Internet of Things (IoT) Based Smart Shop (S-SHOP) System with RFID Technique

Samihah Abdullah[1*], Amerrudin Daud[1], Nor Shahanim Mohamad Hadis[1], Shabinar Abd Hamid[1], Solahuddin Yusuf Fadhlullah[2], Nor Salwa Damanhuri[1]

[1] Faculty of Electrical Engineering, Universiti Teknologi Mara Cawangan Permatang Pauh, MALAYSIA.
[2] School of Engineering and Technology, INTI International College Penang, MALAYSIA.

*samihah.abdullah@uitm.edu.my

Abstract. Billing system technology in the market nowadays is less efficient in parallel with revolution of technology. Conventional method widely uses a barcode scanner that has disadvantages as it is a manual system and requires man power. Besides that, the conventional method does not store the information such as warranty of the product and the information of a buyer. Using the smart shop billing system using Radio Frequency Identification (RFID) reader and RFID tag, the system will become more efficient and automated. The system consists of two main elements which are passive RFID tag (125 kHz) and RFID reader (ID-20LA) that has similar function with a barcode tag and a barcode scanner. For the hardware components, the Espresso Lite V2.0 acts as a microcontroller and UC00C acts as Universal Asynchronous Receiver/Transmitter (UART) converter and Arduino IDE is used as a platform to link between hardware and software. The system is completed with the Internet of Things (IoT) technique to make sure the system can be operated wirelessly. As a result, all the information from the reader will be sent to Google spreadsheet as a cloud to store the information about the item to generate GUI bill. In conclusion this proposed system also uses a real time tracking.

1. Introduction

RFID stands for radio frequency identification that uses radio wave frequency to capture and store the information from the RFID tag that has been attached to the microcontroller [1]. The tag must pass through to the RFID reader to get reading by the reader. RFID is divided into two main components which are RFID reader and RFID tag. There are many types of RFID reader produced by many companies in the market in terms of readability strength of the reader and tag that is influenced by the distance and types of tags. The RFID is the technology that has been widely used in different fields such as education, business, industrial area and system management.

Figure 1 shows an architecture of RFID. Basic RFID consists of RFID reader and tag. RFID reader communicates with the RFID tag to gather the information from the RFID tag which is important to track individual object or the animal tag. The RFID readers are powered by the antenna to generate the radio frequency field [2]. In the market, there are many types of reader based on their application. Choosing a suitable reader is very important to make sure the system is efficient. RFID tagging is an ID system that uses small RFID system for tracking and identification [3]. In the tag, it consists of an antenna and an integrated circuit to operate the tag. The tag is chosen based on the selected

application. In the market, there are also different types of RFID tags which are active and passive RFID tag.

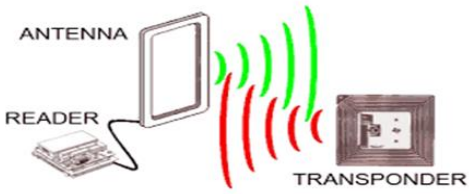

Figure 1. Architecture of RFID [1].

Active RFID tag: Active RFID tag has its own internal power source. It means the integrated circuit is built inside the tag and it uses a power to send the signal to the reader which means that the antenna does not require any external power source to generate the signal [4]. Passive RFID tag: Passive RFID tag does not have its own internal source supply to operate the tag. The tag is powered by the electromagnetic energy transmitted from an RFID reader. In the passive tag, there are two components which are the antenna of the tag and the microchip or integrated circuit (IC). The life time of passive RFID tag is longer than the active RFID tag [5]. Passive RFID tag does not only operate in one frequency. There are three main frequencies for RFID frequencies which are 125 kHz, 13.56 MHz and 865 MHz. All these frequencies have their own functions and suitable application. Table 1 shows the comparison of these three main frequencies that are operated by the passive RFID tag.

Table 1. Comparison of Three Main RFID Frequencies.

	Low Frequency (LF)	High Frequency (HF)	Ultra High Frequency (UHF)
Frequency	125 to 134 kHz	13.56 MHz	865 to 960 MHz
Range	1 cm to 10 cm	10 cm to 1 meter	5 to 6 meter
Application	Animal Tracking	Data Transmission	Laundry management

Todays' technology is growing so fast especially for a developed country. All people want all things to become easier and faster. The IoT is one of the networks that has been used for physical device, health, services, business, vehicles, safety and other items embedded with software, electronics, actuators, sensors and network connectivity to enable these objects to collect and exchange data. Using the Internet, the object can be sensed or controlled remotely because the IoT is created to improve efficiency, reduce human intervention and increase accuracy [6]. By using the IoT technique, the user can monitor the system from another place, and it does not need a direct contact with the system. Nowadays, RFID is employed in many applications because of the efficiency of the system and new technology. In addition, the RFID has always become an option because of its low power consumption, and it is easy to use or handle. For example, RFID has been employed as a school attendance system. The project replaces the function of manual attendance system which the student needs to sign in everyday whenever they reach their class. The system uses an ultra-high frequency RFID card to make sure the reader reads the tag when the student bypasses the reader [7]. This project also is also one of the 'Go Green' projects because it is paperless. Another example, smart shopping cart also uses RFID as its main component. The RFID reader is attached to the trolley with the other features like LCD screen, Ir sensor and Zigbee as its transmitter. Every item that is put in the trolley will be scanned by the RFID reader and the price of the item and total sum of the items will be displayed on the LCD screen [8]. The customer then knows how much is the total value of the item that has been taken by the customer and monitors the amount of expenses.

2. Methodology

Figure 2 illustrates the block diagram of the S-SHOP system. This project is based on RFID technology that is used to make the shop management system to become more efficient and effective. The system will be applied to the shop laptop because it is more practical and suitable. The system employs Espresso Lite V2.0 and UC00C as a UART converter model for the project microcontroller. Espresso functions as a memory to store the information that is displayed using graphic user interface (GUI) and all the source codes so that the system is able to function.

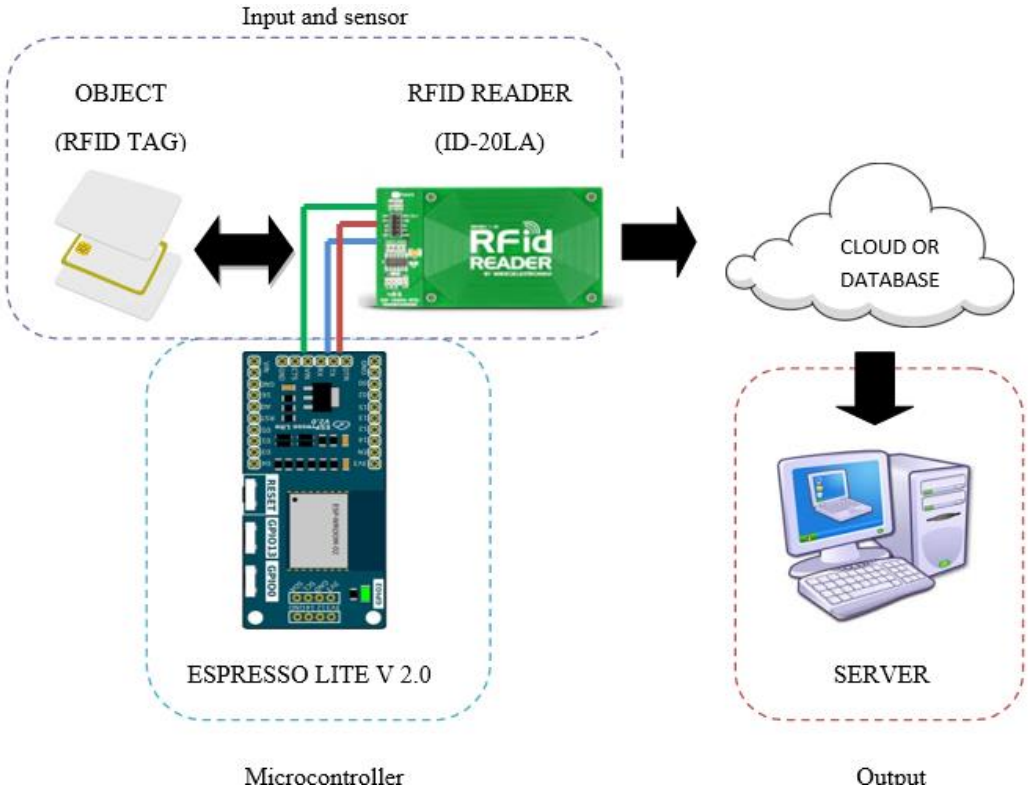

Figure 2. Block Diagram of the Project.

This research project employs RFID ID-20LA that functions like a scanner for the system. The reader is used to gather the information from RFID tag to compare the data in microcontroller memory. It traces the price and information of the laptop and all shopping items. All laptops and the items in the shop must be attached with RFID tag that can be easily read by the RFID reader. The data in the tag will be sent and stored in the system cloud or database. The tag will declare the information of the items like the name of date, tag ID, item, warranty, price, name of user and the other features that to increase the security of the system. If the user wants to recheck to the seller, it will be easier, effective and there will be no cheating in management system since the tag contains the information of the user and the system is connected to the database for the reference. The system allows for fast and easy billing procedure. Lastly, the total price of the products will be summed up to generate final bill for the customer. A monitor is provided to display all the information obtained from the reader. The system then stores all these bills generated in its database in its Google spreadsheet for further reference. The system provides specific reports of sales along the day, month or year and whenever required by the manager. The system also provides the balance of inventory to make the management system to become more effective.

2.1. Flowchart of System Operation

Figure 3. shows the flowchart of the system operation. The system starts when the system is turned 'On' or connected to power supply. RFID reader waits until there is an existence of RFID tag that is attached on the item bypasses the reader. If RFID reader detects the RFID tag, the tag will then transmit the tag ID string to the RFID reader. Microcontroller will compare the string from a microcontroller memory.

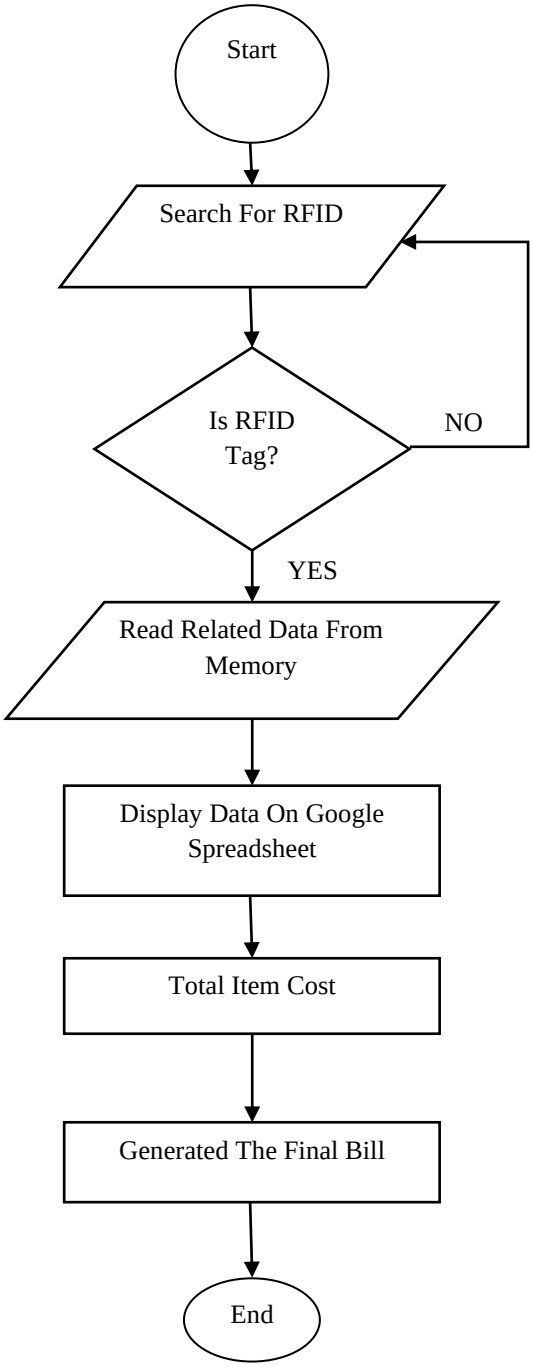

Figure 3. Flowchart of System Operation.

Next, if the string from the tag matches with the string that is stored in the microcontroller memory, the data will be sent and displayed in Google spreadsheet. This data will be displayed on computer monitor. The RFID reader will continue waiting for the next RFID tag to be scanned by the user. If the user does not scan the tag, the total of all items will be summed up and the final bill will be generated. The data is finally saved in Google spreadsheet and it can be monitored by the manager anywhere. Figure 4 shows the flowchart of the main coding of the system.

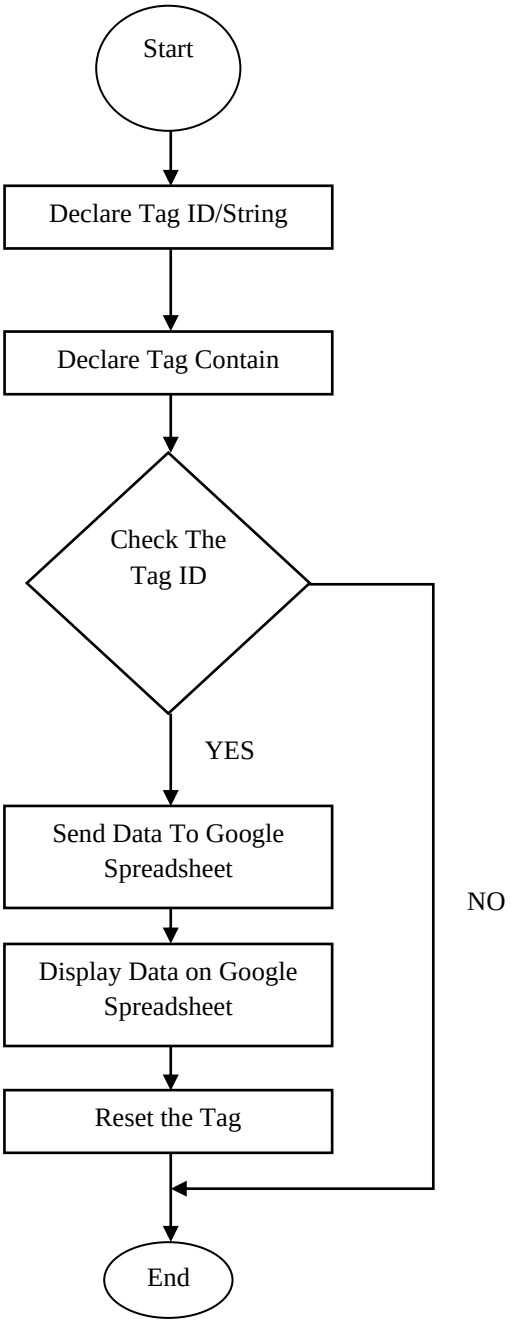

Figure 4. Flowchart of Coding System.

Firstly, the tag ID or tag string must be declared to make sure that the exact item in the shop will be scanned by the reader as all RFID tags have unique 32-bit ID. Every tag ID that has been declared must contain information like type of item, price and warranty of the product. The reader checks the

tag ID in a memory location. If the tag ID is the same as in the memory, the data for the tag will be sent to the Google spreadsheet. If the content does not match the tag ID in the memory, the procedure will be ended, and the reader will wait for a new card. The tag contents from matches tag ID will be displayed in the Google spreadsheet. The previous tag ID will be reset and wait for a new tag ID.

For the hardware setup, it consists of three mains components with are microcontroller as shown in Figure 5 illustrating the connection between Espresso Lite V2.0, UART converter and RFID reader ID 20-LA. The system employs USB connection as a power supply from a power bank or another source. Table 2 shows the connection between UART converters with RFID reader.

A buzzer is connected on the connection that has been declared in software design tool which is Arduino IDE. In this project, positive pin for the buzzer is connected to pin 15 on microcontroller and the negative pin will be connected to the ground pin on the microcontroller.

Table 2. Connection Between UART Converter and RFID Reader.

UART converter	RFID reader
Vsel	VCC, RES
GND	GND, FORM
RX	D0

Figure 5. Hardware Setup.

This paper has discussed the methodology of the project. This project is created for a shop management system that implements RFID as its future technology to make sure all customer information can be saved in one database for future reference. The system employs the IoT technique to communicate between hardware and software. This system consists of two parts which are software and hardware designs. This paper will be used as a reference to create the project to make sure the specification meets the requirement from a user and market.

3. Results and Discussion

This section compares the conventional methods and proposed system. The conventional methods use barcode scanner, receipt book and others. Table 3 shows the comparison between conventional methods and propose system. For this analysis, barcode has been chosen as a conventional method because of its similarity with the function of the proposed RFID system. From the comparison that has been done, the analysis shows that the proposed system using RFID gives more benefit to the user especially in terms of the efficiency of the system. Besides that, the system operates automatically as the user can make the payment by himself or herself and does not require a cashier to handle any

purchasing action.

Table 3. Comparison Between Conventional and Proposed Systems.

Method	Conventional	Proposed System
System	Barcode	RFID
Man Power	Need worker to scan the item	No need workers
Efficiency	One-by-one	Multiple
System Method	Manual (Human Error)	Automatic (No Human Error)
Propagation	Line of sight	EM Wave
Operation	Wired	Wireless

Google Spreadsheet has been used as Graphic User Interface (GUI) and database. Google script editor software tool is employed to integrate between the hardware and the software system. It is also used as a platform to send the data between hardware and GUI of the project. All the information like warranty, item and price will be recorded in the database. In the database, the user can see date, tag IDs, item, warranty and price. Date functions as a reference to the buyer and seller for future reference especially for warranty claims. The system also displays the tag IDs of the product. Tag IDs are very important in this project for the seller to refer the belonging of the item especially for the items like a computer, laptop, smartphone and others. Figure 6 shows the GUI to display a result.

A	B	C	D	E
YOUR COMPANY NAME			TELEPHONE NUMBER:	04-67854
YOUR COMPANY ADDRESS			FAX NUMBER :	04-65867
			EMAIL :	sdn.bhd@gmail.com
CUSTOMER INFORMATION				
NAME :	AMERRUDIN BIN DAUD		TOTAL PRICE (RM) :	350
TELEPHONE NUMBER:	013-6384167		PAYMENT (RM) :	10000
EMAIL :	anaamerrudin@gmail.com		BALANCE (RM) :	9650
DATE :	26/11/2018			
DATE	TAG ID	ITEM	WARRANTY (YEAR)	PRICE (RM)
26/11/2018	0800C666AD05	MONITOR	1	300
26/11/2018	04002843A7C8	MOUSE	1	50

Figure 6. GUI for the S-SHOP.

3.1. Readability of RFID Using Internet Connection and Without Internet Connection

The test has been conducted to compare the effectiveness of readability of RFID using internet connection versus without internet connection. The test of this paper research was conducted for three times and it used 10 different cards for every test. The internet connection is also one of the factors that will affect the data transferring process between hardware and database. For the test using internet

connection, the test was conducted using cellular data. The percentage of the complete reading by the reader was collected in percentage data. Table 4 and Figure 7 shows the percentage of readability of RFID.

Table 4. Readibility of RFID.

Type of Test	Using Internet	Without Internet
Test 1	9%	10%
Test 2	9%	10%
Test 3	8%	10%

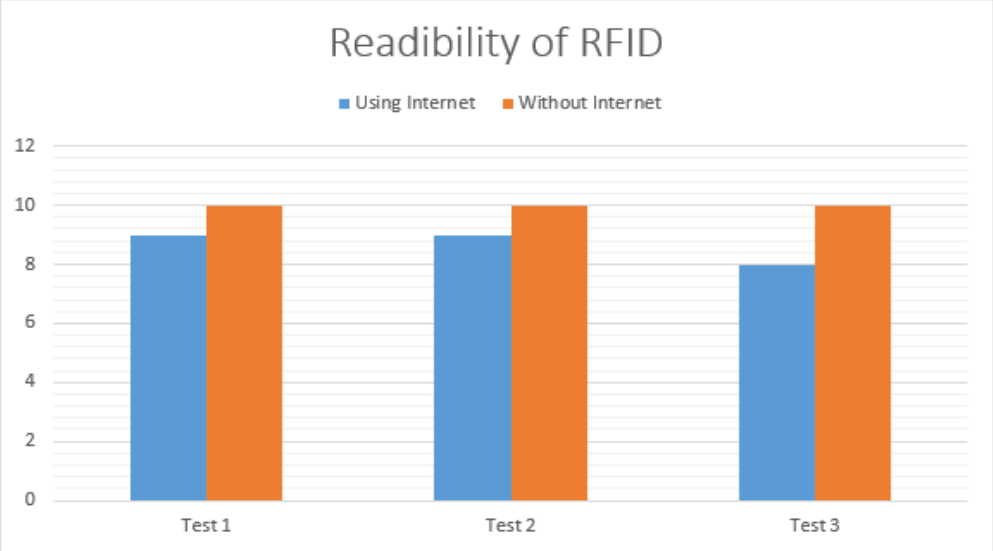

Figure 7. Readability of RFID.

From the experiment that had been conducted, the results of the readability of the RFID test without internet connection have shown that the data was 100% sent to the database (Google spreadsheet). Based on Figure 7, when the system was connected to the internet, the performance of the system in transferring the data to the database decreases. The results for tests 1 and 2 are the same with is only 9 over 10 of the data has been successfully sent. For test 3, the result only shows eight cards are successfully sent to the database. The finding proves that the internet connection is one of the factors that will affect the data transmission. The server connection is also one of the factors that will make the system failure to operate in peak performance.

One of the recommendations that can be done to increase the efficiency of data transmission is to improve the internet connection between the hardware and the project database. The Internet can be connected using local area network (LAN) so that it will become stable. Another recommendation is to choose correct module for Internet-based environment. The correct Internet module will reduce the interference and noise from another signal. High quality signal will produce a good transferring platform causing the system to become more effective and can reduce or even solve many problems.

From the tests that had been conducted in this paper, it is found that the performance of the RFID tag is not effective if the tag is attached to the metal product. It can be seen from the tests that had been conducted. For a real implementation in the market, suitable tag must be chosen to make sure the tag antenna is able to transmit data in various condition and material. Besides, the system is also fully effective without using an Internet as the Internet connection is also one of the factors that affects the efficiency of the data transmission. However, to enhance shopping experience of a customer, it is still

relevant to use Internet connection because the system is still effective and efficient. Based on the tests that had been conducted, it is concluded that the proposed RFID system is more effective than the conventional method system.

4. Conclusion

The technology nowadays is growing faster than expected. The design of smart billing system based on RFID and the IoT helps shopping mall to actually solve their main problem which is long queue at the payment counter. It is because the smart system is easily adapted by the people and it does not require any training to use this system. Besides that, the development of the database of the system to keep the whole history of the item that has been purchased by the customer will enable the manager to monitor the workers more efficiently and identify the number of inventory left in the warehouse. Other than these, the shopping mall will be able to reduce its operation cost in long term since there will be reduction or even no involvement of human beings in this automated RFID system. As the conclusion, the technology of smart shop system based on RFID sensor and the IoT hope will be help the laptop shop to make their management become more efficiency and effective to monitor their sales and their item inventory. Besides, the technology also will be helping to solve the problem like long queue at the counter, number of workers and warranty issue. The system will be easily adapted by the people and does not required any training to using this system because the system easy to use and monitor.

Acknowledgement

Authors would like to thank Universiti Teknologi Mara Cawangan Permatang Pauh for all research facilities provided for this experiment.

References

[1] What is RFID? (2018) Retrieved from https://www.epc-rfid.info/rfid
[2] Machhirke K, Goche P, Rathod R, Petkar R, and Golait M 2017 *Int. J. Recent Innov. Trends Comput. Commun.* **5** no.2 256–9
[3] Rouse M (2018) What is RFID tagging *TechTarget* Retrieved from https://internetofthingsagenda.techtarget.com/definition/RFID-tagging
[4] Y L, Abhishek A, Harshith R, D K S R and Srinidhi K M 2015 *Int. Res. J. Eng. Tech.* **2** 1435–41
[5] Smiley S (2016) Active RFID vs. Passive RFID: What's the Difference Retrieved from https://blog.atlasrfidstore.com/active-rfid-vs-passive-rfid
[6] Internet of Things (IoT) (2018) Retrieved from http://www.itcoordinates.com/iot/
[7] Sutar S W M and Patil M 2016 *Int. J. Adv. Res. Computer. Eng. Technol.* **5** 2278
[8] Chandrasekar P and Sangeetha T 2014 *Int. Conf. Inf. on Information Communication and Embedded Systems (ICICES)* p 978