RFID-Based Cashless Payment System

Mohammad Farid Saaid, Muhammad Naim Handani

***Abstract*— Nowadays, most of the supermarkets or retail organizations use the old-fashioned or conventional data management and payment system. This current technology would affect the productivity and face the consequences of this lacking technology. Thus, some weaknesses such as data losses, longer waiting time and many more will get involved in this matter. Therefore, it is very crucial to propose a new intelligent system with real-time and overcomes the limitations of the conventional management system. Radio Frequency Identification (RFID) technology is the most leading and suitable to be proposed to overcome this limitation because it is wireless technology, which using radio frequency as its method of data transmission. Other than that, the Barcode technology will be used as the way of tracking the product since a barcode system is the cheapest way, and it has still been using widely in a retail management system. Based on the study conducted, an RFID-based Cash less invented to help the customer to make payment without involving any cash but using RFID tag that contains electronically cash yet it can increase the smoothness while making payment. This system is developed with Graphical User Interface (GUI) as user interfaces on the monitor to print out and present the retrieved data information from a database that developed with Microsoft Access, buzzer as the sound indicator to show that the tag already scanned and green and red LED as the light indicator to show the products are ready to be scanned. During the development stage, the hardware, middleware and programming integrated together for a complete system. After that, some experimental test is conducted on investigate the system capabilities such as detection capabilities towards materials and the effect of tag position on tag detection distance. In a nutshell, this cash fewer payment systems helped the customers to make payment in a shorter period instead of the conventional method.**

***Index Terms*— RFID, Arduino, Retail System, Barcode recognition, Item Identification, Wireless, Barcode Scanner**

I. Introduction

IN RECENT YEARS, many retail markets used manual payment system where payment using cash and card. This conventional payment method was not automated to yet have many disadvantages. Some of those disadvantages are tiredness might easily lead to human error for incorrect information such as miscount quantity item, wrong calculate the price and many more. They also tracked their stock manually as there is no adoption of technology on how to track their inventory. There was a higher percentage to miscalculate the number of stock and the incoming order. Thus, some technology needs to be implemented to solve this encountered problem and limitations.

The past few years have witnessed an explosion of interest in radio-frequency identification and supporting technology due to their rapidly expanding used in product tracking and access of a certain area. Radio Frequency Identifications (RFID) is a new technology that invented to make many manual jobs becomes automated. RFID has been widely used in many applications such as a student's attendance system, automatic toll collection, building access control system, animals and goods tracking, warehousing and manufacturing [1-3]. This RFID technology can improve the operating efficiently and reduce the economic losses since it used non-contact to others to operate [4]. Moreover, this technology used tag that does not require any battery and powered by radio frequency signal. The shelf life of tag on the product can be longer [5,6].

Barcode system is a system of labeling with spaces, and bars printed side by side on the product or object [7]. The barcode is widely used because they offer high reliability and a low-cost solution to automatic recognition of product [8]. The information is encoded in the width of the bar-space sequence in the barcode system. Basically, the barcode were provided by the manufacturer or the supermarket themselves. The scanning process consisted in the transitions between spaces and bars (digitalization) and the interpretation of the width sequence (decoding) through the barcode scanner [9].

Barcode is the cheapest and practical in a stock inventory system. Most of the retail shops in Malaysia adopted barcode technology for their stock management system because the barcode image just plainly printed on the product. For this project, 1-dimensional barcode can simply be used since a barcode scanner only can read this type of barcode image.

The application of This system also included a barcode system to scan a product code and interfaced with RFID technology that made a transaction without involvement of any cash flow during payment process.The development of this project was tested as a prototype system for further recommendations.

II. Research Review

Nowadays, RFID-based system is widely used for many applications and has high demand due to its method of

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transmission that using radio signals. Zeydin Pala and Nihat Inanc studied the smart parking application using RFID technology. Their studies show that the RFID technology can increase the efficiency and provide advantages on both company and client-wise because RFID is one of the most basic technologies that can enable something through wireless data transmission yet does not require any direct contact [10]. Due to these advantages of RFID technology, the system that unmanned and fast operating can be created. Based on this information, we know that if RFID technology implemented in the system, it can increase the sale efficiencies and reduce the untracked items.

Shinya Miyazaki, Takashi Washio and Katsutoshi Yada study the analysis of residence time in shopping at supermarket using RFID [11]. They study on the behavior of customers during their residence time in shopping in each sales floor zone. By applying RFID technology, customers can be detected using RFID tag and can see on how often the customer at a certain floor zone. This shows that the RFID can detect the presence of the tagged object without even making any contact with the reader and good in the real time event. This information can be an advantage for the system since we require a real time control that also practical and can easily manage.

A study has been made by a group of students from Sweden. They studied about the RFID technology to be implemented in boarding and debarkation of personnel by controlling the check in and checkout procedures in vessels. They stated that the RFID technology was better than barcode because RFID reader will detect any tagged object while the printed barcode has a high potential to have misread detection [12]. The security and privacy of the personnel can be assured by scanning the tagged card that contained personnel's information. In our project, the tagged card that contains personnel's information has been implemented.

One of the barcode applications is supply chain traceability system that has been studied by Shuyi Qiao, Zhiqiang Wei and Yongquan Yang [13]. They studied that barcode technology can be implemented in order to trace the supply chain for food safety in vegetable industry instead of using RFID technology. This show that barcode technology is relevant and can be used for tracking an item and identification of stocks. In our project, each item has been labeled with barcode image that contains the product's information. To track the information about the product, barcode scanner used to read the label.

III. System Overview

This project is designed in small and compact size but does not portable since it will be allocated at a cashier's counter. Figure 1 shows the block diagram of the system. This project was a integration of two different technology with a same concept of data transmission. In addition, this project also implemented a buzzer as a sound indicator to determine the tag was already scanned and red and green LEDs as a light indicator to show the tags were ready to be scanned. Graphical User Interface (GUI) is implemented as for user interface in the monitor that retrieved and print out the data information that had been stored in the database, once the tag scanned by the RFID reader or the barcode image has been scanned by the Barcode Scanner. The database was an offline-type database where it does not require any internet connection to transfer the data information to the user.

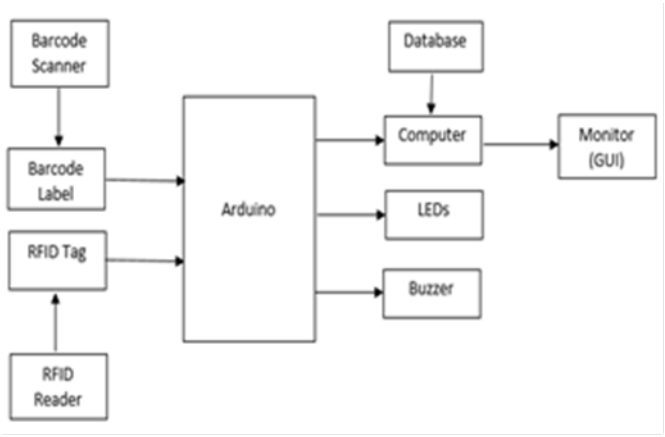

Fig. 1.The RFID-Based Cashless Payment System Block Diagram

This system used a micro-controller that acts as a brain for the whole operation that executes the instruction from the programming created by the user. The user created the programming that controlled the output based on the scanned tag to retrieved the information and to controlled the sound of buzzer and the light of the LEDs. The programming used to show the output once the RFID reader read the tag, and the Barcode Scanner scans the barcode.

After that, the user needs to bring the tag to be scanned by the reader as shown in Figure 2. Once the reader already detected the electromagnetic wave that sends by the build-in antenna in the tag, the detail's information will be compared with the database. The user interface will print out the information based on the unique number of the tag that stored in the database. The database was differentiating by the unique number of the tag. The Barcode Scanner used to scan the barcode image to retrieve the information that contains in that image. The barcode image is the printed series of parallel bars or lines of varying width that contains the unique numbers. Once the image already scanned, the unique number will be compared with the database. If the unique number is true, the information that stored in the database can be retrieved.

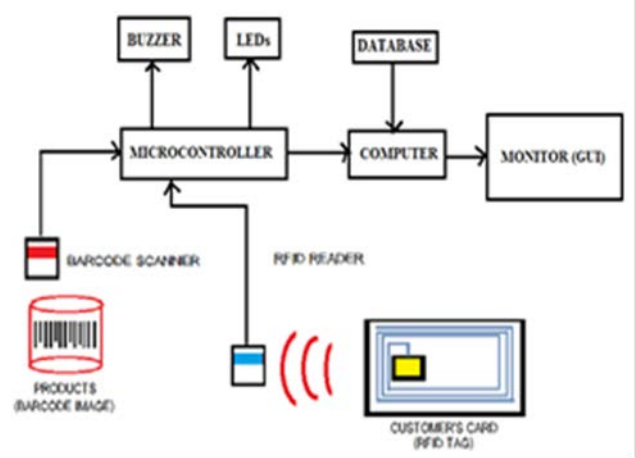

Fig. 2.Internal architecture of this project

In this project consist of several hardware to interfaced with a programming. The main hardware or component were arduino micro-controller, RFID reader, tag and barcode scanner.

The Graphical User Interface (GUI) is a type of interface that allows the user to interact with electronic devices through graphical icons and visual indicator. GUI was developed to act as Application Programming Interface (API) of the communication between RFID system and computer [5]. This middleware created to make customer feel more convenient and easier to access because it was user-friendly. For this project, some user interfaces have been developed such as for owner's card identification and for displaying the product's information.

Fig. 3.Example of user information display

Figure 3 shows a form for the user to wave their card to retrieve the stored information. The port and baud rate need to be initialized first before scanning process. Once the RFID card scanned, the card's unique number retrieved and all the information appear as a reference.

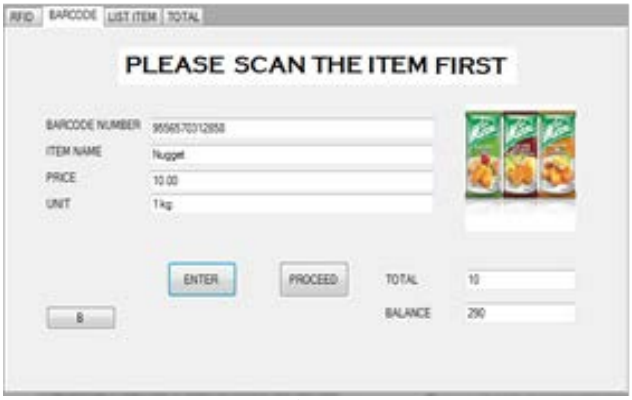

Fig. 4.Example of item scanned display

Figure 4 shows a form for the user to know about the item information. The item was scanned and then the barcode number retrieved at the top textbox. Then, all information such as item name, price, unit and image appeared display window. The card's available balance were deducted based on the total price of the item. A total scanned items was recorded and displayed as shown as in Fgure 5.

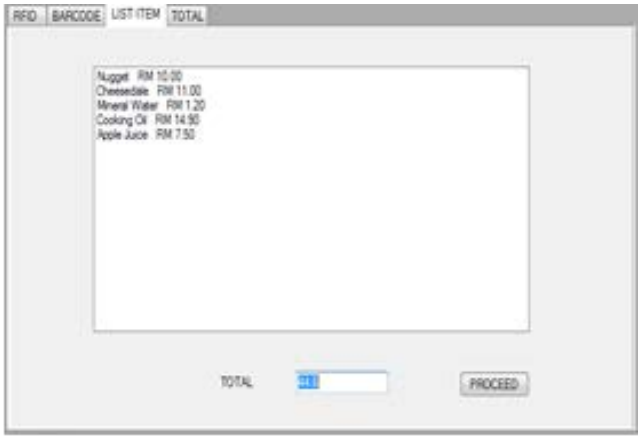

Fig. 5.Example of item scanned display

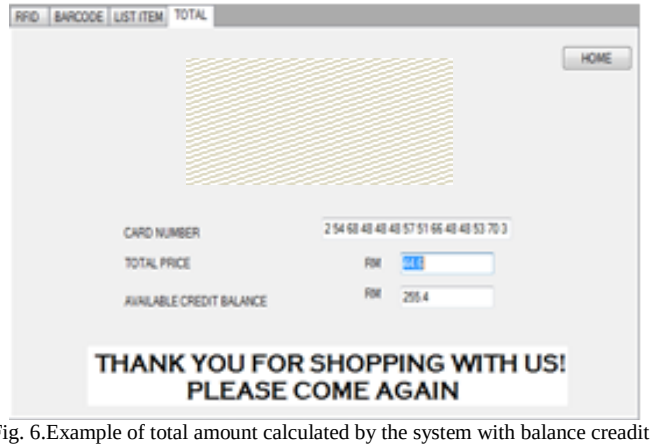

Fig. 6.Example of total amount calculated by the system with balance creadit of a card

Figure 6 show the last window for each transactions. This window was displayed the informatin for the transaction which were card number, total price for the transaction and card's available balance.

IV. Experimental Test

In order to produce a standard electronic device, some experimental test conducted to analyze the specifications of this system. The test focused on a system capabilities, response and precision during the development stage. After obtained the result, a conclusion and discussion derived that elaborated the performance of the hardware and software of the system. The collection of data can be used for future development and improvement.

A. The effect of material types on RFID reader and Barcode scanner detection

This experiment conducted to investigate the RFID reader and barcode scanner detection when tested in different type of materials. To test the capabilities of RFID reader and barcode scanner, the materials that had been tested were paper, colored plastic, metal, transparent Perspex, copper and transparent plastic. The materials were placed on the reader and barcode label in order to test either the materials are able to block the detection from RFID reader and barcode scanner or not. 10 trials have been done for each materials in order to obtain the mean distance. The data of mean detection distance were collected.

TABLE I
THE RFID READER DETECTION VARIED BY SURFACE MATERIALS

Materials	Distance (cm)			
	RFID		Barcode	
	Detect?	Mean	Detect?	Mean
Paper	Yes	5.7	No	-
Coloured Plastic	Yes	5.8	No	-
Metal	No	-	No	-
Transparent Perspex	Yes	4.4	Yes	28.0
Without Cover	Yes	5.8	Yes	30.0
Copper	Yes	3.5	No	-
Transparent Plastic	Yes	5.8	Yes	29.6

The data collection was tabulated in Table 1. This table shows the result for RFID reader and barcode scanner readings and the mean distance after done all the 10 trials. For RFID detection, materials that response to radio frequency signal that send back from the tag are paper, colored plastic, transparent Perspex, copper and transparent plastic while metal did not give any response. These shows that the radio signal cannot passed through metal because that radio signal reflected back to the reader and did not communicate with tag. The best response yet the farther for the detection is without having any cover. For this project, plastic has been used as the reader cover because its reading is approximately same like without using any cover. On the other hand, for the barcode scanner detection, only transparent Perspex and transparent plastic can successfully read the barcode label while the others materials failed to read. This was because the lasers from barcode scanner manage to receive the reflected rays from the label. Therefore, only those two materials that allows the laser to pass through it. Figure 7 shows the lines graph for the data collection in Table I.

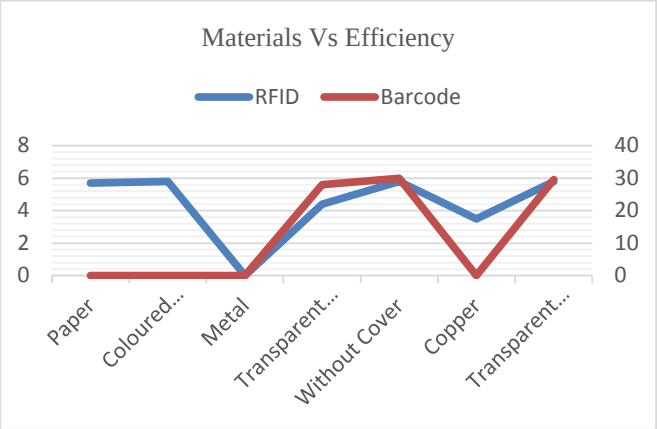

Fig. 7.Material vs efficiency for RFID reader and barcode scanner

B. The effect of tag position on tag detection distance

This experiment conducted to study the effect of tag position on tag detection distance. The positions of reader are varied in some different angle from 0 degree until 180°. Figure 8 shows 3 different region which is blue, red and green. Blue to green region shows the distance between tags to the reader which are 2cm, 4cm and 6cm. The reader was placed on a piece of paper and oriented in the middle point. 10 readings from each angle to determine the mean detection range.

Table II shows a few angles of rotational degree that provides the best mean detection range. Based on Table 2, the best angle that can be detected at the maximum distance is 90°. This perpendicular angle allowed the reader to transmit farther the signal because the signal transmission is an oval-shaped. At angle 45° and 135°, the mean detection range are only at 2.1cm and 2.3cm while at angle 0° and 180°, the reader unable to detect the tag. The best scanning method that highly-recommended to a user was by ensured the tag in parallel position of the reader.

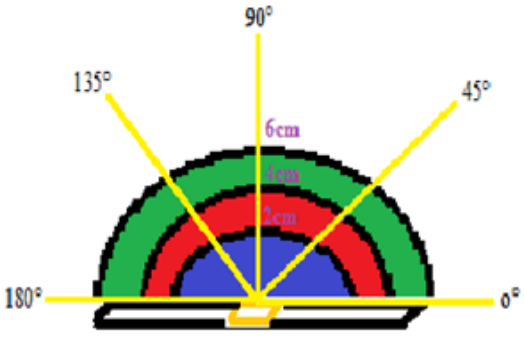

Fig.8. Tag orientation position

TABLE II
THE VARIATION OF ROTATIONAL DEGREE AFFECT THE MEAN DETECTION RANGE

Rotational Degree (°)	Mean Detection Range (cm)
0	0.0
45	2.1
90	5.8
135	2.3
180	0.0

V. CONCLUSION

After this research and project has been finished and completed, all objectives meet the requirement. This system is able to function for tag identification and item tracking system as planned. The RFID enable the data information to be transferred for tag identification purpose during data tracking process. The development and installation of this system help the user to make payment without involving any cash yet increasing the smoothness while making payment. In the other hand, payment system become more efficient and customers feel more comfortable and convenient.

Based on the experimental test, the reader able to identify the electromagnetic signal from the antenna of the tag at maximum distance which is 5.8cm when oriented in parallel position and without any cover between them. In the other hand, the barcode scanner able to scan the label in maximum distance which is 30cm through the transparent materials likes Perspex and plastic.

For recommendations, this system can be improved by build it in portable and compact size. Some battery can be included as power source in order to create a portable device. Moreover, low frequency RFID reader can be replace with a high frequency RFID which has a long range detection range. Barcode label can be replace with RFID technology in order to make the system more efficient and reliable.

REFERENCES

[1] G. Roussus, "Enabling RFID in Retail", in Computer, vol. 39, no. 3 pp. 25 – 30, 2006

[2] Hassan, Mayadah , Ali, Maged , Aktas and Emel "Radio Frequency Identification (RFID) Technologies for Locating Warehouse Conceptual: A Conceptual Framework", in Smart Objects, Systems and Technologies (SmartSysTech), Proceedings of 2012 European Conference, pp. 1–20, 2012

[3] M. S. Umar, J. A. Ansari and M. Q. Rafiq, "Automated Retail Store Based on RFID" in Communication Systems and Network Technologies (CSNT), 2013 International Conference, pp. 17-21, 2013

[4] Lee, Hyangjin and Jeeyeon Kim "Privacy threats and issues in mobile RFID", in Availability, Reliability and Security, 2006. ARES 2006. The First International Conference, 2006

[5] M. F. M. Busu, I. Ismail, M. F. Saaid and S. M. Norzeli, "Auto-checkout system for retails using Radio Frequency Identification (RFID) technology", in Control and System Graduate Research Colloquium (ICSGRC), 2011 IEEE, pp. 193-196, 2011

[6] M. F. Saaid, and M.N. Hanbali, "A Development of Portable Voice Based Device (PVBD) for Stock Identifications", 9th IEEE International Colloquium on Signal Processing & Its Applications, (CSPA 2013) 13 IEEE, pp. 193-196, 2011

[7] Sun Hong-Ying "The Application of Barcode Technology in Logistics and Warehouse Management", in Education Technology and Computer Science, 2009. ETCS '09. First International Workshop, vol. 3, pp. 732–735, 2009

[8] R. Zocca, F. D'Ercoli, and D. Vincenzi, "A Statistical Tools for Barcode misread analysis", in Automatic Identification Advanced Technologies, 2007 IEEE Workshop, pp.156–160, 2007

[9] T. Sriram, K. Vishwanatha Rao, S. Biswas and B. Ahmed, " Applications of barcode technology in automated storage and retrieval systems", in Industrial Electronics, Control, and Instrumentation, 1996., Proceedings of the 1996 IEEE IECON 22nd International Conference, pp. 641-646, 1996

[10] Z. Pala, and N. Inanc, "Smart Parking Application using RFID Technology", in RFID Eurasia, 2007 1st Annual, pp. 1-3, 2007

[11] S. Miyazaki, T. Washio and K. Yada, "Analysis of Residence Time in Shopping using RFID Data", in Data Mining Workshops (ICDMW), 2011 IEEE 11th International Conference, pp. 1170-1176, 2011

[12] K. Papadimitriou, D. Pnevmatikatos, A. Dollas, C. Koulamas, S. Aggelidakis, P. Chatzidakis, L. Vasilikiotis and M. Emmanouilidou, "Developing RFID-based Systems for Security in Marine Transportation", in Informatics (PCI), 2012 16th Panhellenic Conference, pp. 50–55, 2012

[13] Shuyi Qiao, Zhiqiang Wei and Yongquan Yang "Research on Vegetable Supply Chain Traceability Model Based on Two-Dimensional Barcode", in Computational Intelligence and Design (ISCID), 2013 Sixth International Symposium, pp. 317-320, 2013

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