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RFID Based Automatic Shopping Cart

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Abstract

Large grocery stores are nowadays used by millions of people for the acquisition of an enlarging number of products. Product acquisition represents a complex process that comprises time spent in corridors, product location and checkout queues. On the other hand, it is becoming increasingly difficult for retailers to keep their clients loyal and to predict their needs due to the influence of competition and the lack of tools that discriminate consumption patterns.

In this article it is presented the proposal of an architecture and solution of an innovative system for the acquisition of products in grocery stores (Intelligent Cart). The Intelligent Cart explores emerging mobile technologies and automatic identification technologies (such as RFID) as a way to improve the quality of services provided by retailers and to augment the consumer value thus allowing to save time and money.

Keywords: Automatic Product Identification; Electronic Services; Grocery Stores, RFID, Intelligent cart.

1. Introduction

In recent years a deep structural change has occurred, with consequences on economic growth and society, especially in factors such as territorial occupation, urbanization, openness to global markets, demography, family structures and cultural and consuming patterns. Innovation in communication and information technologies have caused a revolution in values, knowledge and perceptions in practically all areas of human understanding, deeply carving the so-called “Age of Information and Knowledge”.

The grocery industry sector is nowadays extremely important in worldwide economy, with its recent evolution in technological, political, social and economic terms making it one of the most convenient and diverse businesses across the globe. In their journal “Consumer perceptions of privacy, security and trust in ubiquitous commerce” mentioned that the proliferation of electronic commerce technologies has utterly transformed the way business is conducted. Causes range from the introduction of new mobile technologies and ubiquitous computing, to the recognition by business of the strategic benefits offered by the implementation of communication and ubiquitous computing structures, to the emergence of new business models made possible due to the new technologies and to the development of new economies that can be used to understand and value the ubiquitous commerce activity. The challenges and opportunities created by electronic business in the supply chain have caused the sharing of information between business partners to improve operational performance, consumer service and solution development. Businesses have evolved from the sharing and coordination of information to the sharing of knowledge and advanced cooperation practices. The emergence of new

technologies, such as Radio Frequency Identification (RFID) and wireless networks, makes the traditional retail processes faster, transparent and efficient. The technology represents to retailers an opportunity to reduce costs and to improve services, allowing to attend clients quickly, precisely and supplying personalised services. The advances in manufacturing, distribution and information combined with the urbanization of modern society and socio-demographical changes created the so-called new consumer. The consumer has a deeper understanding in comparing product costs; is more versatile in brand preferences; shows little loyalty to retailers; has great expectations in services and client regard; is self-sufficient and is more demanding towards supplied information. There was a clear control transference from the manufacturers and retailers to the consumer. Strong competition between larger retail chains caused the minimization of profit margins as a form of keeping aggressive prices and winning more clients. Today, this is no longer enough. One has to bet on offer differentiation and in the adoption of client retention strategies through the strengthening of the relation with the consumer, allowing adequate answers to clients' needs through personalized service and promotion plans that augment their satisfaction and, most importantly, their enthusiasm.

2. System Architecture

The architectural implementation of the system and the main end to this system is to allow the consumer a new way of shopping. When arriving at the supermarket, the consumer heads towards a shopping cart that has a technological system on its handle-bar which consists in a touch-screen monitor, a client card automatic reader, a positioning transmitter and a product reader. Nevertheless, all these technologies become transparent to the consumer because only monitor interaction will occur. Through the client card, the consumer logs in to the system; the system then welcomes the consumer and displays the shopping list. With the help of the shopping cart's navigation system, the client is directed to the locations where the products in the shopping list can be found. The client places the products in the shopping cart the usual way and begins to receive multiple information: the products found inside the cart; the ones missing; total paying amount; total promotion al savings; product details; amongst others. If the client needs 200g of sliced cheese from the cheese-dairy section, it can be ordered through the system. By passing the wine aisle, a message appears referring to an interesting promotion on the client's favourite red wine. The client places two bottles in the shopping cart because one of them is free. Meanwhile, a message adverts that the sliced cheese order is available near the cheese-dairy section. The client passes through and places it on the cart. (Refer fig 1).

Suddenly, it comes to her/his mind she/he has not thought of the dinner yet and checks the recipes that the system has to offer. By choosing a recipe, the client orders the system to add to the shopping list the needed products and sends the recipe to the client's e-mail box. After the remaining products are found in the shopping cart, the client heads towards the exit where it is not necessary waiting to pay. At the exit, the client sees on a screen the list of products in the cart, the total paying amount and the total promotional savings and offerings. The client confirms the payment through the client-card and leaves the previous scenario completely revolutionises the present way of shopping. There is a much bigger integration and interaction between consumer, retailer and advertisers. This new system acts as an intermediate for the different intervening agents allowing several not yet possible functionalities. The proposed system architecture can be seen in Figure 1. As shown, the consumer's "intelligent" shopping cart automatically identifies the cart's contents due to the integrated product reader. The sent and received information passes through the wireless IEEE 802.11b access points that are spread all over the supermarket and communicate with the applicational server where all the information regarding the system's business logic can be found. This server also enables communication with the retailer's back-end system. The shopping cart positioning transmitter sends its location to the diverse receptors connected to a protected server that gathers information about routes and current cart location sending it to the applicational server for processing. Client's shopping lists will be made through the access to their internet accounts connected to the entire system. Advertisers and suppliers also communicate through the internet with the applicational server so they can collect data to analyse promotion efficiency and to offer clients real-time personalised promotions and offers. This way, added value services are created for all the involved agents, allowing them to benefit from several advantages which will be numbered next in the business model.

2.1 Business Model

By offering the consumers added value services, this solution will significantly improve their quality of life through the introduction of advanced B2C electronic services that allow personalised and interactive services that do not exist in today's supermarkets. Users of the B2B type will benefit from advanced marketing, forecast

and analyses services. The creation of a ubiquitous computation environment assumes the tracking of the identification, location, sensor mechanisms and connectivity keys. By using mechanisms that allow the supermarket products' automatic identification and connectivity between systems, the consumer obtains also a series of benefits he would not have any other way: real-time identification of products inside the shopping cart that allows access to additional information; quick exit out of the supermarket without the need to spend time in frequently long queues; product price checking that avoids problems with switched, missing or wrong price labels in shelves which could result in higher cost for the consumer. To have a navigational system available means that it is possible for the consumer to locate any object.

The advantages of this type of service include:

• Locating products through system search, which then displays a map with both cart and product location thus avoiding the waste of time searching for products that often change place.

• The offer of multiple navigation trajectories inside the supermarket based on the consumer's shopping list or on system's suggestion.

• Shopping list suggestions based on previous visits by monitoring navigational trajectories inside the supermarket and choice of products, something which helps the consumer remember any needed product.

• Offering adverts and promotions based on shopping cart's location and on the consumer's profile and history, thus avoiding boring the consumer with advertisement or general uninteresting promotions. With this solution, the consumer finds available a new and innovative way to shop that provides pleasanter, faster, more personalized and economic visits that reach the consumer's demands, needs and lifestyle. In spite of having at its core the consumer's needs, the retailers are actually the target for a possible commercialisation of this solution.

Therefore, there have to be retailer benefits that extend beyond the purpose of offering a better service to clients. With shopping cart navigation monitoring, retailers can obtain advantageous information: analysis of product location inside the supermarket, making possible to conclude about the efficiency of product placements; analysis of client loyalty programs and consuming patterns; analysis of real-time consumer demands' data. Besides this, retailers can increase sales, have a larger number of loyal clients, provide more personalised and higher quality services, reduce hypermarket operating costs, diminish theft, amongst others.

2.2 Technological Model

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. Nowadays, the usage of barcode for product identification presents several limitations: only the product's 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. So that automatic product identification is possible all existing products inside the supermarket need to be identified with RFID tags and each shopping cart must have an RFID reader. The range of the RIFD 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. Vertically, the reader should be able to identify products down to the floor, since there are shopping carts where you can place products from 20 cm above the ground and to about 1,5 m higher then the handle bar since there are both tall products and excessively filled carts. 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 colliding readings in cases when more than one reader is used, something which increases the complexity level. The usage of RFIDs in this solution 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 realtime 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 of the cart's position any time it 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. Yet, the optimal characteristics are not gathered in one single technology. (Refer fig 2)

Because of this, we have chosen to identify the requisites our solution demands and to suggest the technologies most likely to serve its purposes. The necessary requisites for our solution are: (Refer Table 1)

• Middle range, so that a considerable area is comprised thus preventing the usage of an exaggerated number of locating devices.

• Low energy consumption, so that the shopping cart doesn't run the risk of rapidly running out of energy and enables hypermarket navigation.

• High precision, since in relatively small navigation areas errors superior to 1 m must not occur.

• Warrantable and safe connection.

• Strong signals that remain unaffected by obstruction, specially metallic objects.

• Simultaneous reading of the positions of diverse devices.

• 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 require line-of-sight nor depend on angles.Besides that, they consume little energy are not expensive. 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 aforementioned 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 retailers' systems. Lastly, but not least importantly, the necessary energy for the client's optimal system usage should be minimized, since energy can not fail during the process. One way to save batteries is to suspend the system while it is on stand-by.

3. Related Work

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: save consumer's time and money, help the retailers to win loyal clients and to offer concrete data to advertisers about their advertising efficiency and promotions.

The idea of creating an "intelligent" shopping cart that helps consumers navigate through the hypermarkets and offers precise information to retailers and advertisers about consumerism dates from the late eighties. The VideOcart consisted in a small touch-screen monitor coupled to the shopping cart's handle-bar with which the consumers could interact. The VideOcart showed advertising messages based on the location of the shopping cart in the hypermarket; it had a product search system, a cart-location map and several entertainment functionalities.

4. Conclusion

This paper reviews and exploits the existing developments and Different types of radio frequency identification technologies which are used for product identification, billing, etc. Thus the survey paper studies and evaluates research insight in Radio Frequency Identification systems from a big picture first. We have studied in detail

about the business model, technological model and all related work and applications in the domain of RFID based systems that make ease of identification. We have also learned 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. Thus RFID has a wide scope in the supply chain management. In the future, if all studies are favourable, we will advance with the implementation of a prototype for proposed architecture for testing in a real hypermarket scenario because RFID is a technology that has the potential to improve our lives to a very great extent.

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Notes:

Fig.1 Proposed system architecture:

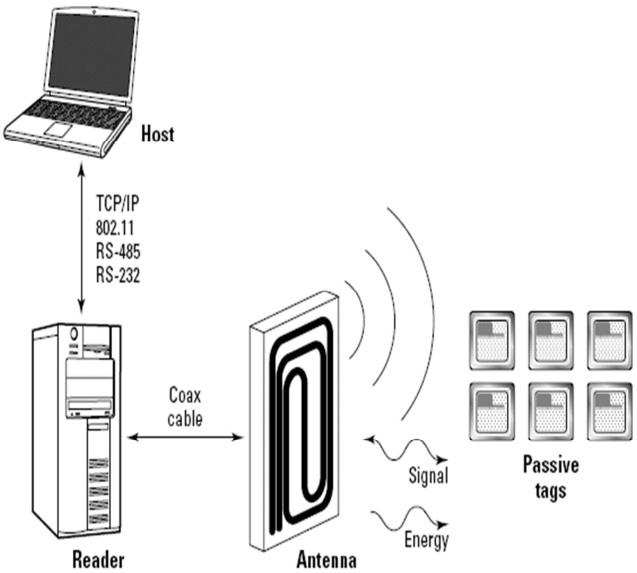

Fig 2. Technological model

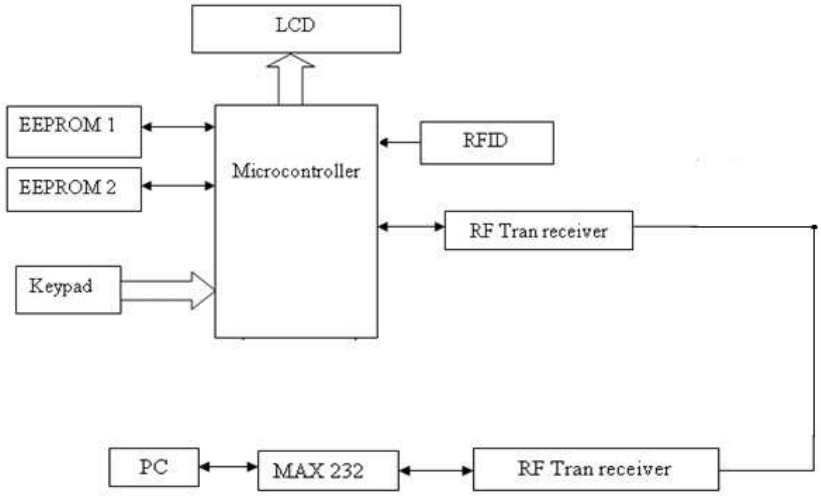

Table 1. RFID characteristics

Frequency	Mode	Range	Transfer Rate	Penetrating Capability
125-135kHz	Passive	Short range (upto 0.5m)	Low	Liquid
13.56MHz	Passive	Medium range (upto 1.5m)	Moderate	Liquid
860-930MHz	Passive	Medium range (upto 5m)	Moderate to High	Liquid and Metal
433MHz	Active	Ultra long (upto 100m)	High	Liquid and Metal
2.45GHz	Active	Long range (upto 10m)	Very High	Liquid and Metal