ID and password in order to sign in to the admin account.

Figure 6: Admin login page for updating RFID tags

Features that an admin can use on the app:

1) An admin can check the database of users at any point in time.
2) The admin can also add or remove the users from the database or modify their details.
3) The admin can check the total bill generated by all users and track the mode of payment.
4) Admin can also track carts and purchases.

The User Login page, on the other hand, is a little different; as it also has a glaringly visible 'Sign Up' button located at the bottom in addition to the usual login features. The Sign-Up button takes the user to a page that requires the personal information of user like their name, contact details, and a password to create an account. Once the account is created, the user can log in and access the smart shopping features of the app.

Figure 7: Customer Login Page on the app

Features that a customer can use on the app:

1) A customer can view the product information on the app before making the decision to buy an item.
2) The user can modify the cart by adding or removing products and their costs from the total value of the cart.
3) The user can view the total value of the cart on the app before generating the bill.
4) The user has the option of either going cashless by paying the bill digitally or over the counter in a traditional manner, thus eliminating the need for queues.

c) Implementation

Our proposed method works on two-way server interaction. It makes the job of the staff easier as they can update the price of any product easily by updating it on the server which will get reflected on the RFID tags. This makes it eco-friendly too as printing and paper wastage on the barcode and at times of discounts to update prices is prevented.

Once the customer gets a trolley and logs in or signs up to the app, he/she can start scanning products into their trolley. Every product scanned will be sent to the server and the app with the help of ESP module and if the customer wishes to remove the product, he/she can scan it again and it will be removed from both the server as well as the cart in their app. Once the customer is done with their shopping, they can press the payment button installed on the trolley, which will lock it to provide for security, so that more products cannot be added during the payment process. The app will now show the summary of the products purchased, with their price and the discounts offered, and will then redirect you to online payment using a debit/credit card. The customer can now head straight to the exit doors where the RFID tags can be removed and can now be reused.

5. Analysis

A system based on RFID technology that could replace the traditional barcode system was successfully established. The barcode system had various drawbacks including the strict requirements on line of sight and its need to be placed in one particular boundary while scanning, not to mention the issues concerning its durability and inability to update information. The only constraint that RFID scanning is known to have is the distance and range coverage. RFID tags are durable and allow constant update of information as well as a rewrite of data to account for changes. They can also operate in extreme temperature conditions and are not susceptible to physical wear and tear or damage under water.

This makes the process reliable, flexible and adaptive. The door fixed along with servo motor ensures that until the payment is done, no unscanned product is placed inside the trolley. The availability of multiple modes of payment through digital wallets or bank accounts ensures that every single penny is paid for and prevents the occurrence of penny scams.

The proposed project is feasible as it is built on technology that already exists. We have improved it by eliminating the long waiting time of queue at the time of billing, secured it by locking after completion of shopping and made the app available to all customers using the ionic framework. The only drawback would be that it would fail if the server is down for any reason.

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