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Shopping Smart With RFID Equipped Trolleys

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Abstract- *RFID (radiofrequency identification) technology is an innovative measure that will make purchasing and shopping more convenient and comfortable. There would be no need to stand in long queues to pay the bill. Shoppers can be guided electronically to find desired products that are tagged with RFID chips and whose locations are tracked by RFID readers in the store (e.g., smart shelves or other reader systems). Smart shopping carts with electronic displays, in communication with a retail computer system, can display a shopping list downloaded by a shopper to identify a route to obtain the desired items. The smart cart, also equipped with RFID tags, can also verify the purchase of the items as they are placed in the cart and communicate with a billing system to automatically bill the shopper for the purchases.*

Keywords- RFID; RF Tags; ZigBee; Smart Cart;

1. INTRODUCTION

Human beings are continuously into the process of adopting innovations in technology to make their life and work easier and faster. One regular task that human beings spend considerable amount of time is in shopping. According to a survey conducted by US Bureau of Labour [10], on an average, human beings spend 1.4 hours every day on shopping. A survey done by Visa in 2005[11], points out that an amazing 70% customers will walk out of a queue if the line is too long, and 10% are "seriously annoyed" the moment they step in a queue. The proposed system intends to assist shoppers that will minimize the time spent in shopping as well as intended to aid the store management with real-time updates on the inventory.

The emergence of new technologies, such as Radio Frequency Identification (RFID) and wireless networks, makes the shopping processes faster, transparent and efficient. Our aim is to develop an intelligent shopping cart (embedded system) which can be used in shopping malls to ease the payment of bills. The Intelligent Shopping Cart is equipped with Radio Frequency Identification (RFID) for product identification and a consistent Wi-Fi connection with the shop's server. It has an LCD display that informs customers about the product, prices, discounts, offers and the total bill. As soon as the object is dropped into or removed from the cart, the RFID tag identifies the product and updates the bill. When the customer is done with shopping, he can just press the "End shopping" button and the details are sent to the shop's server and the customer pays the amount and leave. "This shopping cart will change the way people shop as radically as ATMs changed banking." The proposed cart is easy to use and does not need any special training.

2. RELATED WORK

The purpose of designing such a trolley is to save consumers' time and money and help the retailers to win loyal clients. 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 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].

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 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 [9].

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 [4].
Satoru Uehara et. al., [12] defined the Web shopping cart system as a typical client-server application on the Web. Then they clarified several problems on the implementation of the Web shopping cart system, which are peculiar to the Web. In order to solve the problems, he proposed a new mechanism that can manage user sessions with high reliability and safety. He compared the Web shopping cart system implemented using the proposed mechanism with the one developed by the conventional methods. Chihhsiong Shih, et al., [5] proposed an automatic embedded software generation framework that can create and evolve Zigbee applications. The framework consists of two major modules, pattern extraction and code generation. Pattern extraction and development are designed to provide Zigbee application with model reuse and modification. SysML serves as a medium between pattern development and code generation. State diagrams, class diagrams and sequence diagram help describes a specific application scenario. A smart shopping cart application has been implemented using this pattern based software framework.

3. RFID TECHNOLOGY

RFID system consists of three components: An antenna or coil; A transceiver ; RF Tags

3.1 ANTENNA

The antenna emits radio signals to activate the tag and read and write data to it. Antennas are the conduits between the tag and the transceiver, which controls the system's data acquisition and communication. Often the antenna is packaged with the transceiver and decoder to become a reader (a.k.a. interrogator), which can be configured either as a handheld or a fixed-mount device. The reader emits radio waves in ranges of anywhere from one inch to 100 feet or more, depending upon its power output and the radio frequency used. When an RFID tag passes through the electromagnetic zone, it detects the reader's activation signal. The reader decodes the data encoded in the tag's integrated circuit (silicon chip) and the data is passed to the host computer for processing.

3.2 TAGS *(*Transponders*)*

An RFID tag is comprised of a microchip containing identifying information and an antenna that transmits this data wirelessly to a reader. At its most basic, the chip will contain a serialized identifier, or license plate number, that uniquely identifies that item, similar to the way many bar codes are used today. A key difference, however is that RFID tags have a higher data capacity than their bar code counterparts. This increases the options for the type of information that can be encoded on the tag, including the manufacturer, batch or lot number, weight, ownership, destination and history (such as the temperature range to which an item has been exposed). In fact, an unlimited list of other types of information can be stored on RFID tags, depending on application needs. An RFID tag can be placed on individual items, cases or pallets for identification purposes, as well as on fixed assets such as trailers, containers, totes, etc. Tags come in a variety of types, with a variety of capabilities. Key variables include: "Read-only" versus "read-write" There are three options in terms of how data can be encoded on tags: (1) Read-only tags (2) "Write once" tags (3) Full "read-write" tags

3.2 RF Transceiver

The RF transceiver is the source of the RF energy used to activate and power the passive RFID tags. The RF transceiver may be enclosed in the same cabinet as the reader or it may be a separate piece of equipment. When provided as a separate piece of equipment, the transceiver is commonly referred to as an RF module. The RF transceiver controls and modulates the radio frequencies that the antenna transmits and receives. The transceiver filters and amplifies the backscatter signal from a passive RFID tag.

4. SYSTEM ARCHITECTURE

In the development and discussion of the proposed smart shopping cart, we assume that the shopping arena is organized in aisles/bays, and each aisle is sufficiently wide enough for customers with shopping cart to move [7]. We use IR transmitters placed at both ends of the aisle and on the cart to collect information on the entry/exit status of the cart and the bay identification. Larger the distance between the aisles/bays, we will require stronger IR trans-receivers. Moreover the positioning of these IR trans-receivers on the shopping cart and on the aisles will be crucial to the proper functioning of shopping cart. Further, as IR technology works on line of sight, it is important to ensure that there is no obstruction in the entrance or exit of each aisle. All the product information is stored in a database at a central server along with the location information. We will record the aisle number for the product as the intended product location resolution would be the aisle number. RFID tags are used to uniquely identify products [10].
Figure 1 and 2 depicts a block diagram containing the subsystems of smart shopping cart. Each subsystem is interfaced carefully to form a whole unit. This system consists of a microcontroller interfaced with RFID, IR, ZigBee, RFID Tags, EEPROM forming the hardware unit and ZigBee interfaced to the server making up the software unit. The IR transmitters are placed on the entry and exit of each aisle. The IR receivers are placed on the shopping carts. Whenever the receiver detects an IR signal, it indicates that a shopping cart is in that aisle. Once the cart location and entry/exit status is detected, this information is then sent to the main server using the wireless ZigBee unit [14]. The data sent is the aisle number. At the server end, the database is queried based on the aisle number.

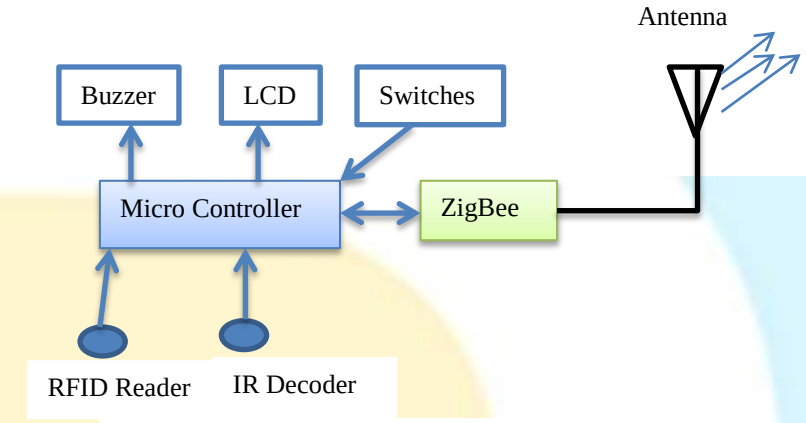

Fig.1-Block Diagram for Trolley Section

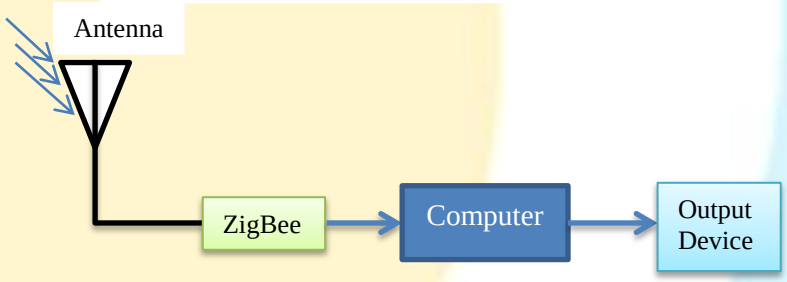

Fig.2-Block Diagram for Billing

The main technological objective for our presented solution is the usage of RFID technology for the automatic product identification inside the shopping cart thus eliminating consumer intervention in the process of product reading for payment. The usage of barcode for product identification presents several limitations:

- only the product class is identified;
- information is static;
- allows one single reading at a time;
- requires line-of sight;
- has low range and security.

RFID technology is more resistant, safer, identifies products in a unique way, can provide other types of information, can make several simultaneous readings, doesn't need line-of-sight and it has a high range. It requires that all existing products inside the supermarket can be identified with RFID tags and each shopping cart must have an RFID reader. The range of the RFID reader must not extend beyond the horizontal shopping cart limits so that reading products inside other shopping carts or on shelves does not happen. Nevertheless, range cannot be less than the cart's limits with consequence of not identifying products that are inside the shopping cart but out of the reader's range. The RFID reader should be able to read all the tags no matter the material (paper, plastic, metal, etc) they are inserted into.

By suggesting a single RFID reader per cart, we are thinking not only in terms of costs, battery duration and data quantity but also in preventing collision of readings in cases when more than one reader is used, something which increases the complexity level. The usage of RFIDs in this system comprehend benefits such as increasing safety and the consequent reduction in product loss, reduced human intervention and error, increased speed in involved processes, unique identification of products with additional information and availability of real time information, amongst others. Besides the advantage of accessing real-time information about the diverse products inside the shopping cart, the client can also be helped by the navigation system, meaning that they can be guided through the supermarket avoiding time losses that occur when searching for products in unknown locations. Through the interactive map that shows product location and the shopping cart's current position, it is then possible to follow the route indicated by the map to reach the desired product. There will be immediate updates any time the cart is moved by the consumer. To make this possible, a shopping cart positioning technology is required in several Supermarket locations so that the permanent monitoring enables real-time cart position updates. The choice of a positioning technology to our solution is particularly difficult because of the diverse characteristics each technology presents. Aspects such as range, energy consumption, safety, precision, amongst others, are important for our solution

Frequency should be Middle range, so that a considerable area is comprised thus preventing the usage of an exaggerated number of locating devices. The system must

consume low energy, so that the shopping cart doesn't run the risk of rapidly running out of energy. Maximum automation of location processes and tracking of any shopping cart featuring the location device inside range and angle positioning technologies such as WLAN, Bluetooth, RFID and Indoor GPS have a larger range and neither requires line-of-sight nor depends on angles. Besides that, they consume little energy. The RFID or Wi-Fi based RTLS also appears to be a good choice. The choice will also depend on the environment of the application, establishment requisites (if existing infrastructures are used or not) and budget amongst others, but never forgetting that the elected technology should obey to the above mentioned requisites. Regardless of the Positioning technology used for this solution, each shopping cart should have a location transmitter. Also the supermarket should have the necessary number of receptors to cover its entire area. All the electronic equipment featured by the shopping cart should be prepared for hostile environments, accounting for scratches, beatings, dirt, liquids, etc. This equipment can also be prepared for parking lots where atmospheric conditions can affect the cart. Nevertheless, this decision will have to be made by each supermarket, since they are the ones that must take their own security measures so that the equipment is not stolen. All system communication should be trustworthy and safe, since personal client data will be transmitted. Clients will therefore have to fully trust the system so that they will use it regularly. The system should also be easily integrated with all kinds of technologies used by the previously existing systems. Lastly, but not least importantly, the necessary energy for the client's optimal system usage should be minimized, since energy cannot fail during the process. One way to save batteries is to suspend the system while it is on stand-by. In the proposed system, if the object is dropped into or removed from the trolley, the RFID tag identifies the product and updates the bill. After shopping, if we press the "End Shopping" button and the details are sent to the master computer and the customer has just to pay the amount and leave the mall, which saves the precious time of the consumers.

5. IMPLEMENTATION

When any selected product is dropped into the cart, RFID reader reads the tag inside the product and the information of the product is extracted and displayed on the LCD screen. At the same time billing information is also updated.

Fig. 3 The working of the Intelligent Shopping Cart can be explained with the following steps:

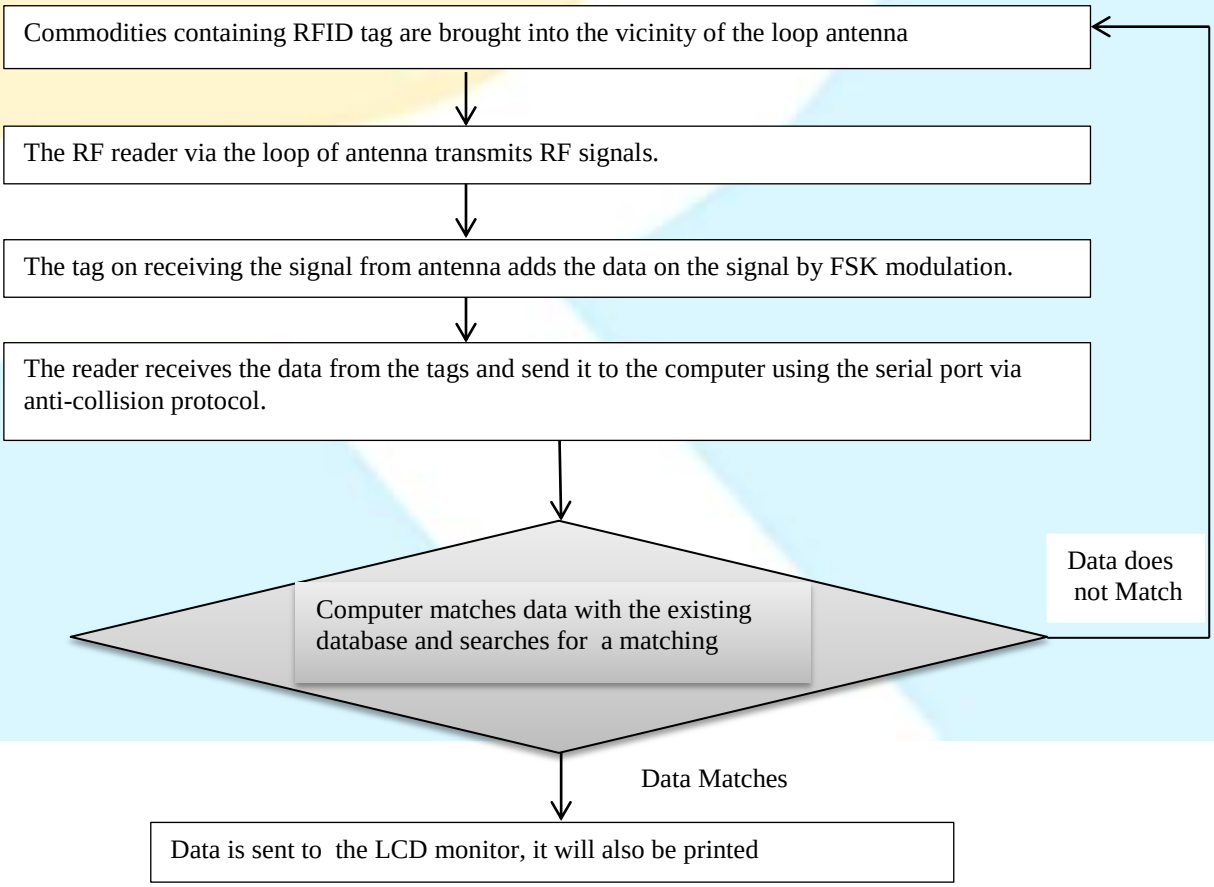

Fig. 3 Flow Diagram of the Intelligent Shopping Cart

When shoppers with the cart press "start button" the system turns ON and then all the components such as RFID reader, microcontroller and ZigBee start working. Every product has an RFID tag which contains unique id. These Ids are fed in the database assigned to the corresponding products. When the shopper drops any product in the cart then the RFID reader reads the tag. The information of the product is extracted and displayed on the LCD screen. At the same time billing information is also updated. These steps are repeated until the end of shopping button is pressed. Once the "End Shopping" button is pressed the total bill is send to master pc via Wi-Fi (ZigBee). There is also an option to delete some of the products from the cart and the bill will be updated accordingly, this goes by the customer choice. At the end of shopping, the customer can straight away pay the bill and leave. Inventory status of the products is also updated at the end of shopping.

All test cases were successfully tested. The system developed is user friendly and no special training is required to use the cart.

6. CONCLUSION

The study discusses the architecture of the system that can be used in the shopping systems for intelligent and easy shopping in the malls to save time, energy and money of the consumers. Present trends point towards the fast growth of RFID in the next decade. With around 600 million RFID tags sold in the year 2005 alone, value of market including systems, services and hardware is likely to grow by factor of 10 between years 2006 -2016. It is expected that total number of RFID tags delivered in the year 2016 will be around 450 times as compared to the ones delivered in the year 2006. There are a few challenges/drawbacks that can be resolved to make proposed system more robust. This issue will have to be resolved specifically with respect to billing to promote consumer confidence. Further, a more sophisticated microcontroller, larger display system, GPS to track the product, internet facility inside the card to browse the offers, deals and facility of payment within the cart by using swapping card can be used to make cart more advanced to provide better consumer experience.

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