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Smart Trolley System for Automated Billing using RFID and IoT

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Abstract - *An automated smart shopping system is formed by introducing the concept of IoT to connect all items in the grocery shop. 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, expiry date of the product is displayed and the damaged products can be identified with respect to its weight. Thus, expired and damaged products will not be considered for bill calculation. In addition to that, smart shelving is added to this system by introducing RFID readers that can monitor stock, perhaps updating a central server. Thus, inventory management becomes easier. Finally, the checkout points can validate the purchase made by a client. A prototype of a smart shopping system is also presented in this paper.*

Key Words: **RFID tag, IoT, smart shopping, smart cart, grocery shop**.

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 brought a new revolution in industrial, financial and environmental systems and triggered great challenges in data management, wireless communications and real-time decision making [1]. Also, numerous security and protection issues have risen and lightweight cryptographic techniques are in high demand to fit in with IoT applications. There has been a lot of IoT experimentation on various applications such as smart homes, e-health frameworks, wearable gadgets, and so on [2]-[4]. This paper centers around a smart shopping framework based on Radio Frequency Identification (RFID) technology [5]. All things available to be purchased are joined with a RFID tag, so they can be tracked by any gadget outfitted with a RFID reader in the store. This brings the accompanying advantages:

1) Items put into a smart shopping cart (with RFID perusing capacity) can be read by default and the billing information is generated. Subsequently, clients do not have to hold up in long lines at checkout.

2) Smart racks that are likewise outfitted with RFID readers can screen every single loaded item and send item status updates to the server. At the point when items wind up sold out, the server can tell representatives to restock.

The utilization of ultra high frequency (UHF) RFID technology [6] is proposed in the smart shopping framework, as UHF passive tags have a more drawn out range from 1 to 12 meters. Past research on the design of smart shopping frameworks principally centered around utilizing low/high frequency RFID [7]– [14], which have insufficient ranges and leave clients to physically check items with a RFID scanner. In this proposed framework, each smart cart is furnished with an UHF RFID reader, a microcontroller, a LCD touch screen, a GSM/GPRS module, and a load cell. The smart cart is able to automatically read the items put into a cart via the RFID reader. A micro controller is installed on the cart for data processing and a LCD touch screen is equipped as user interface. In order for the smart cart to communicate with the server, we have chosen GSM/GPRS technology. We also have a load cell (weight scanner) installed on the smart cart for weighing items. The weight scanner also helps do a security check. For example, if a malicious user peels off one item's RFID tag and puts it into the cart, an extra unaccounted weight will be added. When shopping has been done by a customer, the payment can be made at the checkout point using the billing data generated on the smart cart. An RFID reader is kept before the exit door in order to check if all the items in the cart have been paid for. Security and privacy issues related to smart shopping system are considered. Wireless communications among the server, smart carts and items are vulnerable to various attacks. If there is no proper security method, an adversary can easily intrude with the communication process. Privacy issues also exist ie., the competitor of a store might get easy access to the circulation of commodities for financial strategy and customer preferences can be inferred by easily collecting the product information in shoppers' shopping carts.

The paper is organized as follows. Section 2 describes the proposed system. Section 3 summarizes the processing steps in grocery store. The various outputs obtained are explained under section 4. We conclude this paper with future research discussion in section 5.

2. PROPOSED SYSTEM

In the current system, bar codes are used for scanning the product details where the customers tend to wait in long queue for generating the bill followed by payment. At times, the bar codes would have been damaged and that particular product cannot be scanned by a barcode scanner leading to confusion. Also, each and every product has to be scanned manually.

In order to solve the problems previously identified and save consumers time, money and help the retailers to win loyal clients, in this proposed system, each product will have a passive Radio Frequency ID tag which is bearing a unique Electronic Product Code. This Electronic Product Code provides the information about the product i.e. its name and price. When the customer puts the product in the Smart Trolley, the Radio Frequency ID reader scans the tag and the Electronic Product Code number is generated. Radio Frequency ID reader passes the Electronic Product Code to the microcontroller. The name and price of the product obtained by the controller gets displayed on the LCD of the Smart Trolley, where client can see the item data. To store the item price and total billing data, microcontroller memory is used. LCD is interfaced with microcontroller in 4bit mode. It is used to indicate the purchaser, the action taken by the purchaser that is inserting of an item, removal of an item, item's price and total billing cost of items in the trolley. At the billing Counter, the total bill data will be transferred to PC through GSM/GPRS module.

As per the test, when putting an item into the smart cart or expelling an item from the cart, the smart cart is able to precisely read it. One astonishing outcome is that the metal outside the cart obstructs the signal to a high degree that when the reader is inside the cart, no item outside the cart can be read. This clearly indicates that an item put into a smart cart will not be perused by a nearby cart accidently. A RFID reader is installed at the checkout point so that the items in the cart can be meticulously read.

As shown in figure-1, the smart trolley system architecture involves two sections such as embedded and Java. In the embedded section, microcontroller is used to coordinate with the RFID reader, weight scanner, and LCD touch screen, GSM/GPRS module to perform computing functions. Via serial communication, the information is passed to GPRS module and then under the Java section, the data is retrieved and viewed in the website using the cloud access.

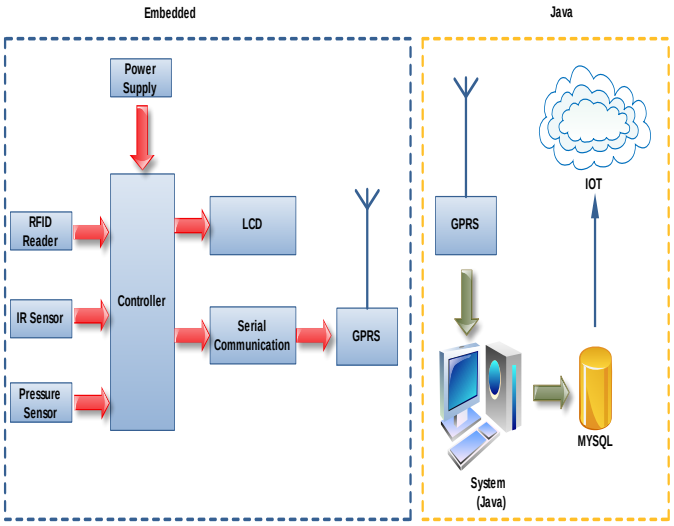

Fig -1: System Architecture

2.1 Design Goals

The proposed smart shopping system should achieve the following major goals:

1. Items reading: The smart cart should be able to accurately read items put into or removed from the cart. An item put into one cart should not have the ability to be perused by another cart nearby.

2. Items tracking: The server should maintain the state of items in the store. With RFID readers installed on the shelves, the items can be monitored and the item stock can be updated to the server.

3. Payment verification: RFID readers installed before the exit door can scan all the items in the smart cart and check with the server if everything in the cart has been paid. If an unscrupulous shopper tries to leave the store without making a payment, he will not pass the verification.

Fig- 2 shows the basic block diagram of a smart trolley. The microcontroller interrelates with RFID reader, LCD touch screen, load cell, GSM/GPRS for the processing of data, while the GSM/GPRS being interconnected with the server.

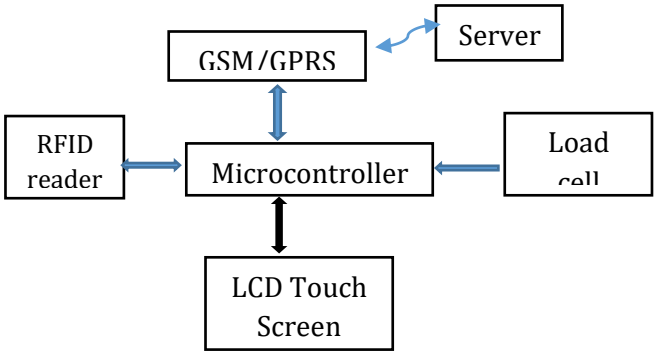

Fig -2: Cart Components

3. PROCESSING STEPS IN GROCERY STORE

The various steps involved in the processing of a Smart Trolley system in a grocery store are as follows.

3.1 Registration

Before moving all items to the shelves, the store needs to register all of them. Information such as price, location, and coupon are stored in a database of the server, rather than in the tags because such information might change over time and it is more convenient for the server to manage them. The Tag design is composed of producer number, product number, product name, weight, expiry date, HMAC which is given in Fig- 3.

Producer number	Product number	Product name	weight	Expiry date	HMAC

Fig -3: Tag Design

3.2 RFID Tag Scanning

Radio-Frequency Identification tags are used to identify and locate items using radio signals. They consist of a microchip and an antenna which transmit a signal to a 'reader'. RFID tags have been suggested as substitution for barcodes in some areas because they use radio waves, RFID tags can be 'read' out of the line of sight and at distances ranging from a few centimeters to over 100 meters. They also enable individual items to be given a unique identification number, rather than just a product code. The retailers and wholesalers are expected to use these RFID tags to track the package of goods between stores and warehouses.

In this Futuristic Billing Trolley System environment, each product will contain the passive Radio Frequency ID tag which is bearing a unique Electronic Product Code. This Electronic Product Code provides the information about the product i.e. its name and price. As soon as the buyer puts the product in the Smart Trolley, Radio Frequency ID reader scans the tag thereby generating the Electronic Product Code number. The fetched data is passed to the microcontroller where further processing takes place.

3.3 Weight Scanning

The weight scanner can weigh the items that are put into the cart to ensure the tag corresponds to the correct item. It can also help with a security check: if a malicious user peels off the RFID tags before putting it into the cart, the cart can detect it as an extra unaccounted weight is added. Here, weight scanner is implemented in the form of a load cell which is a transducer that is used to create an electrical signal whose magnitude is directly proportional to the force being measured. In specific, a double bending beam load cell element is used in this proposal.

3.4 Billing Generation On Smart Carts

A smart shopping system should involve lightweight cryptographic methods due to limited computational power. Both symmetric and asymmetric encryption is combined to tackle this issue. When a commodity is placed in the cart, RFID reader reads the tag information and conveys the same to the microcontroller that will then communicate with the server through GSM/GPRS. We adopt ECDSA to sign the message and Elgamal encryption on Elliptic Curves to encrypt the message. At this point, the smart cart needs to perform the encryption and signing of the message, which are computationally lightweight. In order to avert the system from performing asymmetric decryption, heavy-load work, the smart cart is expected to randomly generate two symmetric keys s1 and s2 which are sent to the server with its requests. The server then encrypts the requested information using s1 and creates a message authentication code (MAC) with s2. Therefore, upon receiving a message from the server, the smart cart needs to perform only symmetric decryptions and MAC checking.

3.4.1 Smart Checkout Point

The checkout point is installed with a Point of Sale (POS) for the buyer to make a purchase. After making the payment, a buyer has to go through a lane where an RFID reader can read all the items in the cart and check with the server if all the items have been paid for. Any overpay or underpay will trigger an alert.

3.5 Data Transfer and Sharing Using IoT

In order to view the list of purchased items by the store administrator and client via website, the following steps are involved.

3.5.1 Security

To prevent a malicious user from rewriting a tag, a HMAC is created and appended to the tag for each item. After reading an item, the smart cart needs to first check the HMAC of the item to make sure it has not been modified maliciously. The keys used for the HMAC is stored in each smart cart and the allocation can be done at the back-end. We insist that the tags must be tamper-proof so that any action on taking off a tag or switching tags between items will lead to a failure. Finally, we utilize the weight scanner on the cart to prevent a fraudulent shopper from underpaying. If the weight of the items in the cart is greater than they should be, an alarm is triggered.

3.5.1.1Cryptographic Method

A combination of symmetric and asymmetric cryptographic systems is been adopted. The server is assigned with a pair of asymmetric keys Ps and Ss. Each smart cart is assigned a unique ID i and a pair of asymmetric keys Pi and Si. Each checkout point is assigned a unique ID j and a pair of

asymmetric keys Pj and Sj. For asymmetric encryption and decryption, we denote the encryption to cipher text c of data d with public key P by c = EP (d) and decryption of cipher text c with private key S by d = DS(c). For symmetric encryption and decryption, we denote the encryption to cipher text c of data d with key s by c = Es(d) and decryption of cipher text c with key s by d = Ds(c).

3.5.2 GPS Module

The NAVSTAR GPS (Navigation System with Time and Ranging Global Positioning System) is a satellite based radio navigation system providing precise three- dimensional position, course and time information to suitably equipped user. The GPS module is used for transfer of data from microcontroller memory to the cloud from where the data can be fetched via website.

After microcontroller receives the information, it will get displayed on the LCD screen simultaneously storing the data in flash memory. When we press the send button, it is passed to the GSM/GPRS module where 1.Checks the connection with the main module. 2.Initializes the SIM card. 3.Checks for internet connection. 4.Transfers the data over cloud. 5.Using the website, data stored can be retrieved.

The communication between microcontroller and GSM/GPRS module is of serial communication mode. The microcontroller uses TTL/CMOS logic whereas GSM/GPRS module uses RS232 logic. To convert the TTL/CMOS logic levels to RS232 logic levels during serial communication of microcontroller with GSM/GPRS module, MAX232 is used. The intermediate link is provided through MAX232.

3.5.3 Website Creation

The website is intended to screen the report from any place utilizing web association. The website is planned utilizing HTML and JSP. JSP is server side scripting dialect for the web improvement. JSP can be utilized with HTML code and with different web motor systems. The page can be effectively questioned and data can be retrieved in a proficient way. All items are registered to the server before moved to the shelves. The product details such as location, price and expiry date are stored in a database by the server. The server communicates with all the other entities in the smart shopping system through GSM/GPRS.

4. OUTCOME

The various outputs of the proposed system are as follows.

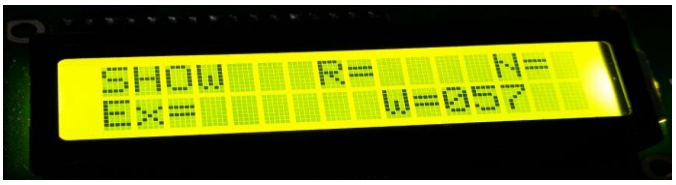

Fig -4: Initial LCD display

Initially, when the smart trolley is empty, LCD displays as shown in fig-4. "SHOW" indicates to put the product into the cart as the cart is initially empty. "R" denotes price. "N" denotes no. of items. "Ex" refers to expiry date and "W" shows weight of the item. Here, it shows W=057 which is the initial extra weight due to noise. Firstly, the shopper needs to put the product into the cart. Then, RFID tag embedded within the product gets scanned by the reader.

When the consumer puts a product named "BOOST" into the trolley, it shows BOOST+, its cost, expiry date, weight and no. of items is updated as shown in fig-5. If a product that is expired is chosen by a consumer, it indicates that the product is expired by displaying "EXPIRED" and its expiry date as shown in fig-6. As the expired product is rejected by the system, the cost, weight and no. of items will not be updated.

Fig -5: Good product output

Fig -6: Expired product output

Fig-7 shows smart shopping kit which contains a microcontroller with its driver circuit, LCD, piezo buzzer, load cell with its amplifier, 230/12V transformer, RFID reader, GSM/GPRS module.

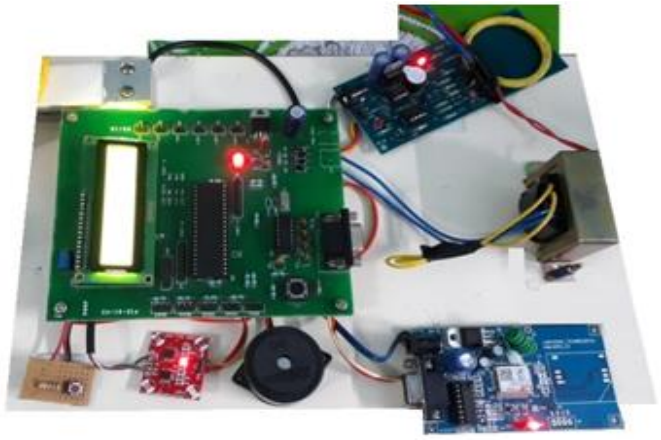

Fig -7: Smart Shopping kit

Finally, as soon as the purchase is over, the customer is supposed to press the send button and thus the bill of the purchased items is transferred via GSM/GPRS and stored in the database. Then, the same can be retrieved using a website as given in fig-8 and 9. The user has to enter into the shop's website and login. Thus, the bill of the items purchased gets displayed. Online payment can also be done by giving the account details. In case of payment by cash, the purchaser has to go through a lane and pay the bill in the billing section of the shop.

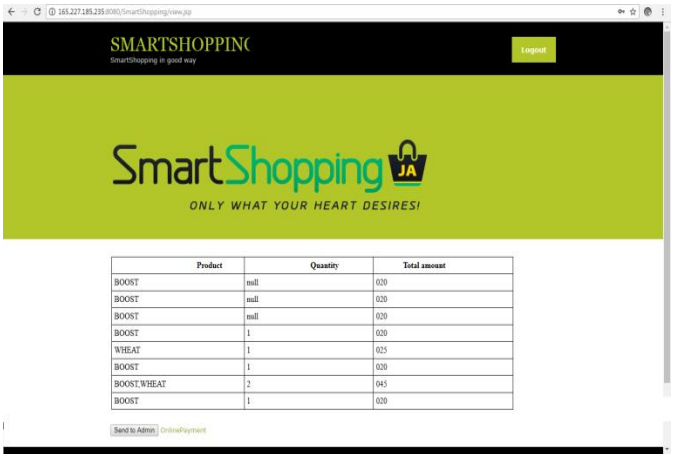

Fig -8: Website result

Product	Quantity	Total amount
BOOST	null	020
BOOST	null	020
BOOST	null	020
BOOST	1	020
WHEAT	1	025
BOOST	1	020
BOOST,WHEAT	2	045
BOOST	1	020

Send to Admin OnlinePayment

Fig -9: List of products purchased

5. CONCLUSION

In this proposed paper, a secure smart shopping system utilizing RFID technology is employed in enhancing shopping experiences and security issues. The smart shelves are able to monitor the items on the shelves by reading the RFID signals from the tags. The smart carts are able to read and retrieve information of the items inside the carts and finally, the checkout points can validate the purchase made by a customer.

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