Smart Library Management System using QR code

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ABSTRACT

The importance of this project lies in the technological development of libraries. Even with digitized information, libraries remain to be 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 require significant human labor, supervision and large amounts of funding and resources. This QR code management system relieves most of the human labor 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. The proposed management system simplifies library processes, keeps track of all records, and makes the library more directly accessible to its users.

KEYWORDS

library system, QR code, smart technology, user independence
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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 create more efficient library processes. 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 and keep track of 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, i.e. checking out books without assistance. [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 not feasible for most libraries due to a lack of available resources.

In lieu of the current systems with the issues presented above, this paper explains a library system using Quick Response (QR) code. This system is geared towards college libraries and student users specifically. A lot of colleges do not have the resources to implement high-tech solutions. However, especially students would benefit greatly from being able to be more independent in a library by using technology to find what they need and complete the tasks they need to on their own. During stressful periods in school, students are often in a time crunch and need to access information quickly and independently. The proposed library system can help students use library resources more efficiently and independently and it is a system that is feasible for all colleges, even those that do not have financial resources. This system provides a student interactive and operational library management software solution. Students can access the library and manage their library activities through their own phone. This application provides an end to end solution for easy library management: issuing and returning books, exploring books, and maintaining book records. QR code technology is very simple to use and understand and it is able to store the user information and book details in a database which controls the application. There is a student version and librarian version of the application. More details on the application 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; Section 4 explains the test plan for the application; and Section 5 concludes the project.

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 QR system proposed here since both 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 and they can 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 or 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 good alternative 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 introduced issues of libraries 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 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 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 and still, there is usually 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 and be able 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 can make 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 the ticket holder. In SLMS, it represents book details. Hence, a 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 needed capital significantly.

3 DESIGN

The following section describes the design structure of the 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 features.

3.1 Overwiew

This SLMS includes two interfaces of the library application: One for the library users (students) and one for the library employees. Figure 1a displays the features and processes of the student version whereas figure 1b shows the features that the librarians can access and perform managerial tasks with.

The student version of the library system provides the following features for users that access the system:

- issue books
- return books
- search books
- check book status (homepage)
- manage book status (homepage)

With these features, users can effectively manage their library transaction themselves through authentication technology (google firebase) and the QR code technology. The application automatically gives the user access to the student page if they log in with a student ID.

The library staff has a different application that they access by logging in with 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, hence the librarian interface includes an "Inventory" and "Add Book" option which allows them to add or remove a new book from the database. Librarians can also access the backend of the application to run interference on possible issues, like cancel Issue Requests that were made in error by a student. 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 in Section 3.2.

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
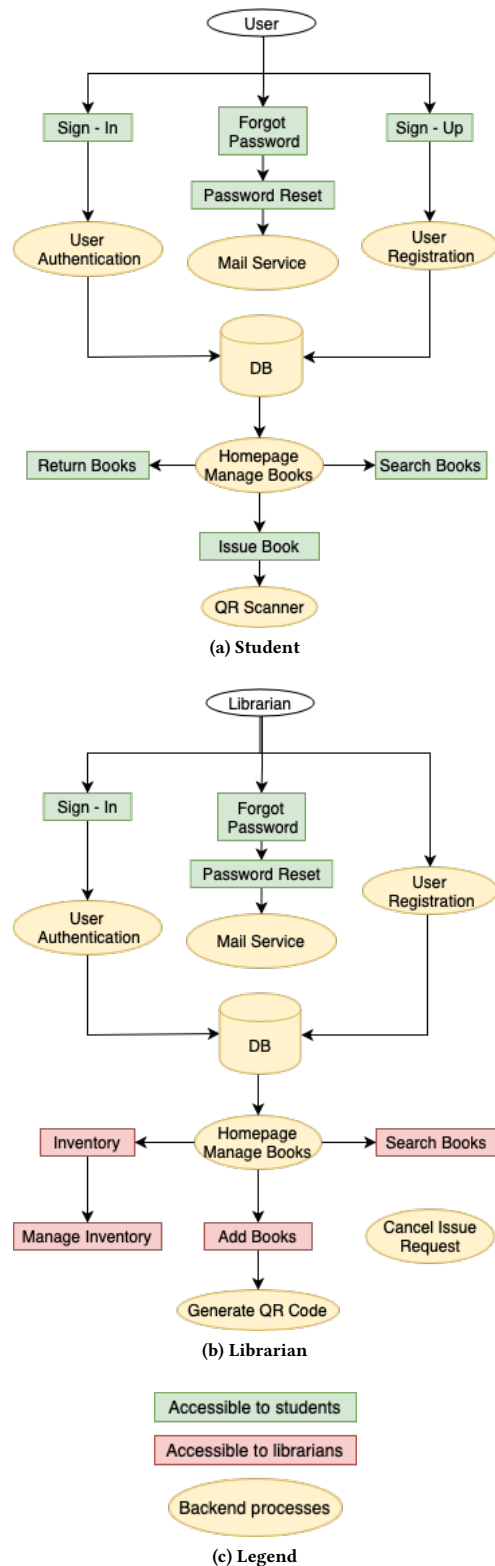

(a) Student

(b) Librarian

(c) Legend

Figure 1: Applications Structure

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 Firebase database to register users, store books, authentication and management of all the in going and out-going books. All the data is encrypted before being stored which reduces the probability of hacking vulnerabilities.

3.2 Features

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 is 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. To return books the user confirms the return of the book by pressing the return function. The returned books will be placed in a physical shelf near the librarian's desk. The library staff is notified when a book is returned and they can verify the return by scanning the QR code for each book. The application tracks the due date from the database and checks if the book is returned before or after that date. In case of the latter, the fine is calculated accordingly and the user is notified. If the book is late by 1-4 days then the fine is $1, for 5-29 days its $20 and if it's late for more than a month, the student has to pay the price of the 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 books 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 in the application, but the feature is unique and 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: 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 it for one week.

3.2.6 Database. The user information and metadata for each book is stored in the Firebase 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 a 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 will be required to sign-up, login and use the different features. The following is a list of experiments that the application should successfully pass:

4.1 Add Books

From the sample collection of books, we add a book into the database. This test is only for the librarian application as the feature is not available in the student application. To ensure that the book is successfully added, we will search for the same book from the 'search button' function. 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, if a user tries signing up with the same email again, the new user registration should be unsuccessful as a login account already exists. Since there are only 3-4 library staff members, they will be asked to login to the library application and confirm if they received notification about new user registrations. It is also important to ensure that a student ID is rejected in the library application.

4.3 Search Books

The user should be able to search any of the 20 books stored in the database. The search result should provide brief details about the book. The user can search the book from any of the book's attributes. Users 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 extent the time the book is issued to a user, the user can put in a request for an extra time period. This feature will be tested by customizing the time period to a few hours. If a borrowed book has been requested for an extension within 30 minutes of the issue, it can be re-issued for another hour.

5 CONCLUSION

The SLMS application and QR code implementation has been built and tested: The login, profile data, library management and QR code have been successfully implemented. The homepage of the application also gives the user options to choose between the librarian or the student edition. Each student user has a personal page which contains their information and the history of books they issued with the library. This allows the user to choose between past interests and track movement of the books they have issued. Each staff user gets access to the list of books in and out of the library. Whenever a book is issued by a user and taken out of the library, it is added to the list of books away. The system was tested with a sample data set of 20 books. The test user was successfully able to issue and return a book using a smartphone and search for books as per convenience.

With this successful application of a SLMS through using QR code, students are now able to use a library more efficiently and independently. Through this SLMS the library staff required to manage a library reduced significantly. The future work involves a website interface for the SLMS along with recommended search option through machine learning.

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