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Real-Time Detection and Notification System of Forgotten Items using Ultra High Frequency - RFID Technology

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Abstract

Objectives: Nowadays, people are expected to do different tasks in quick succession. Hence, even simple lapses can be frustrating especially when we forgot to bring important things when leaving home. This study proposes a real-time detection and notification system of forgotten items. **Methods**: The system is composed of a base device and at least one portable device. The base device can detect tagged items which can easily be attached to any vehicle or equipment that can contain multiple items. It comprises an Ultra High Frequency (UHF) - RFID technology which has extended the range of detection, a single board computer or a microcontroller, a pocket WiFi router and a power source or a power supply. **Application**: Meanwhile, the portable device is a smartphone with a mobile application installed, necessary for control and notification purposes. The user will be notified of the forgotten items through an alert in the mobile application. It will be triggered when the items are no longer detected within 1.5 meters from the base device through a wireless network. **Findings**: Based on the evaluation results conducted in terms usability and functionality, the proposed system received positive feedbacks from users of the system.

Keywords: Detection, Forgotten Items, Notification, Raspberry Pi, RFID, UHF

1. Introduction

In this modern age, humans are bound to become more productive and versatile than ever before. It is because of the technological advancements that made work and life way much easier. As a result, people are pushed to the limits as they are expected to perform different tasks or focus on different things in quick succession[1]. It is undeniable that because of the demand for improved productivity and versatility, even simple lapses can frustrate many people especially when they left home and forgot to bring important things or belongings. Moreover, due to the fast-phased shift as a worker to a family person and everything in between, it is just normal for people to be confronted by forgetfulness issues. A person often forgets about what they should do or what they need to bring. Hence, several technological solutions were developed which tried to address this problem.

In 2011, a group of researchers in Dubai came up with IPURSE, an Intelligent RFID System built on a mobile platform which keeps track of items a user carries in their purse/handbag and also alerts the user when any item is

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missing from the purse or handbag[2]. Another presented solution is the[3], a ladies fashion bag with embedded RFID system to keep track of the items going in and out of the bag. Moreover, An RFID-based Reminder System was developed in 2013, which aims to remind users of forgotten items in a smart home environment. The detection distance of their system is ten (10) centimeters; thus, requiring the user to put all the tagged items close to the reader one by one[4]. Recently, An RFID-based Interactive Log Bag for Poor Memory Prevention was proposed in order to overcome poor memory problem of bringing essential items before leaving home, which uses Arduino Mega 2560 and low frequency RFID technology[5]. However, all proposed solutions are limited to the range of Near Field Communication (NFC) that operates within a few centimeters, which makes them bothersome to use as it requires the user to individually log or put items close to the reader one by one for them to be detected. Table 1 shows the comparisons among RFID technologies[6].

Hence, this study aims to develop aReal-time Detection and Notification System of forgotten Items using Ultra High Frequency (UHF) - RFID technology that will remind the user of the things he forgot before leaving the place with an optimized range of detection and easy to use features. Specifically, the study aims to (1) Design a Real-time Detection System using UHF-RFID reader interfaced to Raspberry Pi to serve as base device; (2) Develop a mobile application for controlling system features and receiving notifications or alerts from the base device; and (3) Test the system's functionality, usability[7] on actual users.

Table 1. Comparison of RFID technologies

Frequency Band	Description	Operating Range	Application	Benefits	Drawbacks
125KHz to 134 KHz	Near Field Communication (NFC)Low Frequency	Less than 0.5m to 1.5 ft.	Access control, animal tracking, Point of Sale application, product authentication, vehicle immobilizer, etc.	Works well with around water and metal products	Short read range and slower read rate
13.56 MHz	High Frequency	Less than 1m to 3ft	Library cards, airline baggage, etc.	Low cost of tag	High read rate compared to low frequency
860 MHz to 930 MHz	Ultra High Frequency (UHF)	3m to 9ft	Parking lot access, electronic toll gate collection, etc.	EPC standard built around this frequency	Does not work well with high water or metal content
2.4 GHz	Microwave	1m to 3ft	Airline baggage, electronic toll, gate collection	Fastest read rate	Most Expensive

2. Materials and Methods

2.1 Real-Time Detection System of Forgotten Items RFID Module: Interfacing the UHF-RFID Reader to Raspberry Pi

The most crucial part of this study is interfacing the UHF-RFID reader to Raspberry Pi. Early versions of UHF-RFID readers are bulky and very expensive, but recent improvements significantly reduced the effects of the above-mentioned constraints. Radio-frequency identification (RFID) uses electromagnetic fields to automatically identify and track tags attached to objects. The tags contain electronically stored information. In passive RFID systems the reader and reader antenna send a radio signal to the tag. The RFID tag then uses the transmitted signal to power on, and reflect energy back to the reader. The RFID reader used in this study is the VM-5GA UHF-

Figure 1. UHF-RFID Reader.

Figure 2. Passive UHF-RFID Sticker tags.

Table 2. Technical Features of VM-5GA UHF-RFID

Features:
Stable reading distance 2-3 meters
Multi-tags Identify, > 50 pcs. tags
Reading distance speed, > 50 pcs. / second
No need for connecting any other outer radiating device.
It can work without exothermic reaction in the normal indoor temperature.
Sustain electricity < 200mA @ 3.5V (26 dBm Output). Pulse peak current < 260mA.

RFID Reader Module as shown in Figure 1. Table 2 shows the technical features of VM-5GA UHF-RFID Reader.

A Radio Frequency Identification Tag (RFID tag) is an electronic tag that exchanges data with a RFID reader through radio waves. Figure 2 shows the Passive UHF-RFID tags in sticker form that will be associated to corresponding items that the user wants to detect. Meanwhile, Table 3 presents the Technical Features of Passive UHF-RFID Sticker tags.

Similarly, Raspberry Pi models have drastically dropped in cost in recent years making it more affordable for professionals and hobbyists alike. Shown in Figure 3, is the Raspberry Pi 3, the third-generation Raspberry Pi. It replaced the Raspberry Pi 2 Model B in February 2016. Raspberry Pi is a perfect tool for building Internet of Things (IoT) projects. Table 4 depicts the technical features of Raspberry Pi 3 Model B.To interface the RFID reader module to Raspberry Pi 3, they must be connected serially, corresponding terminals of the RFID module must be mounted on the appropriate pins the Raspberry Pi 3 board as shown in Figure 4.

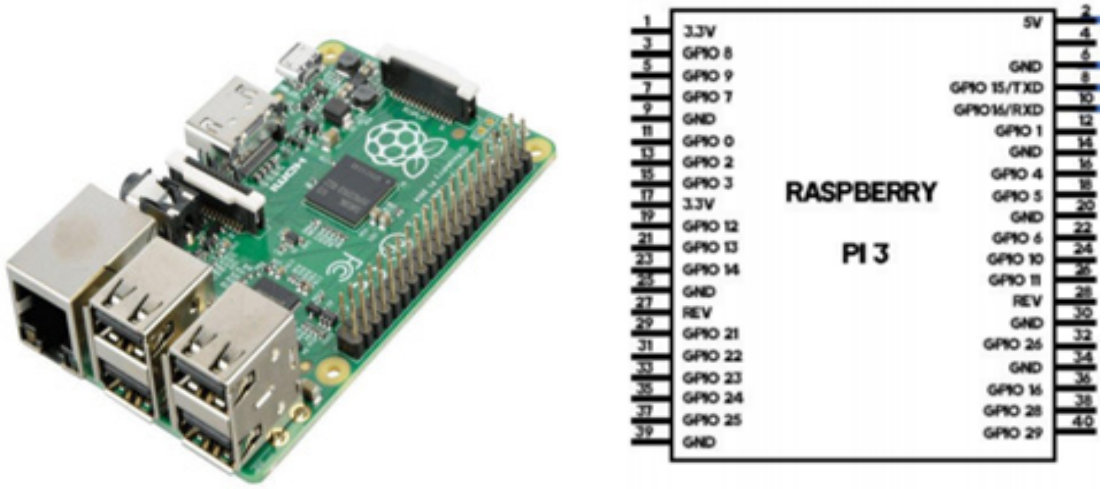

Figure 3. Raspberry Pi 3 Model B with Pinouts.

Table 3. Technical Features of Passive UHF-RFID Sticker tags

Features:
Read only
Operating Frequency: UHF (860MHz-960MHz)
Protocol: ISO 18000-6CEPC C1 Gen2
Size: 97*15mm
Reading Distance: 1-10m (depends on reader and IC tye)
Material: Aluminum and Paper

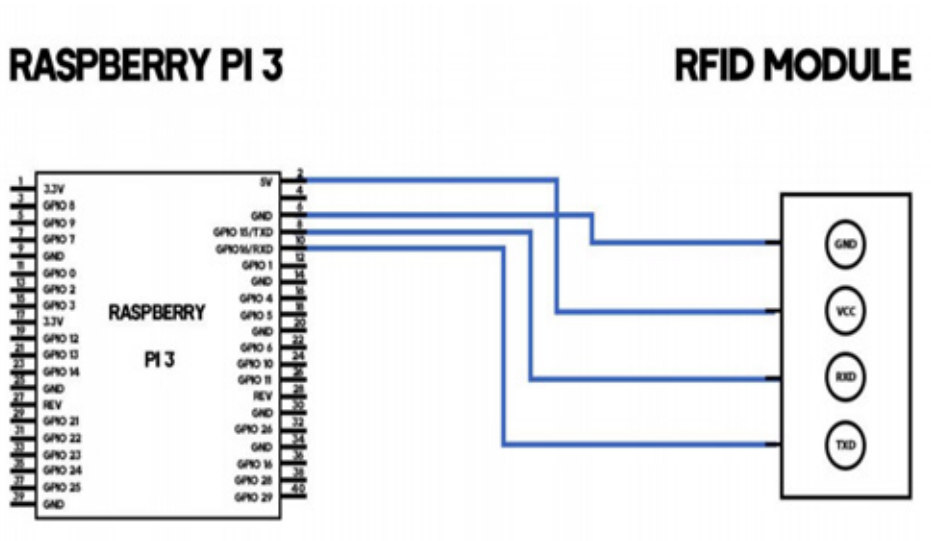

Figure 4. Raspberry Pi and RFID Module Schematic Diagram.

Table 4. Technical Features of Raspberry Pi 3 Model B

Features:
Processor: Quad Core 1.2GHz Broadcom BCM2837 64bit CPU
Memory: 1GB RAM
Protocol: ISO 18000-6CEPC C1 Gen2
Wireless Communication: BCM43438 wireless LAN and Bluetooth Low Energy (BLE) on board
I/O pins: 40-pin extended GPIO
Ports: 4 USB 2 ports

2.2 Memory Module: Preparing Data Storage

MySQL Database Server is needed to store data locally, which basically interconnects the modules of the entire system. It contains two database tables where data related to users and items are stored as shown Figure 5. To implement this, it will need to setup a typical Client-Server Architecture in which the Raspberry Pi 3 will act as the database server and the mobile devices will be the client nodes running an application that accesses the database on a wireless network as shown in Figure 6.

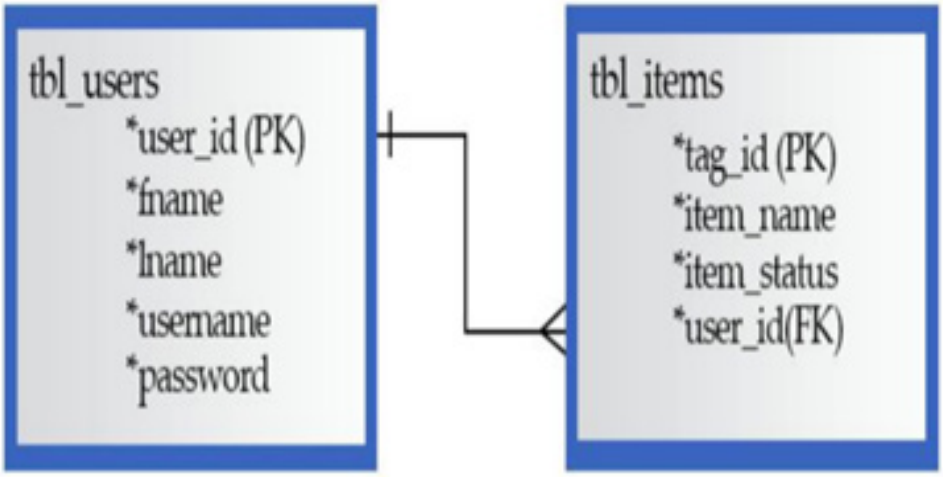

Figure 5. Database structure for storing item information.

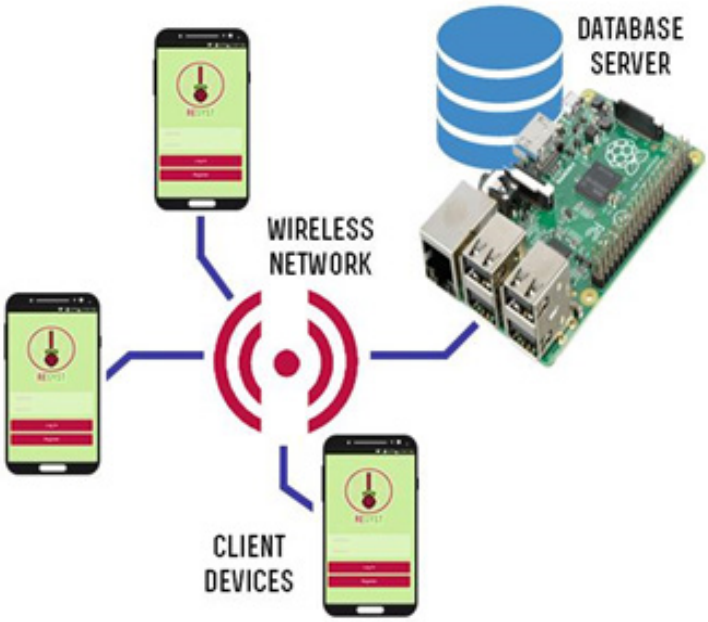

Figure 6. Client Server Architecture of the Proposed System.

2.3 Programming Module: Storing, Processing and Fetching Data

The Raspberry Pi 3 is powerful enough to do all processing tasks of the system. It is programmed in Python 3 which allows it to store data from other modules to the database, process input data to produce output, and fetch data to provide notification for the end users. Figure 7 shows the Program Flowchart that will be implemented in the Python Programming Language.

The code snippet shows in Figure 8 how the RFID reader module is configured to detect multiple tags all at once and also the program logic in which a particular item is marked as missing if it is no longer detected within the 1.5-meter range from the base device. It also shows how the database is updated when setting the status of items in the detection list.

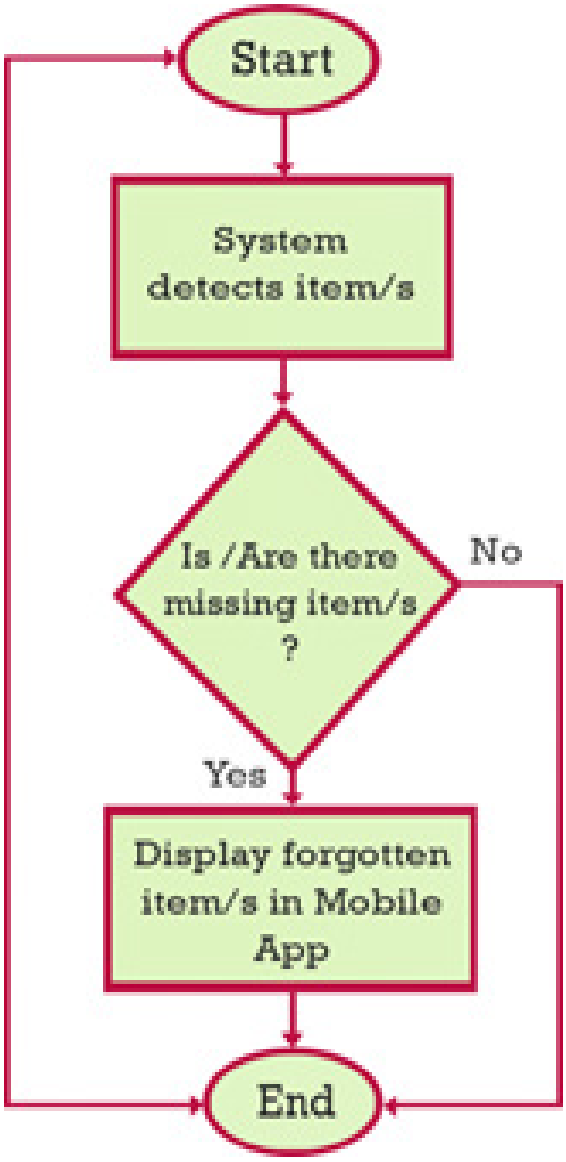

Figure 7. Program Flowchart.

Code Snippet 1

```
#!/usr/bin/env python
import time
import serial, binascii
import MySQLdb


db = MySQLdb.connect(host="localhost",    # your host, usually localhost
                     user="root",         # your username
                     passwd="123",        # your password
                     db="resyst_db")      # name of the database

# you must create a Cursor object. It will let
# you execute all the queries you need
cur = db.cursor()

ser.close()
ser.open()

#set rfid reader to Multiple tag reads via UART
ser.write('\xBB')
ser.write('\x00')
ser.write('\x27')
ser.write('\x00')
ser.write('\x03')
ser.write('\x22')
ser.write('\xFF')
ser.write('\xFF')
ser.write('\x4A')
ser.write('\x7E')


print("RFID module started in Auto Read Mode, Waiting for Card ...")
```

Code Snippet 2

```
rfid_counter=100
counter=0

detected = []                              #initialize list of detecte


while True:

        data = str(binascii.hexlify(ser.read(8)))       #read from rfid anc

        if data != "bb01ff000115167e":          #remove hex sequence for nc
                detected.append(data)
                for x in detected[1::3]:
                        print "Tag Detected: " + x

                        if counter < rfid_counter:
                                result = cur.execute("SELECT tag_id from tbl_detected_items where tag_id ='%s'" % (x))

                                if result == 1:
                                        cur.execute("UPDATE tbl_detected_items SET detection_status= 1 WHERE tag_id='%s'" % (x))
                                        print("UPDATE QUERY")
                                else:
                                        cur.execute("insert into tbl_detected_items VALUES('%s',0,1)" % (x))
                                        print("INSERT QUERY")
                                print counter
                                counter=counter+1
                                db.commit()

                        else:
                                cur.execute("UPDATE tbl_detected_items SET detection_status= 0 WHERE tag_id!='%s'" % (x))
                                print("-------------------------------------------------")
```

2.4 System Control and User Notification/ Alerts Software Module: Developing the Mobile Application

In order to gain overall control of the system, a mobile application is in place. It is an Android application that has access to the database server through a secure wireless network. In the development process, Android SDK was used along with other packages needed to be downloaded and installed separately. Figure 8 shows the first instance of tags that are detected by the RFID module; from that view detected tag IDs can be associated with the corresponding items. Meanwhile, Figure 9 shows that list of items that has been associated already with their respective tag ID. Lastly, Figure 10 shows the User Notification Page which depicts two scenarios when the system notifies the user if there are forgotten or missing items or there is none.

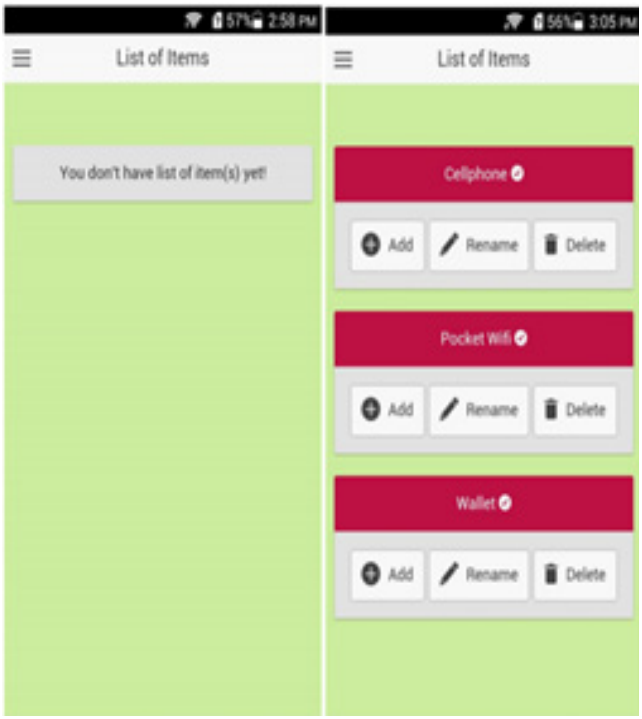

Figure 9. List of Added Items Page.

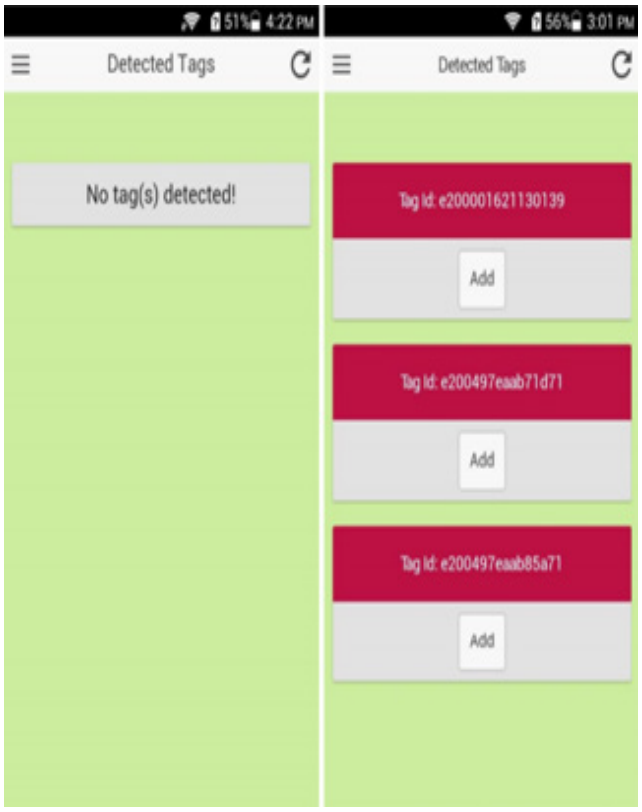

Figure 8. Detected Tags Page.

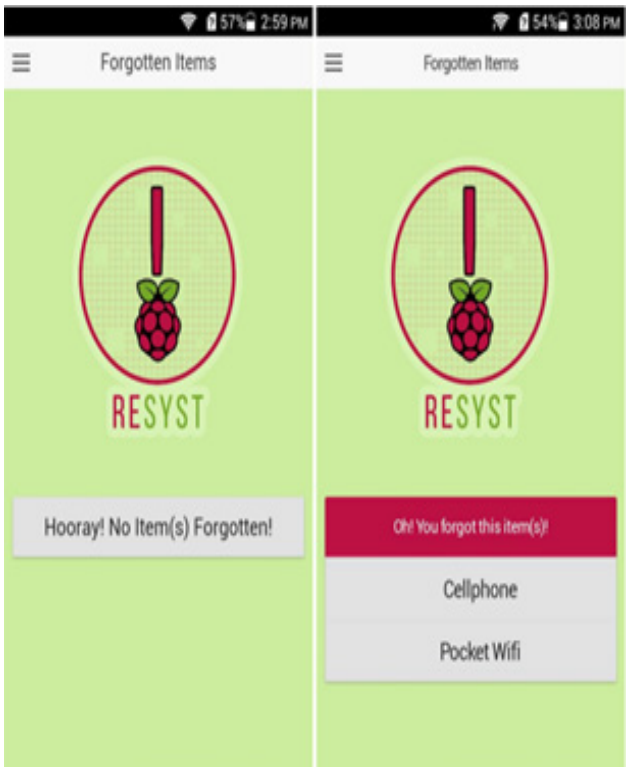

Figure 10. User Notification/Alert Page.

3. Results and Discussion

Figure 11 shows that 16 (80%) of respondents are strongly agree that the system is very useful to prevent important things to be forgotten to bring with the rating of 5, 3 (15%) of respondents just agree with the rating of 4 and only 1 (5%) of respondent is satisfied/fair with the rating of 3. Meanwhile, Figure 12 shows that 17 (85%) of respondents

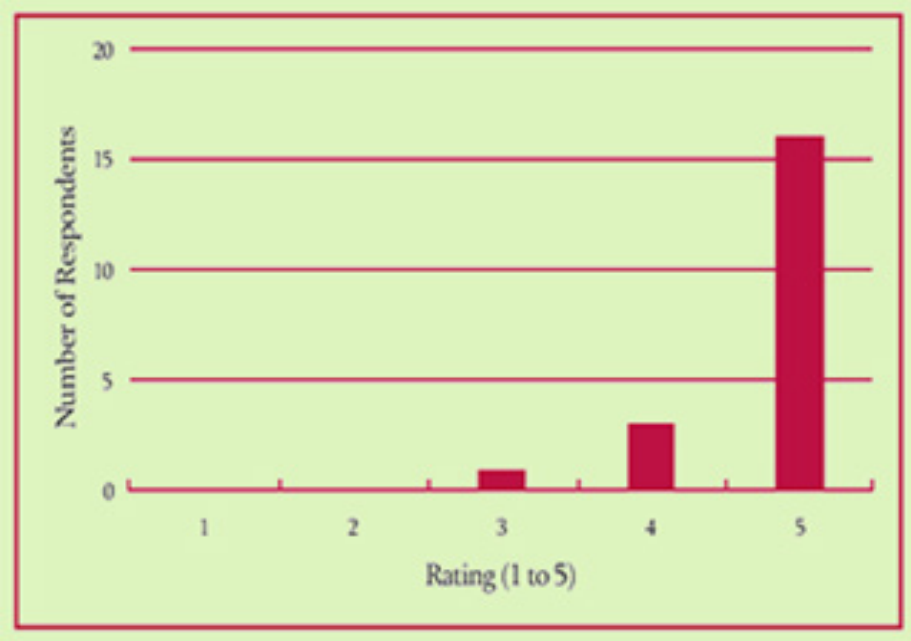

Figure 11. Usability Test Result.

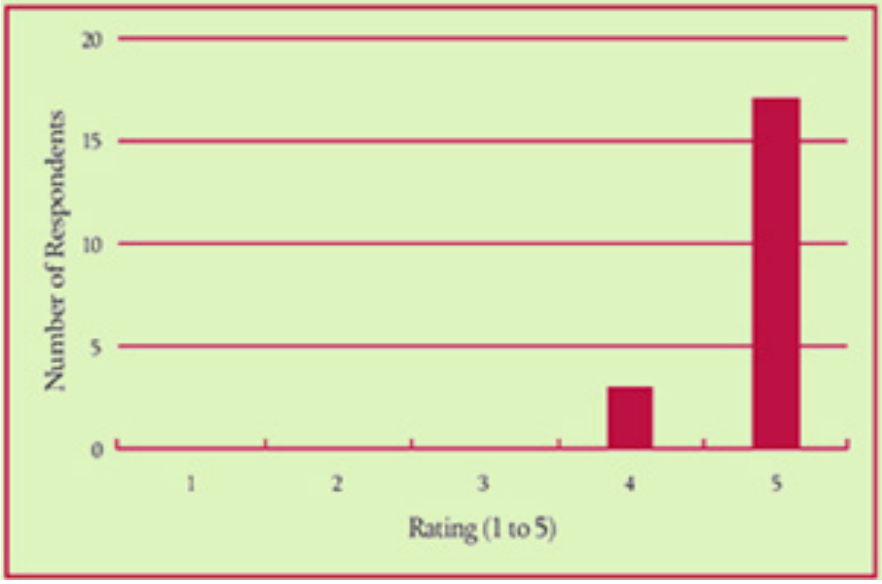

Figure 12. Accuracy Test Result.

are strongly agree that the range of detection is accurate in detecting the forgotten items with the rating of 5 and 3 (15%) of respondents just agree with the rating of 4.

4. Conclusions

The researchers concluded that the developed Real-time Detection and Notification System of forgotten Items is functioning well and is useful in reminding people of the important things they needed to bring before leaving the place. Furthermore, UHF-RFID significantly extends the range of item detection which opens new doors for more IoT researches in the future. And unlike its predecessors, this system is not limited by the size of a purse or bag. As a result, more important items can be added in your detection list and is more convenient to use.

5. Acknowledgement

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6. References

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