SMART LIBRARY MANAGEMENT SYSTEM: A SURVEY

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Abstract

"Everything you need for a better future and success has already been written. And guess what? All you must do is go to the library" quoted by a RenownedSwiss writer Henri Frederic Amiel. Libraries play a key role in providing access to knowledge, building community Hubs, fostering creativity, supporting Education, etc., however in the present times libraries still encounter hurdles in books circulations,classification,arrangement in the departmental shelves, and books retrieving. The ultimate solution to all these issues is one of the most widely RFID technology. The major focus of this survey paper is to optimize library workflows through automation. The main aim of this paper is to present different methodologies used by library management system for increasing the effectiveness, rapidity, and reliability to meet the technological standards.

Key words: Library, community, RFID, management, reliability

Introduction:

The major objective of this paper is demonstrating the role of RFID technology Libraries are a main source of knowledge as they allow information flow across various fields. Initially libraries used barcode technology that had many limitations like they required direct line of sight, limited data storage, security concerns, etc but as technology advanced RFID tags proved to be efficient than that of barcode scanners as RFID tags perform simultaneous scanning at once, they do not need a direct line of sight, they can be used as anti-theft system to prevent book theft etc., Most of the technologies used have an integration of both hardware as well as software. The Hardware part includes RFID Tags, reader modules and different processing units, while the software part includes usage of multiple programming languages which are freely accessible. There are multiple databases used that provide high level safety from preventing data leakage. The in enhancing the user experience, present the integration of RFID technologies with the growing technologies IOT, AI etc.,

Methodologies:

1. **Smart Library Management System Using RFID and IoT Technologies**

The smart library management system implemented in this project utilizes a two-module approach powered by RFID and IoT technologies. The first module automates the check-in/check-out process through RFID-based tracking. Each book is embedded with an RFID tag, and RFID readers installed at entry and exit points logbook movements in real time. The second module focuses on intelligent shelving. Department-specific RFID sensors, in conjunction with ESP328 microcontrollers, detect if a book has been placed in the correct location. If a book is incorrectly shelved, a voice module provides immediate auditory feedback to alert the user. A web-based application developed with HTML, CSS, and

JavaScript offers a user-friendly interface to monitor book status and location, while a Python-powered backend handles data processing and system logic. Python IDLE was used for development and testing to ensure robustness.

The outcome of this implementation is a highly efficient and user-friendly smart library system that reduces book misplacement, enhances catalog accuracy, and accelerates borrowing and return procedures. The integration of real-time tracking and voice-assisted shelving significantly improves organization and security. Users benefit from a more interactive and responsive environment, while librarians experience a reduced manual workload. Overall, the system transforms a traditional library into a dynamic, technology-enhanced space that better serves the needs of modern readers and educational institutions [1].

2. Library Management System Using RFID Technology

The proposed RFID-Based Library Management System employs passive RFID tags attached to each book and RFID readers placed at strategic points within the library. When a user wishes to borrow or return a book, the RFID reader scans the tag, automatically recording the transaction in the system without manual entry. The RFID tags store essential book information such as title, ID, and status, which is read electronically to facilitate quick identification. The system is also programmed to calculate and display fines automatically based on the duration the book has been checked out, ensuring accountability and reducing manual error. To ensure system reliability and performance, high-quality RFID readers and tags are used, and the information encoded on each tag is carefully structured to support traceability and accurate data retrieval.

The implementation of this RFID-based system significantly enhances the speed and accuracy of library operations. It streamlines book issuing and returning processes, reduces human error, and minimizes the need for staff involvement in routine tasks, allowing them to focus on more user-centric services. The system improves security by reducing the chances of book theft and enables real-time tracking and inventory updates. Additionally, it ensures timely fine calculations, accurate record-keeping, and easier book searches, ultimately transforming library management into a more efficient, automated, and user-friendly process [2].

3. Effectiveness of RFID Smart Library Management System

The study implemented a Smart Portable Library Management System (SPLMS) at Perusahaan Raja Tun Uda (PRTU), designed to enhance traditional library operations through the integration of UHF RFID technology. The system was developed with a user-friendly dashboard allowing librarians to manage book inventories, perform research, and delete records efficiently. The core of the study focused on testing the performance of the ZK-RFID101 reader by analyzing how different angle adjustments affected its ability to read RFID tags placed on the spines of books. System testing was conducted at various distances (1 to 6 meters) and angles (0° to 90°) to evaluate the reader's success rate. The tests revealed that while the reader achieved a 100% success rate at distances between 1 and 3 meters, performance dropped to 80% at 5 to 6 meters due to radio frequency interference. Importantly, increasing the reader's angle from 0° to 90° significantly improved its tag-reading capability, identifying 90° as the optimal angle for performance.

The implementation of the SPLMS successfully modernized the library's management capabilities by streamlining book tracking and improving operational efficiency. The study's findings highlighted the critical role of RFID reader placement and angle adjustment in ensuring optimal system performance. The results provided clear evidence that properly adjusting the angle of RFID readers can enhance tag readability, even in challenging conditions. However, issues with certain tags indicated a need for further optimization in tag design, placement, and antenna configuration. Overall, SPLMS not only improved the efficiency and productivity of library staff but also laid the groundwork for future research into refining RFID integration in library environments [3].

4. RFID Based Library Management System

The proposed RFID-based Library Management System automates and streamlines the core operations of library management by integrating Radio Frequency Identification (RFID) technology. Each book, journal, CD, or other library item is tagged with a unique RFID identifier, which is mapped to a centralized database containing detailed metadata about the item. RFID scanners are installed to read these tags without physical contact, enabling quick check-in and check-out processes. Users can log in to the system after registration and perform various functions, such as issuing and returning books, tracking the location of specific items, and viewing their personal transaction history. The system also includes an administrator module for librarians, which supports issuing and returning books, adding or updating item records, managing user accounts, monitoring overdue books and fines, and replacing damaged tags. The system design ensures that all transactions are automatically updated in real time, enhancing traceability and efficiency.

The implementation and testing of the system among various users demonstrated that the RFID-based Library Management System significantly improves operational efficiency and user satisfaction. It reduces manual workload, eliminates the need for physical book scanning, and speeds up item location and tracking. Librarians found the system intuitive and helpful in managing inventory and user records, while users experienced smoother and faster library transactions. The automation of routine processes also enhanced library security and accuracy in record-keeping. Overall, the system proved to be a reliable and effective solution for modern library management, making operations more secure, user-friendly, and data driven [4].

5. Developing RFID library systems in the direction of integration into the global identification system EPC

In his study, Igor Timoshenko explores the integration of RFID-based library systems into the global EPC (Electronic Product Code) identification framework, proposing a methodological shift in the regulatory standards that govern RFID use in libraries. The method implemented involves an in-depth analysis of existing international RFID standards—particularly ISO 28560—and their compatibility with the EPCglobal Network standards. Timoshenko examines the evolution of both HF and UHF RFID systems, identifies inconsistencies within ISO 28560's parts, and proposes harmonization through the adoption of EPC-compatible formats for both frequency bands. He supports this with technical analysis, including tag memory structure compatibility, dual-frequency reader feasibility, and real-world applications of EPC encoding in libraries and supply chains.

The outcome of this methodological approach demonstrates the practical and strategic viability of aligning library RFID standards with EPCglobal protocols. Timoshenko's findings reveal that such integration would allow libraries to reduce RFID implementation costs, reuse tags from earlier supply chain stages (e.g., publishers), and seamlessly connect with broader identification systems like IoT. The study emphasizes that interoperability between HF and UHF systems is achievable and essential for expanding library services, improving cataloging accuracy, and enabling efficient interlibrary loans. Overall, the work provides a blueprint for transforming libraries from isolated systems into globally connected, technologically advanced knowledge hubs [5].

6. Library Management System Based On RFID Technology And GSM

The study implements a library management system based on **RFID technology** integrated with an **Arduino microcontroller** and a **Microsoft Access database**. In this system, each book and library user are assigned a unique RFID tag. When a tag is scanned by the RFID reader, the Arduino processes the tag data and communicates with the database on a personal computer to manage and track book transactions. The system automates book identification, issuance, return, and tracking, minimizing manual effort. It also supports **self-check features** for users and staff to manage books independently. The RFID setup reduces the workload of administrators and improves book search efficiency for users. Additionally, the project outlines future integration with **web technology**, aiming to develop a web-based platform that enables users to search for available books online via computers or mobile devices.

The outcome of this implementation was successful, as the system was deployed in a university library and showed **satisfactory performance** in automating routine tasks, reducing book misplacement, and enhancing the user experience. The planned extension involving web technology is expected to further improve accessibility and system functionality, positioning RFID as a scalable and efficient solution for both small and large library environments [6].

7. RFID Based Library Management System

The study explores the implementation of a **Radio Frequency Identification (RFID)-based Integrated Library Management System (ILMS)** aimed at enhancing efficiency, security, and user experience within libraries and information centers. In this system, RFID tags are affixed to library materials, and RFID readers are used at various service points including **self-check-in/check-out kiosks** and **external book drop stations**. These components are integrated with the library's digital database to automate book lending, returning, inventory tracking, and theft prevention. The RFID infrastructure reduces the dependency on manual processing by library staff, enabling them to focus more on user engagement and advanced library services.

The outcome of this implementation demonstrates significant improvements in operational efficiency, item tracking, and user convenience. Libraries benefited from **reduced queue times**, **enhanced security**, and **streamlined inventory management**. The technology aligns with Dr. S.R. Ranganathan's fifth law of library science"Library is a growing organism"by supporting the scalable expansion of resources and services. Overall, the adoption of RFID within ILMS has proven to be a practical solution for modern libraries, offering both innovation in service delivery and enhanced capabilities for library staff [7].

8. Smartlib using RFID and Android

The paper **"Smartlib using RFID and Android"** outlines the development of a smart library management system integrating **RFID technology with an Android-based application** and a **Virtual Private Network (VPN)**. The system architecture connects students and faculty (clients) to the central library server (admin PC) via a secure network, allowing real-time access to the library database. The librarian manages data such as book inventories, user information, and issue/return transactions through a PHP-based server interface, while users interact through an Android app that provides services such as **viewing available books, searching titles, requesting books, and returning books**. RFID tags attached to library items enable quick and contactless identification and tracking of books, facilitating efficient **self-check-in/check-out**, enhanced security, and accurate stock verification.

The outcome of this implementation demonstrated that the system significantly **reduced manual workload**, minimized user waiting time, and improved the overall **efficiency of library operations**. It enhanced the user experience by enabling remote access to the library catalog via mobile devices and allowed the staff to manage book transactions with greater speed and accuracy. Furthermore, RFID integration improved **anti-theft measures and document tracking**, and the Android app ensured users could check book availability before visiting the library. The project was found to be a practical, user-friendly solution that modernized library management while providing scalable benefits across educational institutions [8].

9. Library Management Robot with Line Following Navigation and RFID Based Book Identification

The Library Management Robot (LMR) employs a combination of **RFID technology**, **infrared (IR) sensors**, and a **servo-controlled robotic arm** to automate the process of book retrieval in libraries. The system is powered by an **ESP32 microcontroller**, which processes real-time sensor data, controls navigation and motor functions, and facilitates communication with a **mobile application**. The robot follows a **line-guided path using IR sensors** to reach a designated bookshelf. Once at the location, an **RFID reader** on the robotic arm identifies the correct book. The arm, equipped with **servo motors and a gripper**, then retrieves the book while minimizing the risk of damage. Users interact with the system through a **custom Android app** that allows them to search for and request books remotely.

In testing, the LMR successfully demonstrated its ability to **accurately identify, locate, and retrieve books**, proving its effectiveness in reducing manual labor and streamlining library operations. While some limitations were noted—such as difficulties in gripping books of various sizes, restricted RFID reading range, and battery constraints—these did not significantly impact performance. The system's integration of automation with user-friendly mobile interaction offers a **scalable and efficient solution** for modern library environments. Future improvements like **AI-driven navigation and enhanced gripping mechanisms** could further optimize its functionality [9].

10. RFID BASED SMART LIBRARY

The proposed RFID-based library management system integrates **RFID technology with IoT and web-based platforms** to enhance library circulation and reduce manual workload. The system uses **RFID readers and passive RFID tags**, which are attached to books and library

ID cards. These tags store encrypted information that can be read electronically, enabling quick identification and processing. A central **RFID middleware layer** connects the RFID hardware to the library management software, ensuring seamless data exchange and real-time updates. Users can **scan their RFID-enabled ID cards** to access the system, browse available books via an interactive interface, and get books issued without the need for physical interaction. The system also **automatically tracks due dates and calculates fines** for overdue returns, streamlining circulation tasks.

The outcome of the implementation is a **more intelligent and automated library system** that supports contactless book browsing, efficient check-in/check-out processes, and better transaction management. It enhances the overall user experience for both students and staff by reducing queues, minimizing errors, and improving book tracking. The architecture is **scalable and efficient**, making it suitable for deployment in schools and colleges. By combining RFID with IoT and web technologies, the system modernizes traditional library operations and fosters a more organized and accessible environment [10].

11. Smart Library System

The Smart Library System (SLS) is developed as a **mobile-based library management application** aimed at modernizing traditional library operations to suit today's smartphone-driven, online environment. The system integrates core functions of a **Library Management System (LMS)**such as maintaining records of users, books, borrowing, and returning—into a **mobile application interface**, allowing for real-time, remote access to library services. The application is designed with user-friendly features that enable students and staff to **search for books, check availability, request books, and monitor due dates** through their smartphones. By focusing on **mobility and accessibility**, SLS leverages information management principles to organize and distribute library-related data efficiently to authorized users.

The outcome of implementing this system is a **highly accessible, on-the-go library solution** that enhances user convenience and streamline operations. Users no longer need to visit the library physically for basic queries or book transactions, significantly reducing congestion and manual workload. The system improves **information flow, data accuracy, and operational transparency**, making it especially beneficial in educational environments. Overall, the Smart Library System delivers a **modern, mobile-first solution** to library management that aligns with current digital trends and user expectations [11].

12. Intelligent library management system

The proposed Intelligent Library Management System (ILMS) integrates **Artificial Intelligence (AI)**, **Radio Frequency Identification (RFID)**, and **Global System for Mobile communication (GSM)** to modernize and streamline academic library operations. The system automates core functions such as **book issuing, returning, tracking inventory, student registration**, and **alert notifications** through a combination of these advanced technologies. **AI** is utilized for predictive analytics and personalized user interaction, enabling the system to anticipate book demand and optimize resource allocation. **RFID** facilitates quick and contactless identification of books and users, significantly reducing the time required for transactions. **GSM** ensures real-time communication by sending alerts and notifications to users about due dates, fines, and availability.

The outcome of implementing this ILMS is a **more efficient, user-friendly, and scalable library system** that reduces the reliance on manual processes and lowers operational costs. Users benefit from **faster service, real-time updates, and enhanced personalization**, while librarians experience a reduced workload and improved inventory accuracy. The system's deployment in a real college library demonstrated its practical success, improving both **workflow efficiency** and **user satisfaction**. Overall, the integration of AI, RFID, and GSM has proven to be a transformative advancement, positioning libraries to better meet the evolving demands of the digital age and provide **equitable access to information**[12].

13. Research on Intelligent Library Management System

The system was developed using the **Struts framework**, an open-source Model-View-Controller (MVC) architecture for Java-based web applications. The key method implemented involved utilizing **Struts' control aspects** to handle user request permissions efficiently, ensuring a secure and organized workflow within the library system. The **Tag lib (tag library)** provided by Struts was leveraged to simplify user interface development, allowing for cleaner and more maintainable code, while improving development speed. Additionally, a well-structured **web page navigation system** was established through a centralized configuration file, enabling clear and manageable connections between different system components. The core modules implemented included the **reader information management module**, **book information management module**, and **library information management module**, each responsible for handling relevant data and operations.

As a result, the use of Struts enhanced the **overall development efficiency, scalability, and maintainability** of the system. The configuration-driven navigation and modular structure allowed for easier updates and debugging, while the Taglib support facilitated rapid UI creation. The outcome was a well-organized, functional, and robust library management system capable of handling key administrative tasks with improved performance and user experience [13].

14. Smart library architecture based on internet of things(IOT) and software designed Networking(SDN)

In this study, a novel architecture was proposed to develop a cost-effective and efficient smart library system using Internet of Things (IoT) and Software Defined Networking (SDN) technologies. The methodology involved designing a cluster-based network topology where SDN was used to manage and optimize the communication between various network components. Passive RFID tags were employed to track and manage books and library assets, while face recognition and image-matching techniques were integrated for user authentication. The proposed architecture was evaluated in two phases. In the first phase, a real-world implementation was carried out in a medium-sized library to assess performance metrics such as processing time, error rate, sensitivity, and specificity. In the second phase, computer simulations were used to evaluate the scalability and network efficiency of the SDN-based routing algorithm based on parameters like Packet Delivery Ratio (PDR), latency, and energy consumption.

The outcomes demonstrated that the proposed system significantly reduced member waiting times and error rates, thereby improving overall operational efficiency. The SDN-based approach proved to be scalable and suitable for large library networks, with notable enhancements in network performance. However, the study acknowledged limitations such as

the small library size and short testing period. Future research could focus on implementing the system in larger environments and extending its application to other smart systems like storage or inventory management [14].

15.Library management system based on IOT

The proposed system adopts Internet of Things (IoT) technology to design a smart and user-friendly library management system aimed at enhancing efficiency while minimizing human effort. The methodology involves integrating IoT-enabled devices, particularly RFID (Radio Frequency Identification) technology, to automate key library operations such as book tracking, check-in/check-out processes, and inventory management. All library devices are connected and centrally managed through an IoT-based platform, allowing staff to monitor and control operations from a single interface. This reduces manual work, improves accuracy, and ensures better resource utilization.

The expected outcome of this system is a modern, efficient, and environmentally conscious library that offers convenience to users and reduces the workload on staff. By automating routine tasks, the system not only improves time and energy efficiency but also enhances user experience. The approach promotes sustainable library management by limiting resource consumption and optimizing human effort. The success and effectiveness of the system will be validated through its real-time implementation, which will provide insights into its practical performance and scope for further enhancement [15].

16.**A study on smart library management system**

The methodology of the proposed system involves the implementation of an RFID-based library automation system to enhance efficiency in book tracking, circulation, and security. RFID tags embedded with microchips are attached to each book, and RFID readers are installed at strategic points within the library to detect and track these tags using radio-frequency signals. Unlike barcode systems, RFID allows for non-line-of-sight reading, which means books can be scanned regardless of orientation or alignment. The system also integrates with Bluetooth-enabled devices to facilitate real-time updates and communication between the RFID readers and the central database. This setup enables automated check-in and check-out processes, efficient inventory management, and theft detection, significantly reducing the manual workload on staff.

The expected outcome of the system is a comprehensive solution that addresses both the tracking and security needs of modern libraries. The use of RFID technology streamlines library operations by speeding up the borrowing and returning process, reducing human errors, and freeing staff to focus on user-oriented services. It also enhances inventory accuracy and minimizes the time spent on routine tasks. Overall, the RFID system improves operational efficiency, provides quick returns on investment, and offers a scalable solution for future library automation, especially as RFID tag costs continue to decrease [16].

17. **Microcontroller Based Robotic Arm Development for Library Management System**

With the advancement of robotics, automation in various industries and processes has become widespread. This project aims to introduce library automation system, which addresses the fulfillment of the objectives of automatic retrieval of queued books, arrangement of returned books on the racks as well as automated updating of the library

database. The proposed system is based on the Arduino microcontroller and python programming Microcontroller based robotic arms are used to fetch books from or return books to the different shelves in the library. The library database is also updated after completion of an action. The uniqueness of the proposed system lies in the fact that it can be applied to any existing library and is capable of handling individual books rather than a bulk. The system aims to bring new dimensions to the concept of library automation.

The proposed system has brought an efficient way to manage libraries. One of the most notable things about it is its versatility, as it can easily be appended to any existing library, and the cost is proportional to the task load. Smaller libraries can be handled by cheaper microcontrollers whereas large scale management may be done using PLCs (especially if the system is applied to maintain store houses in industries). The system can be effectively implemented in medium and large sized libraries for simple and efficient management. It can also find application in other inventory management with minor modifications in programming. The described system reduces time, labor and brings about a safe and innovative way to manage libraries [17].

18.**Intelligent Library Management System.**

The implemented method in this project involves the integration of **Artificial Intelligence (AI)**, **Radio Frequency Identification (RFID)**, and **Global System for Mobile Communications (GSM)** to develop an **Intelligent Library Management System (ILMS)**. The system is designed to automate and enhance key library operations such as book issuance, return, search, and inventory management. RFID tags are used to uniquely identify and track books, enabling quick check-in/check-out processes and real-time inventory updates. AI algorithms are employed to analyze user behavior, recommend books, and manage library data efficiently, while GSM technology is utilized to send automated alerts and notifications to users about due dates, overdue books, or reserved items.

The system interface allows students to search for books, view availability, request and return books, and access their borrowing history. Librarians can manage student records, update book information, and monitor book circulation through a centralized dashboard. This reduces manual data entry and minimizes human error, significantly improving overall operational efficiency.

The outcome of implementing this ILMS in a real college library has demonstrated **substantial improvements in user experience and administrative efficiency**. Book processing time was drastically reduced, queues at the library counter were minimized, and communication with users became faster and more reliable through GSM alerts. Additionally, AI-enabled recommendations and data insights allowed for better decision-making regarding resource allocation and user engagement. Overall, the ILMS proved to be a scalable, intelligent solution capable of transforming traditional library services into a modern, tech-driven system aligned with the needs of today's digital learners [18].

Conclusion

The integration of technologies like RFID, IoT, and AI in library management systems has revolutionized traditional library operations, enhancing efficiency, accuracy, and user experience. These smart library systems automate tasks such as book tracking, check-in/check-out processes, and inventory management, reducing manual workload and

minimizing errors. With features like real-time updates, voice-assisted shelving, and mobile-based interfaces, users can easily access library resources and services. The implementation of these systems has demonstrated significant improvements in operational efficiency, user satisfaction, and resource utilization, transforming libraries into modern, tech-driven environments that better serve the needs of users. Overall, the adoption of smart library management systems has proven to be a practical solution for modernizing library services and improving overall performance.

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