

# Smart Library Management System using QR code

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## ABSTRACT

The importance of this project is in the development of library technologies because even today, libraries are the primary source of information for thousands of people. The aim of the project is to create a smart and simple solution for managing libraries through a QR code system. Most library management systems currently used either require significant human labor and supervision or large amounts of funding and resources. This QR code management system relieves some of the human labor otherwise required and barely requires funding or other resources. This management system works through one application directly accessible to library users. Through the QR code function, the users can use the application to issue, return, and manage books, with minimal to no employee assistance. This system will simplify library processes, keep track of all records, and make the library more directly accessible to its users.

## KEYWORDS

library system, QR code, smart technology, user independence

## 1 INTRODUCTION

A library is required to keep up with the digital world using various technologies that are available in this modern age [9]. Over the past two decades, library management systems have been increasingly used by libraries to store data digitally and make library processes more efficient. The primary issue for any library system is organization and record keeping due to its large number of users and items. Misplaced items are especially an issue due to the frequent movement of books within and outside of the library, creating a struggle for the librarian and the user to find books. The second focus of a library management system should be the user. Since a library's function is primarily to enhance education and gain knowledge, it should be geared towards public accessibility and their ease of use. In the end, it is desirable for the user to be more directly involved with the information and become independent users in a library [12]. Although there are library systems using different technologies such as RFID, Barcode, IoT (Internet of Technology), the application of technology in library management is usually not satisfactory. This is either because these systems are time consuming and highly human dependent or because they are unfeasible for most libraries due to a lack of available resources.

In lieu of the current systems with the issues presented above,

this paper proposes a library system using Quick Response (QR) code. This system provides a student interactive and operational library management software solution. This project will provide an end to end solution for easy library book management, i.e. issue and return books, exploring books, and maintaining book records. The user information and book details are stored in a database which controls the application. There is a student version and library version of the application. More details are provided in the later sections.

The paper is organised as follows: Section 2 discusses related works, introducing different technology and library management systems; Section 3 describes the design and implementation of the QR code solution proposed; Sections 4 and 5 present the budget and an approximate timeline for implementation of the project respectively.

## 2 RELATED WORK

This section presents related works of commonly used technologies in Library Management Systems and applications of QR code. The first part of this section will be introducing management systems currently used by libraries: the barcode, RFID (radio frequency electromagnetic wave) technology, and an IoT system. The second part will introduce the QR code and two systems currently using the QR code: ATM transactions and ticketing systems.

### 2.1 SLMS using Different Technologies

A fair amount of work has been published on Smart Library Management System (SLMS) and the following section gives a brief description of three different technologies that are used most commonly in university libraries: Barcodes, RFID, and IoT.

**2.1.1 Barcode.** A barcode is a piece of Automatic Identification Technology (Auto ID) that stores real time data. It is a series of vertical bars that encode numbers and letters in a format which can easily be retrieved and interpreted via a reader by measuring the intensity of the reflected barcode light. Nearly every type of industry uses a barcode technology to replace keyboard data entry as barcodes work much faster and are more accurate. The design of a barcode based library systems is very similar to the system proposed here since both the methods involve the scanning of a matrix. However, a QR code is more efficient than a barcode. It stores information in both horizontal and vertical patterns. QR codes can hold much more information than a regular barcode. QR codes also store larger data in a smaller area. These features are helpful in a library where large data has to be compressed for easy handling.

**2.1.2 RFID.** Radio frequency electromagnetic wave (RFID) technology is a form of automatic contact-less data capturing technique. RFID technology, as a library management system, has several components to it: tags, a micro-controller, reader and database software [15]. The readers are placed in certain locations to recognise the tags. RFID technology can detect tags through larger distances than barcodes and can detect multiple tags at once. It can also be used for ID cards, making library transactions more efficient than working with a barcode. Addepalli describes an RFID library system as consisting of tags and sensors. When a student walks in/out of the library, the sensor scans and displays the actions possible or required [1]. However, high cost of tags and time consuming installation are substantial drawbacks of this technology. The QR code is a tough competitor as it eliminates the use of tags and scanners thereby saving a great amount of capital.

**2.1.3 IoT.** Larsan discusses an Internet of Things (IoT) based SLMS which provides the luxury of fetching a book from its place with the assistance of an interconnected system using a Wi-Fi based Local Positioning System (LPS) and Near Field Communication (NFC) tags [3]. This IoT solution is revolutionary in the sector of education to produce a smart library system as it expands functional competence, user experiences of learning, and real-time visibility. The user places his NFC enabled phone over the NFC reader placed at the entrance of the library to get access to the library's local area network. Here, the user can check-in/out books, reserve rooms, make appointments and more. This system is probably the most successful in solving the issues of libraries as introduced compared to the previous two technologies. However, this is a system that requires a complete reconfiguration of libraries which would require immense amounts of resources. Resources unavailable to small libraries like Earlham's Lily Library. This is why a QR code system is still a much more attractive option for many libraries.

## 2.2 QR Code

The QR code is the main feature of the proposed library management system therefore it is important to understand its detailed functions and capabilities. A QR code is a matrix barcode readable by smartphones and mobile phones with cameras. They were developed in 1994 by Denso-Wave, a Toyota subsidiary [8]. On most phones purchased in the United States, a free application is accessible to process the QR code. The QR code usually appears as a small white square with black geometric shapes, although some colored and even branded QR codes are now being used as well [2]. To store data efficiently, a typical QR code uses four standardized encoding modes: numeric, alphanumeric, binary, and kanji. QR codes can hold much more information than a regular barcode. The information encoded in a QR code can be a URL, a phone number, an SMS message, a V-card, or any text. They are referred to as QR because they allow the content to be decoded at high speed. One of the drawbacks of this technology lies in error-correcting and error-detecting abilities of the Reed Solomon Code [5].

## 2.3 Different Systems using QR code

QR codes have become widely popular in recent years and they are being used in a wide range of contexts and systems. This section will help introduce the QR code system and how it can be used

which will help make clear the intended application of QR codes in a library management system. This section introduces two different QR code applications that have become popular: ATM's and Ticketing Systems.

**2.3.1 ATM.** One of the areas where QR code has become popular is in ATM transactions. QR codes are used for authenticating users to ATM's and other secure machines for card less transactions. These transactions work through an image code being displayed on an external device. Users then need a mobile device with a decoding function, usually provided through their banking application. This function decodes the transaction information encoded in the image and authorizes access to a secure resource [11]. It transmits the information and an identifier of the mobile device to an authentication system, granting access to the secure resource if the transaction information and the identifier satisfy the authentication test.

The ATM system provides an example of how personal information of library users can be stored and how library users can gain access to the library system through using QR code authentication methods. The QR code system can keep track of library users, their information, and their borrowed items. Most importantly, through the QR code authentication system, the user becomes self-reliable without someone having to regulate the transaction to ensure proper use. The method is simple and ensures the organization and safety of users, staff, and materials in the library.

**2.3.2 Ticket System.** Ticket sales are usually powered by humans where the application of internet technology is still at its beginning. QR codes are starting to be used more and more in ticketing processes, yet, usually there is still some human power needed to assist and oversee the code scanning and entrance procedures. Zhang and Yao describe a system that combines the QR code with scenic spot's eTicketing system [16]. Their system is directed at tourists who are exploring different sites. The tourist has access to an official webpage and only needs to click a "buy the ticket" button, fill in some personal information (name, ID card number) and then make the payment through online banking or a third party platform. On approval, the mobile operator would send the QR code to the tourist's cellphone. The tourist's only need to scan the QR code via a two-dimensional code reader at the entrance in order to verify their identification to enter the premises.

This system provides an easy explanation to understand how keeping track of books and other library items will be easy and user friendly. Especially in combination with the authentication characteristic described in the previous section, the QR code is an efficient and simple technology that makes library management much easier.

The proposed SLMS and both systems described in this section are based on the QR code technology. QR code can be used for specific purposes. In the ATM system, it authenticates users, i.e. represents unique user in 3d barcode. In the ticket system, it represents the ticket and the information of ticket holder. In SLMS, it represents book details. Hence, QR code can be used to represent information in a non recognizable format. These three systems eliminate the use of human labor and hence reduce the capital needed significantly.

### 3 DESIGN

The following section describes the design structure of the proposed library system. It gives further insight on the QR code technology, talks about the framework of the system, and gives brief implementation details of the proposed features.

#### 3.1 Overview

Figure 2 shows the different components of the proposed SLMS and how they are interconnected with each other.

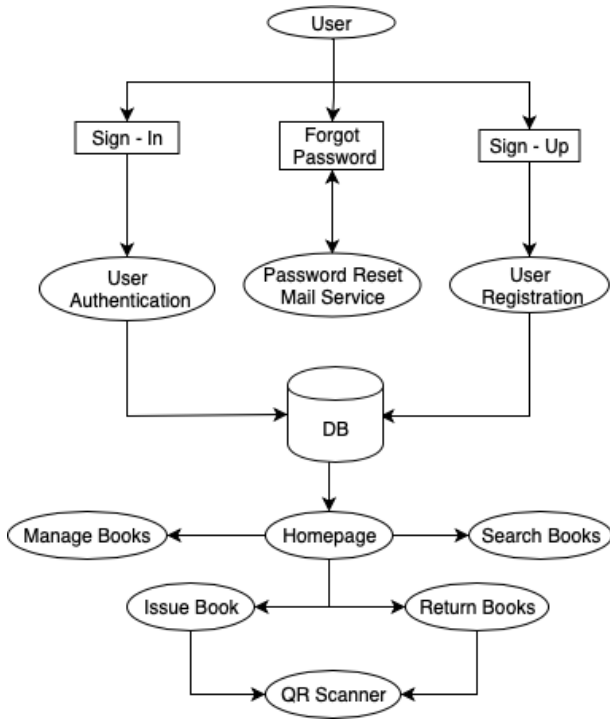


Figure 1: Design Framework

This library system provides the following features/applications for users that access the system:

- issue books
- return books
- explore books
- check book status
- manage book status

With those features, users can effectively manage their library transaction themselves through authentication technology (google firebase) and the QR code technology. The above listed features also sum up the user interface for the proposed application. The student interface of the application gives the options to: issue books; return books; search books. The library staff can do additional tasks, hence the librarian interface consists of a "Manage Books" option which allows them to add or remove a new book from the database.

The application gives the user access to the student page if they log in with a student ID. The library staff has a different application and they log in from their staff user ID. The library staff will

have access to some extra features that allow them to regulate the incoming/outgoing of books, contact students, and run interference as necessary. While some staff regulation and overseeing is still needed, the amount of staff work needed will decrease greatly through the QR code as it can replace a lot of the check in/out and record keeping work. The focus of the project will be the student interface. The different features and components introduced in this section are further explained below.

When the application is launched, the user is directed to the welcome page where they can login, sign up or choose to reset the password of their application. New users can choose to sign up by providing information such as name, student ID and cell number. On successful registration of the user, the user is redirected to the homepage. The homepage is the main page of the application where the user has access to all the primary features of the application such as issuing a book, searching a book, finding the issuance status of a book, extending the lending time, and returning a book.

The application uses the MySQL database to register users, store books, authentication and management of all the in going and outgoing books. All the data is encrypted before being stored which reduces the probability of hacking vulnerabilities.

#### 3.2 Features

The features of the proposed SLMS can be summed by the following figure:

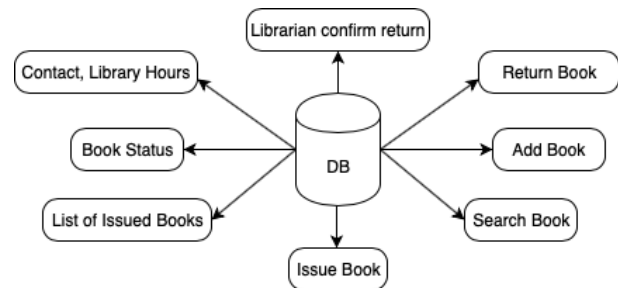


Figure 2: UI Components

As introduced in the previous subsection, there are four main features to the application: searching books, managing books, issuing books, and returning books. The issuance and return of books are two features that will require the use of the QR code scanner which will be built into the application.

**3.2.1 Issue Books.** The process of issuing a book starts by pressing the 'Issue Book' button which opens the rear camera of the android phone through the application, which searches for a QR code present on the books. On successfully scanning a valid QR code, the application decrypts the information of the QR code and fetches the relevant details about the book from the database. It then automatically calculates the due date of the book as the time period is based on the popularity of the book. The popularity is calculated on the basis of the number of requests to borrow the book. For example: Harry Potter is extremely popular and several students want to borrow it, so its time period is one week; whereas a history book has lower demand and can be borrowed for a month. The due

date is calculated based on the current date thereby allowing the user to issue the book at a click of a button.

**3.2.2 Return Books.** Using the QR code scanner just like above, the user scans the code of the book to return a borrowed book. The returned books will be placed in a physical shelf near the librarian's desk. The application tracks the due date from the database and checks if the book is returned before or after that date and in case of the latter, the fine is calculated accordingly and the user will be notified. The user confirms the return of the book by pressing the return function. The library staff is notified when a book is returned and they can verify by scanning the QR code for each book.

**3.2.3 Search Books.** This feature gives the user a chance to search the book collection of the library. They can check for book availability, browse through different genres and get acquainted with the library. This saves the user time and energy as they essentially have to go to the library to just pick up the book. For example: on a bad weather day, a user can verify the availability of the book through the application rather than physically visiting the library to find out its unavailable.

**3.2.4 Manage Books.** The importance of this feature is to regulate the movement of books and prevent thefts in the library. Its access is granted only to the library staff. It provides a list of outgoing and incoming books and notifies the staff if the book is overdue. If the staff is informed about a possible mishandling of book by a user, they have the option to prohibit the user from issuing further books. It also allows the staff to add new books, edit books and manage the database.

**3.2.5 Time Period.** This is not a primary button but the feature is unique and is based on the popularity of books. The popularity of the book is measured by the number of requests (n.r), i.e. number of people interested in borrowing the book. Time period is divided into three categories, i.e. one week ( $n.r > 10$ ), two weeks ( $n.r > 5$ ) and three weeks ( $n.r < 3$ ). This feature is in sync with the number of copies available of the same book. Each book in the library has a unique QR code. For example: Python Programming I is extremely popular ( $n.r > 10$ ) hence the user is only allowed to issue for one week.

**3.2.6 Database.** The user information and metadata for each book is stored in the SQL database. The QR code for each book is generated from its metadata and is unique for each book stored in the database. As shown in Figure 3, each book has four parameters by which it is stored. The book can be searched by its title, year, author, publisher. To give a brief information about the book, a small abstract is also provided with the book search. The database can be accessed only by the library staff members. Any change in the book inventory is notified to the librarian. This protects book thefts and ensures smooth flow of books in and out of the library.

## 4 TEST PLAN

The application will be tested in Earlham's Lilly Library. An experimental data set of 20 random books is considered for the testing. At minimum, one user would be required to sign-up, login and use the different features. The following list of experiments that the application should successfully pass are

MySQL DB Structure

	TitleID	ISBN	Author	BookTitle
1	898823	4515283136792	John Doe	Lorem Ipsum
2	283908	8139585904671	Jane Doe	Lorem Ipsum
3	463447	5525868552474	John Doe	Lorem Ipsum
4	296781	4290215104189	Jane Doe	Lorem Ipsum
5	152110	267522790609	John Doe	Lorem Ipsum
6	314961	5105683359088	Jane Doe	Lorem Ipsum
7	161402	54022607515	John Doe	Lorem Ipsum
8	401614	5944113316113	Jane Doe	Lorem Ipsum
9	52560	45079025802	John Doe	Lorem Ipsum
10	299567	858675676816	Jane Doe	Lorem Ipsum

Figure 3: DB Structure

### 4.1 Add Books

From the sample collection of books, we add a book into the database. This check is only for the librarian application. To ensure that the book is successfully added, we will search for the same book from the 'search button' function. This feature is not available in the student application. To check for security, the same book can be attempted to be added again, if the system rejects the book, then it confirms that each stored book is independent of the other.

### 4.2 Login System

The user registers as a new user and a successful sign in would imply that the login system is functional. The user is sent an email on successful registration. The forget password button also sends an email to get new password. To make sure the login system is efficient, about 5-10 students will register and confirm if they receive emails. For security, same email new user registration should be unsuccessful. Since there are only 3-4 library staff members, they can login to the library application and confirm if they received notification about new user registration. It is also important to ensure that a student id is rejected in the library application.

### 4.3 Search Books

The user is able to search any of the books from the 20 books stored in the database. The search result provides brief details about the book as shown in Figure 2. The user can search the book from any of the book attributes. They can search the year, title, publisher, author and the required book should be retrieved from the database. Since this feature is for the users to explore the library content, a brief abstract about the book also appears with the search function.

### 4.4 Issue Books

Attempt to scan the QR code of the book and borrow the book from the library. A unique QR code for all the 20 books will be generated. It is important to ensure each book is independent and hence two copies of the same book will be in the sample size. Two students should be able to borrow the books independent of each other. For the experiment, all 20 books can be borrowed for two weeks. To re-issue, the user can request for extra time period. This feature will be tested by customizing the time period to few hours. If a borrowed book has been requested for extension within 30 minutes of the issue, it can be re-issued for another hour.

## 5 BUDGET

The project is software based and requires no more than a personal computer for hardware. The application will be built on Android Studio using the existing modules and libraries. The database used to store the library data has a negligible cost. Therefore there are no required software or hardware purchases, and the monetary cost of the project is effectively zero.

## 6 TIMELINE

Following is the estimated timeline for CS 488:

- Jan 15 - Jan 28 : Read documentation, setup and get familiar with the tools.
- Jan 29 - Feb 11 : Implement login system and database, test the system.
- Feb 12 - Feb 25 : Study QR code algorithms to check in check out books.
- Feb 26 - Mar 8 : Store sample books in the database, connect with the application
- Mar 9 - Mar 22 : Add the librarian features and make the changes in database. All features are added at this point.
- Mar 23 - Apr 04 : Work on user-interface, make the application well designed.
- Apr 05 - Apr 18 : Demo SLMS in Lily Library.
- Apr 19 - May 03 : Review feedback and make required changes. Continue with testing. The project is complete.
- May 5 : Submit thesis paper!

## 7 ACKNOWLEDGEMENT

I would like to thank Professor Xunfei Xiang for her encouraging help and support throughout the semester. As class professor and project advisor, she constantly gave me valuable input and feedback which helped me complete my project proposal. I would also like to thank Charlie Peck, Department of Computer Science and Earlham College as well, for giving me the opportunity to work on this project.

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