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ARDUINO BASED SMART CART

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ABSTRACT — There has been an emerging demand for quick and easy payment of bills in supermarkets. This project describes how to build an automated and time saving system for the world of retail which will make shopping experience impetuous, customer friendly and secure. In this paper, smart cart is proposed that will be capable of generating a bill from the cart itself. The customer will make the payment in no time through a rechargeable credit card which will help to maintain database and introduce schemes and offers in stores accordingly. The designed cart eliminates the effort of self packaging, makes the best use of cart storage space and involves security mechanism for theft control.

The smart cart uses RFID technology for shopping and payment, AVR microcontroller for peripheral interfacing and inventory management. This innovative system will help the stores to see a rise in their sales along with delighting customers.

KEYWORDS — AVR Microcontroller, Intelligent car, RFID technology (products, card and tags), Retailing system.

I.INTRODUCTION

The past two years have witnessed an explosion of interest in RFID and supporting technologies primarily due to their rapidly expanding use to track products through the grocery supply chain. Such applications monitor Store-Keeping Units (SKU) rather than individual product items, since item-level tagging was not yet practical due to the relatively high cost of RFID deployment and the very low profit margin of supermarket products. But decreasing economic and other technical concerns to a large extent, one can easily envision a situation where each item in a supermarket is tagged with an RFID label, shopping carts feature RFID readers and potentially on board computers that recognize products put in the cart, and display information and promotions retrieved wirelessly/wired from the system back-end.

Item-level deployment of RFID technology would also allow for quick checkout aisles that scan all products at once and thus eliminate queues, which are consistently reported as one of the most negative aspects of supermarket shopping. A simple extension of this system would be to use RFID embedded in consumers' loyalty cards to identify individuals. This option could be useful for faster login to the system and to charge the shopping cost directly to the customer account at the point-of-sale (POS) [1].

II.LITERATURE SURVEY

Shopping in the present day usually involves waiting in line to get your items scanned for checkout. This can result in a great deal of wasted time for customers. Furthermore, the technology currently used in checkouts barcodes - is from another era, developed in the 1970s. Today barcodes are found on almost every item. Barcodes are a universal technology in that they are the norm for retail products; stores that own a barcode reader can process barcodes and imprint it on the products. The most important factor that is involved in barcode scanning is that the product should be in the Line of Sight (LOS) of the reader in order to get the barcode imprinted on the product scanned.

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 [2].

Nearly 15 billion pairs of shoes and 10 billion fashion apparel items ship from manufacturers every year. The costs for conducting manual inventory of these items, managing out-of-stocks, and preventing theft continue to rise. Apparel retailers are rapidly adopting item-level tracking to enable accurate visibility of each garment. Perpetual inventories are running at 60-70 percent in real-time, making it difficult to make proactive business decisions for creating in-store sales lift. Specialty apparel retailers that design, source, and sell products bearing their own brands are realizing significant results, such as a 14 percent sales lift and a 90 percent reduction in the time required to conduct weekly inventory [3].

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 [4].

Bill McBeath in April 2013 said, to survive in 2013 and beyond, retailers need to make it easy for consumers to buy anywhere, receive anywhere, and return anywhere. The key to this cross-channel order promising is the ability, in real-time, to locate and allocate available inventory from any location, whether in the store, in DCs, in transit, or on order from the manufacturer. This requires having a very accurate, real-time, item-level picture of inventory at all these sources. RFID has proven to improve perpetual inventory accuracy in stores dramatically, by 20%-30%. JC Penney improved perpetual inventory accuracy from 75% to 99% in categories using RFID [5].

Ankit Anil Agarwal, Saurabh Kumar Sultania, Gourav Jaiswal, Prateek Jain (2011) in their paper RFID Based Automatic Shopping Cart described the implementation of a system to allow the consumer a new way of shopping. When arriving at the supermarket, the consumer heads towards a shopping cart that has a technological system on its handle-bar which consists of a touch-screen monitor, a client card automatic reader, a positioning transmitter and a product reader. Nevertheless, all these technologies become transparent to the consumer because only monitor interaction will occur [6].

In the present paper we aim to develop a system that will use RFID item level tagging to exploit the benefits of RFID as well as provide a system which being cost effective will see its implementation in small and large scale store.

III.SOLUTION PROPOSED

This project brings to market tremendous opportunities for retailers using Radio frequency identification (RFID) technology. Traditionally RFID was used to track inventory along supply chains, retailers placed RFID tags onto pallets. Now with this automated system retailers will recognize the value of tagging individual pieces of merchandise [1] that will overcome the problem of the product being in the Line of Sight (LOS) of the reader.

Item- level RFID tagging is proving to deliver product inventory data that is up to 99.5% accurate [7].Retailers will have a precise understanding of their entire inventory and a quick means to assess it. As such, they are equipped to make decisions on which products to carry and which to restock and have an effective means to significantly increase inventory visibility, lower labor costs, decrease operational expenses and slash the high price of shrinkage[3].

The wait is over. With RFID-enabled kiosks and fixtures throughout the store, customers can enjoy speedier checkouts and greater convenience [7]. This line-busting technology can simply communicate with shoppers' smart phones to complete transactions on the spot via mobile banking. And as customers shop, RFID can collect customer information that retailers can turn into insight to attract them back again and again. The big payoff of RFID is 14%-21% more sales and 19% more units sold.

IV.SYSTEM ARCHITECTURE

The modules included in the system architecture are as follows:

1. Microcontroller
2. RFID Reader
3. LCD
4. Buzzer
5. EEPROM
6. MAX232
7. Cart Lock Mechanism

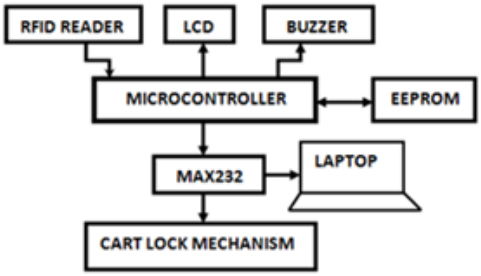

Fig.1 Block Diagram of Smart Cart

1. *Microcontroller* – ARM has modified Harvard Architecture and is 8-bit RISC single chip microcontroller. It has complete System-on-a-chip. On Board Memory (FLASH, SRAM & EEPROM) and On Board Peripherals are present. The atmega8535 provides the following features: 8K bytes of In-System Programmable Flash with Read-While-Write capabilities, 512 bytes EEPROM, 512 bytes SRAM, 32 general purpose I/O lines, 32 general purpose working registers, three flexible Timer/Counters with compare modes, internal and external interrupts, a serial programmable USART, a byte oriented Two-wire Serial Interface, an 8-channel, 10-bit ADC with optional differential input stage with programmable gain in TQFP package, a programmable Watchdog Timer with Internal Oscillator, an SPI serial port, and six software selectable power saving modes.AVR is interfaced with LCD, switches, motor and a buzzer using various ports (Refer Fig 2).

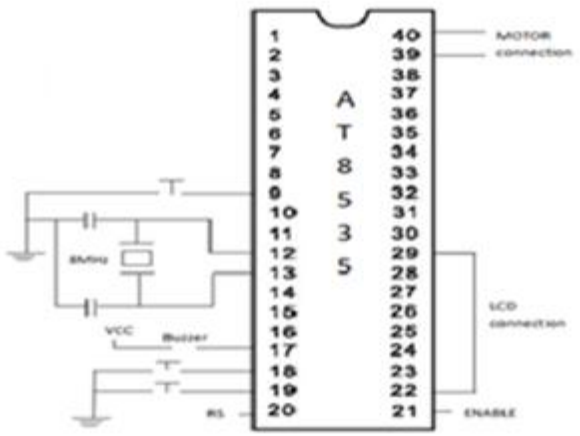

Fig.2 Interfacing of Microcontroller

LCD is interfaced with port C and D Motor is interfaced with port A Switches and buzzer are interfaced with port D.

2. *RFID reader* - Radio frequency identification (RFID) is a generic term that is used to describe a system that transmits the identity (in the form of a unique serial number) of an object or person wirelessly, using radio waves. Unlike ubiquitous UPC bar-code technology, RFID technology does not require contact or line of sight for communication. RFID data can be read through the human body, clothing and non-metallic materials.

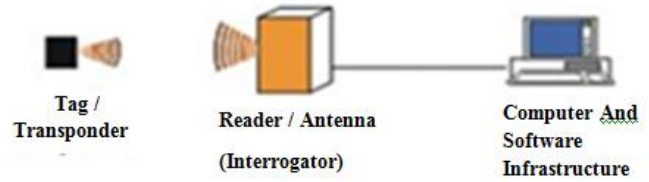

Fig.3 RFID Scanning

RFID consists of two parts:

i. RFID tags - Passive RFID tags for products-Passive RFID tags are attached to the products and are scanned by the reader attached to the cart. The data (product name, RFID number and cost) corresponding to respective card gets displayed on the LCD.

Passive RFID tags for user – RFID credit cards are of great advantage because they permit contactless payment transactions which are fast, easy, can be more reliable than magstripe transactions, and require only physical proximity (rather than physical contact) between the credit card and the reader. RFID based credit cards are issued to the user at the time of registration and the card is recharged with money. Other important user information like customer name, contact number, email id, RFID number and balance are also entered.

ii. RFID Reader - RFID reader (EM-18) is installed in the cart which scans the products which pass through the inlet and are entered to the cart. After reading the RFID number corresponding data about the product gets displayed on the LCD.

3. *LCD* – LCD displays the information i.e. cost, RFID product number and name of the product when the product is scanned by the RFID reader. Up/down switches are interfaced with the microcontroller which can be used to view all the purchases (Refer Fig. 4)

4. *Buzzer* - A buzzer is an audio signaling device, which may be mechanical, electromechanical, or piezoelectric. A buzzer is interfaced with the microcontroller to indicate scanning of the product by the RFID reader.

5. *EEPROM* - EEPROM stands for Electrically Erasable Programmable Read Only Memory and is a type of non-volatile memory used in computers and other electronic devices to store small amounts of data that must be saved when power is removed. A memory unit, EEPROM is connected with microcontroller to save the database of the Information like cost and quantity of product is read from the database stored in EEPROM at the time of billing.

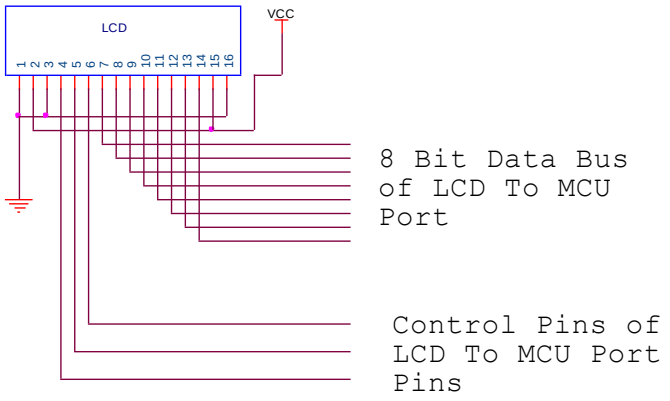

Fig.4 Pin Configuration of LCD

6. *MAX 232*- This chip is used when interfacing micro controller with PC to check the Baud rate and changes the voltage level because micro controller is TTL compatible whereas PC is CMOS compatible. The MAX 232 IC contains the necessary drivers and receivers, to adapt the RS- 232 signal voltage levels to TTL logic.

RS 232 is used at the time of billing. Cart is connected to the laptop via MAX 232 and after connection is made details about the purchases are transferred to the laptop and lock is

opened. The bill is calculated and it is debited from the user RFID credit card and process is complete.

RS232 is not compatible with today's micro controllers, we need a line driver to convert the RS232's signals to TTL voltage levels that will be acceptable to the AVR micro controller TxD and RxD, that is why we are using MAX232.

7. *Cart locking mechanism*- For locking the cart motor is used along with motor driver L293D. To derive the DC geared motor near about 50-100 mA current is required. But any I/O pin of any MCU can source/sink a current of near about 20 mA. So for its interfacing with microcontrollers a power or current amplifier circuit is required, known as motor driver circuits (Refer Fig.5) L293D is used which is a H bridge IC to control the direction of motor rotation.

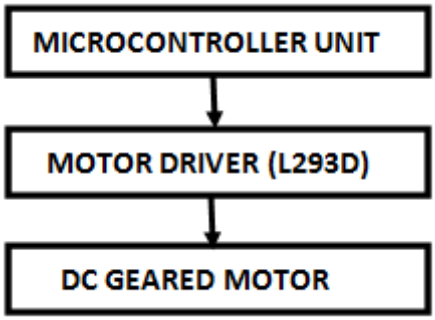

Fig.5 Cart Lock Mechanism

When battery is attached to the cart i.e. when it is powered up, it automatically locks itself. The cart opens up only when it is authenticated by the operator at the billing section. When the cart is connected via serial port and details are transferred to the laptop then the motor rotates in anticlockwise direction and the cart is unlocked. The term *H bridge* is derived from the typical graphical representation of such a circuit. An H bridge is built with four switches (solid-state or mechanical). When the switches S1 and S4 (according to the first figure) are closed (and S2 and S3 are open) a positive voltage will be applied across the motor. By opening S1 and S4 switches and closing S2 and S3 switches, this voltage is reversed, allowing reverse operation of the motor. Using the nomenclature above, the switches S1 and S2 should never be closed at the same time, as this would cause a short circuit on the input voltage source. The same applies to the switches S3 and S4. This condition is known as shoot-through.

V. PROTOTYPE IMPLEMENTATION

The smart cart can be implemented in the following way in the store.

Stage I (Refer Fig. 6) -

Stock from various suppliers arrives at the store. Products are added to the stock and are registered by using the product registration form, wherein information about the product like product name, product brand, color, RFID tag number, cost and product ID number are added. For product registration (Refer to section V.1).

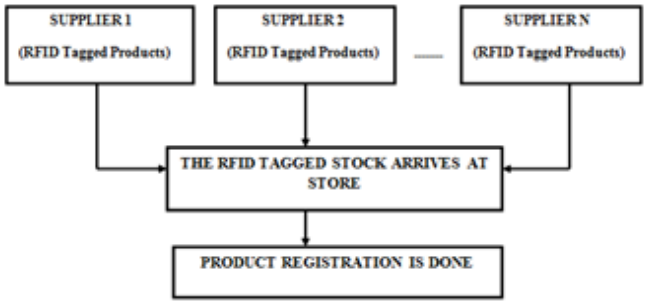

Fig.6 Block Diagram of Stage I

Stage II (Refer Fig. 7) –

The customer arrives at the store. There can be two cases:

- If a new customer arrives to the store then he will move to the user registration counter. User will be registered and a RFID rechargeable loyalty card is issued. The customer will then take the smart cart which is already locked and start shopping.
- If an old customer arrives to the store he can get his RFID loyalty card recharged and proceed to the shopping with the smart cart. For user registration (Refer to section V.2).

Stage III (Refer Fig. 8) –

When the customer is done with the shopping, he will move forward along with the cart to the billing counter. At the billing section cart is connected to the server via the serial port and is authenticated which results in opening of the cart. The data of the purchased RFID tagged products is automatically transferred to the server. The bill is computed and customer is provided with a facility to remove undesired products.

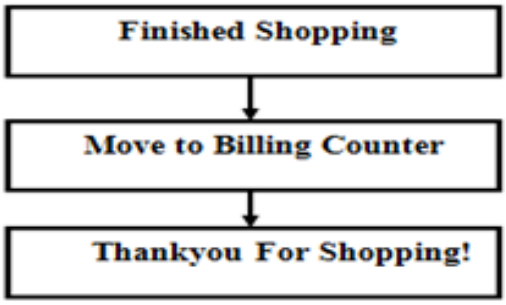

Fig.8 Block Diagram of Stage III

The user RFID loyalty card is scanned and the balance is checked. If the balance is less than the calculated bill then user can get the card recharged and pay the bill. For billing section (Refer to section V.3).

Fig.7 Block Diagram of Stage II

A. Product Registration-

Each product is tagged with passive RFID tags, with a unique product identification number. The details of which need to be added in the database that is done using the product registration form (Fig.10).

Product registration is done at the back end when details about RFID tagged products are added. Details of the product include –name, brand, color, cost, quantity (Refer to Fig.9). All this information is stored in the EEPROM. This stored database is used to maintain the inventory stock and give a notification whenever number of products is below a certain limit.

B. User Registration-

When a customer enters the store, they are registered and a RFID credit card is issued to them (Refer Fig.11). This RFID credit card is used for payment to replace cash and hence making payment process fast and customer friendly. At the time of registration there are two possibilities (Refer Fig.12):

I. Either the customer is a new customer – In such a case RFID credit card is issued and other user details like name, contact number, email id, card number and amount are entered.

II. Or the customer is an old customer – In such a case card Recharge form is opened and the customer card is recharged with the requested amount.

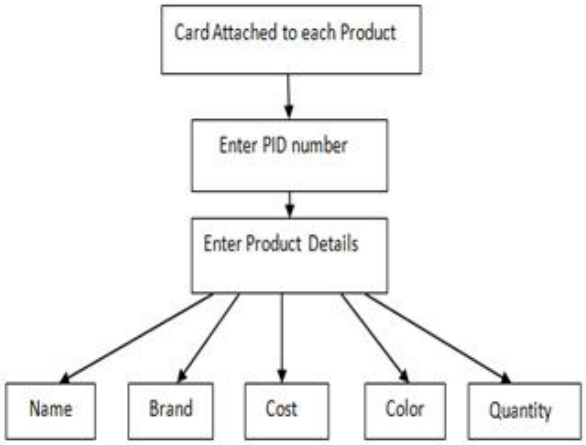

Fig.9 Product Registration

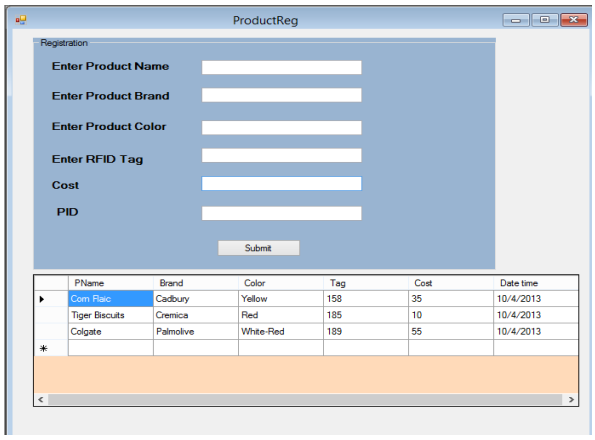

Fig.10 Product Registration Form

C. Billing –

When all the purchases which are inside the cart have been scanned by the RFID scanner (Refer Fig.13) and the total

amount has been stored inside the microcontroller then the cart is connected to the server laptop using MAX 232.

When the cart is authenticated and details of purchased products is transferred from cart to the laptop then the locking mechanism operates and cart is opened automatically.

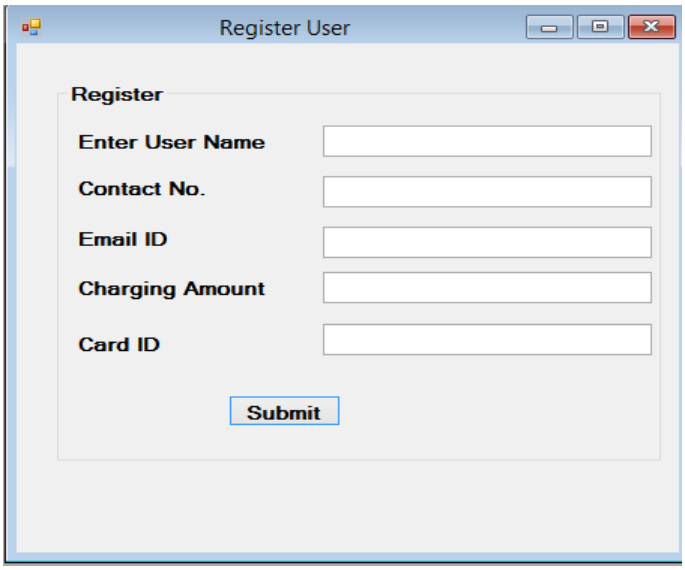

Fig.11 Register User Form

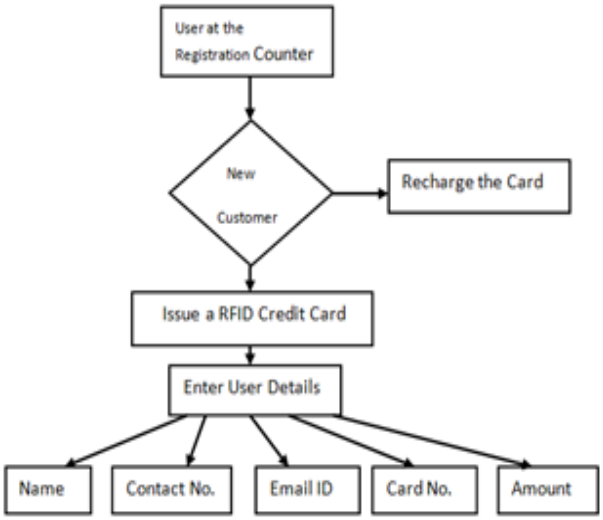

Fig.12 User Registration

The RFID credit card issued to the user at time of registration is scanned to get its RFID number and to check the balance.

If the customer wants to remove any product from the purchased products list then he can do so by selecting the products he wants to remove from the list. In this way, cost of all the selected products would be removed from the final bill amount (Refer fig.14).

Fig.13 Adding Products to Cart

There can be two cases (Refer Fig 15):

(i)If the balance is greater than the billed amount then the amount is debited from the card and shopping is complete.

(ii)If the balance is less than the billed amount then user is directed to the recharge or registration section, where the customer can recharge the card with additional amount.

In case any product quantity falls below the threshold value then a notification would pop up so that stock could be updated.

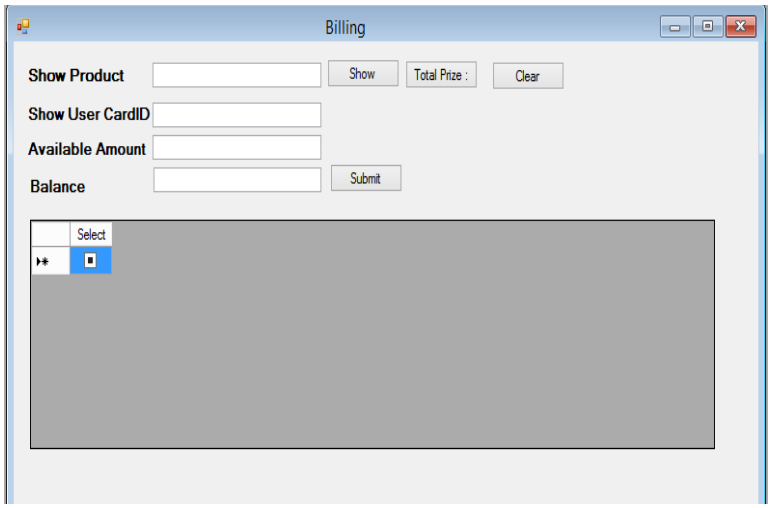

Fig.14 Billing Form

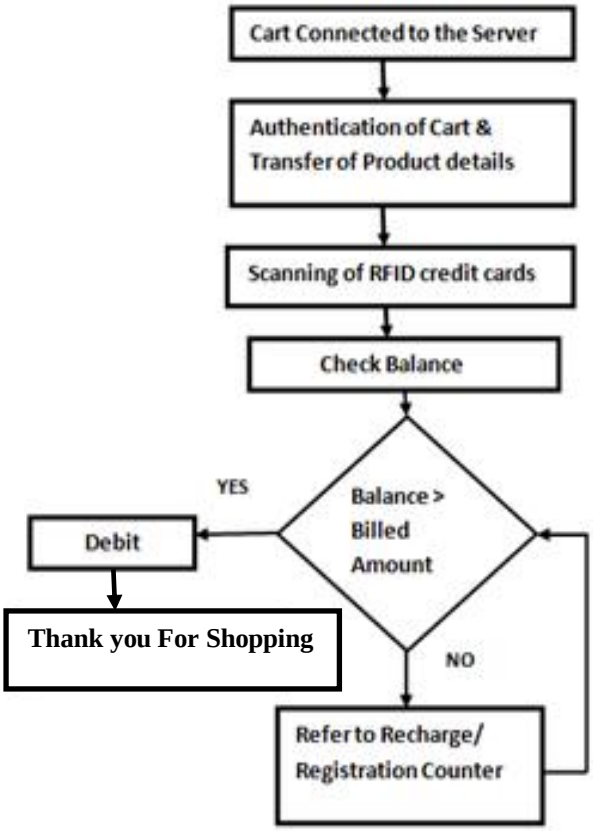

Fig.15 Billing Section

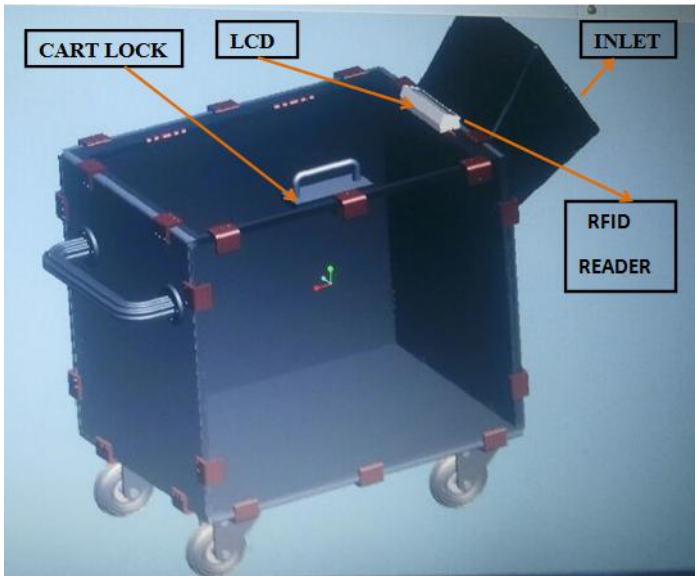

Fig.16 Cart Designed in PRO-E

Fig.17 Real Designed Cart

Fig.18 Purchase display on LCD on cart

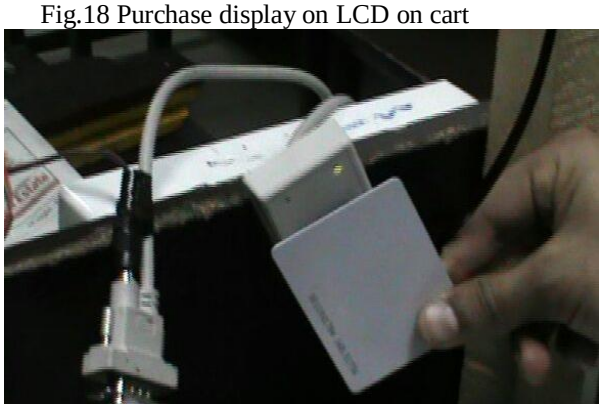

Fig.19 Scanning of user RFID loyalty card

VI.CONCLUSION

The payment of bill by standing in long queue is a tiring factor when people want to purchase commodities from marts. Though people can pay instantly using electronic money facility, they are forced to wait in the queue for longer time. The idea which is proposed using RFID technology will overcome the problem and it gives. The combined effects of easy and flexible implementation, secure transmission of account information, and reduced disputes offer the following benefits for all. It will save time, energy and manpower of Customer, Owner and supplier.

VII.FUTURE SCOPE

Smart cart can be interfaced with wireless technologies to make it completely portable in the near future. Payment of bills using mobile can be implemented. A low cost RFID scanner can be manufactured and used which can scan multiple tags (products) simultaneously for faster processing and lesser resources. Automatic scanning & availability of products can be introduced. Pay scheduling feature will be the latest trend in upcoming years due to the boost in the e-commerce industry.

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