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Library Book Search and Management System Using RFID Technology

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Abstract: This project is related to the common problem that occurred in almost all libraries in Malaysia. A library is a place where people can find any reading material to add knowledge. As a place for a learning center, a library plays a crucial role in academic fields, especially in universities, where many written materials are provided for students and staff. However, there are still obstacles faced by users, such as locating and borrowing books. In terms of locating books, many library-users cannot locate a specific book on the specific shelf in the library while some may miss-placed the books. In addition, the time needed to borrow or return books could be longer because they need to queue in line. This project aims to overcome the problem by developing a library book search and management system using RFID technology. This project consisted of two main parts, which are a radio-frequency identification (RFID) reader and its tag. There are also other components such as RTC 12C module and SD card module. These components have been programmed using Arduino that will be the brain of this project, and the RFID tag for each book consists of the book details. A reader will read the book tag within 3 cm from the reader display, regardless if the user wants to check in or check out the book. The reading data will be saved in the SD card slot, recording the time and date of the tag detected, and the process is successful. The prototype of the overall circuit is completely functional and able to give an output.

Keywords: RFID Technology, Book Management System

1. Introduction

A library, especially in universities provide many written materials that are important for students and lecturers. As a library's user, it is expected that all of the books in the library are in the right place where they should be. The common problem that happened in almost all libraries is that the previous user did not return the material on the appropriate shelf after they read it. They just want to minimize their time by putting it on the shelf that near to them [1-2]. This problem indirectly will make the other user take their time to find that particular book. This problem also gives extra work for the administrator to locate that particular book, wherein the system could not tell the exact location.

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The traditional libraries' management system that is widely used in the world is the bar code system. Barcode is a type of coding system that turns any information into a black & white rectangle or square bars or dots. Through scanners or readers, librarians can scan those code and retrieve the information much faster than regular processes. However, this traditional management system is complicated and the system is easy to be hacked, which affect the efficiency of the library management system. Moreover, the barcode-based book retrieval system may not provide precise book location information, which not only affects book search effectiveness but also leads readers to be very unhappy with the status quo [4]. Furthermore, by using this barcode system, the user will face trouble to borrow and return the book. Therefore, smart book management is needed urgently.

These concerns have attracted the interest and study of researchers, practitioners, faculty, and students in the field of library management system or technology. For example, [5] explained the application of barcode in IIT Kharagpur library as well as highlights its future applications. Zebra Technologies shows the print technologies with the application of Zebra Printing [6]. Previous study by [7] explored a survey of overall barcode technology, its uses, applications, merits, demerits in the 8 libraries in Dhaka [7]. Singh shows from the implement to present status of barcode technology in Central Library, GNDEC, Ludhiana [8].

For RFID technologies, Yu defines the purpose, design, methodology and approach of RFID library management system based on Shih-Hsin University Library UHF RFID system. From the study, the authors found that the application not only estimates benefits in advance and lower the risk of failure setups, but it also provides innovative library services [9]. Study by [10] stated the principles, advantages, limitations and applications of RFID in the library management system. While Pandey and Mahajan describe the role of librarians in RFID libraries [11]. In a different study, RFID tag that can be used as book's location system in library was mentions by V. S. Nayagam et al.. In this study, the books containing RFID Tags are placed in two different Shelves .before doing this the required amount of data is to be entered into the books to identify them individually. Then the RFID Tags are placed inside the books which we need to trace with the help of RFID Readers. Separate RFID Readers are attached to shelves in order to avoid the collision of collection of data from the misplaced books. This entire system is connected to the main server of the Library to note the count of the books.

Now when a book is misplaced the librarian will be alerted by the alert system provided in library after a required amount of time is given to the person to notify the book with the librarian finishes. If the person notifies the book in required amount of time then the count of availability of books will be updated. The study by J. F. Zhang and C. J. Wen proposed the design plan of university library management system based on RFID and elaborates the overall structure design of the system including the system hardware and software environment. The authors have use case diagram to explain the overall function of the system and its sub functions, and realize the intelligent management from the book entry to the circulation of books [3]. Meanwhile, Singh M.K. and Mahajan P. have discussed the components and technical features of a modern RFID library system, as well as its advantages and issues related to use of RFID in libraries. From the study, the authors concluded that RFID based library management system benefits can be realized in terms of "Return On Investments" as it will speed up the circulation process and the staff can perform other user centric services [12].

In summary, many interesting results indicating the potential of RFID in library management system have been reported. Hence, this project proposed to design a system that able to locate the book location, and able to provide easier way to check in and check out the book without bringing the book to the counter.

1.1 Objectives

The objectives of this paper are as follows:

1. To design a system that able to detect the book that is not on the right shelf by using RFID technology.
2. To create an easiest way for librarian and user to borrow and return books.
3. To create an effective RIFD tag system in handling the borrowing and returning process of the library's books

1.3 Scopes of Study

The scopes of the study are:

1. The RFID reader is limited to each row of a shelf with the RFID tag.
2. Focus on a small scale of the shelf and books which involve a few tags.
3. Getting the exact date and time to borrow and return the books and save the data into the SD card.
4. The range limit for the tag to be read by the reader is approximately 2 to 3 cm.

2. Component and Circuits

2.1 Component

The Arduino Uno is the main component that was used for coding. The components and coding were chosen precisely. Table 1 shows the list of components for the hardware used.

Table 1: The list of components

Component	Function
Arduino Uno	To read inputs and turn in into output that based on easy-to-use hardware and software.
SD card Module	To transfer data to and from a standard SD card.
Tiny RTC 12C Module/ DS1307	Operates at either the 24-hour or 12-hour format with AM/PM indicator and provides seconds, minutes, hours, day, date, month, and year information.
Rfid reader/ Rfid tags	To read and capture information stored on a tag attached to an object
DC buzzer	To give a beep sound for tags that detect to readers.
LED 5mm	To give an indicator for check in and check out.

1.2 Circuit

- Design circuit

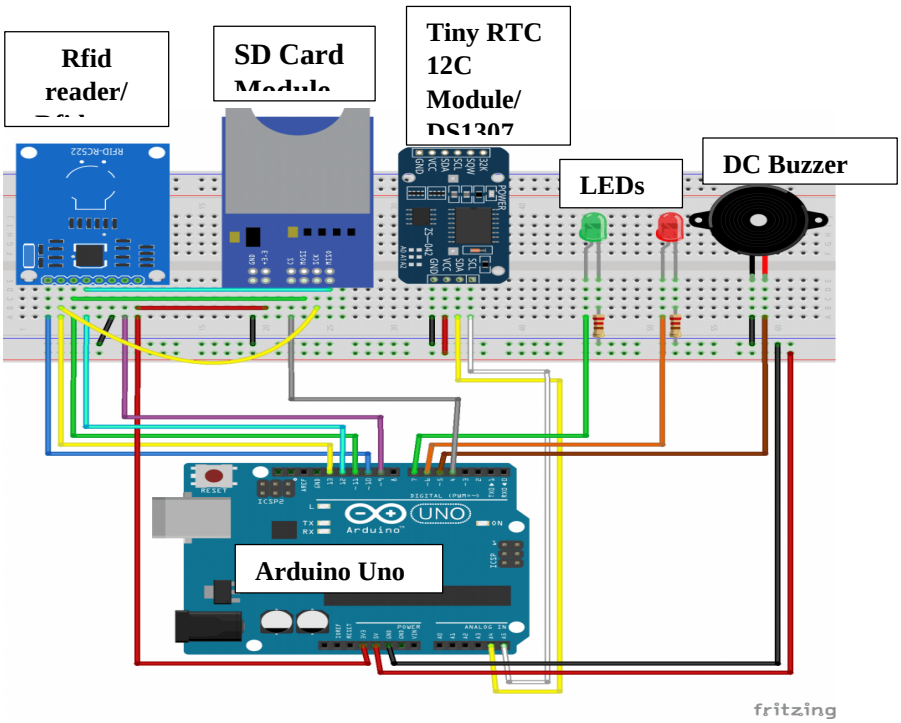

Figure 1: The connection for the component in a circuit

- Flow of the overall system

Figure 2 shows the flow of the overall system. The developed system using tags that usually consist of SD Card Module and RFID reader, LED indicator, buzzer, and each tag has its own unique e-code. A mark is used to attach or embed objects to mark targets with related target information. Based on the situation of each library, the RFID reader should be placed at a certain distance. The range of books should be indicated by each RFID reader. And the most effective scenario is to put an RFID reader on each bookshelf. The user has to tag the desired book to the reader, and then the buzzer will make a beep sound, and after that the green light will appear. This process is for borrowing purposes. The data will then send and saved to the SD card. Meanwhile, for returning the book, the user has to tag back the book to the reader, and red light will appear, beep sound will be beeped and the system will display as Check Out which means the book is available for other user to borrow. All the data can be found in the created file in SD card.

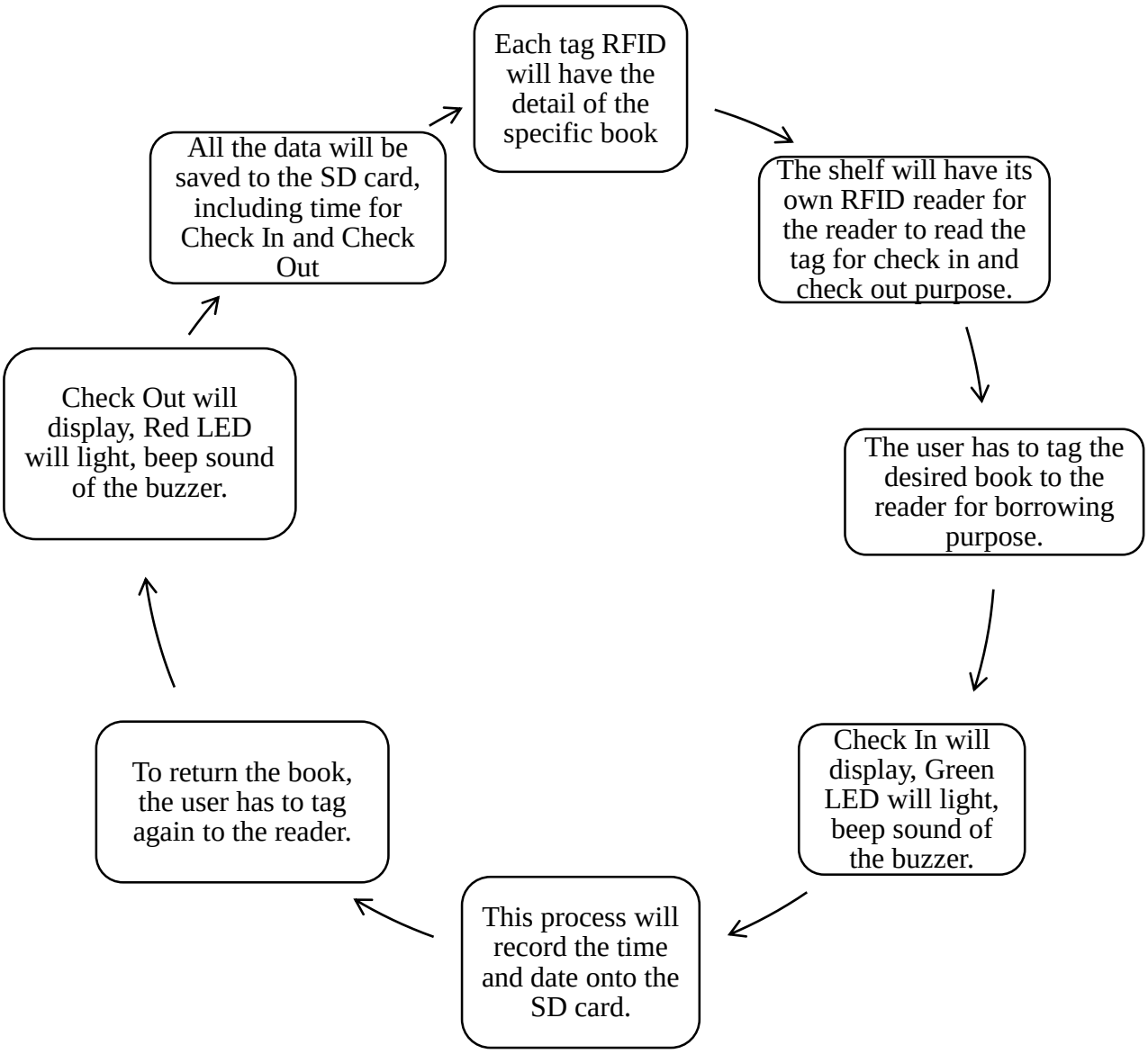

Figure 2: The flow of overall system

1.3 Flowchart of the System

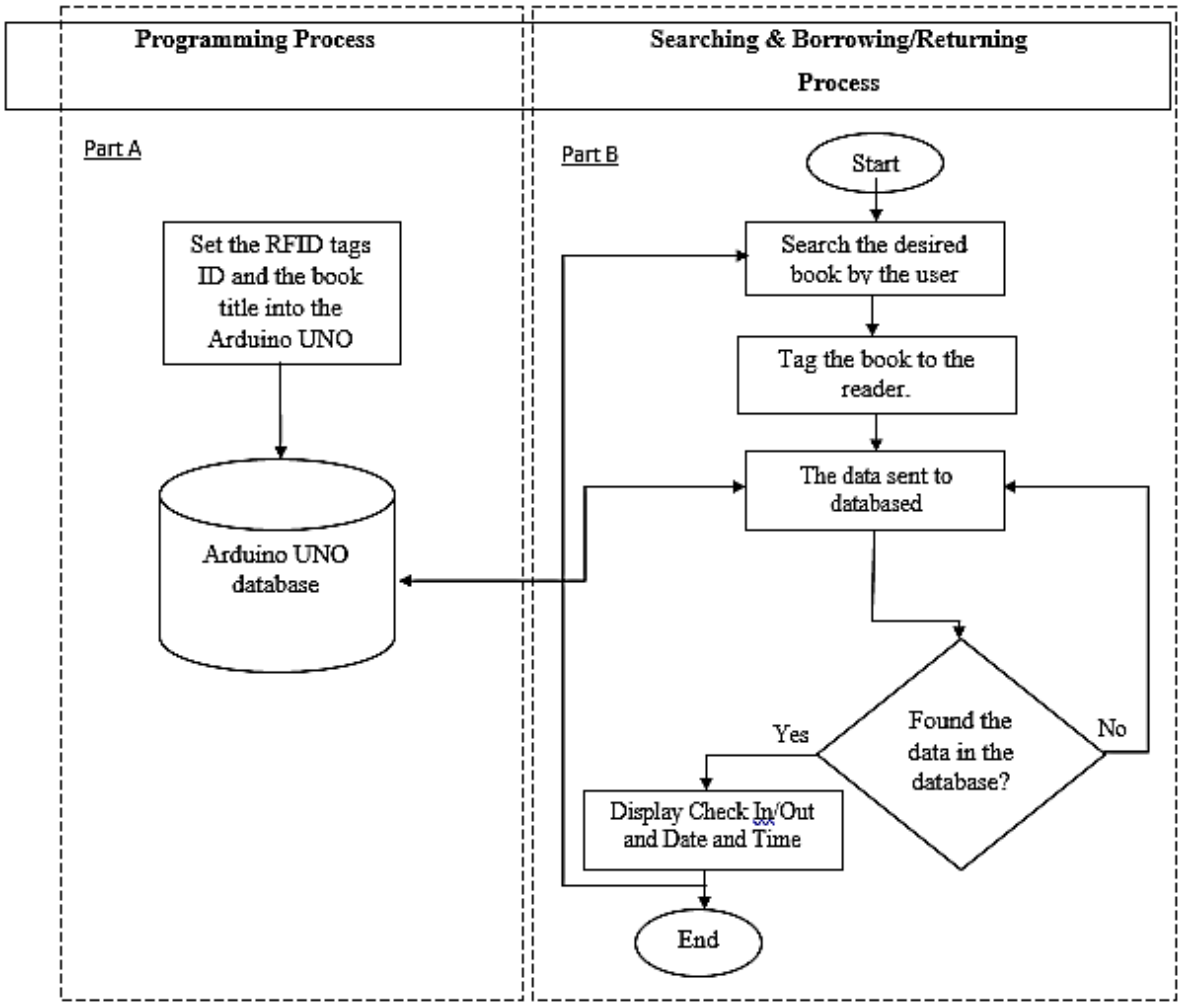

Figure 3: The Flowchart of System

Figure 3 shows the flowchart of the proposed system. The process consists of two parts which are the Programming Process (Part A) and Searching and Borrowing/Returning Process (Part B). The process for Part A starts by setting the RFID tags ID with the specific books into the Arduino database. Next, for Part B, the user will search the desired book and tag it to the reader. If the data are not recorded in the Arduino database, the process will be repeated again where the system will re-search the information in the Arduino database. If the data is found, the basic information about the book such as title, the author, the time, and date of the borrowing/returning will be displayed to the user. Then, the process will be repeated again if the user wants to find another book. Else, the process will end. The overall block diagram of the proposed system is depicted in Figure 4.

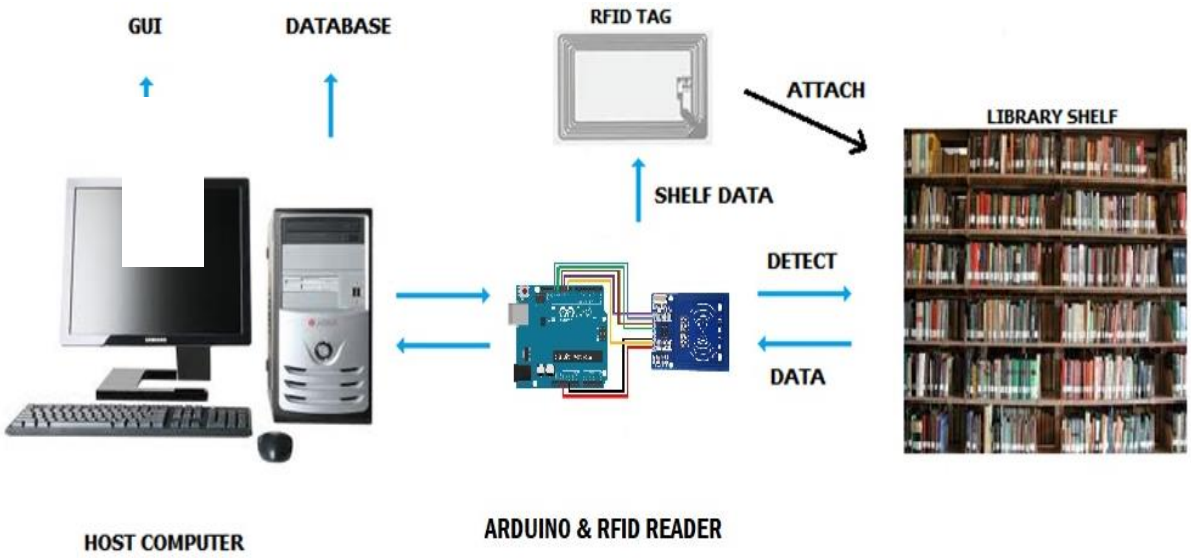

Figure 4: The Block Diagram

3. Results and Discussion

3.1 Hardware Connection

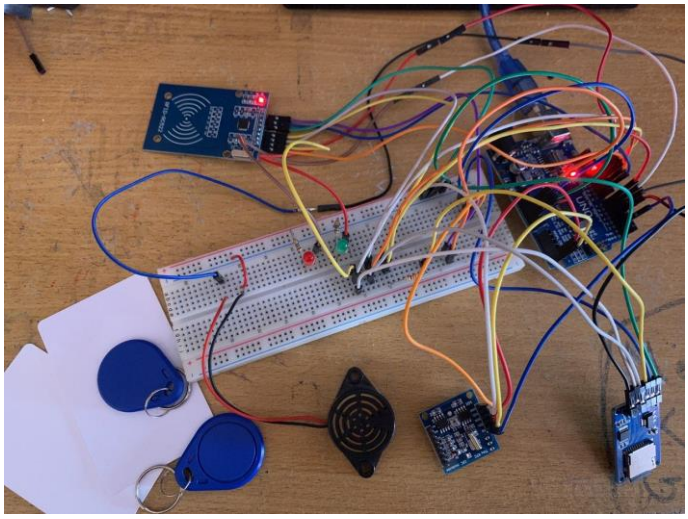

Figure 5: The hardware

The hardware part of this project consist of Arduino UNO, RFID RC522, SD Card Module, RTC 12C module, LED indicator and buzzer. The hardware are developed on a breadboard and tested to function well. Figure 5 depicted the hardware of the developed system.

3.2 Programming in Arduino Uno

The coding of this system was developed in Arduino IDE environment. This software is user friendly and easy to access. The sensor that was attached to the Arduino should be included in the coding library or otherwise, the coding will give error. After complete typing the coding, there are tools to verify those coding whether there is any error or not. The coding cannot be uploaded to Arduino board if there is error.

```
#include <MFRC522.h>
#include <SPI.h>
#include <SD.h>
#include "RTClib.h"
#include <Wire.h>


#define CS_RFID 10
#define RST_RFID 9
#define CS_SD 4


File myFile;
MFRC522 rfid(CS_RFID, RST_RFID);
String uidString;
RTC_DS1307 rtc;

const int checkInHour = 23;
const int checkInMinute = 50;

int userCheckInHour;
int userCheckInMinute;

const int redLED = 6;
const int greenLED = 7;
const int buzzer = 5;
```

Figure 6: The pin and library configuration

In the first step to start the program, library of components that will be used during the simulation need to be installed in Arduino IDE library. In this coding, the time is set at 23:50, which is in 24 hours system. The pin and library configuration are shown in Figure 6.

After defining the library, the LEDs and buzzer were set as outputs. The program will then sent the command to start the coding by writing “Serial begin (9600)”. The program will start to detect the SD card module, RTC 12C module, and begin to initialize and setup. If the SD card is detected, it will say “initialization done”. Otherwise, it will display “initialization failed”. If the RTC could not be detected, it will display "Couldn't find RTC". When the RTC is found, it will set the RTC to the realtime value for date and time. Otherwise, it will display "RTC is NOT running!", indicating that the time is not set to the exact time. Coding of the program is shown in Figure 7.

```
void setup()
{
  pinMode(redLED, OUTPUT);
  pinMode(greenLED, OUTPUT);
  pinMode(buzzer, OUTPUT);

  Serial.begin(9600);
  while(!Serial);

  SPI.begin();
  rfid.PCD_Init();

  Serial.print("Initializing SD card...");
  if(!SD.begin(CS_SD))
    {
    Serial.println("initialization failed!");
    return;
    }
  Serial.println("initialization done.");

  if(!rtc.begin())
    {
    Serial.println("Couldn't find RTC");
    while(1);
    }
  else
    {
    rtc.adjust(DateTime(F(__DATE__), F(__TIME__)));
    }
  if(!rtc.isrunning())
    {
    Serial.println("RTC is NOT running!");
    }
```

Figure 7: The coding for starting the system

When the tag is read to the reader, the “beep” sound will be heard, and the tag will display the UID in the serial monitor. The UID tag will be saved into the created file on the SD card and "File opened ok" will be displayed if no error is detected. It will also display the time and date for the tag. A successful process will display "successfully written on SD card" on the serial monitor. Otherwise, the programming will show "error opening data.txt". The figure for detection and RFID reading process is shown in Figure 8.

```
void readRFID()
{
  rfid.PICC_ReadCardSerial();
  Serial.print("Tag UID: ");
  uidString = String(rfid.uid.uidByte[0]) + " " + String(rfid.uid.uidByte[1]) + " " +
    String(rfid.uid.uidByte[2]) + " " + String(rfid.uid.uidByte[3]);
  Serial.println(uidString);


  tone(buzzer, 4000);
  delay(100);
  noTone(buzzer);

  delay(100);
}

void logCard()
{
  digitalWrite(CS_SD,LOW);
  myFile=SD.open("DATA.txt", FILE_WRITE);
  if (myFile)
    {
    Serial.println("File opened ok");
    myFile.print(uidString);
    myFile.print(", ");


    DateTime now = rtc.now();
    myFile.print(now.year(), DEC);
    myFile.print('/');
    myFile.print(now.month(), DEC);
    myFile.print('/');
    myFile.print(now.day(), DEC);
    myFile.print(',');
    myFile.print(now.hour(), DEC);
    myFile.print(':');
    myFile.println(now.minute(), DEC);


    Serial.print(now.year(), DEC);
    Serial.print('/');
    Serial.print(now.month(), DEC);
    Serial.print('/');
    Serial.print(now.day(), DEC);
    Serial.print(' ');
    Serial.print(now.hour(), DEC);
    Serial.print(':');
    Serial.println(now.minute(), DEC);
    Serial.println("sucessfully written on SD card");
    myFile.close();


    userCheckInHour = now.hour();
    userCheckInMinute = now.minute();
  }
  else
  {
    Serial.println("error opening data.txt");
  }
  digitalWrite(CS_SD,HIGH);
}
```

Figure 8: The coding for detecting RFID card and save data in the SD card module

Lastly, if the user's check in hour is lower than the set time of the check in, the green LED will On, and will display "Check In" at the serial monitor. And if the user's check in hour is higher than set time and date, the red LED will On and Check Out will be displayed on monitor. The delay for the both LED to stay turned on is 2000 ms. The coding for this stage is shown in Figure 9.

```
void verifyCheckIn()
{
  if((userCheckInHour < checkInHour)||((userCheckInHour==checkInHour) && (userCheckInMinute <= checkInMinute)))
    {
    digitalWrite(greenLED, HIGH);
    delay(2000);
    digitalWrite(greenLED,LOW);
    Serial.println("Check In");
   }
  else
   {
    digitalWrite(redLED, HIGH);
    delay(2000);
    digitalWrite(redLED,LOW);
    Serial.println("Check Out");
    }
}
```

Figure 9: The coding for verification of the Check In/Out time and date

3.3 Hardware Implementation

In this section, the circuit and programming of the project will be tested to make sure the result functions. Firstly, after the coding is uploaded to the Arduino, the "Initializing SD card" will appear and if no error detected, "initialization done." will be displayed on the serial monitor. The display on the monitor is shown in Figure 10.

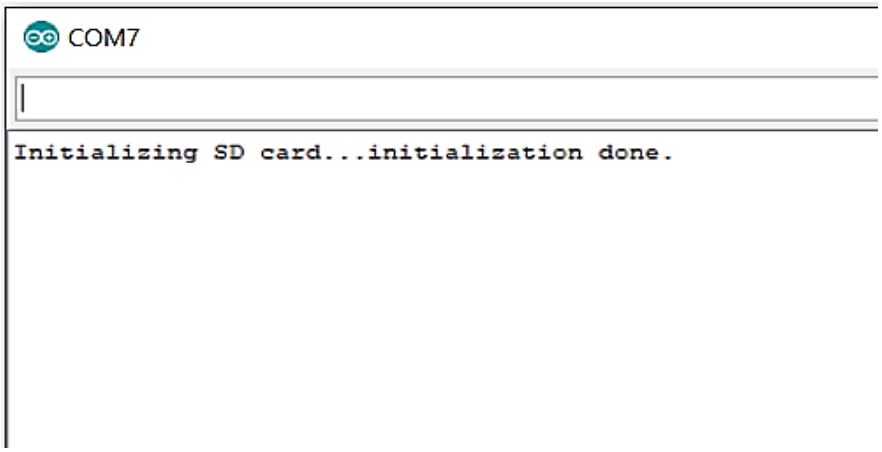

Figure 10: Verification of SD Card Module test

After that, when the tag is detected on the reader, it will show the tag UID, status of the file opened, date and time. The user must check if the data is successfully saved or not and the status either check in or check out. If the card is checked in, the green led will turn on for 2 second. The figure is shown in Figure 11-13.

```
const int checkInHour = 23;
const int checkInMinute = 50;
```

Figure 11: setup time to 23:50 hours

```
Tag UID: 25 29 162 153
File opened ok
2020/7/24 16:27
sucessfully written on SD card
Check In
```

Figure 12: Display the UID tag, Date and Time, and Status of SD card and Check In Status

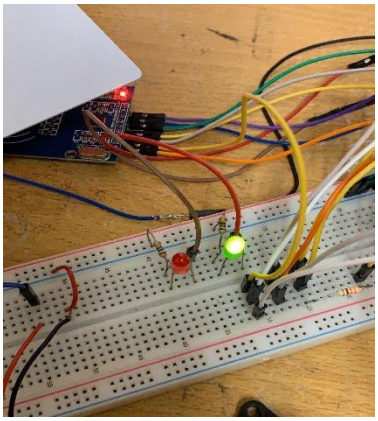

Figure 13: Green LED turned on when Check In status

And if the tag detects the time is late, which is after the set time that has been set in the coding, the red led will turn on and will display Check Out. The result, is shown in Figures 14-16.

```
const int checkInHour = 17;
const int checkInMinute = 00;
```

Figure 14: Change the time to 17:00 hours for Check in

```
Tag UID: 25 29 162 153
File opened ok
2020/7/24 17:29
sucessfully written on SD card
Check Out
```

Figure 15 : The display of the UID tag, Date and Time, and Status of SD card and Check Out Status

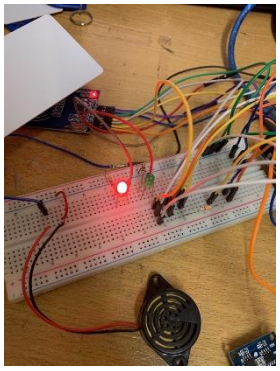

Figure 16: Red LED turned on when Check Out status

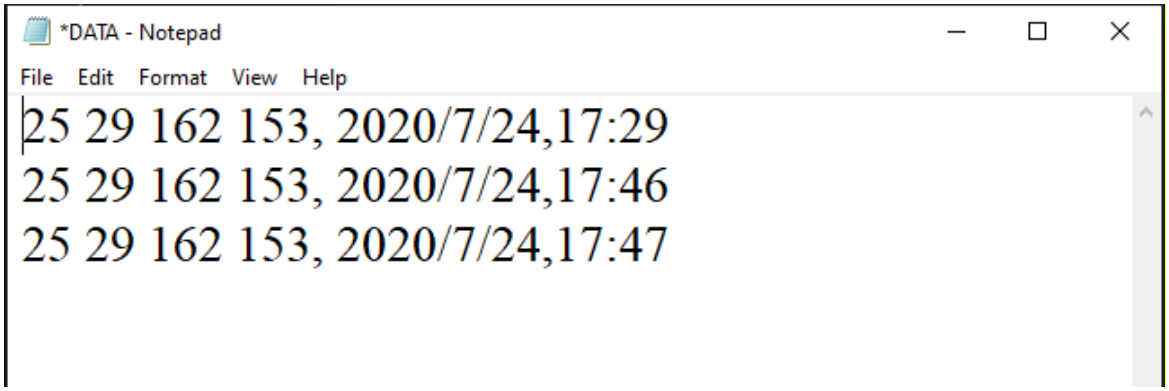

Figure 17: The saved data from the reader

Then, the data will be saved to the created file that has been coded in the Arduino. The result for the saved data is shown in Figure 17.

4. Conclusion

The research work was to develop a library book search and management system using RFID technology that able to locate the book location, and able to provide easier way to check in and check out the book without bringing the book to the counter. In general, it can be concluded that the objectives of this project are partially achieved. As in the flowchart depicted in Figure 2, the tag must have its own identities such as the title of the books, location, and other information. However, due to some limitations, the tag can't be uploaded with the required information. The system can only detect the tag UID number, not by the given title of the books. Nonetheless, the RFID reader was successfully developed according to the project objectives and the circuit able to give the desired output. Additionally, the system had successfully read the RFID cards and creates file into the SD Card module as well.

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References

[1] H. Cheng, L. Huang, H. Xu, Y. Hu, and X. A. Wang, "Design and implementation of library books search and management system using RFID technology," Proc. - 2016 Int. Conf. Intell. Netw. Collab. Syst. IEEE INCoS 2016, pp. 392–397, doi: 10.1109/INCoS.2016.35.

[2] V. S. Nayagam, S. Vedullapalli, M. Saikrishna, and R. S. Sivakumar, "Radio frequency identification technology for advanced library management," ICONSTEM 2017 - Proc. 3rd IEEE Int. Conf. Sci. Technol. Eng. Manag., vol. 2018-January, pp. 641–644, doi: 10.1109/ICONSTEM.2017.8261401.

[3] J. F. Zhang and C. J. Wen, "The university library management system based on radio frequency identification," Proc. - 2017 10th Int. Congr. Image Signal Process. Biomed. Eng. Informatics,

CISP-BMEI 2017, vol. 2018-Janua, pp. 1–6, doi: 10.1109/CISP-BMEI.2017.8302176.

[4] W. Rahaman, “Enhancin Library Services Using Barcode, QR Code and RFID Technology: a Case Study in Central Library National Institute of Technology, Rourkela,” Int. J. Digit. Libr. Serv., vol. 6, no. 3, pp. 39–50, 2016.

[5] V. K. J. Jeevan, “Barcoding for Faster Library Transactions,” DESIDOC Bulletin of Information Technology, vol. 20, no 3., pp. 15–19, May 2000.

[6] Zebra Technologies, “Barcoding 101: What You Need To Know”, Whitepaper. [Online]. Available: https://www.zebra.com/content/dam/zebra/white-papers/en-us/barcoding-101-white-paper-en-us.pdf .

[7] M. S. Islam, & N. Z. Shuva, "Barcode technology and its use and applications: A study of selected libraries of Bangladesh", The International Information and Library Review , Vol. 42, no.1, pp. 27–33, doi: https://doi.org/10.1016/j.iilr.2010.01.001.

[8] G. Singh, & M. Sharma, "Barcode Technology and its Application in Libraries and Information Centers", International Journal of Next Generation Library and Technologies, vol.1, no.1, pp. 1–8, 2015.

[9] S. C. Yu, RFID Implementation and Benefits in Libraries. The Electronic Library, vol. 25, no.1, pp 54–64, 2007, doi: http://doi.org/10.1108/02640470710729119.

[10] M. Kaur, M. Sandhu, N. Mohan and P. S. Sandhu, RFID Technology Principles, Advantages, Limitations & Its Applications. International Journal of Computer and Electrical Engineering 3(1): 151–157, 2011, doi: http://doi.org/10.7763/IJCEE.2011.V3.306.

[11] Prabhat Pandey & K. D. Mahajan, Application of RFID Technology in Libraries and Role of Librarian, 12th MANLIBNET Convention 2010, 22-24 November 2010, Jaipur (India).

[12] N. Singh, “Application of RFID Technology in Libraries”, International Journal of Library and Information Studies, vol. 4, no. 2, 2014.