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Smart Library Management System Utilizing RFID Technology

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Abstract: American journalist Carl T. Rowan once said, "The library is the temple of learning, and learning has liberated more people than all the wars in history." We believe this quote rings true to this day. Libraries have been a pillar of knowledge for as long as civilizations have existed. Yet, many libraries still struggle to operate efficiently as the librarians manually keep track of every item in the library, book issuing and retrieving, new book entries, cataloging, shelving et cetera. Our proposed Library Management System aims to streamline and automate these library operations. The Library Management System will utilize RFID tags which will be attached to books, and RFID readers placed with the librarian. Furthermore, the LMS also provides a very simple and user-friendly software interface for all the library operations. All aspects of hardware and software are linked to ensure smooth operation on every front. The database is stored in a local MySQL server, ensuring data integrity and security. Our approach to the project was based on prioritising cost-effectiveness and improved accuracy. This project aims to contribute to the modernisation of library operations and facilitate a seamless borrowing and returning process for library users.

Keywords: Library Management, RFID, Arduino, MySQL Database, Docker, Cost-effectiveness, Scalability

I. INTRODUCTION

In today's fast-paced digital age, libraries continue to play a crucial role as repositories of knowledge and sources of learning. However, many libraries still grapple with manual processes and outdated systems that hinder their efficiency and effectiveness. The manual tracking and management of library materials is a time-consuming task that places a significant burden on librarians. This limits their capacity to offer an optimal user experience and drains their resources[1]. In many digitally advanced libraries, a barcode scanner is used to perform the library operations. We believe that barcode scanner is a receding technology that does not realize the full potential of the heights to which library technology can reach. So, we hypothesize that the RFID technology is much more efficient, faster, and more reliable than the barcode technology. To address these challenges and leverage better technology, we have developed a Library Management System (LMS) that uses RFID (Radio Frequency Identification) technology[2]. The primary objective of this system is to streamline and automate various library processes, including book issuing, retrieving, cataloging, and inventory management[3]. Our objective is to enhance the efficiency and effectiveness of library operations, freeing up librarians' time to interact with patrons, improve services, and foster a lively learning environment within the library. Our proposed LMS harnesses the power of RFID technology to provide a comprehensive solution that simplifies the day-to-day tasks involved in managing a library, while enhancing accuracy and data integrity[4].

II. KEY FEATURES

The proposed Library Management System incorporates several key features designed to optimize library operations and enhance the user experience. Some of the notable features include:

- 1) **RFID Technology Integration:** By utilizing RFID tags attached to library materials and RFID readers placed strategically within the library, the system enables seamless tracking, identification, and management of books and other resources.
- 2) **Automation of Library Processes:** The LMS automates time-consuming tasks such as book issuing, returning, cataloging, and shelf management[5]. This automation not only reduces manual effort but also minimizes errors and improves overall operational efficiency.
- 3) **User-Friendly Software Interface:** The system offers an intuitive and user-friendly software interface for both librarians and library users. This interface simplifies the borrowing and returning process, facilitates easy search and access to library resources, and enhances the overall user experience.[6]
- 4) **Data Integrity and Security:** The LMS securely stores library data in a local MySQL server, ensuring data integrity and protecting sensitive information[7]. Additionally, the system provides access control and security features to prevent unauthorized access and theft of library materials.

III. HARDWARE ARCHITECTURE

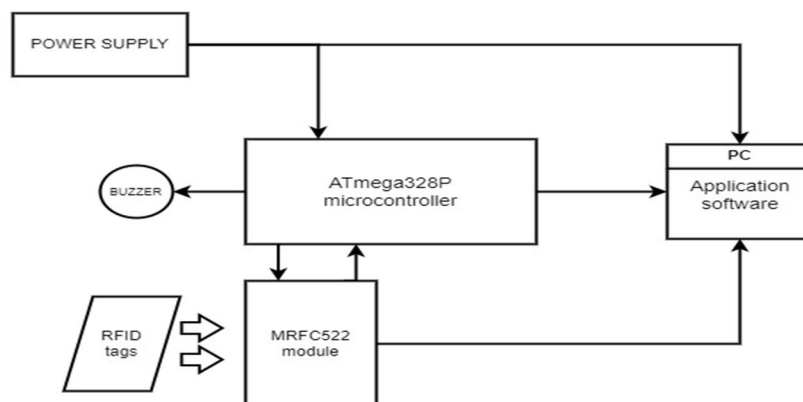


Figure 1- Hardware Architecture

The above block diagram depicts our hardware architecture. We have used an Arduino UNO as the primary microcontroller, interfaced it with MFRC-522 reader module in order to read MiFARE HF 13.56 MHz Passive RFID tags, a buzzer is added to system for generating audible alerts and in this manner this hardware system is connected to a computer. The system works in such a way that, RFID tags are read by the reader module and corresponding details to RFID ID are retrieved from a database stored on the computer.

- 1) *Arduino UNO Microcontroller:* We have used Arduino UNO[8] as the primary microcontroller of our hardware system as it is easy to incorporate, the Arduino UNO is responsible for controlling and executing the outcome model of the system.
- 2) *MFRC-522 RFID Reader Module:* Our hardware consists of an MFRC-522 RFID[9] reader module. This module is used to read data from MiFARE High Frequency 13.56 MHz passive RFID tags. Then it communicates with the Arduino UNO board to send and receive data from the RFID tags.
- 3) *MiFARE HF 13.56 MHz Passive RFID Tags:* Our projects involve use of 13.56 MHz passive RFID tags[10]. These tags are passive, meaning they do not require an internal power source and rely on the energy from the RFID reader to operate. The RFID reader module can read the data stored on these tags.
- 4) *Buzzer:* We have included a buzzer in our hardware, which is connected to the Arduino UNO board. The buzzer is used to generate audible alerts or signals based on certain conditions or events in the system.
- 5) *Connection to Computer to access Database:* The Arduino UNO board is connected to a computer. This connection allows the Arduino UNO to read the Unique ID of RFID Tags and communicate with the computer to access its related book details from a database. The database stores information related to the RFID tags, such as book details or user information.

IV. SOFTWARE ARCHITECTURE

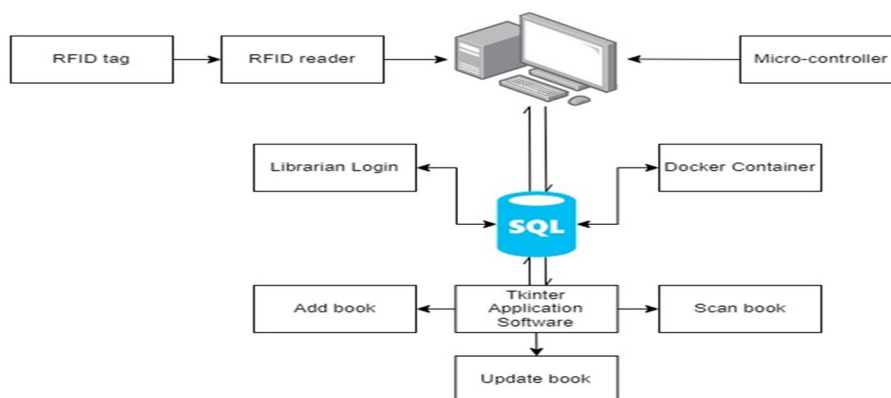


Figure 2- Software Architecture

Our proposed system, Library Management System (LMS) has the above architecture. We have incorporated RFID Technology in our project and integrated the hardware with user-friendly application software, which allows secure log-in, and uses Docker to containerize MySQL database. Our aim is to simplify various library operations such as book addition, updating, and scanning by using our proposed Library Management System.

- 1) *Library Management System Software:* The Library Management System (LMS) software is developed in such a manner that it seamlessly integrates database and hardware for accessing information and carrying out various library operations.
- 2) *RFID Technology:* As mentioned we are using RFID tags which are ready by the Reader module. We have programmed using Arduino IDE to read values of tags and transfer it to our LMS Software.
- 3) *Application Software:* We have developed the LMS software using Tkinter Library[12] in Python3, Tkinter enables the creation of graphical user interfaces (GUIs). The user-friendly software acts as the user interface for the librarians and patrons to access various library operations such as adding a book, searching a book or updating a book.
- 4) *Secure Librarian Log-in:* We have added a secured log-in feature for librarians to prevent unauthorized access to the library resources and LMS. This ensures that only authorized librarians can perform operations within the system.
- 5) *Library Operations:* The system allows automation of tasks such as adding a book, updating a book, searching a book. These options allow efficient execution of library operations by using the Tkinter based software.
- 6) *Database Management with Docker:* The LMS Software is always in sync with the Database. To containerize the database, we have made use of the Docker [13] application which ensures consistent and isolated environments across various systems, docker also will allow scalability. By containerizing the database and its dependencies into a Docker image, it becomes easy to share and deploy.
- 7) *MySQL Server and Docker:* To host the MySQL[14] server within a container, Docker is used. This setup offers flexibility, scalability, and simplified management. Docker's container orchestration capabilities, such as Docker Compose or Kubernetes[15], enable efficient scaling and load balancing of the MySQL server instances. This approach promotes faster development cycles, reproducibility, and streamlined deployment of MySQL databases in various environments.

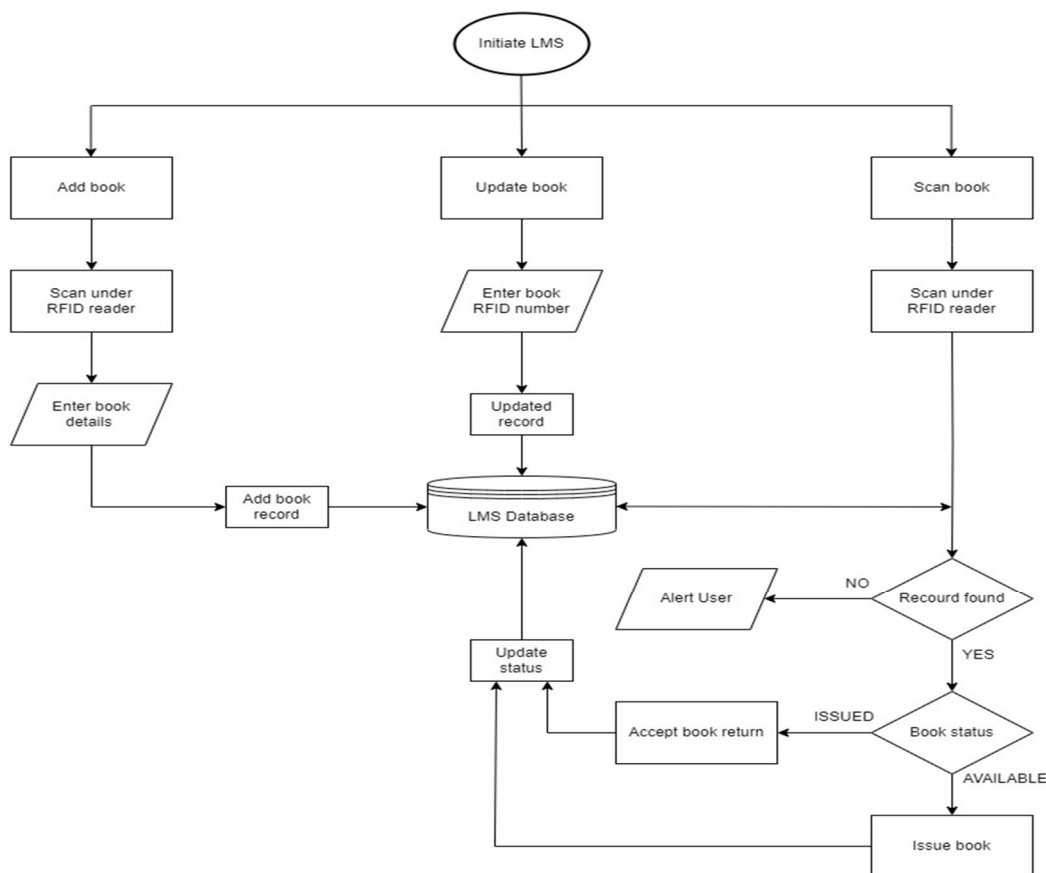


Figure 3- Flowchart of Software Model

The flow involves selecting one of the options (Add Book, Update Book, or Scan Book), performing the necessary actions based on the chosen option, and updating the LMS Database accordingly. The system utilizes RFID scanning, data entry, and database operations to manage book records, status updates, and book transactions.

- 1) *Initiation of the System*: When the Library Management System is initiated, the user is presented with three options to choose from. When we initiate the Library Management System, the following steps occur in flow:
- 2) *Add Book*: If the user selects the "Add Book" option, they are required to scan the book with an RFID tag under the reader. After scanning, the user enters the book details, and the information is added as a new book record in the LMS Database.
- 3) *Update Book*: If the user chooses the "Update Book" option, they need to enter the book number. The user can then update the corresponding record for that book in the database, modifying any necessary details.
- 4) *Scan Book*: If the user selects the "Scan Book" option, they simply scan the book under the RFID reader. The system searches for a record in the database based on the scanned RFID tag value.
- 5) *Record Found*: If a record is found, the system displays the book status. If the book is available, it can be issued to a user. If the book is already issued, the system allows the user to accept the book return and updates the status of both processes in the LMS Database.
- 6) *Record Not Found*: If no record is found for the scanned RFID tag value, the system alerts the LMS user about the non-existence of the book.

V. CONCLUSION

In conclusion, the proposed Library Management System offers a technologically advanced and comprehensive solution for efficient management of library resources. Further, based on our initial hypothesis that RFID exceeds the barcode scanner in terms of advantages, we can firmly conclude that the hypothesis has proven to be correct. It is much more efficient and faster as it can perform simultaneous scanings at once, unlike barcode which can only perform one reading. RFID also does not require a direct line of sight, thereby creating a more accurate and reliable system. Since Tags can be placed inside the books, they are less prone to damage and theft. Also, they can be used as an anti-theft system to prevent book theft. RFID also provides a better automation and user experience than barcode scanner. By integrating RFID technology, user-friendly software developed using Python and Arduino IDE, and a secure database powered by MySQL, containerized using the Docker, the system streamlines various library operations. As explained in the paper, our system demonstrates the seamless interaction between hardware components such as the RFID reader and microcontroller, and software functionalities implemented through modules like MFRC522, Tkinter, and MySQL Connector. The system enables librarians to easily add and update books using RFID scanning, retrieve book information from the database, and facilitate book transactions with accurate status tracking. The use of Docker for containerization ensures portability and simplified management of the system. Overall, the proposed system harnesses the power of technology to enhance resource management, streamline processes, and provide an enhanced user experience for librarians and library members.

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