IoT Based Smart Shopping System Using RFID and Zigbee Technology

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Abstract ---- Now a days IoT is changing human life easy by connecting things together. One of the IoT application is Smart Shopping. A super market or shopping mall is a place where people buy products for their regular use. At malls there will be huge rush especially on holidays and weekends. If a customer buys few products, he/she has to wait in queue to get their products scanned using barcode technology. It consumes more time and man power is required to scan each and every product. In this paper I propose a Smart Shopping System using RFID and Zigbee technology which reduces time and man power. RFID technology is used to automatically identify the products and Zigbee technology is used to communicate wirelessly between Shopping Cart and Server. In Smart Shopping System an RFID tag is attached to every product and a Shopping Cart is equipped with an RFID reader. When a product is placed in cart, it automatically scans the product and displays the details of product on the LCD screen which is attached to cart. Each time a product is added in the cart the cost of products is added and displayed on screen. Hence billing is made at the shopping cart itself. After purchasing all the products the customer pays the bill and leaves the mall.

Keywords --- Shopping Cart, IoT, RFID reader, RFID tag, Shopping mall, Zigbee.

I.   INTRODUCTION

Internet of Things (IoT) connects physical devices, objects, things and machines together to transfer data over a network wirelessly without human intervention. IoT has some enabling technologies to connect these physical objects such as Sensors and RFID.

There has been a lot of research on IoT on different applications such as Smart Homes, Smart Health Care, Smart Cities, and Smart Dust. In this paper the focus is on Smart Shopping System using RFID (Radio Frequency Identification) technology. RFID is an automatic technology which identifies object and records data using radio waves. There are two main components of RFID technology. One is RFID reader and the other is RFID tags.

The RFID reader is used to record data from the RFID tags. RFID reader sends radio waves, whenever the object is in the range of reader the RFID tag transmits its data to the reader. RFID tags hold some data about an object or product. These tags are available in different sizes. RFID tag has two components: Antenna and Integrated Circuit(IC). Antenna is used to transmit and receive radio waves and Integrated Circuit is used to store and process data. RFID has an advantage over barcode technology as barcode reader requires a line of sight to read the data but RFID reader reads the data within the range of reader. In Shopping malls, customers have to wait in queues to scan every product using barcode. This is a very time consuming process. In this paper I propose RFID and Zigbee technology in smart shopping to reduce the time of customers waiting in queue. In this shopping system, all the items are attached with an RFID tag. The tag contains some information such as Price, weight etc. which can be tracked by a device equipped with an RFID reader. Using such a system has some benefits. 1) Smart Cart: The cart is equipped with an RFID reader, when a customer puts an item in the cart, it automatically reads the item and billing will also be generated at smart cart itself. 2) Smart Racks: The racks can be equipped with an rfid reader to track the status of items and updates to server. When the items are sold out or only few items are left in rack, the server notifies to the staff to restore items.

In this smart shopping system Ultra High Frequency (UHF) passive RFID tags are used. UHF passive tag range is between 1 to 12 meters.

Zigbee is a wireless communication technology used to communicate between smart cart and server. Zigbee is a low-cost device and consumes less energy even at lower bandwidth. By using these technologies it is easier for customers to purchase their products as they no need to wait in queue and also they can pay bill at the cart itself. It is easy for the staff to maintain inventory control.

II.   LITERATURE SURVEY

In the survey I found some of the research papers on smart shopping which are published in recent years.

In 2013, T. Shanmugapriyan, "Smart cart to recognize objects based on user intention" proposed a basic design of smart cart which assists the user to buy products. It also assists how the cart has been designed.

In 2014, P. Chandrasekar and T. Sangeetha, in "Smart shopping cart with automatic billing system through rfid and zigbee," proposed a shopping cart with automatic billing system.

In 2015, M. R. Sawant, K. Krishnan, S. Bhokre, and P. Bhosale, in "The rfid based smart shopping cart," proposed a smart shopping cart using RFID technology which automatically identifies the products.

In 2016, A. Yewatkar, F. Inamdar, R. Singh, A. Bandal et al., in "Smart cart with automatic billing, product information, product recommendation using rfid & zigbee with anti-theft," proposed a shopping cart using central billing system.
In 2017, Ruinian Li, Tianyi Song, Nicholas Capurso, Jiguo Yu, Jason Couture, and Xiuzhen Cheng, in "IoT applications on Secure Smart System", proposed shopping system using UHF RFID tags and also discussed about security on smart shopping system.

III. SYSTEM ARCHITECTURE

A. SYSTEM MODEL

The Fig. 1 depicts system model. The smart racks, smart cart, smart checkout point communicates with the server. The smart racks monitor the items on the racks by reading RFID signals from the tags. The smart carts are able to read the information of items in the cart. The smart checkout point checks whether the customer has made valid purchase or not.
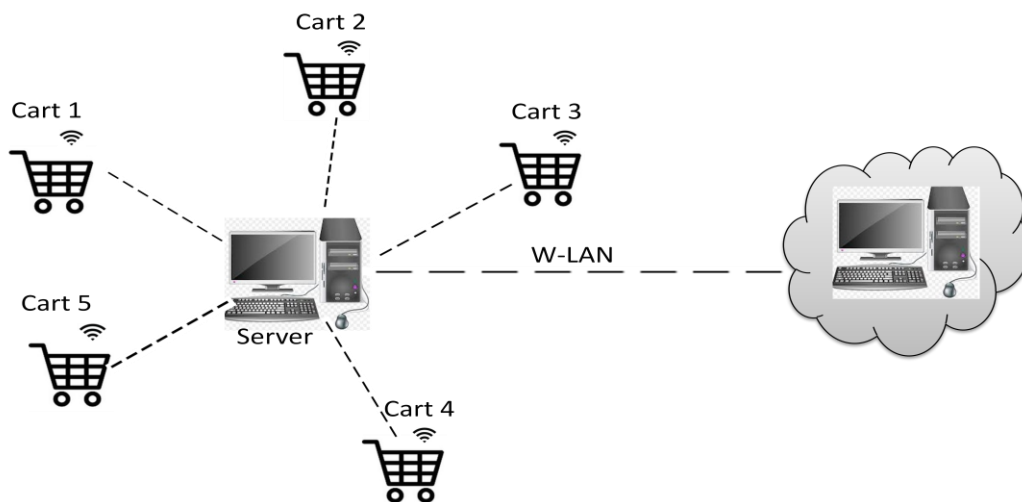

Fig. 1 System Model

B. HARDWARE ARCHITECTURE

The Fig. 2 shows the architecture of the Smart Cart. Smart Cart is equipped with some components.
1. *Micro Controller:* The micro controller coordinates with RFID reader, LCD screen and Zigbee module.
2. *Zigbee Module:* Zigbee is a wireless module which is used to communicate between server and smart cart.
3. *RFID reader:* The rfid reader is used to read the items when an item is put in the cart.
4. *LCD screen:* LCD displays the items details such as price, expiry date, quantity etc on the screen.
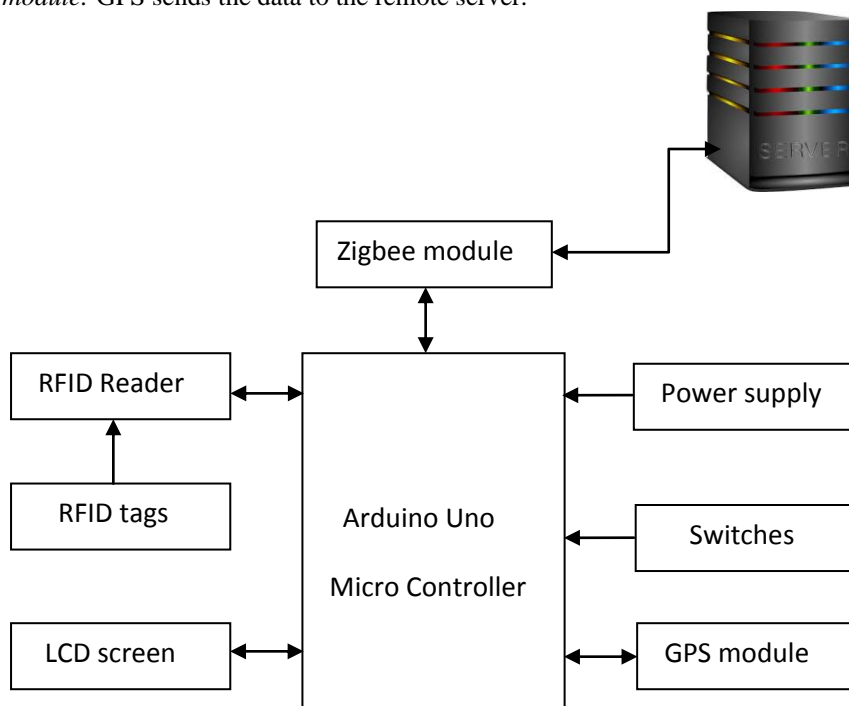5. *GPS module:* GPS sends the data to the remote server.

Fig. 2 Architecture of Smart Cart

C. *COMPONENTS*

1) *Arduino Uno:* The Arduino Uno is a micro controller board based on the ATmega328. It has 14 digital input/output pins, 6 analog inputs, 16MHz crystal oscillator, USB connection, Power jack, an ICSP header and reset button. The Atmega328 has 32 KB of flash memory for storing code. It has also 2 KB of SRAM and 1 KB of EEPROM. Arduino Uno is used to perform various functionalities of the smart shopping cart. Fig 3.Shows the Arduino Uno board.

Fig. 3 Arduino Uno

2) *RFID Reader:* RFID reader is used to record the data from RFID tags. RFID reader is composed of radio frequency module, a control unit and an antenna. RF module acts as both a transmitter and receiver of Radio Frequency signals. The control unit is composed of processor and memory to filter and store the data. RFID reader is interfaced with micro controller to send the recorded information. Fig 4.Shows the RFID reader module.

Fig. 4 RFID reader

3) *Zigbee Module:* The Fig 5. Shows Zigbee module. Zigbee is a low-cost and low-power wireless module used to transfer data or information between Arduino and server. Zigbee is interfaced to Arduino Uno. Zigbee is built for control and sensor networks on IEEE 802.15.4 standard for Wireless Personal Area Networks (WPAN). It operates at 868 mhz, 902-928 mhz and 2.4 ghz frequencies. Zigbee transfers data at the rate of 250 kbps.

Fig. 5 Zigbee Module

4) *RFID tags:* The Rfid tags are attached to products or items in the shopping mall. There are different sizes of tags. Fig 6.shows RFID tags. Rfid tag is made up of antenna, IC and battery. The tag can be of 3 types. 1) Passive tag doesn't contain battery. It depends on reader for source of energy. It is cheap and can store 1kb of information. 2) Semi Passive tag contains battery, but for transmitting feedback signal to reader it depends on the signal of reader. 3) Active tag contains battery but it doesn't depend on the reader to transmit feedback signal.

Fig. 6 RFID Tags

RFID tag operates at various frequencies such as Low Frequency(LF), High Frequency(HF) and Ultra High Frequency(UHF). In this Smart shopping system passive UHF tags are used. The tag stores some information about the product such as product ID, product name,price, expiry date etc. The Fig 7. Shows the tag details.

Product-Id	Product Name	Price	Weight	Expiry date

I. TAG INFORMATION

5) *LCD Module:* LCD is a electronic display module interfaced to the micro controller. It displays the cost, name, weight of the product. A 16x4 Lcd display is used. The Fig 8. Depicts LCD module.

Fig. 7 LCD module

6) *GPRS module:* A General Packet Radio System (GPRS) is also known as Global System Mobile communication-Internet Protocol (GSM-IP) as it keeps the users of system online allows making voice calls and accesses internet. The Fig 9. Shows GPRS module. GPRS is used to transfer user data packets in an efficient way between GSM mobile stations and external packet data networks. GPRS is used to communicate between micro controller and remote server. GPRS transfers the data from micro controller to the remote server.
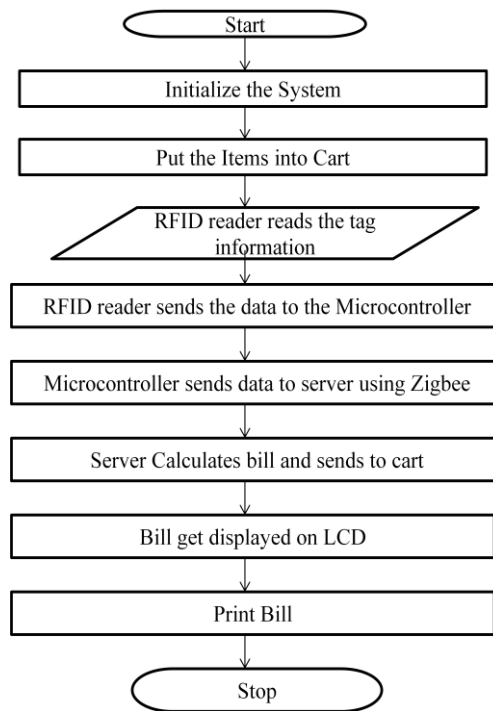

Fig. 8 GPRS Module

IV.   **WORKING OF SMART SHOPPING CART**

The steps involved in smart shopping cart in a shopping mart are as follows.
1. Before moving all the items to the racks, the mart needs to register the details of items in a database server. The details of items are name, price, product id, weight, location etc.
2. The Smart Cart is equipped with microcontroller, RFID reader, Zigbee, Lcd screen, Power supply, switches and GPRS module.
3. When a customer puts a product in the cart, the cart automatically reads the product information and sends it to micro controller.
4. The micro controller communicates with the server through Zigbee to check whether the product information is correct or not. If it is correct it displays the product details on the Lcd screen. This process is applied to every product when it is put in the cart.
5. Each time a product is placed in cart, the cost of product is added and the total cost is displayed on screen.
6. If a customer wants to remove a product from the cart, he/she has to press and hold the delete button and can remove the product. The cost of the removed item is deducted from total cost.
7. After purchasing the products the customer has to press the complete button. Then bill will be generated at the cart itself.
8. The customer can pay the bill and leaves the mart.

V.   FLOWCHART

```
                    ( Start )
                        │
            ┌───────────────────────┐
            │   Initialize the System │
            └───────────────────────┘
                        │
            ┌───────────────────────┐
            │   Put the Items into Cart │
            └───────────────────────┘
                        │
            ╱───────────────────────╲
            │ RFID reader reads the tag │
            │      information          │
            ╲───────────────────────╱
                        │
            ┌────────────────────────────────────┐
            │ RFID reader sends the data to the Microcontroller │
            └────────────────────────────────────┘
                        │
            ┌────────────────────────────────────┐
            │ Microcontroller sends data to server using Zigbee │
            └────────────────────────────────────┘
                        │
            ┌───────────────────────────────┐
            │ Server Calculates bill and sends to cart │
            └───────────────────────────────┘
                        │
            ┌───────────────────────┐
            │   Bill get displayed on LCD │
            └───────────────────────┘
                        │
            ┌───────────────────────┐
            │       Print Bill        │
            └───────────────────────┘
                        │
                    ( Stop )
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VI.   RESULTS

The implementation of the Smart Shopping System is shown in the Fig 9. It consists of Arduino microcontroller, RFID Reader, LCD Display, GPRS and Zigbee.
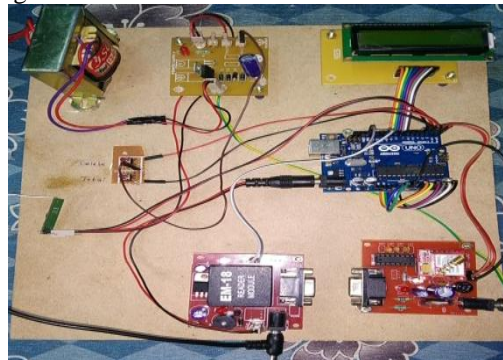

Fig. 9 Smart Shopping System Implementation

When the system is "ON", initially the LCD displays"SMART SHOPPING" as shown in fig. 10. When a customer puts an item in the cart, RFID reader reads item details and displays on the LCD which is equipped on the cart. For example a customer puts Maida flour packet in the cart. The details of item such as Maida flour packet weight, price, expiry date is displayed on LCD as shown in Fig.11.
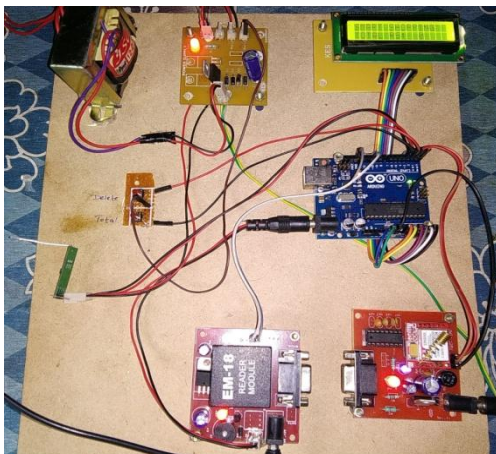

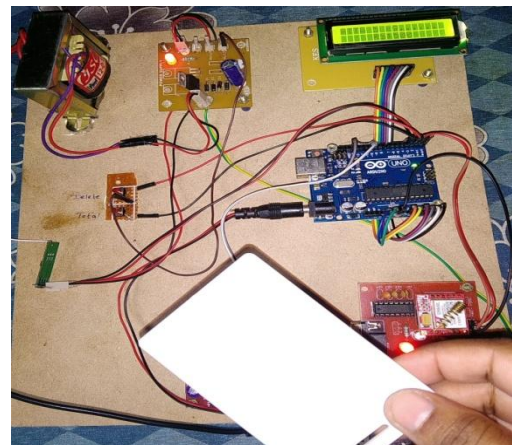Fig. 10 When System ON   Fig. 11 Product price, weight

After purchasing all the products the customer should press complete button. The total cost of the entire products is displayed on screen as shown in fig.12. When the bill is generated the LCD displays as" Thank you Visit Again" as shown in fig. 13.
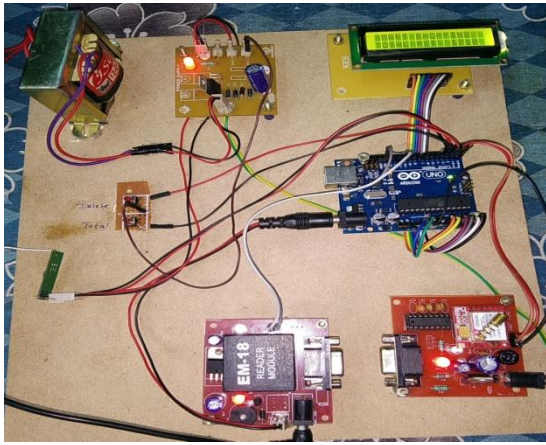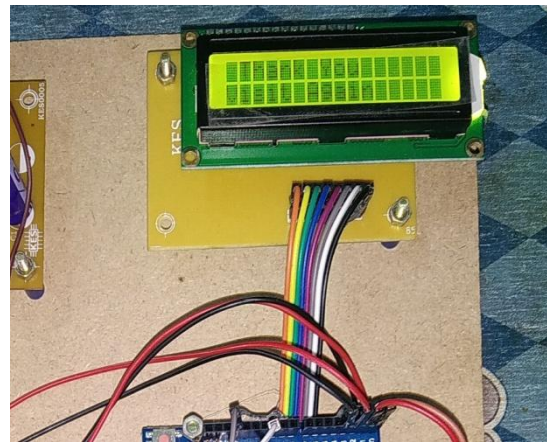
Fig. 12 Total amount of all products

Fig.13 When Bill gets generated

Once the bill is generated, the customers purchased item details all are sent to server using GPRS module as shown in fig. 14 and fig.15.

Fig. 14 Sending purchased data to server

Fig. 15 Completion of sending data to server

VII.   CONCLUSION

The Smart shopping Model using RFID and Zigbee technology has been designed and developed successfully. In this model an UHF RFID is employed for better frequency range. This model avoids customers waiting in long queues at the billing counter and saves time. It also reduces man power required at billing counter. In this model all the functionalities has been successfully executed. In future it can be extended to displaying all the list of items on screen before a customer finishes shopping, so that the customer can buy the item which has forgotten. Functionality can be added such as tracking the items location through GPS, as this reduces time to search an item.

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