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RFID Based Smart Shopping and Billing

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Abstract: The advent of wireless technology along with other communication techniques has helped in making electronic commerce very popular. A modern forward looking product is the one that aids the comfort, convenience and efficiency in everyday life. In this paper, we discuss an innovative concept of RFID Based Smart Shopping and Billing. The key idea here is to assist a person in everyday shopping in terms of reduced time spent while purchasing a product. The main goal is to provide a technology oriented, low-cost, easily scalable, and rugged system for aiding shopping in person. The developed system comprises of Cart location detection unit (CLDU), Server Communication unit (SCU), User Interface and display unit (UIDU) and Billing and Inventory management unit (BIMU). CLDU is used to smartly locate the position of shopping cart inside the shopping market to help in obtaining relevant product information. SCU will help in establishing and maintaining the connection of the shopping cart with the main server. UIDU will provide the customer with user interface and BIMU deals with the billing and inventory management in collaboration with the SCU. These units are integrated into a smart enclosed system and are tested to satisfy the functionality. The smart shopping cart will help shorten the checkout lines thereby helping the customers at retail stores. The customers will be able to scan the items themselves and the LCD screen on the shopping cart will keep updating the total. This will turn out to be very beneficial for the retail stores as more people will enjoy the shopping experience and come more often to shop.

Keywords: Radio Frequency Identification (RFID), Wireless ZigBee Module, Infra-Red (IR) transmitter and receiver, RFID tags, Microcontroller, Server database.

I. INTRODUCTION

Human beings have always developed technology to support their needs ever since the beginning of mankind. The basic purpose of innovation in technology, irrespective of the domain, has been in simplifying tasks and making everyday chores easier and faster. One quotidian task that human beings spend considerable amount of time is in shopping. According to a survey conducted by US Bureau of Labour [5], on an average, human beings spend 1.4 hours every day on shopping. A large number of customers will tend to walk out of a queue if the line is too long. The current Shopping environment can be simply be classified it into two categories (1) Shopping in-person and (2) Shopping in absentia. Shopping in absentia is supported in numerous ways including online shopping, tele-shopping, etc. wherein a shopper does not have to be physically present in the shopping area. Shopping in-person involves a personal visit to the place of shopping and selecting the product/s based on various factors including need, convenience, brand, etc. [4]. The proposed Smart Shopping Cart system intends to assist shopping in-person that will minimize the time spent in shopping as well as locate the desired product with ease. It is also aimed in aiding the store management with real-time updates on the inventory. The proposed system is based on four important technologies (i) Infrared sensors – used in an intelligent manner for dynamic location detection and tracking (ii) RFID tags for product identification (iii) ZigBee for achieving wireless communication with Server, and (iv) Integrating System with display for billing and inventory management[1]. All of these are discussed in detail in different sections. One of the critical design decisions has been in developing a novel approach to dynamically detect the location of the shopping cart and integrating it suitably into a useful low cost embedded system. Widely used location determination technologies including Global Positioning Systems (GPS) does not augur well for solving the proposed problem. Some demerits include, higher implementation cost, movement of cart in an enclosed area, and location accuracy. In this paper, we discuss the System Design, Working, Testing, and Conclusions. In conclusions we discuss about opportunities of improving the cart to make it into a commercially viable product as an excellent way to help customers reduce the time spent in shopping by displaying the list of products, their cost and automatic billing [2].The system helps the store management with an automatic update of the inventory on every purchase of an item. The Smart Shopping Cart has the potential to make the shopping experience more pleasurable and efficient for the shopper and the inventory control easier for the store management.

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II. SYSTEM DESIGN

Objective: To develop a low-cost intelligent shopping aid that assists the consumer to locate and select products and inform them on the product/s details dynamically as they move in the shopping arena. Additionally, with each product identified uniquely and usage of centralized server, support billing and inventory updates [1].

A. SYSTEM ARCHITECTURE

In the development and discussion of the proposed smart shopping cart, we assume that the shopping arena is organized in aisles/bays as indicated in Figure 1, and each aisle is sufficiently wide enough for customers with shopping cart to move [1]. 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 with the location information as a ascribe. 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 [3].

Figure 1. Aisle based organization of shopping arena.

Figure 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 [7]. The data sent is the aisle number. At the server end, the database is queried based on the aisle number. All the products and their respective details stored in that particular aisle are retrieved and sent back to the shopping cart. The information received from the server is temporarily stored in the shopping cart memory and then displayed on the display unit affixed on the cart. The customer can then select the product with the information being shown on the display unit. Every product is uniquely identified using RFID tags [6].

As the products are selected and added into the cart, the RFID reader will identify the product and the price will be added to the temporary bill. If a customer chooses to drop a selected product, it needs to be done by selecting the appropriate button (‘cancel’) on the display unit. After completing the shopping, the customer has to select the ‘Complete’ button. This enables the total bill being generated after confirmed purchase of all the selected products in the shopping cart. At the same time, this information is sent to the database server through the wireless ZigBee unit [2]. The server database is then updated to reflect the existing stock available after deducting the number of products purchased. This ensures a smooth inventory management [1]. The integrated system is built around P89V51RD2 microcontroller and has a 4x4keypad, 16x2 LCD display unit and miscellaneous circuit including power supply.

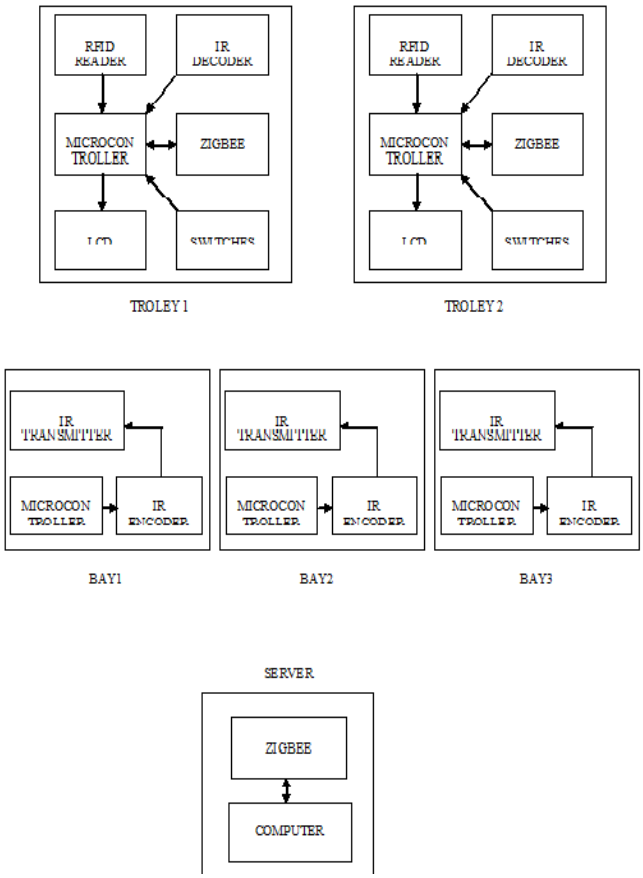

Figure 2. Block Diagram of smart shopping cart

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B. WORKING

1) When a customer with the cart enters a shopping aisle, the cart is brought in range of the IR Receiver and the microcontroller checks for the aisle information code.
2) The aisle information code is transmitted over the ZigBee wireless from the cart to the server [7].
3) Based on the aisle number received the database is queried and relevant information is retrieved and transmitted to the cart via the ZigBee module.
4) The received information is stored in the EEPROM present on the cart. This serves as a temporary database until the customer exits the particular aisle that he/she is in. The relevant products information is displayed on the display unit.
5) Every product has an RFID tag which contains a Unique ID. These ID's are fed in the database assigned to the corresponding products [6].
6) If there needs to be a purchase done, then that product can be dropped in the cart where 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. [1]
7) Upon exit of the aisle, the aisle info is sent to the server along with details of purchase. Server then stores them in the database.
8) These steps are repeated until the end of shopping button is pressed. Once the "Complete" button is pressed there is an option provided to end the shopping with the same products or to delete some of the products from the cart. This goes by the customer choice.
9) At the end of shopping, the customer can straight away pay the bill and leave.
10) Inventory status of the products is also updated at the end of shopping.

III. TESTING

Testing was a very crucial component of this project [1]. Unit testing of various modules was performed independently followed by integrated system testing. Unit testing scenarios included:
(a) Detecting the location dynamically – aisle numbers.
(b) Entry and Exit status of the cart from Aisle
(c) Shopping cart and server communication using the wireless ZigBee unit.
(d) Retrieval of relevant information based on the shopping cart location from server and display on the display unit
(e) Identifying items based on RFID tags and synchronizing with central database
(f) Automatic billing
(g) Inventory update of products purchased and billed

Table 1 provides a sample database that was used to test the smart shopping cart. The aisle number was passed on to the ZigBee module from the shopping cart which in turn communicated with the server [7]. Based on the received aisle number, all items in the location aisle number were transmitted back to the shopping cart. The received items were manually checked with the product details on the server and found the same to be matching with the contents on the server. Finally, to simulate shopping, unique RFID cards were used to indicate distinctive products being shopped. As the RFID card reader read the product, details were displayed on the display unit [2].The product details of the shopped items were temporarily stored in the local memory. Once the shopping "Complete" button was pressed, the memory contents were read and billing was done.

TABLE 1

Product Name	Product Id	Bay No.	Stock	Unit Price	Cart 1 Total Price	Cart 2 Total Price	Grand Total
Mobile	19008	B1	100	6000	1800	6045	7845
Shirt	48CD3	B2	200	800			
Watch	D9EFA	B1	75	500			
Lays	B9F1D	B3	50	20			
Soap	7708E	B2	100	25			
Perfume	830F3	B3	150	500			

The same product information data was sent back to the server to update the inventory.
The following test case scenarios were used in the integrated system testing to prove the working of the developed system.
(a) Complete listings of the products and their information on the cart display on entering each aisle.
(b) Automatic billing as and when the products are dropped in the cart.
(c) Update inventory in the central system upon each purchase of a product.
All test cases were successfully tested. The system developed is user friendly and no special training is required to use the cart.

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IV. CONCLUSION

The intended objectives were successfully achieved in the prototype model developed. The developed product is easy to use, economical and does not require any special training. Though the project showcases the proof of concept, there are a few aspects that can be included to make the smart shopping cart more robust. To begin with, in this project the latency time of the wireless communication with the server may need to be considered. Secondly, the communication is not very secure. Another ZigBee module operating at the same frequency can easily intercept the transmitted data. This issue will have to be resolved specifically with respect to billing to promote consumer confidence. Further, a more sophisticated micro-controller and larger display system can be used to provide better consumer experience.

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