

A Smart QR: Based Library Management System

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Abstract:- This research is important since libraries are becoming more technologically advanced. For thousands of people, libraries continue to be the main source of information, even in the age of digital information. This research goal is aimed to provide a smart, easy and user-friendly method for managing library materials using QR code system. Currently, the majority of library management systems need a lot of finance, resources, supervision, and human work. With the implementation of this Quick response (QR) code management system, lots of challenges and efforts is reduced drastically ranging from; money, time, energy and other resources. Users of libraries can access a single application that powers this management system. Users can use the system to issue, return, and manage library materials with little to no help from library staff, thanks to the QR code capability. The developed management system streamlines operations, maintains an audit trail, and increases user accessibility to the library.

Keywords:- QR Code, Library, Resources, Smart.

I. INTRODUCTION

In order to stay current with the digital world and the range of technology available in this day and age, a library is necessary (Rahaman, 2016). Libraries have been using Library Management Systems (LMS) more often during the last 20 years in order to digitize data storage and streamline operations. Due to the high number of users and materials of the libraries, organization and record keeping are the main challenges for such system. The regular movement of library resources inside and outside the library makes it difficult for both the librarian and the user(s) to locate and maintain track of such resources, which makes misplaced materials a particular problem. The user should be the second priority of a library management system. A library should be designed with the general public's accessibility and ease of use in mind, as their primary purpose is to further education and knowledge acquisition (Varadarajan and Malpani, 2022). Ultimately, it's preferable for the user to interact with library resources directly and develop into an autonomous library user; that is, to be able to access resources without assistance (Whitchurch, 2021). While some library systems use various technologies, like barcodes, Radio Frequency Identifier (RFID), and the Internet of Things (IoT), the use of such technologies in library management is typically subpar. This is either because most libraries lack the resources to implement these systems, or they are too time-consuming, lack flexibility and heavily reliant on humans.

This paper describes a library system that uses QR code in place of the existing systems that have the problems mentioned above. This system is designed for tertiary institution libraries and their student users in mind. Many tertiary institutions lack the funding necessary to adopt cutting-edge technologies. But being able to use technology at a library to find what they need and finish the activities they need to on their own would be incredibly helpful. Students frequently have time constraints during hectic school times and need to be able to obtain information quickly and on their own. Apart from time constraint, congestion in libraries tends to become the commonest source of communicable diseases. The proposed smart QR based library management system is practical for all tertiary institutions in Nigeria, including those without financial resources, and can assist students in using library resources more effectively and independently. This system offers an operational and interactive library management software solution for students. Using their own phone, students can use the library and keep track of their activities there. This program offers a comprehensive solution for library management, including library resource exploration, resource returns and resource record keeping. In addition to being incredibly easy to use and comprehend, QR code technology can store user data and book details in a database that powers the program. The application is available in two versions: one for students and one for librarians.

The structure of the paper is as follows: In Section 2, relevant works are discussed, along with an introduction to various technologies and library management systems; while in Section 3, the design and implementation of the QR code solution is described; in Section 4, the application's test strategy is explained; and in Section 5, the paper is concluded.

II. REVIEW OF RELATED WORKS

This section discusses the various applications of QR code and related works of different authors on commonly used technologies in library management systems. The section will begin by introducing the three management methods that libraries currently use: IoT system, barcode technology, and RFID technology. The QR code and the two common systems that presently use it will be introduced in the second section; Ticketing systems and ATM transactions.

A. Different Technologies Used by Smart Library Management System

The Smart Library Management System (SLMS) has been the subject of a good deal of research, and the following part provides a brief overview of three technologies that are most frequently utilized in tertiary institutions libraries: barcodes, RFID, and IoT.

➤ Barcode

The bar code provides a real-time data storage which is a component of Automatic Identification Technology (Auto ID). It consists of a set of vertical bars that, when a barcode reader is used to measure the intensity of reflected barcode light, can be used to readily recover and understand numbers and letters encoded in that format. Barcode technology has replaced keyboard data entry in almost every industry because it is more precise and operates at a far faster pace. Given that both approaches require scanning a matrix, the design of the QR system put out here and a barcode-based library system are extremely similar (El Mhouthi and Erradi 2018).

But compared to a barcode, a QR code is more effective (Zhang *et al.*, 2018). It keeps data organized both vertically and horizontally. Compared to a standard barcode, a QR code can store far more data in a smaller space. These features come in handy in libraries where managing huge amounts of compressed data is necessary.

➤ RFID

RFID is an automatic contactless data collecting method technology. Tags, a microcontroller, a reader, and database software are some of the parts used in RFID technology in library management system (Yu *et al.*, 2021). To identify the tags, the readers are positioned in specific areas. Compared to barcodes, RFID technology can detect tags across greater distances and numerous tags at once. According to Whitchurch (2021), using the RFID instead of a barcode makes library transactions more efficient. It can also be used for ID cards. According to Addepalli (2022), an RFID library system is made up of sensors and tags. The sensor scans and shows the actions that are necessary or possible when a student enters or exits the library (Addepalli and Addepalli, 2022). However, this technology has significant downsides, including expensive tags and time-consuming installation. The QR code is a good substitute since it saves a significant amount of money by doing away with the need for tags and scanners (Kieseberg *et al.*, 2022).

➤ IoT

The luxury of retrieving library resource from its location with the use of an interconnected system that uses a Wi-Fi based Local Positioning System (LPS) and Near Field Communication (NFC) tags is discussed by Larsan *et al.* (2019) in his discussion of IoT based SLMS (Brian *et al.*, 2022). This IoT solution is innovative in the field of education because it creates a smart library system that enhances real-time visibility, user experiences, and functional competence. To enter the local area network of the library, the user places his NFC-enabled phone over the NFC scanner that is situated

at the entrance. The user can check books in and out, book rooms, schedule appointments, and do a lot more things here.

Comparing this method to the barcode and RFID technologies, it is most likely the most successful in resolving the problems that libraries have encountered (Brian *et al.*, 2022). Nevertheless, this approach necessitates a thorough redesign of libraries, which would demand a massive resource commitment. For this reason, many libraries will find the QR code system to be a far more appealing option.

B. QR Code

A QR code is a matrix barcode that can be read by cameras on mobile phones and smart phones. A Toyota subsidiary called Denso-Wave created it in 1994 (Narmadhaa *et al.*, 2017). The QR code can be processed using a free application on the majority of phones bought in the US. Although some colorful and even branded QR codes are already being utilized, the typical QR code is a small white square with black geometric elements (Ashford, 2020). A conventional QR code uses four defined encoding modes (binary, kanji, alphanumeric, and numeric) to store data efficiently. When compared to a standard barcode, a QR code may store far more data. A QR code can contain any type of text, including phone numbers, URLs, SMS messages, V-cards, and more. Because they enable rapid content decoding, they are known as QR codes. The Reed Solomon Code's error-correcting and error-detecting capabilities are one of this technology's shortcomings (Kieseberg *et al.*, 2022).

C. Various Applications of QR Code

In recent years, QR codes have gained a lot of popularity and are being utilized in many different systems and scenarios. In order to clarify the usage of QR codes in a library management system, this section will help introduce the system and explain how to utilize it. ATMs and ticketing systems are two distinct QR code applications among others that have gained popularity. These are introduced in this section.

➤ ATM

ATM transactions are one area where QR codes have gained popularity. Users can authenticate themselves at ATMs and other security machines for card-less transactions by using QR codes.

An external device displays an image code that facilitates these transactions. Next, users require a mobile device typically offered by their banking application that has a decoding feature. This feature permits access to a secure resource by decoding the transaction information encoded in the picture (Varadarajan and Malpani, 2022). If the transaction data and the identifier pass the authentication test, it sends the data and the mobile device's identifier to an authentication system, allowing access to the secure resource. The ATM system serves as an illustration of how library patrons' personal information can be kept safe and how QR code authentication techniques can be used to grant users access to a system. The QR code technology can monitor library patrons, their personal data, and the items they have checked out. Most notably, the user gains self-reliance

through the QR code authentication mechanism, negating the need for an intermediary to oversee the transaction in order to guarantee appropriate use. The approach is straightforward and guarantees the organization and security of patrons, employees, and library materials.

➤ Ticketing System

Humans are typically the driving force behind ticket sales in places where internet technology deployment is still in its infancy. Even though QR codes are being employed in ticking operations more and more, human intervention is still typically required to help supervise the code scanning and entry processes.

A method that integrates the Scenic Spot e-Ticketing system with the QR code is described in (Zhang *et al.*, 2022). Their system is intended for visitors who are visiting several locations. The visitor merely needs to click the "buy the ticket" button on the official website, enter their name and ID card number, and then complete the payment process via online banking or a third-party platform. The tourist's cellphone would receive the QR code from the mobile operator upon clearance. To validate their identity and get access to the premises, visitors simply need to scan the QR code using a two-dimensional code reader at the entry.

This method offers a clear explanation of how managing books and other library resources will be simple and straightforward to use. In particular, when used in conjunction with the authentication feature mentioned in the preceding section, the QR code is a simple and effective technique that can greatly simplify library management.

Both the systems covered in this part and the suggested SLMS are built using QR code technology. There are specific uses for QR codes. Users are authenticated by the ATM system, which uses a 3D barcode to represent each individual user. Both the ticket and the ticket holder's information are represented in the ticket system. It stands for book details in SLMS. Hence, information in an unrecognizable format can be represented using a QR code. Because these three systems do not require human labor, a considerable amount of capital is not required.

III. METHODOLOGY

The library system's design structure is explained in the section that follows. It provides more information about QR code technology, discusses the system's architecture, and provides a synopsis of how the features are implemented.

Two interfaces for the library application are included in this SLMS: one for staff members and one for students who utilize the library.

Figure 1 demonstrates the features and procedures of the student version.

The following features are available to users who access the library system through the student version:

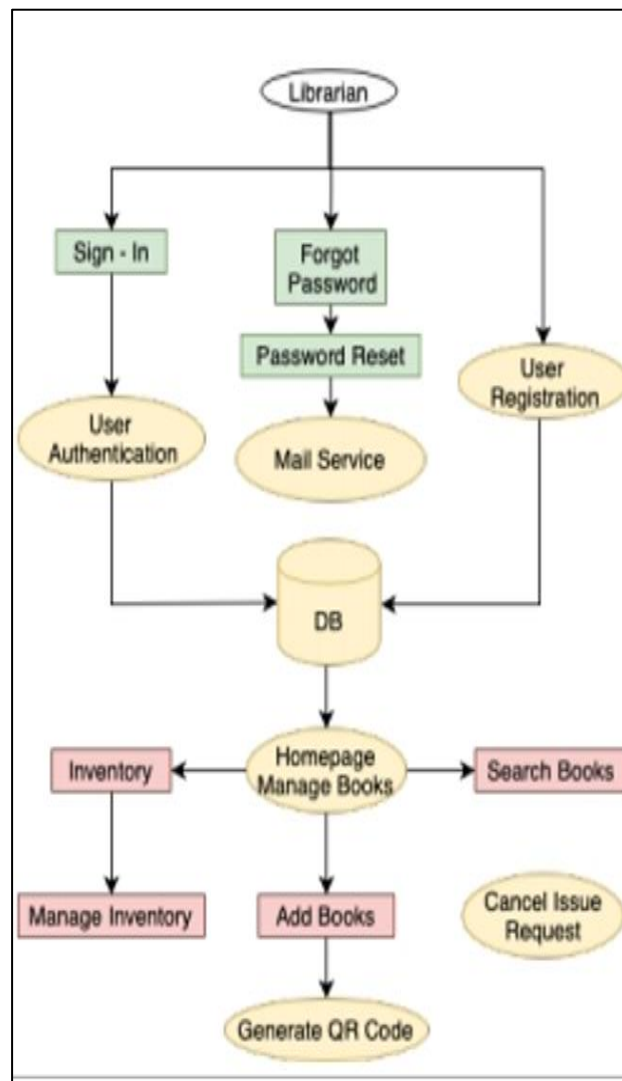


Fig 1: Student Flowchart

- Search library resource
- Issue library resource
- Return library resource
- Manage library resource status (homepage)
- Check library resource status (homepage)

With the help of these features, users may efficiently handle their own library transactions using QR code and Google Firebase authentication technologies. If the user logs in with a student ID, the application immediately grants them access to the student page.

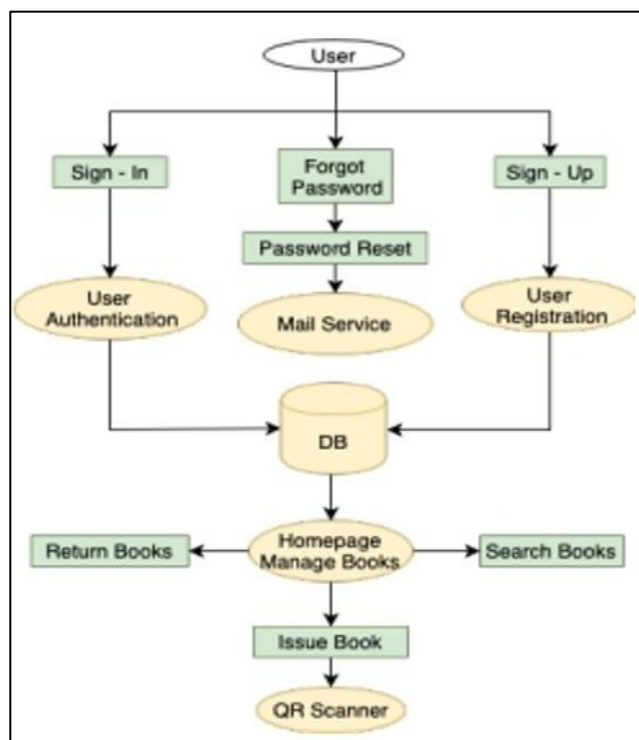


Fig 2: Library Staff

Figure 2 depicts the features that librarians can use to access and carry out administrative duties and controls access to how to efficiently manage library resources. The staff of the library uses their staff user ID to check in to a separate program. The librarian interface includes an "Inventory" and "Add Resource" option that allows the staff to add or remove a new resource from the database. Other features that the staff will have access to include the ability to control the in-coming and outgoing of library resource, contact students, and run interference when needed. Librarians can also access the application's backend to investigate any problems, such as canceling Issue Requests that students issued in error. The QR code may replace a lot of the work associated with checking people in and out and maintaining records, so while some staff supervision and regulation is still necessary, the quantity of staff work required will significantly drop. The student interface will be the project's main focus.

Upon launching the application, the user is redirected to the welcome screen, where they can select to reset their application password, sign up, or login. When registering, new users have the option to enter personal data such as name, student ID, and cell phone number. Following a successful registration, the user is taken to the homepage. The homepage is the application's home screen, from which the user can access all of its core functions, including checking the status of a library resource issue, returning or extending its loan period, and issuing and searching library resource.

The program stores resource(s), manages all incoming and outgoing resource transactions, authenticates users, and registers users using the Firebase database. Before being saved, all of the data is encrypted, which lowers the likelihood of hacking vulnerabilities.

A. Features

The system has four primary features, which were covered in the preceding subsection: searching library resource, managing library resource, issuing library resource, and returning library resource. Two functions that call for the usage of the QR code scanner integrated into the application are the issuing and returning of library resource.

➤ Search for Library Resource

User can search the library's resource collection with this capability. They can look for library resource availability, peruse various genres, and become familiar with the library. Since the user would otherwise need to visit the library in order to simply pick up the library resource, this saves them time and energy. For instance, a user can use the program to check the availability of a book on a bad weather day instead of going to the library in person to find out if it's available. This saves lots of time, effort and resources.

➤ Issue Library Resource

Pressing the "Issue Library Resource" button causes the Android phone's rear camera to open. The program then looks for a QR code on the library resource to begin the library resource -issuing procedure. Once a valid QR code has been scanned, the application decrypts the data contained within and retrieves pertinent library resource details from the database. The book's due date is then computed automatically because the amount of time is determined by how well-liked the library resource is.

The popularity is determined by counting how many requests there have been to borrow the library resource, for instance: A history book has lower demand and can be checked out for a month, but Harry Potter is so popular that many students want to borrow it for a week. With just a single click, the user can issue the book because the due date is determined using the current date.

➤ Return Library Resource

By using the return function, the user verifies that a library resource is being returned. The returned library resource will be arranged on a real shelf next to the desk of the librarian.

When a library resource is returned, the library staff is notified, and they may confirm the return by scanning the QR code on each book. The application keeps tabs on the due date via the database and determines if the library resource is returned prior to or subsequent to that date. If the resource is returned after the due date, the user is informed and the fine is computed appropriately. A ₦100 fine is assessed for books that arrive late by 1-4 days, a ₦200 fine for books arriving late by 5-29 days, and a larger penalty of more than one month is due by the student.

➤ Manage Library Resource

This function is crucial since it controls library resource movement and deters theft in the library. The library staff is the only one with access to it. It gives a list of library resources that are coming in and going out and alerts the staff when a library resource is past due.

Staff members may decide to prevent a user from releasing library resources going forward if they learn of potential library resource mistreatment. The staff can also use it to administer the database, add new library resource, and change existing library resources.

➤ *Time Period*

Although the feature is exclusive to this application and is dependent on library resource popularity, it is not a main button. The number of requests (n.r), or the number of persons interested in borrowing a library resource, is used to determine how popular the library resources is. Three time intervals are distinguished: one week ($n.r > 10$), two weeks ($n.r > 5$), and three weeks ($n.r < 3$). This attribute corresponds to the quantity of the same book that is on sale. In the library, every library resource has a different QR code. For instance, because Python Programming I is so popular ($n.r > 10$), users are only permitted to utilize it for a single week.

➤ *Database*

The Firebase database houses the metadata and user data for every library resource. Every library resource has a unique QR code that is produced from its metadata and is kept in the database. Every book is saved according to four criteria, as illustrated in Figure 3. You can search the library resource using its publisher, author, year, and title. A brief abstract is also included with the book search to provide some background information about a library resource. The database is exclusively accessible to library employees. The librarian is informed of any modifications to the library resource inventory. This keeps library resources safe from thieves and guarantees that they enter and exit the library without incident.

IV. TEST STRATEGY

The Federal Polytechnic Bauchi library will be used to test the application. For testing, a set of two hundred (200) randomly selected experimental library resources are taken into consideration. It will be necessary for at least one person to register, log in, and utilize the many functions. The experiments listed below are ones that the application needs to pass:

A. *Access System*

The user creates a new account, and if they are able to log in successfully, the login mechanism appears to be working. After their registration is approved, the individual receives an email. In addition, the "forget password" button generates a new password by email. Approximately 20 students will register and validate whether they receive emails in order to ensure the efficiency of the login system. If a user tries to register with the same registration number again, for security reasons, the new user registration should fail because the login account is already active. Since there are just three or four library employees, they will be prompted to confirm that they received notice of new user registrations by logging into the library application. Making sure that a student ID is turned down in the library application is also crucial.

B. *Include Library Resource*

A library resource was added to the database from the sample resources collection. Since the feature isn't present in the student application, this test is solely for the librarian application. We will use the "search button" function to look for the same library resource to make sure it is correctly added. The same library resource can be tried to be added again to verify security; if the system rejects the library resource, it verifies that each library resource stored is independent of the others.

C. *Library Resource Search*

All 200 of the library resources that are kept in the database should be searchable by the user. A concise synopsis of the book should be provided in the search result. Any attribute in the library resource can be used by the user to search it. Users should be able to search if it is books by publisher, author, year, or title, and the database should return the necessary book. A brief synopsis of a book is also displayed along with the search function, since the purpose of this feature is to allow users to explore the library's content.

D. *Library Resource Issue*

Try to borrow a library resource from the library by scanning the library resource's QR code. Each of the 200 library resources will have a distinct QR code.

Two copies of the same library resource will be included in the sample size because it is crucial to guarantee each library resource is independent. The library resources ought to be available for independent library resource borrowing by two students. All volumes are available for two-week loan for the experiment. A user has the option to request an extension of the time that the library resource is issued to them. We'll test this feature by adjusting the time period to a couple of hours. A borrowed library resource may be reissued for an additional hour if a request for an extension is made within 30 minutes of the original release.

V. CONCLUSION

The QR code implementation and SLMS application have been developed and tested: The implementation of the QR code, library management, login, and profile data has been completed successfully. The list of library resources is always updated each time a user checks out a library resource from the library. 200 library resources were used as a sample data set to evaluate the technology. Using a smartphone, the test user was able to check out and return library resources as needed and search for library resource at their convenience. With the effective implementation of the SLMS via QR codes, students can now utilize libraries more effectively and on their own. The number of library employees needed to run a library was greatly decreased by using SLMS. Future work will include SLMS security and a machine learning-based search option recommendation.

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