

## QB – (Quick Buy) – Convenient Modern Shopping System Based on RFID Technology with Indoor Maps

P. Tharaneetharan<sup>1</sup>, M.I.M. Shafni<sup>2</sup>, F.F. Marikar<sup>3</sup>, K.D.S. Thiwanka<sup>4</sup> and S.G.S. Fernando<sup>5</sup>

<sup>1,2,3,4,5</sup>Faculty of computing, Sri Lanka Institute of Information Technology, Metro Campus, Kolpetty, Colombo, Sri Lanka

*Abstract:* Today in the fast moving and evolving lives of people they have less and less time to spend on their day to day activities. When it comes to shopping in a supermarket or retail store people have to face many issues. As an example customers get delayed at the cashier, have trouble finding the exact location of the product they need as they are not aware of where the goods are placed within the shops, miss or forget the goods they need to buy. This research explores the extent to which shopping could be simplified and automated within super markets and retail stores. The “QB” system focuses on providing a solution to all the above mentioned problems by using a Mobile Shopping List Application to maintain a list of what to buy so that the customer will not forget once they are at the super market. This Mobile Application will show the customer the internal map of the Super market or retail store and navigate the customer to the relevant product which is in their list. An automated billing system is implemented to the shopping cart using RFID Tags so that the bill will be auto calculated at the time when the customer adds products to the cart so that they will not have to waste time standing in long queues at the cashier.

*Keywords:* RFID Tags, Automated Shopping Cart, Mobile Shopping List Application, Indoor Navigation.

### I. INTRODUCTION

This research explores the extent to which shopping and business could be simplified and automated within super markets and retail stores. In particular the research focuses on the factors of convenient business deals.

Automation or automatic control simply means that a process, a systems or machine works on its own with minimal or reduced human intervention. The major advantage is the saving of human labor, other than that it saves energy and materials and the outputs are of high quality, accuracy and precision [1]. The technology is fast replacing human beings with machines in virtually every area and industry in the global economy. With economic growth, technology changes and with the advancement of time, large shopping malls have sprung up. The main concept behind such shopping complexes is to provide all the things the customer wants to buy under-one-roof [2].

The emergence of new business concepts made possible with the new technologies and to develop new economies that can be used to value the common commerce activity.

At the same time emergence of new technologies such as Radio Frequency Identification (RFID) and wireless networks makes the conventional retail processes faster, accurate and more efficient. The “QB” system focuses on providing a solution to all retail shopping problems by using,

- a. Mobile Shopping List Application - to maintain a list of what to buy so that the customer will not

forget once they are at the super market. This will show the customer the internal map of the store and navigate the customer to the relevant product which is in their shopping list.

- b. An automated billing system - will be implemented to the shopping cart using RFID Tags so that the bill will be auto calculated on-the-go when the customer adds products to the cart.

The objective behind the project is to implement a compound system to manage the shopping experience of the customer by solving the commonly faced issues this consists of automating the billing process and an application to navigate the customers to the relevant products they wish to purchase. This will:

- **Reduce time wastage of Customer at the cashier** since the bill is generated on-the-go.
- **Increase accuracy of billing process** with the use of RFID Tags
- **Increase security of the Cart and Data Transfer** with the use of RFID tags to detect the presence of the item.
- **Navigate the customer to the desired location within the premises** by loading the indoor map into the mobile device

#### A. Research Problem to be Addressed

In South Asian and South East Asian countries level of automation is negligible in retail market complexes.

When considering the Supermarkets and retail stores in Asian countries people face many issues. In traditional retail shops customers have to wait at

cashier for several minutes and in today's society people do not have time to waste, as soon as the customer is done with shopping if they cannot leave the shopping premise that is frustrating. Goods at super markets and retail stores are tracked by barcode and taking time to scan each and every item to generate bill makes the customer delay at the cashier, also it is in human nature to forget the purchase list planned at home as a result they buy fewer goods than planned. If they forgot to buy something it is tiresome to visit back the supermarket and waste precious time. Adding to the problem is the fact that customers are not aware of where the goods are placed within the shops, resulting in difficulty of locating them, Senior citizens with mobility problems may have difficulty in traversing the mall looking for products they need, because of the largeness of the place. Also crowded aisles and stores make shopping very difficult which again wastes precious time.

Furthermore a huge rush can be seen during weekends, holidays and various festival seasons, in view of businesses it's very difficult to manage customers and cater to their need at these situations. Therefore the "QB" system will address the above mentioned problems and help customers to do their shopping more conveniently and easily without dissipating their time at supermarkets.

#### B. Research Gap

Though there are many Shopping cart systems for many purposes in developed countries, in south Asia there is no such automated system for a retail store. The available systems are not that economically feasible to organizations, and also the existing research and project components are scattered. "QB – (Quick Buy)" will be a targeting this, hoping to fill the gap. Below are some reasons which make this project to be unique and to justify its need.

- Intelligent shopping cart, purchase list with indoor mapping navigation, and data mining are combined together under one concept.
- Navigating guide for customers to locate products.
- There are no such current researches or projects implemented in South Asia.
- Cost vice cheap.
- High Reliability and Security.

Since Sri Lanka and most South Asian countries are developing countries, this project will be a huge improvement and also will be an inspiration to other researchers who have similar interest on this research area. Developing the "QB" system will lead to many benefits such as reduced need of additional labor [3] and many more. In 2013 research shows 48% of people think queuing is the biggest waste of time and QB can handle this issue [4].

This project, more than being a solution for a particular set of problems, it is an addition to the existing automated shopping cart technology. The concept, methods and algorithms used in

implementing this system can be integrated with other hi-tech automation projects.

## II. LITERATURE REVIEW

In recent years a great deal of time and effort has been spent on developing systems to reduce customer purchase time and to get high customer satisfaction. For this task many research and innovations happen day to day in retail industry with the use of RFID, Wi-Fi transaction, Bar code, Kindest, online shopping, mobile applications etc. "QB"-(Quick Buy) will be developed to reduce customer purchase time and to get high customer satisfaction with intelligent shopping cart, indoor navigation and prediction of goods.

There are rather few research projects done in relation to bill automation, indoor mapping and navigating from universities and other organizations/companies worldwide. In Sri Lanka or other South Asian countries there are no exact system in use to automate the billing process from the shopping cart level or to navigate a customer indoor. The following sections contain an overview of the research done in regard with intelligent shopping cart, indoor map navigation, business prediction methods and Wi-Fi data transaction.

#### 1) Use of RFID Technology to detect products

The project "Low cost smart shopping facilitator for the visually impaired" uses Radio Frequency Identification (RFID) technology to identify the products. The audio instructions will assist them inside the supermarket based on real-time situations. This system will eliminate the need of another person's help for the visually impaired people in shopping and provide them a convenient and sophisticated environment [5]. Whereas Roussos uses Item-level deployment of RFID technology which would allow for quick checkout aisles that scan all products at once and thus eliminate queues. The carts could potentially include on board computers that recognize products placed inside and that display information and promotions retrieved wirelessly from the system back end. A simple extension of this system would be to embed RFID devices in consumers' loyalty or frequent-shopper cards to identify individuals [6].

Weigelt et. al. in their article discusses some of the automatic identification (auto-id) technologies that include printed ID codes, 1D/2D bar codes, RFID, magnetic stripe and smart card (chip) to label various products [7].

In relation to the method of controlling multiple RFID readers where multiple readers recognize the RFID tag to reduce collisions and interferences of frequency between RFID readers, the multiple RFID reader control method proposed by Sun-Youbet. al. in "A Study on Control Method to Reduce Collisions and Interferences between Multiple RFID Readers and RFID Tag" is composed of several steps which are repeated to recognize all RFID tags [8]. Also "Mobile

RFID reader-initiated LLRP connection management” is another project which involves the communication between RFID reader and client[9].

### 2) Use of other technologies in shopping cart

The commercialized Kinect sensor employs to detect the gestures of the human body. The mobile shopping cart equipped with Kinect could execute different gesture commands which reshape the shopping cart as a mobile robot[10]. Whereas Unsanget. al. automatically detects shopping carts and verify their emptiness at the checkout station. It uses motion segmentation, line detection, a template matching methods for the cart detection and emptiness verification. All detected carts are compared with empty cart models and the dissimilarity scores are calculated to verify the emptiness [11].

According to Nishimura et. al.the driving module and the sensor module are developed for development of a shopping cart robot. The outdoor running of the robot is attained by reforming a drive mechanism. This sensor has stereo camera and is used for person following system [12].

### 3) Use of Indoor Navigation

In order to navigate the customers within the store the researchers Zhongminet. al.uses an anchor-free localization algorithm for large scale shopping cart proposes. Specifically, by introducing the procedure of Fast Map Algorithm, a fast mapping from pair wise proximity matrix between shopping carts to corresponding coordinates implement [13]. The “Supermarket customer routes-and-times identifier” system monitors the route taken by customers inside the store using the technology of Radio Frequency Identification (RFID). This technology is used to identify the shopping carts as they move around the store. Customer route information is sent to a central computer wirelessly so it can be processed, stored, and displayed on a screen. The system also processes and stores the time taken by a customer while following his/her path through the store [14]. Other than the above mentioned, there are many relevant projects such as the one done by Kundra and Ekler[15].

### 4) Use of Wi-Fi for Data Communication

The Project “Design of an ARM-based power meter having WI-FI wireless communication module” uses an AMR system scheme using Wi-Fi technology and an ARM-Based PMWCM (Power Meter with Wi-Fi Communication Module) scheme. The paper also proposes the functions of wireless communication module and design detail and discusses the security of the communications [16].

Kjaergaardet. al. addresses the joint identification of the movement indoors of multiple persons forming a cohesive whole - specifically flocks - with clustering approaches operating on three different feature sets

derived from Wi-Fi signals which are comparatively analyzed [17].

### 5) Use of Arduino Hardware

Arizagaet. al. introduced an automated control system for the sterilization process of biological material. This System is based on Arduino Board. Arduino allows fast prototype development and the microcontroller is programmed on C++ making development and tests not a difficult part of overall work[18].

### 6) Use of Data Prediction

The authors of the paper “Predicting Missing Items in Shopping Carts” expedite the search for frequently co-occurring groups of items in shopping cart type of transactions; less attention has been paid to methods that exploit these frequent item set for prediction purposes. Uses partial information about the contents of a shopping cart for the prediction of what else the customer is likely to buy[19].

## III. METHODOLOGY

Prototype Methodology will be used for the development of QB. The prototyping methodology performs the analysis, design, and implementation phases concurrently, and all three phases are performed repeatedly in a cycle until the system is completed.

### A. Planning

The planning phase is the most critical and important step, here the team identified why QB should be built and determined how the project team should get on with development. The basic functionalities that are expected from QB were also clearly defined. Where the major are:

- Automatic Billing.
- Eliminate traditional billing process.
- Indoor Navigation Guide.
- Business forecasting methodology.

Feasibility analysis helped to identify the risks associated with the project and determined whether to proceed with the project.

### B. Requirement Gathering

In order to address the research question a survey was carried out among a variety of people who belong to both genders and different age groups in Sri Lanka. The primary method for gathering data was by the online questionnaire which consisted of around 10-12 questions where most questions were close-ended while only 1 or 2 being open ended. Furthermore, the authors used external journals, research papers and case studies to gain secondary data.

The assumptions such as the sample used, were clearly used to represent the population in Sri Lanka, the respondents having given truthful information without any hesitation, no invisible intervention for the respondents in providing trustworthy facts were

used to support the research in order to get more precise results.

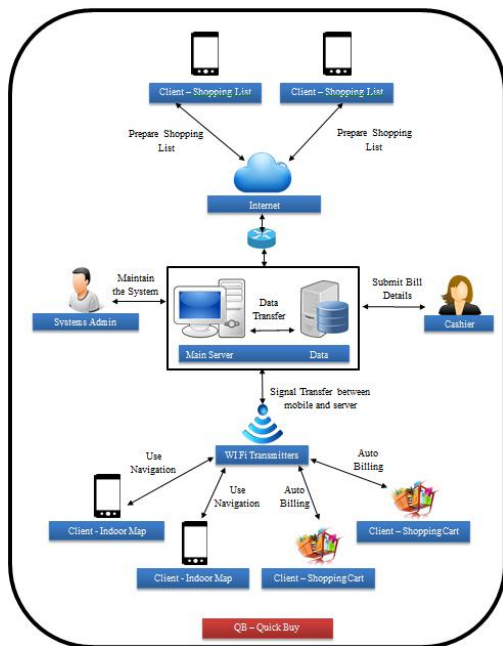
**C. Analysis**

The analysis phase answers the questions of who will use the system, what the system will do, and where and when, how it will be used.

In problem analysis stage the current process was identified, how they operate, strengths, weaknesses and came up with a solution that is the QB system. In the Data modelling stage the data model will be compromised with the data types, attributes, relationships between data. This system has used advanced techniques as it's expected to transfer navigation information. In this special techniques are used to retrieve fast and securely from the data stores.

**D. Design**

The primary goal of the design phase is to create a design that satisfies the agreed application requirements. The input, output, storage, processing, recovery and backup requirements were identified. As the QB system comprises of 3 major components the developers' had to design the connectivity and integration of each and every component. To simply and easily understand the overall QB system the software architecture diagram is illustrated in figure 1.0 below:



**Fig 1.0 – Diagram of the Complete System**

**E. Implementation**

Implementation is the final stage here what the project team did was the transformation of the design output into programs that are executable.

Construction – The hardware and software components required to solve the research problem such as the cart with micro-controller, RFID readers was developed in parallel with software components for the mobile application and data transfer services.

Programming language MicroC, C, Android, and Java were used for programming. Microsoft SQL Server was used for database development.

**F. Testing**

Once developed, testing was done systematically and the results were documented. Unit tests were carried out to ensure that the module or program performed its function as defined and integration tests were carried out to assess whether the set of modules or programs that must work together did so without error. Acceptance test was performed in order to make sure the system is complete and meets the need.

**IV. RESULTS AND DISCUSSION**

This section covers the results that were achieved from the research project and the new approaches found to be addressed further in the undergraduate context. The principal implications of the findings, regardless of statistical significance of this research are discussed below. Identifying the limitations and weaknesses of this research can be beneficial for future researchers. During the development of the research the following problems were faced:

- Accuracy for indoor mapping was low.
- When the mobile device is offline products could not be loaded in to the List.
- Passing the whole bill of a transaction to the cashier PC.

The team used the following techniques to solve the above mentioned issues in order to complete the system in a fool proof manner. For better accuracy the team developed our own algorithm for indoor mapping instead of using the Google map API. The use of cached data base for storing data when the device is in offline mode and the use of Ethernet or Wi-Fi and PHP web services for connectivity between Arduino and Database.

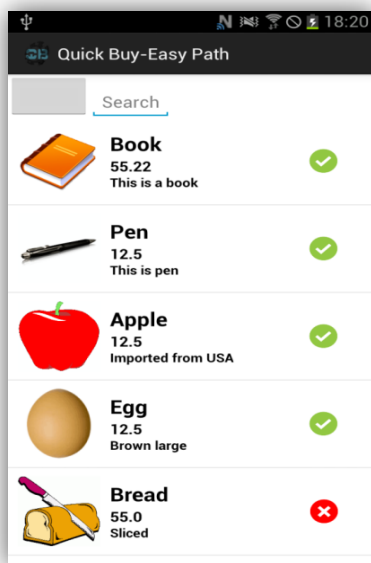
In order to ensure a high reliability to the system Powerful open source tools were used such as Android, Arduino, MySQL database, PHP, JAVA. The use of sound alerts at the shopping cart to alert the customer in order to avoid confusions and to make the steps of the shopping experience easy were used. Providing suggestions to customers through data mining using the open source tool WEKA is implemented to make the experience easy. Caching is used in the mobile device with SQLite to avoid loss of data when offline. Use of RFID identification for every product in order to avoid theft, secure Wi-Fi connectivity for data transaction between server, cashier PC and other devices and also Password oriented login for cashier PC are methods used to ensure maximum security.

Figure 2.0 shows how when a customer adds a product tagged with RFID to the cart, it automatically calculates the bill and displays on-the-go to the customer.



**Fig 2.0 – Display in Cart**

A customer using the shopping list application can use the following interface illustrated in figure 3.0 to add products to the list. The product suggestion happens here by analysing the combination of products the user adds to the list and accordingly the suggestions will be shown.



**Fig: 3.0 Product List View**

Once the products are added to the list the app will point out the rack position of the products added in the list as placed within the store and at the same time the current position of the user within the premise will also be shown in a small dot as shown in the figure 4.0 below. Racks with the products which have been selected will be in a different colour whereas the rest would be greyed out.



**Fig 4.0 – Indoor Map with selected racks and user position**

When designing the QB – (Quick Buy) system there were some assumptions observed. Such as that all the customers have the basic knowledge of using smart

phone in order to use the Mobile app in the QB system, only one administrator can make changes to the system at a time. Also the automated mobile application will be developed only for a particular floor of a shopping complex, the wireless connection between the device and the main controlling-server should not be lost, shopping floor changes will not take place while customers are inside the shopping complex and also that the servers have sufficient processing power to serve all the customers.

Among the various levels of testing the final System has been tested in the Unit level, integration and system test levels and proved to be error free under the constraints mentioned. Under the testing that was done the QB-(Quick buy)system has a 95% level of accuracy when the data provided in the Database are accurate and reliable. Also the level of reliability were found to be around 80% when the Wi-Fi strength and battery power of the RFID reader as well as the mobile device are taken into consideration.

The following section explains how the algorithms and functions work in the QB system. The MapActivity of the shopping list application has the layout of the Supermarket, receives Wi-Fi scan results on start and receives shopping cart information from the shopping cart class and update the view with highlighting the racks.

The MapView Handles all the on touch listeners of the Map Activity, records the points touched by the user. While the MapViewActivity receives the Wi-Fi scan results from the MapActivity, reads the Wi Fi finger print data previously stored in the mobile databaseand gets the closest match and stored finger prints.

The QBWifiFingerPrint method is used to compare and get the closest match of the Wi-Fi scan results and users position. It compares distance using the Euclidean distance.WiFiPointView method highlight's the user's position, a blue circular dot when the map is in active mode and red circular dot when in editing mode.The MapEditActivity is used to record the locations of the floor to the device. Currently the results are stored to the internal SQLITE DB itself, but with the implementation of fixed routers the results could be stored in cloud.QBIndoorLocator method works as an interface for the SQLITE DB. While QBFingerPrintDatabaseController is the SQLITE DB which contains 2 tables.

When we consider the Shopping Cart of QB the following activities are handled,the RFID reader is programmed to read the product id and send it to the DB through Wi-Fi which in return sends the unit price which is displayed in the LED display of the cart. With the information the Arduino board is programmed to calculate and display the total bill. Once at the cashier point the button click event will send the final bill to casier pc. If changes are required the bill can be customized in the cashier pc and printed.

## V. CONCLUSION

There is no doubt Sri Lanka as well as many of the South Asian countries are still developing countries regarding automation. By developing “QB – (Quick Buy)” the research team hope to automate the billing process of retail stores and provide the customers with an efficient and hassle free shopping environment. As products are added to the cart, the system will calculate the total bill and display it to the user on-the-go so that the customer will not have to face the hassle of waiting in queue till the cashier scans the products and bills it. At the same time the customers who are unfamiliar with the location of the products placed within the premises can use the mobile application to navigate themselves to the desired product. Finally we aim to fulfill all the objectives of this system and hope our research would be of benefit on a global level. We hope that this study will be helpful for other researchers who are interested in automated systems and navigating systems and will develop similar models or to develop the same device further and use this concept with other hi-tech automation projects.

During the development of the project the following limitations and constraints were figured out. Customers should be using smart phones with adequate processing power, security of the data should be taken into consideration as the database holds personal and sensitive data, response time for the map to show navigation path of items on the shopping floor should take no longer than five seconds, small items cannot track using RFID tags. The system should be able to Facilitate and cater to multiple client requests and once products are added to the cart removing them must be done one by one because of the RFID reader tracking speed.

Sri Lanka as well as the South Asian countries are now showing rapid development in the IT industry, with these developments everyday activities are getting automated. It makes people depend on technology instead of other people. In this current trend our project “QB - (Quick Buy)” would be a great step in automating the shopping environment. QB can be expanded in the future to provide the following features:

- Eliminate the Cashier human and provide the feature to pay by themselves using a bank card.
- Digitalize the tags (name, price) so it would be updateable anytime from anywhere.
- Reach nearby people through mobile phone and give promotions and advertisements.

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