ARM Based Smart Cart and Automatic Billing System with Theft Detection

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***Abstract*— As shopping at the malls has become a daily activity in metro cities and due to the heavy rush the whole shopping experience is ruined by long billing queues and checkout lines. The main aim of this paper is to provide an automatic billing system to avoid queues in malls and super markets. This can be done by replacing the item bar code with RFID tags, and the cart is equipped with a microcontroller, LCD, an RFID reader, EEPROM, keypad, Load-cell and ZigBee module. The item placed in the cart will be read through a RFID reader on shopping cart and the item information will be stored in EEPROM .once the shopping is done the information will be sent to the central billing system where it calculates the total billing of the specific cart. Along with this ability, the system design also ensures detection of theft performed by dishonest customers, which makes the smart system fair and attractive to both the buyers and sellers.**

***Keywords:* - RFID, Microcontroller, ZigBee Modules, DC Motors and Loadcell**

I. INTRODUCTION

In this modern world, technology changes our culture, society as well as our lifestyle. One such upcoming technology is Wireless Sensor Networks (WSN), which is maturing at a very fast rate because of its suitability in a wide range of application areas. It consists of a large number of small, low-power, cost-effective, autonomous devices termed as sensor nodes. When interfaced with sensors and actuators, they play the combined role of environment sensing, special-computing and wirelessly communicating devices. In this new era, WSN finds its use in consumer application areas such as Smart Home, Smart Grid, etc.

In this paper we take the particular application of Supermarket/Shopping malls. While doing survey on shopping malls we found that most of the people prefer to leave the shopping mall instead of waiting in long queues to buy a few products. People find it difficult to locate the product they wanted to buy, after selecting product they need to stand in a long queue for billing and payment. To try to solve the problems previously identified, recent years have seen the appearance of several technological solutions for hypermarket assistance. All such solutions share the same objectives of save consumer's time and money, help the retailers to win loyal clients.

A number of attempts have been made to design a Smart Shopping Cart with various different functionalities.

Awati and Awati [2], describe a Smart Trolley design that concentrates on how to get the customers rid of dragging heavy trolleys and to automate billing, but it assumes all the customers to be honest and hence does not tackle cases of deception, if there are any.

Further, Chihhsiong Shih, et al., [3] proposed an automatic embedded software generated 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. (System Modelling Language)SysML serves as a medium between pattern development and code generation A smart shopping cart application has been implemented using this pattern based software framework.

In this paper, the system is designed in such a way that each cart is identified by their unique identification number. The cart is equipped with a microcontroller, LCD, an RFID reader, keypad, EEPROM, Load-cell and ZigBee module. The item placed in the cart will be read through a RFID reader on shopping cart and the item information will be stored in EEPROM .once the shopping is done the information will be sent to the central billing system where it calculates the total billing of the specific cart. Along with this ability, the system design also ensures detection of theft performed by dishonest customers.

II. METHODOLOGY

This system uses the RFID and ZigBee wireless communication technologies

Radio frequency identification (RFID) is the wireless use of electromagnetic fields to transfer data, for the purposes of automatically identifying and tracking tags attached to objects. The tags contain electronically stored information. Some tags are powered by electromagnetic induction from magnetic fields produced near the reader. Some types collect energy from the interrogating radio waves and act as a passive transponder. Other types have a local power

source such as a battery and may operate at hundreds of meters from the reader. Unlike a barcode, the tag does not necessarily need to be within line of sight of the reader, and may be embedded in the tracked object. Radio frequency identification (RFID) is one method for Automatic Identification and Data Capture (AIDC).

There are multiple reasons why one would want to use RFID:

- It is used when you want to wirelessly identify something without line of sight
- It is used when a simple wireless means to store a small amount of information on things, and even better: change the information dynamically:
- It is used when we need a computing device but not humans to see the ID
- It is used when a computing device to see an object from far away

ZigBee modules are designed with low to medium transmit power and for high reliability wireless networks. The modules require minimal power and provide reliable delivery of data between devices. The interfaces provided with the module help to directly fit into many industrial applications. The modules operate within the ISM 2.4-2.4835 GHz frequency band with IEEE 802.15.4 baseband.

ZigBee protocol has many benefits:

- The ZigBee network is very scalable and it consumes little energy.
- The consumer has complete authority to add or remove devices as he/she sees fit.
- ZigBee compliant products only use one lithium battery that lasts the lifetime of the device.
- It supports many network topologies.
- ZigBee design is used in many areas of operation such as scalability of large networks, security, network resilience and ease of commissioning.

III. BLOCK DIAGRAM OF THE SYSTEM

The project consists of two sectional units

- Trolley or Smart Cart Section
- Automated Billing System Section

The main board is resided at the Trolley/Smart Cart Section as shown in Figure 1, so as to, program according to the requirements of cart section. In the automated billing system section there is a server computer which is maintained with the front end application and database according to the requirements of the project. The Communication between Cart Section and automated billing Section can be done wirelessly using ZigBee Modules. Each cart in the Retail Store is equipped with an RFID Reader, motor, keypad and load-cell as shown in block diagram figure1. Initially the cart is sealed. Once the start button is pressed the cart will be opened with the help of the motor. Every item that is dropped into the cart is identified by the RFID tag which is attached to the item. The main board monitors if the customer is adding the item or removing the item from the cart using the keypad and load-cell. The controller even detects the malfunction of the process using the load-cell. Once the shopping is done the cart will be closed and the items information will be sent to the billing section through the ZigBee modules.

As shown in the Figure 2 at the Automated billing system section the total operation of displaying the items of the selected cart number, calculating the total amount of items and theft detection are handled by the visual basics and the database applications. RFID in the Retail store speeds up shopping processes and thus reduced the manual delays to provide the services and also enhances more user-service tasks. But the performance varies with respect to the vendors of RFID readers and tags. The efficient utilization of the technology also depends upon the information to be written in tag. Experimental results with respect to effectiveness of RFID reader, ZigBee Modules are presented in the paper. The work is in progress to utilize more enhancements using RFID technology. Developments in RFID technology continue to yield larger memory capacities, wider reading ranges, and faster processing.

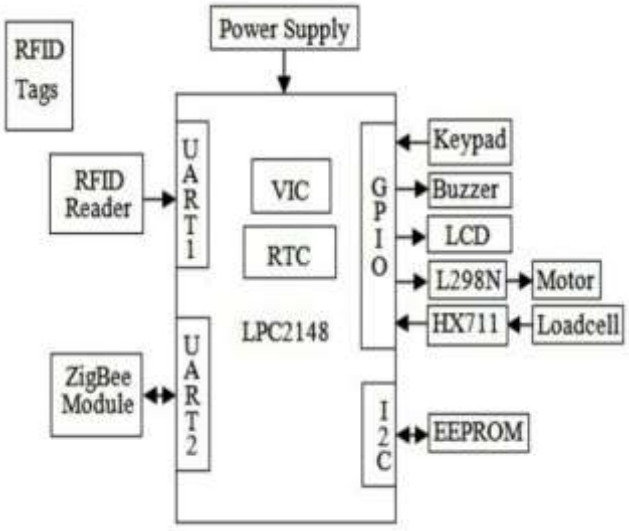

Fig.1. Block Diagram of Smart Cart Section

Fig.2. Block Diagram of Automatic Billing Section

IV. OPERATION OF THE SMART SHOPPING SYSTEM

As the customer enters the Smart Shopping Centre, he/she first picks a Smart Shopping cart. Each cart is given a unique ID and every customer is associated with the ID of the shopping cart chosen. The functioning of the system is listed below:

- Initially the cart is sealed using a motor. Once the start button is pressed the cart is opened and the cart is ready for shopping
- By default the smart shopping cart will be in add mode.
- When the customer picks the product then he/she drops the item into the cart that is identified through the RFID tag which is attached to the item and the information related to the product will be stored on to the EEPROM. At the same time the loadcell identifies the item added to the cart.
- If the customer wishes to remove the items from the cart. He/she needs to press the remove button and remove the item from the cart so that RFID reader reads the tag details, by which the particular item will be removed from the EEPROM too.
- If the customer wishes to remove the item from the cart and doesn't press the remove button and removes the item. Then loadcell identifies the decreasing of weight indicating item is removed and RFID identifies which item is removed and removes that particular item from the EEPROM.
- If the customer wishes to remove the item and press the remove button, but instead of removing, if he/she adds the item to the cart. The loadcell identifies the increase of weight indicating item is added in remove mode, which activates the theft flag and alerts that seller of theft. At the same time RFID reader identifies which item is added in remove mode.
- Once the shopping is done and when he/she presses the "shopping done" button the cart gets sealed with the help of motor and all the information from the EEPROM with the Cart identification number and theft flag status will be sent to the central billing system through the ZigBee module.
- At central billing system, with the help of database all the products information like item name, quantity and price will displayed and calculates the total bill. Once final bill is ready the total bill amount will be sent to the cart and displays on the cart for the customer notification that the bill is ready and his/her's total bill amount.
- If the central billing system identifies the theft flag, it also displays the theft information on the bill.
- Once the shopping is done and got the bill customer just pays the amount and leaves the mall.

V. HARDWARE IMPLEMETATION

The various components that are used in the implementation along with the important considerations are explained in details.

A. RFID Reader and Cards

A radio frequency identification reader (RFID reader) EM-18 is a device used to gather information from an RFID tag, which is used to track individual objects. Radio waves are used to transfer data from the tag to a reader.

The EM-18 RFID Reader module operating at 125 kHz, The Reader module comes with an on-chip antenna and can be powered up with a 5V power supply.

Fig.3. EM-18 RFID Reader and Passive Card

B. Loadcell and HX711Amplifier

A load-cell is configured as a weight sensor. This straight bar load cell (sometimes called a strain gauge) can translate up to 10kg of pressure (force) into an electrical signal. The HX711 load cell amplifier is used to get measurable data out from a load cell and strain gauge in digital form.

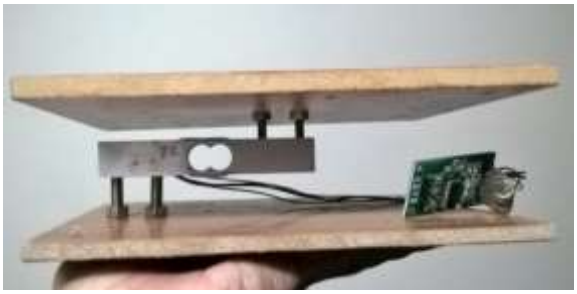

Fig.4. Loadcell and HX711 Arrangement

C. ZigBee Transceiver

The Tarang F20 ZigBee modules require minimal power and provide reliable delivery of data between smart cart device and billing device. The interfaces provided with the module help to directly fit into many industrial applications. The modules operate within the ISM 2.4-2.4835 GHz frequency band with IEEE 802.15.4 baseband.

Fig.5. ZigBee Module

D. LCD Display

LCD has the ability to display numbers, characters & graphics. The display is interfaced to I/O port of microcontroller. The display is in multiplexed mode i.e. only one display remains on at a time.

Fig.6. LCD Display

E. DC Motor and L298N Driver

As the controller can't handle the 5v output motors, we use this H bridge motor driver board to switch the 5v motor to forward/ reverse directions. The L298 is an integrated monolithic circuit in a 15- lead Multiwatt and PowerSO20 packages. It is a high voltage, high current dual full-bridge driver designed to accept standard TTL logic levels and drive inductive loads such as relays, solenoids, DC and stepping motors.

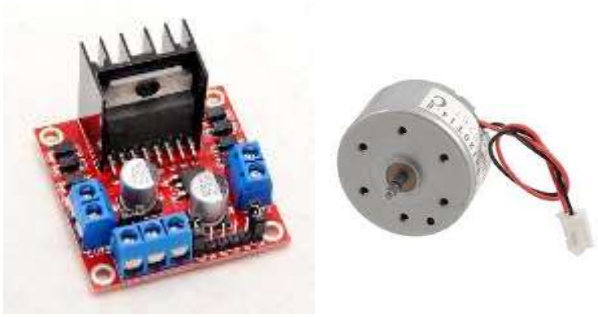

Fig.7. DC Motor and L298N Driver

VI. RESULTS

The experimental set-up is tested for various test cases, with various products tested for all the possible cases. As the RFID card reader read the product, details were displayed on the display unit. The product details of the shopped items were temporarily stored in the EEPROM. Once the "Shopping done" button was pressed, the memory contents were read and billing was done. The same product information data was sent 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.

- Identifying items based on RFID tags and storing the information.
- Identifying whether the items are getting added or removed from the cart based on switch and load-cell data.
- Displaying the complete process step by step on LCD
- Automatic billing update when the products are dropped in the cart or removed from the cart.
- Identifying the theft in add and remove modes.
- Detecting the cart seal is open when start button pressed and seal is closed when shopping is done.
- Shopping cart and server system communication using ZigBee modules.
- Display of the individual item and total billing on the server system.
- Finally displaying the total billing on the cart display.

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

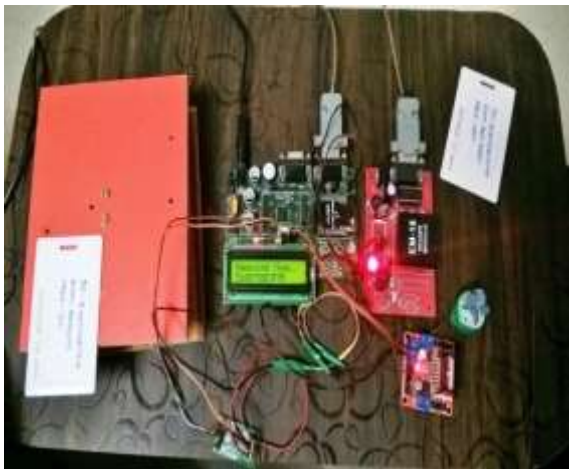

Fig.8. Prototype Model of Smart Cart Section

Fig.9. Prototype Model of Automatic Billing Section

Fig.10. Generated Theft Free Bill

Fig.11. Generated Theft Detected Bill

VII. CONCLUSION

The project successfully demonstrates the possibility of using WSN for developing a Smart Shopping System which automates the entire billing procedure. RFID in the Retail store speeds up shopping processes and thus reduced the manual delays to provide the services and also enhances more user-service tasks. The system developed is highly reliable, fair and cost-effective. It is reliable and fair because of the effectiveness of WSN combined with a highly reliable RFID Technology. The system is also energy constraint as it uses a passive sensor and it reduces the communication requirement. The decision making process is done locally within the cart, thereby eliminating an overhead to the communication between the nodes. In the bigger picture, it reduces the man-power requirements, easy to use, low-cost and does not need any special training.

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