IntelligentCart: Architecture of an Innovative System for the Acquisition of Products in Grocery Stores

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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 (IntelligentCart). The IntelligentCart 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; Grocery Stores; Electronic Services

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 [1]. 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 [2].

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 [3].

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 [4]. Businesses have evolved from the sharing and coordination of information to the sharing of knowledge and advanced cooperation practices [5].

The emergence of new technologies, such as Radio Frequency Identification (RFID) and wireless networks, makes the traditional retail processes faster, transparent and efficient [6]. This technology represents to retailers an opportunity to reduce costs and to improve services, allowing to attend clients quickly, precisely and supplying personalised services [5, 6].

The advances in manufacturing, distribution and information combined with the urbanization of modern society and socio-demographical changes created the so-called new consumer [7, 8]. This 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 [6]. There was a clear control transference from the manufacturers and retailers to the consumer [5].

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 [5, 6, 9].

These tendencies represent the large forces that are revolutionising the supply chain. In this paper, we propose the architecture and solution of IntelligentCart, an information system for the acquisition of products applied to the fast moving consumer goods sector. This ubiquitous retail system aims to transform grocery shopping into a *retailtainment* experience by eliminating the actual

associated problems. In section 2 we identify today's problems in the supply chain that directly affect the consumer. Section 3 shows diverse commercial and academic solutions that aim to solve these problems. In section 4 we present our resolution proposal for these problems presenting an information system architecture that utilises new technologies. Finally, section 5 concludes the article and presents several proposals for future investigation.

2. Motivation

Throughout the years, large distribution's supply chain has made considerable operational profits through the adoption of several technologies and thus achieving a certain degree of success. Growing demand on the part of the new consumers towards products and services of the large retail chains has revealed a supply chain that is not ready to answer demands in a totally efficient way [10].

There are several inefficiencies verified throughout the supply chain: high return rates; out-of-stock products; long lead times; low accuracy on consumer demand forecasts; low on-shelf availability; replenishment is not consumer based and tends to be inefficient [10, 11].

When trying to overcome these inefficiencies retailers have created solutions that have only worsened the situation: by increasing the inventory levels to answer unpredictable requests they have widened the variety of products while ignoring consumer data [12].

These solutions are not viable since they increase the costs in the supply chain, the probability of damage or deterioration in products not sold, the cycle time and the inventory investment while the replenishment is based in estimations and not in real data about consumer demands.

To make things worse there are still unconnected or incompatible information systems in the supply chain, decreasing the cooperation between business partners and the amount of useful information.

Nowadays, the prediction of consumer demands is based on data originating from Point-Of-Sale, which, together with decision-making support systems and data mining techniques, tries to timely answer consumer demands [13, 14]. Nevertheless, these results do not take into account promotions and advertising influence that associated with pressures in the supply chain and fast alterations in consuming patterns do not allow enough time to make thorough analysis [15].

On the other hand, consumers feel frustrated with their visits to the large retail chains establishments resulting in a negative impact on their shopping habits. The causes for this are: long waiting lines in the checkout and in the fresh food section; difficulties in product finding; sold-out products; low service quality; difficulty in finding personnel to assist or answer questions; weak employee knowledge about store products; low visibility of product prices on shelves; inexistent or out of place prices on shelves; promotions on uninteresting products [6].

In fact, consumers hope that retailers help them save time and money and make their visits to their establishments interesting. Since retailers are the most interested in having loyal clients, consumers believe they should do something to improve service quality. Retailers are responsible for the creation of conditions that influence the shopping experience. Factors such as environment, weather pressure, store service quality, image and crowding [12, 16, 17, 18, 19] are fundamental for the consumer's choice of store, placing on retailers the responsibility to innovate and improve their services.

Advertisers too have realised that they fail to have concrete results about their advertisement and promotions, since these are often ignored by consumers due to its lack of differentiation.

One possible solution for the identified problems consists in implementing an information system to assist consumers inside the hypermarket improving their shopping experience and at the same time offering real-time useful and precise information to all who intervene in the supply chain. Next section identifies some solutions that have emerged in the market and in the research field throughout the years.

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 [20].

Two years after the failure of the VideOcart in 1994, Klever Marketing bought its intellectual patent and created the KleverKart. The KleverKart allows

advertising and personalised promotions to clients who use it with the client card. Besides this new function, clients can also pass all their products on the system incorporated barcode scanner thus avoiding queues at the exit [21, 22].

This type of solution can be found mainly in several hypermarkets most of which located in the USA. MediaCart [23] also allows barcode reading and offers such functions as: price comparison and verification; hypermarket product location and map visualisation; access to personalised promotions according to the shopping cart location; shopping lists storing, nutritional information and recipes visualisation; remote orders of fresh products, amongst others.

There are also several other commercial solutions that provide this type of functionalities: the Shopping Buddy [24, 25], developed by Symbol Technologies and Cuesol Inc.; Springboard Retail Networks Inc.'s Concierge [26], the U-Scan shopper [27], which resulted from a partnership between Klever Marketing and Fujitsu Transaction Solutions Inc.; and the Wincor-Nixdorf's Personal Shopping Assistant [28] that can be found in METRO Group's Future Store in Rheinberg, Germany.

MyGrocer stands out amidst the previous mentioned solutions due to the fact that allows automatic reading of the products inside the sopping cart through RFID technology thus replacing barcode scanners. As part of the Information Society Technologies program and financed by the European Commission, this investigation project was implemented and tested through a prototype created for that effect. Beside the hypermarket scenario, MyGrocer extends to the consumer's home by making inventories of the products stored in house [12, 29].

IntelligentCart is distinguishable from the aforementioned solutions due to the fact that it uses RFID technology to identify products inside the shopping cart. RFID technology is advantageous when compared to barcode technology because the consumer does not have to conduct product reading manually. In the presented solutions, barcode reading presents several problems: damaged labels that cannot be identified by the scanner; products that the consumer forgets to pass on the reader thus damaging him/herself or the retailer; products that are too heavy or have labels in hard-to-read places. On the one hand, besides having multiple applications in several areas [30, 31], RFID technology presents itself today as "barcode's next generation", having attracted the attention of the supply chain intervenients [32]. On the other hand, the RFID technology that allows the unique identification of objects and devices is vital in a shared knowledge network, belonging to one of the four keys connected to a ubiquitous computing environment: identification, location, sensor mechanisms and connectivity [33].

Next section presents IntelligentCart's general architecture as well as its technological and business model.

4. System Architecture

Our proposal offers an information system that seeks to explore emerging wireless technologies and automatic identification technologies applied to the large retail grocery surfaces. This system's main goal consists in the introduction of B2C advanced electronic services through "intelligent" mobile access devices within the food retail sector allowing interactivity, personalisation and automation.

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 promotional 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. 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.

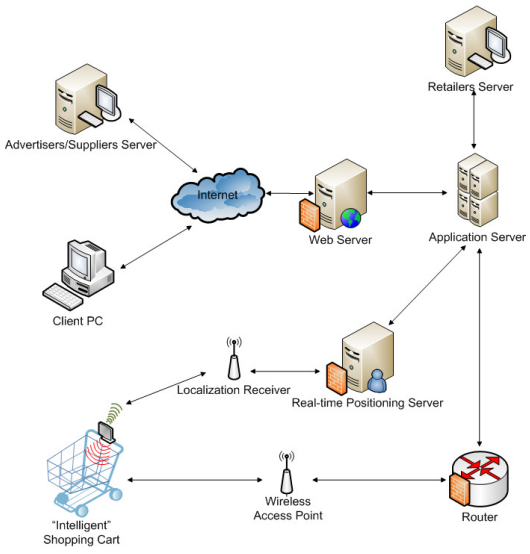

Fig 1. Proposed system architecture

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 [33]. 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.

Brand advertisers can also profit from this solution, since 70% of the consumer's buying decisions are made inside the hypermarket [34]. This way, advertisers can effectively act in the moment. They will also be able to: monitor consumers' shopping habits as a way to understand client's needs; apply different marketing strategies to different consumerism profiles and to infer on their efficiency; increase they loyalty to their products; improve their products or to introduce new ones based on consumers' demands; reduce costs on market studies and statistics; fight against today's consumer disregarding attitude towards advertisement.

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 [35].

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 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 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. 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:

- 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 obstructions, 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 minimised, since energy can not fail during the process. One way to save batteries is to suspend the system while it is on stand-by.

5. Conclusions and future work

This paper has presented a proposal for a new information system architecture (IntelligentCart) for the retail sector that completely transforms today's hypermarket shopping experience.

The impact of changes imposed by new technologies on the supply chain paradigm has created new possibilities for increased efficiency and for the expansion of commercial power of distribution companies. Also the occurring changes in consumption patterns have created more demanding clients that are less faithful to commercial establishments. In this context, we have identified a series of flaws that the supply chain started to reveal mainly because of the fact that there were no precise forecasts of consumer's demands. Frustration resulting from the visits to the large retail chain establishments has had negative impact on consumers' shopping habits, and that was a major concern for our study.

The analysis of the several existing technological solutions has revealed us this problem's importance and alerted even further for the necessity to find a suitable solution.

IntelligentCart's proposal tries to combine several autonomous emerging technologies in ways to automate several retail sector procedures. The usage of wireless and positioning technologies along with the RFID automatic identification technology applied to IntelligentCart, has allowed us to create a ubiquitous environment. We have established an information system architecture that helps consumers with the shopping process, offering a hypermarket navigation service that allows the retailers to infer on consumption patterns so that advertisers may analyse publicity impact and time spent on product choice. Simultaneously, problems such as shoplifting, long waiting lines and human resources availability, are minimised. The big IntelligentCart's advantages consist in:

- offering consumers a new and more pleasant way of shopping (close to entertainment);
- supplying retailer with real-time information about consumerism patterns;
- offering advertisers a unique way of making personalised advertising;
- saving time and money to all those involved in the process.

Right now we have a high level architecture that can offer a precise and explicit idea of what we what to continue to research. The research will be extended to positioning technologies advanced study, to tests on RFID technology to know its technological limitations, to consumer inquiries about the possible usage of the Intelligent Cart and to understand the real needs of retailers and advertisers, amongst others.

In the future, and if all studies are favourable, we will advance with the implementation of a prototype for the proposed architecture for testing in a real hypermarket scenario.

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