Integration of Web-Based and Mobile Application with QR Code implementation for the library management system

Marina Md Din¹, Ahmad Fazal Fazla²

Institute of Informatics and Computing in Energy (IICE)
Universiti Tenaga Nasional (UNITEN)
Putrajaya Campus, Jalan Ikram-Uniten
43000 Kajang, Selangor, Malaysia.

marina@uniten.edu.my

Abstract. In recent years, the various institution has adopted the use of two-dimensional bar codes which are also known as Quick Response (QR) Code for information dissemination which can be decoded using smartphones, digital tablets, and other electronic devices. One of the institutions' benefits from QR usage is the libraries to promote their services as well as in asset tagging. This paper proposed the use of QR codes on the existing library system in one of the private higher learning institutions in Malaysia for fast data retrieval at a minimal cost. Random functional acceptance tests (FAT) were conducted and improvements were made accordingly. In this proposed work, the physical location of the library assets can be found easily, fast retrieval of information, and hence the unnecessary wastage of time is avoided.

1. Introduction

The use of Quick Response (QR) Codes has proliferated in the advertising and marketing strategies affiliated with the explosive use of smartphones in our daily lives. There are a huge variety of mobile phones with different features and capabilities. Phones with a camera are most popular in used nowadays where businesses or institutions start to utilize this feature by having implemented the QR feature in most of their marketing and advertising purpose to disseminate information. The COVID-19 pandemic has propagated a safe, touch-free dining experience to limit contact from one another to curb the spread of the virus. Digital menu QR Codes are incorporated onto the tabletops of any restaurant or eatery so customers can simply scan the QR Code to view the menu, place their order, and enjoy their food promoting a safe touchless experience. Some of the most popular eating joints that have switched to digital menu QR Codes are K-Fry, KFC, and McDonald’s. QR codes have characteristics that allow companies to share information with their customers in a quick and hassle-free way. It can handle different types of data such as numeric (digits 0 – 9), characters and symbols (letters A–Z, blank space, %, * +, -:, /, _ $), kanji, kana, hiragana, binary and control codes (Ascii and others) [1]. Scan the QR, may encode information such as URLs, a map of a location, assets details with its location, as well as for the registration of an event. All can be done in a short period. Its capability of 360-degree readability [2] makes it possible to be scanned from an angle via the QR scanner on the mobile phone. This introduces a flexible representation of QR code where shapes and colors can be changed, even allowing for artistic representation. QR codes have superior information storage capacity when compared to one-
dimensional barcodes. Finally, QR codes are compatible and can be read by any smartphone, tablet, or laptop with a camera using freely available software [3].

In this work, we implement the QR code technology in the existing library system at one of the private higher learning institutions in Malaysia by taking advantage of all its features at a minimal cost. QR code helps the users to keep track of the books. The user can know if the books are on loan or available on the library premises. This development helps users to locate the books quickly and avoids unnecessary delay in searching the books, unlike the manual method. The information embedded in the code attached to the library materials is readable by the QR scanner on a mobile phone. As this technology is low-cost, convenient, easy to implement, and easy to use, there is no doubt that in the future it will be expanded to other areas of interest.

Universiti Tenaga Nasional (UNITEN) existing library reservation service allows users i.e. students and faculty members to reserve materials that have been borrowed or loaned by other users, materials that are located within the premise but inconvenient for them to retrieve, or materials that have been ordered but have yet to receive by the library. However, any materials that can be found within the library premises cannot be reserved by the users. Meanwhile, the existing library borrowing service can be considered outdated because users are required to manually present the materials that they intended to borrow to the library administrator located at the library’s information and services counter before leaving the library. With that being said, through this project, the proposed application is developed to enhance both services by introducing a procedure involving multiple applications integrated with QR code technology. The procedure is conducted via two mechanisms; a web-based and a mobile application.

Section 2 of this paper elaborates on the current situation of asset tagging of the library materials in the institution. Section 3 discusses the system architecture of the proposed library system with QR code implementation. Section 4 exposed the design and setup of the proposed system and lastly, the conclusion is expressed in Section 5.

2. Current asset tagging implementation

2.1. UNITEN Information Resource Center (UIRC): Borrow and Reservation Procedure

The Universiti Tenaga Nasional (UNITEN) library system is known as UNITEN Information Resource Center (UIRC). It is a web-based application that provides a wide range of library services for library users enabling a high standard of learning, teaching, education, and research in the university. There were two methods implemented in the process of locating and retrieving the materials. The first method is based on own experience manually locates and retrieves the materials located in the library. This method utilizing the Library of Congress Classification Scheme (LCC), Information and Services counters, etc. may be helpful to the library users when locating the materials. The second method is by accessing the UNITEN’s library web application. The developer had the opportunity to use the IRC search (OPAC) features to search for materials available in UNITEN’s library.

Based on the first method, it was found out that LCC is prominently displayed at each level of the library to assist library users in locating the materials. The LCC can be defined as a classification system to organize and store the materials by using letters and/or numbers so the materials on the same topic are together. Figures 1 & 2 are samples of the LCC which can be found at level 5 in UNITEN’s library.
Figure 1. UNITEN’s Library of Congress Classification Scheme (LCC) with alphabetical order from (Q - Z)

Figure 2. UNITEN’s Library of Congress Classification Scheme (LCC) with a combination of alphabetical and numerical letters

Figure 1 shows the LCC in alphabetical order from Q to Z. In this figure, the letters represent classes or main class and each class represents a subject area; i.e. science, medicine, physics, chemistry, etc. Meanwhile, figure 2 shows the LCC in both alphabetical and numerical letters i.e. QA 76.73 C15 P47 and QA 76.73 J38 C47. These letters seen in figure 2 represents the subject area that falls under the main class as in figure 1.

Figure 3. Explanation of LCC for both alphabetical and numerical classification

The letter QA represents the mathematics subject area. It is a sub-class to the main class of Q which represents the science subject area. Meanwhile, the letters i.e. 76.73 J38 C47 and 76.73 C15 P47 represent a specific subject area that falls under the subject area of sub-class QA. 76.73 J38 C47 represents the C programming subject area. Meanwhile, 76.73 C15 P47 represents the Java programming subject area. The whole shelves which have the LCC shown in figure 3 contain materials.
related to C and Java programming subjects. Using this method, there is a need to understand the meaning behind each alphabetical and numerical letter that is used to construct the LCCs. With that, locating materials manually at the library has proven to be time-consuming especially for library users who are not familiar with the LCC classification scheme. LCC can be difficult for some users in this case.

The second method of locating the materials was accomplished by accessing a web-based library system. This method has been proven to be a quicker and easier way of locating the materials. The web application provides a feature called online IRC search (OPAC) which allows library users to search for all library materials available in UNITEN. Figure 4 shows the IRC Search (OPAC) features provided in UNITEN’s library web application.

![IRC Search (OPAC) feature provided in UNITEN’s library web application](image)

Figure 4. IRC Search (OPAC) feature provided in UNITEN’s library web application

However, this method only allows the user to search for the materials’ information. Users would have to manually locate and retrieve the searched materials at the library using the LLC method. With regards to the reservation process, there are features called “Place Hold” and “Add to your cart”. Both appeared after the web application returns the search result made by the user. This is shown in Figure 5.

![Result of search, Place hold feature and Add to your cart feature in UNITEN’s library web application](image)

Figure 5. Result of search, Place hold feature and Add to your cart feature in UNITEN’s library web application

The place holds feature allows users to reserve the materials that have been borrowed or loaned out from the library. This feature can only be accomplished using this web-based application. The user needs to provide the holder and the holder’s materials details in the application for reservation purposes. However, the materials that are available or have not been borrowed or loaned out from the library cannot be reserved. On the other hand, the Add to your cart feature enables the user to select multiple materials they wanted to reserve.
3. UIRC System Architecture

This project enables library users i.e. students and faculty members to reserve and borrow materials that are available in the library. Figures 6 and 7 show the graphical illustration of the overall architecture for both reservation and borrowing procedure as introduced in [4].

Both procedures are accomplished using two mechanisms;

Through the web-based application and mobile application. The reservation and borrow procedures involve:

a. Library users search for library materials.

b. Make a reservation by specifying the collection date. This feature allows the user to reserve the materials even though it is still on loan. The user only needs to wait for the loaner to return the materials at the counter, and the librarian will store the materials under KIV to be collected by another user (the person who reserved the materials). This feature is more practical and time-efficient in terms of reducing time manually locating the materials.

c. When collecting time arrives, the user goes to Information Counter to complete the reservation process with the borrowing procedure.

d. Users are required to scan the QR code located at the material’s hardcover by using the library mobile application.

e. Once the scanning process is completed, data retrieved from the QR code is processed and the new timestamp is issued.
6

f. If the borrowing procedure is a success, users are allowed to leave the library with the material they have just borrowed.

4. System Design for UIRC

4.1. Web-based application: Administrator

There are two targeted users to this system; administrator and faculty members (users). Five admin roles involve Create, Read, Update, Delete (CRUD) operations:

a. Managing existing and new materials - to perform multiple administrative tasks such as view, update and delete materials as well as generating QR Code for every material.

b. Managing reservation – able to view reservation details made by the library users.

c. Managing borrow procedures - able to view and update both material status and user’s details. This procedure also able to issue a summons for any overdue materials to be returned.

d. Managing uncollected items.

e. Managing users.

The admin is responsible to create or add new library materials for both services offered in this project can be executed, refer to figure 8. Simple and straight forward CRUD operations are used to manage all information.

![Figure 8. Insert library material interface](image8)

![Figure 9. View material details interface](image9)

The administrator thus has the privilege to manage all of these set of information; Material’s title, author, description, publisher, language, publication date, number of pages, category, ISBN, LCC’s location, floor level location, rack number, library location and most importantly the material’s QR code as shown figure 9 and 10. It is known that QR is capable of storing a huge amount of information [5] which makes QR a success.
The following figures 11 until 14 show some interface design with regards to the reservation and borrow material procedures.

Figure 10. Update and delete material interface

Figure 11. View list of users’ reservation details interface

Figure 12. View user uncollected reserved material details interface
4.2. UIRC Mobile application wireframe: User Module

A mobile application with multiple functionalities including a QR code scanning capability was developed to provide a platform for UIRC’s users to reserve and borrow the library’s material. Figure 15 shows the library mobile application wireframe.

There’re several features provided in this mobile application. The first feature is the searching function. This function allows users to search for material by inserting its title in the search field. If the searching hits results, users may choose to view the material’s details and consequently allowing them to proceed with the reservation procedure. Users may complete the reservation procedure by specifying the date of collection. Once the procedure is completed, they can view the reserved material details in the view reservation details features.
The next feature is the scan QR code function. It enables users to scan QR codes that are available on the material’s hardcover which then will allow them to proceed with the borrowing procedure. If the scanning process is a success, the mobile application will be able to retrieve data from the QR code and display them on the mobile application. Once, data are displayed, they can borrow the library material.

4.3. UIRC Mobile application: User Module
Figure 16 shows the user’s homepage which contains six different types of options where each of the options starts an activity based on the user’s selection. Borrow material function was developed using a Java class called Intent, an object that provides runtime binding between two separate components i.e. two activities (page). This option redirects the user to the scan QR code activity whereas the view reservation option takes the user to the view reservation details activity. The view borrow option opens up the view to borrow details. The profile option purposely for the user to view their profile. Finally, the log-out options execute a function that enables the user to exit the application.

Users may search for materials based on category as shown in figure 17. For example, General Works category only displays a list of material where its LCC scheme falls under the main class General Works, any materials that are not included in this class will not be displayed. The purpose of developing such functionality is to ease users when searching for library materials.

Figure 18 shows the list of material under a specific category in a vertical scrollable manner where once a title is selected it displays the material details as shown in figure 19. On this page, the user can view the details and the location of the materials is described shortly and simply, easy for the user to locate it.

Users can reserve and borrow library material through various activities or pages in the mobile application. Any materials that have been reserved by a user cannot be reserved or borrowed by another user. In this situation, two or more users cannot reserve the same material at the same time. To execute such logic, the activity holds a value that determines whether the material can be reserved or not, material status in the material’s details activity represents the mentioned value used to indicate its availability. However, this value changes based on the user’s actions. To make a reservation, the user is required to specify the date of collection to complete the reservation process as shown in figure 20.
The user can cancel the reservation. Such action is composed of multiple CRUD operations which involve deletion of the user’s reservation details and make changes to the availability of material. If the user chooses not to cancel the reservation, the user will be directed to the scan QR page to proceed with the borrowing procedure. Once the scanning process is a success, data from the QR code will be displayed and the user can identify whether the material can be borrowed or not. If the user chooses to borrow the material, it brings the user to the view borrow details page where it has similar functionality as to the view reservation details but without CRUD operation.

5. Software Development

The scope of this work is to enhance the existing library system with additional QR code features for huge data storage, fast data retrieval, and easy to locate materials. This could assist the librarians in more active management of materials in the library. The web application is developed using software composed of several packages known as WampServer. It is a windows-based web development environment that allows the developer to create a web application with Apache2, PHP, and MySQL database. The mobile application is created by using an open-source Integrated Development Environment (IDE) provided by Google which is called Android Studio, the official IDE for android application development which includes features that allow developers to enhance their productivity when building an android application. Tables 1 and 2 summarize all the details of specifications and settings used to develop both web and mobile applications.

| Software packages and version | WampServer 3.1.3 |
|------------------------------|------------------|
| IDE product name and version | Notepad++ 7.8.2  |
| Scripting language and version | PHP 5.6.35 |
| Standard Markup Language and version | HTML5 |
| Stylesheet framework and version | Bootstrap 3.1.0 |
| Server software and version | Apache 2.4.35 (Win32) |
| Database administration software tool and version | PhpMyAdmin 4.9.2 |
| Database system and version | MySQL 5.7.21 |
Table 2. Mobile application tools and technologies specification

| IDE product name and version | Android Studio |
|-----------------------------|----------------|
| Server software and version | Apache 2.4.33 (Win32) |
|                             | OpenSSL/1.1.0g PHP 5.6.35 |
|                             | Port defined for apache: 80 |
| Database administration software tool and version | PhpMyAdmin 4.9.2 |
| Database system and version | MySQL 5.7.21 |

WampServer is the main component for the whole construction of the project’s web application, where multiple components have contributed to specifying types of languages to be used for the user interface (UI) and also for its backend components suits as a communication module between pages and servers.

The use of Android Studio in this project is to construct and build the mobile application. To support application development within the Android operating system, Android studio uses a Gradle-based build system, code templates, and emulator which enables the project’s application to run on any android device. By default, the android studio only supports some databases i.e. firebase, SQLite, etc. However, in this project, we utilize the MySQL database system to store data retrieved from the mobile. Hence, a customized network operation known as Volley is implemented. The customization allows the Android application to make an HTTP request to the Apache webserver running on the host’s local machine. This request allows data to be stored in the MySQL database system.

6. Conclusion

The use of QR code implementation in the library has been discussed. The use of QR Codes in information dissemination has become normal in our daily life. The system was developed to enhance the existing library system without changing the current flow of managing the library materials. The entire system was intended to allow for the reservation of the materials on loan. In addition to this, it is aimed to reduce the need for searching materials solely referring to the LLC. There were approximately 17 functional acceptance test cases that were thoroughly conducted for both applications to detect any defects and corrects them. With acceptance testing, the applications can be delivered once a certain level of confidence is established in the applications and any enhancements can be integrated while undergoing a maintenance period. By taking advantage of the capabilities of QR code that can store a huge amount of data and also capable of speed reading, we enhanced the current UIRC system by implementing QR code.

References
[1] Espejel-Trujillo, A., Castillo-Camacho, I., Nakano-Miyake, M., & Perez-Meana, H. (2012). Identity Document Authentication Based on VSS and QR Codes. Procedia Technology 3, 241-250.
[2] Zare Farashbandi F, Soleimanzade Najafi NS. Quick, Response Code Applications in Library and Information Centers, Jentashapir J Health Res 2014, 5(2):73-78.
[3] https://www.denso-wave.com/en/technology, QR Code development story, [Accessed: 25-June-2019]
[4] Din, MM, Anwar. RM, Fazla, AF (2020). Asset tagging for library system - does QR relevant?, Accepted for International Conference on Computer Engineering and Mathematical Sciences. ICCEMS 2020. 24-25 December 2020.
[5] Rahaman, W. (2016), Enhancing Library Services Using Barcode, QR Code and RFID Technology: A Case Study in Central Library National Institute of Technology, Rourkela, International Journal of Digital Library Services, Vol. 6, pp. 39 - 50.
[6] Muthuselvi, R. (2016), Asset tracking and management system for library using active radio frequency identification (RFID), Biomedical Research-An International Journal of Medical
Sciences

[7] Chow Y.W., Susilo W., Yang G., Phillips J.G., Pranata I., Barmawi A.M. (2016) Exploiting the Error Correction Mechanism in QR Codes for Secret Sharing. In: Liu J., Steinfeld R. (eds) Information Security and Privacy. ACISP 2016. Lecture Notes in Computer Science, vol 9722. Springer. https://doi.org/10.1007/978-3-319-40253-6_25

[8] QR Code Error Correction, 2011, https://blog.qrstuff.com/2011/12/14/qr-code-error-correction, accessed on 2 Sept 2020.

[9] Parabhoi, L., Bhattacharjya, N., & Dhar, R. (2017). Use of QR Code in Library. Applications of Modern Tools and Technology in Library Services, 238-242.

[10] Schultz, M. K. (2013). A case study on the appropriateness of using quick response (QR) codes in libraries and museums. Library & Information Science Research, 35, 207-215.

[11] https://www.pinterest.com/pin/239957486370215132/ One interesting way to incorporate QR Codes. | High School Library Ideas | Library programs, Library book displays, Library shelves, [Accessed:25 June 2019].

[12] Whitchurch, M. J. (2012). A Quick Response: QR Code Use at Harold B. Lee Library. The Reference Librarian, 53, 392-402.

[13] Walsh A. (2011), Blurring the boundaries between our physical and electronic libraries Location-aware technologies, QR codes and RFID tags. Electronic Library [Serial Online]

[14] Shettar, Iranna (2008). Copyright Issues in Digital Media. In K.M. Khan et al. (Eds.). Proceedings of PROFUSE 2017: Professionalism in Library and Information Services for User Empowerment: Opportunities and Challenges (pp 144-151). Mangalore: DLISc, Mangalore University.

[15] Saleeq Ahmad Dar and Margam Madhusudhan (2016), Quick Response Codes in University Libraries: User Expectations for Fast Retrieval of Information at theUniversity of Delhi, Journal of Knowledge & Communication Management, Volume 6, Number 2, October 2016, pp. 114-127, DOI: 10.5958/2277-7946.2016.00010.3.

[16] Lambodara Parabhoi, Nivedita Bhattacharjya and Rupashree Dhar (2017), Use of QR Code in Library, Applications of Modern Tools and Technology in Library Services, pp. 238 – 243.

[17] J. U. Duncombe, “Infrared navigation—Part I: An assessment of feasibility (Periodical style),” IEEE Trans. Electron Devices, vol. ED-11, pp. 34–39, Jan. 1959.

[18] R. W. Lucky, “Automatic equalization for digital communication,” Bell Syst. Tech. J., vol. 44, no. 4, pp. 547–588, Apr. 1965.

[19] S. P. Bingulac, “On the compatibility of adaptive controllers (Published Conference Proceedings style),” in Proc. 4th Annu. Allerton Conf. Circuits and Systems Theory, New York, 1994, pp. 8–16.