Design and implementation of RFID based e-shopping system

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Abstract— **The emergence of new wireless technologies opened new opportunities to develop more efficient information systems. RFID is among those technologies, which extended the potential of wireless identification, and represent a potential replacement to old-fashioned identification systems such as the barcode system in retail sales. This paper presents a new RFID-based cost efficient approach for pervasive retail sales. The suggested new system architecture is based on aisle-level scanning and new event management procedures at the level of RFID middle ware. It also discusses the impact of deploying such systems in retail stores, and more specifically supermarkets, on the supply chain. The motivation behind such approach is not only reducing the number of RFID readers compared to existing RFID based systems, but providing customers with an interactive shopping experience and fast checkout and bill payment, making this approach transparent, efficient and cost effective.**

Keywords— **RFID, middleware, retail sales, supply chain**

I. INTRODUCTION

The RFID technology encompasses the collection of information and communication technologies aiming at the wireless identification of objects and individuals. From supply chain management to kids tracking systems, the domains of application of this technology are in a continuous spread. In the field of retail sales, the current applications use RFID readers embedded in shopping carts, additionally, the products available on the shelves are not being recognized by those systems. The limitations of those systems' approaches prompted a considerable interest in research towards more pervasive information systems in retail sales. This paper's main contribution to the current state of the art research in the field of distributed of distributed RFID retail management systems is the presentation of a new architecture focused on the detection and tracking of moving products and shopping carts inside the supermarket or shopping area. This architecture differs from previous research by focusing on aisle-level instead of cart-level scanning, by relying on RFID reader antennas placed at the endpoints of each aisle instead of the shopping carts. Consequently, customers are able to make their purchases by putting products on their shopping carts, read the corresponding cart items and current bill on the cart's interactive touch screen, and benefit from directions to specific aisles inside the shopping space.

The checkout is then an easy last step in the purchase process since the customer's bill is already computed and available for payment. The waiting time lost in long checkout queues is hence eliminated. In addition to the highly improved customer experience, the number of RFID readers is lowered and their maintenance costs diminished. The LANDMARC algorithm, which is based on the KNN algorithm, is used to locate the moving products in the shopping space using the received signal strength of the RFID tags attached to them. Products are then assigned to the shopping carts they belong to using clustering algorithms. This paper also discusses the impact of such an approach on supply chain management on the macro-level, and on the retail management at the level of the store. The present paper is organized in the following manner. The system architecture is presented in Section II, along with the system design in Section III. Section IV presents the problem formulations and methodology, followed by the simulations and results in Section V. The impact of the system deployment on the supply chain is discussed in Section VI. Finally, a conclusion and future work are presented at the end.

II. SYSTEM ARCHITECTURE

The goal of establishing the system's architecture is to construct a bridge between the IP-based domain and the physical level RFID domain. The present architecture's role is to route instructions and data from one layer to the other [6].This section presents the system architecture in this pervasive RFID retail sales application along with the description of the different layers. Fig. 1 describes the data an instruction flow between the different system layers. As soon as the RFID tags attached to the products are detected (observed) by the reader layer, those signal observations are processed by the device manager middleware, and event manager in order to maintain the integrity of the data at the information system level.

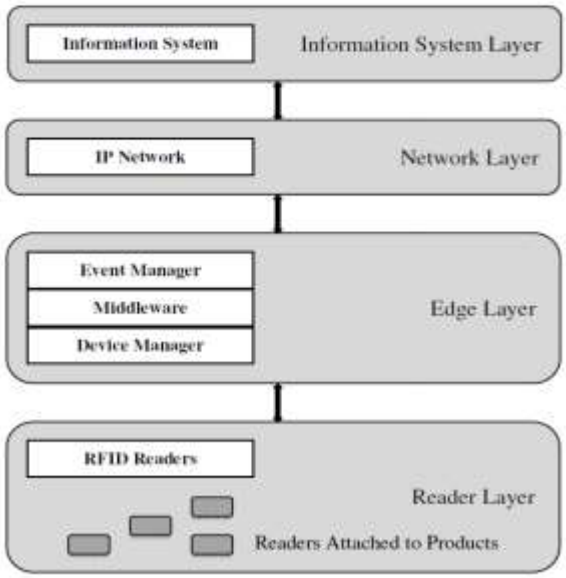


Fig. 1. System Architecture.

Reader Layer

The reader layer is composed of RFID readers and tags. In this layer, communication takes place following specific protocols presented in the system design. The tags in the shopping carts and on the shelves are detected by the which can identify different parameters concerning the observation of the tags such as tag identity and observation time.

Edge Layer

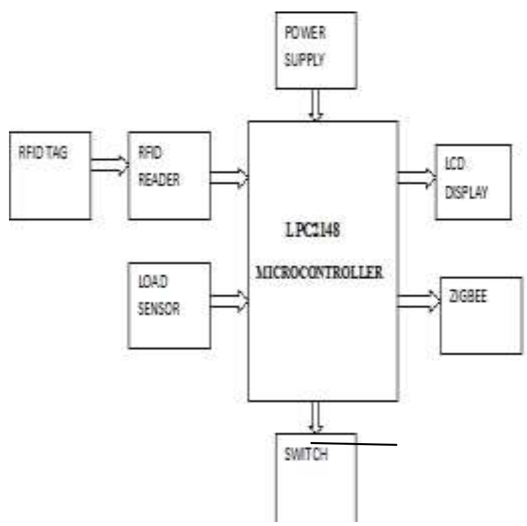
Once an observation is performed using the RFID reader antennas deployed at every aisle, it is necessary to filter the data collected in order to eliminate redundancies and correct irrelevant data. The edge layer is considered as a preprocessing stage where the filtering and smoothening of the data is performed in order to construct events that can be understood by the higher-level layers of the architecture. The events manager contained in this layer filters the data and transforms is to events that fit in contexts. The innovative added value of this paper lays in the event management and context forming during shopping. When users' carts circulate in the shopping space, the tagged products are detected by the event manager and are identified as part of a in this case a purchase. This context is formed when tags have the same direction and velocity after a significant number of observations.

Network Layer

In order to communicate the purchase context to the system core with the corresponding data, the event manager communicates the events to the IP network. This layer represents the link between the low level data and the higher level system, i.e., the information system. It ensures identifier resolution in a way that keeps each item recognizable by the system in term of name, price, description, and others.

Information System Layer

The information system layer represents the application or set of applications visible to the administrator or the users. It constitutes the management system where business logic is implemented. It encompasses the database or data warehouse, the desktop, web, or mobile applications for administrators and users. In our context, the carts' touchscreen are also part of the information system so as to interface with the customers. This system is required to have a constant access to the current transactions being made, to information about users still in the process of purchase and all other business significant information.



III. HARDWARE DESCRIPTION

ARM Microcontroller

The LPC2141/2/4/6/8 microcontrollers are based on a 32/16 bit ARM7TDMI-S CPU with real-time emulation and embedded trace support, that combines the microcontroller with embedded high speed flash memory ranging from 32 KB to 512 KB. A 128-bit wide memory interface and unique accelerator architecture enable 32-bit code execution at the maximum clock rate. For critical code size applications, the alternative 16-bit Thumb mode reduces code by more than 30 % with minimal performance penalty.

In this Project the ARM processor is attached to a RFID reader. As the user puts the items in the trolley the reader on the trolley reads the tag and sends a signal to the ARM processor. The ARM processor then stores it in the memory and shows the name of item on LCD &also the total amount of items purchased, the quantity of the product and expire date also displayed.

RFID Reader

RFID stands for radio frequency identification. It is an automatic identification technology to identify objects by using invisible radio waves. Instead of optically scanning bar codes on a label, RFID uses radio waves to capture data from tags. One of the key characteristics of RFID is that it does not require the tag to be seen to read the data stored in it. This means that the tag can be placed either inside or outside. To accomplish this, 2 components are essential: reader and a tag.

The RFID reader is designed for fast and easy system integration without losing performance, functionality or security. The RFID reader consists of a real time processor, operating system, virtual portable memory, and transmitter/receiver unit in one small self-contained module that is easily installed in the ceiling or in any other convenient location. A reader, also called interrogator, comprises of a transmitter, receiver, control module and a transceiver. The transceiver acts as a communication link between the person and the controlling PC. A reader should have an attached antenna which is used to transmit and receive the RF signal. Each reader has associated software that allows the user to read and program the tags.

RFID Tags

A tag, also called as transponder, is made of a micro-chip with a coiled antenna. The tag can be programmed with unique information about the object and hence can be used to identify it. RFID tags can be encased in hardened plastic coatings making them extremely durable. RFID tags can store large amounts of data. High end RFID tags can store up to 1 megabyte of data. Some RFID tags supports read/write operations, enabling real time information updates as the tagged item moves from one location to another.

There are two types of tags: active and passive. In this project, passive tags are used. Passive RFID tags have no internal power supply. The minute electrical current induced in the antenna by the incoming radio frequency signal provides just enough power for the CMOS integrated circuit in the tag to power up and transmit a response. Most passive tags signal by backscattering the carrier signal from the reader.

Active RFID tags have their own internal power source which is used to power any ICs that generate the outgoing signal. Active tags are typically much more reliable (e.g. fewer errors) than passive tags due to the ability for active tags to conduct a "session" with a reader. Active tags, due to their onboard power supply, also transmit at higher power levels than passive tags, allowing them to be more effective in "RF challenged" environments like water (including humans/cattle , which are mostly water), metal (shipping containers, vehicles), or at longer distances.

LCD display

LCD has the ability to display numbers, characters & graphics. The display is interfaced to I/O port of microcontroller (P0.0-P0.7). The display is in multiplexed mode i.e. only one display remains on at a time. Within 1/10th of a second the next display switches on. In this way sequentially on and off display will result in continuous display of count due to persistence of Vision

Zigbee

XBee and XBee-PRO Modules were engineered to meet ZigBee/IEEE 802.15.4 standards and support the unique needs of low-cost, low-power wireless sensor networks. The modules require minimal power and provide reliable delivery of critical data between devices. The modules operate within the ISM 2.4 GHz frequency band and are pin-for-pin compatible with each other.

RF module consists of RF transmitter and RF receiver. It is a small electronic circuit used to transmit and receive radio signal. It selects one out of a number of carrier frequencies. Types of RF module are:

1) Transmitter module
2) Receiver module
3) Tran receiver module

In this project we have used Tran receiver type RF module. It is a small PCB sub assembly and is capable of transmitting and modulating a radio wave that carries data. Transmitter modules are implemented alongside a microcontroller which will provide data that can be transmitted to the module.

RF Receiver

RF Receiver receives the signal from the transmitter. The range of RF transceiver is as follows:

- Indoor/Urban: up to 100’ (30 m)
- Outdoor line-of-sight: up to 300’ (100 m)
- Transmit Power: 1 mW (0 dBm)
- Receiver Sensitivity: -92 dBm

Temperature Sensor

The LM35 series are precision integrated-circuit temperature sensors, whose output voltage is linearly proportional to the Celsius (Centigrade) temperature. The LM35 thus has an advantage over linear temperature sensors calibrated in ° Kelvin, as the user is not required to subtract a large constant voltage from its output to obtain convenient Centigrade scaling. The LM35 does not require any external calibration or trimming to provide typical accuracies of ±1⁄4°C at room temperature and ±3⁄4°C over a full −55 to +150°C temperature range. Low cost is assured by trimming and calibration at the wafer level.

IV. SOFTWARE SYSTEM DESIGN

Keil uVision4 MDK ARM

This software is mainly used to activate ARM7 (lpc 2148) microcontroller according to the input received by it. “Embedded C” code is written using this work bench. In this project, coding is written for GPS, GSM and Voice playback circuit ,measuring body temperature , fall detection of children of which is interfaced with ARM7 board at the transmitter end. As per the code embedded in the controller, the interfaced modules generate appropriate output at the receiving end.

PROTEUS

Proteus 8 is a best simulation software for various designs with microcontroller. It is mainly popular because of availability of almost all microcontrollers in it. So it is a handy tool to test programs and embedded designs for electronics hobbyist. You can simulate your programming of microcontroller in Proteus 8 Simulation Software.

After simulating your circuit in Proteus 8 Software you can directly make PCB design with it so it could be an all in one package for students and hobbyists. So I think now you have a little bit idea about what is proteus software.

V. CONCLUSION

In the present paper, a novel approach based on aisle-level RFID scanning has been presented as a new way to integrate RFID in the retail sales domain. Indeed, users will be able to view their current bill in real-time, get directions in the shopping space, and more importantly check out and make the payment in a glimpse of an eye without having to wait for long periods of time in waiting line.

A background on the RFID technology has been presented in the beginning in order to contextualize the overall system. Then, the adopted methodology consisting in deploying an adequate reference RFID tag environment, using the LANDMARC methodology in addition to clustering and context building was presented. Extensive simulations using MATLAB showed a significant and accurate localization scheme within the environment constraints such as propagation issues.

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