RFID-Based Library Service Automation as Online and Self-Service Support

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Abstract

This study explores the development and implementation of an RFID-based library automation system at Universitas Negeri Semarang (UNNES) in response to the increasing need for efficient, technology-driven academic library services. As the central hub for intellectual and research activities, academic libraries are undergoing significant transformation due to the integration of Information and Communication Technology (ICT). Utilizing a qualitative descriptive approach and system development methodology, the research identifies core user needs, system challenges, and solutions for enhancing service delivery. The proposed system, developed using the Waterfall model with PHP and MySQL, includes digital catalog access, online borrowing and returning, reservation management, and administrative functions. Radio Frequency Identification (RFID) is employed to automate circulation services, reduce manual workload, and improve user experience through self-service stations and real-time tracking. The system also incorporates autonomous features and security enhancements to streamline operations. Findings indicate that RFID-based systems significantly enhance library efficiency, user autonomy, and resource management. However, challenges such as implementation costs and digital literacy gaps remain. The study concludes that RFID technology holds transformative potential for modern academic libraries and offers a replicable model for other institutions seeking to adopt similar innovations.

Keywords: Library; Library Service; Strategic Policy; Rfid System

Introduction

The academic library is universally acknowledged as the intellectual nucleus of a university, serving as a cornerstone for advancing educational and research endeavors. As a critical service unit within higher education institutions, the library assumes a multifaceted role encompassing the provision of scholarly information, the facilitation of lifelong learning, the preservation and dissemination of academic output, and the cultivation of cultural literacy [1]. To ensure optimal functionality and user satisfaction, the effectiveness of library services must be underpinned by robust and responsive information systems [2].

The evolving landscape of higher education, characterized by the pervasive integration of Information and Communication Technology (ICT), has compelled academic libraries to reassess and reconfigure their service delivery frameworks. Empirical studies affirm that strategic promotion of library resources and services enhances user engagement and fosters a culture of informed usage among students, as evidenced in research conducted at the University of Education, Winneba and the University of Cape Coast [3]. Further investigations underscore the transformative capacity of ICT in overcoming traditional operational constraints and facilitating seamless knowledge exchange [4], thereby reimagining the roles of library professionals and the user experience itself [5].

In alignment with this paradigm shift, Universitas Negeri Semarang (UNNES) has articulated a strategic commitment to the development of ICT-based library services. Central to this initiative is the adoption of a web-based digital library system designed to deliver core services—including circulation, reservation, and information retrieval—via digital platforms [6]. Web-based implementations have been shown to enhance user accessibility and engagement, positioning them as pivotal to institutional strategies aimed at modernizing library infrastructures [7].

The successful deployment of digital library systems is contingent upon several interrelated factors. System architecture, information quality, and service delivery parameters collectively influence user perceptions of system usefulness, usability, and affinity [8]. Among the chief advantages of digital libraries are their capacity to provide rapid, flexible, and remote access to both physical and digital collections, thereby extending the reach and relevance of library services [9].

Library automation, understood as the application of technology to streamline and enhance service functions, is instrumental in addressing operational inefficiencies and expanding service capabilities. Automation facilitates the processing of bibliographic materials—cataloging, classification, and labeling—and enables the introduction of innovative services such as virtual reference assistance, digital resource access, and support for distance education modalities.

Moreover, comprehensive access to scholarly resources—ranging from monographs and academic journals to curated databases—remains a fundamental tenet of academic librarianship, enabling users to conduct research and participate in scholarly discourse effectively [10][11]. Reference services, in particular, play a crucial role in assisting users with identifying and locating relevant information sources tailored to their specific inquiries [12]. Technological support mechanisms further enhance this experience by enabling users to navigate and utilize the library's digital platforms efficiently [13][14].

Despite these advancements, ICT-based library services are not without challenges. Technical constraints, such as the selection and maintenance of appropriate software systems, and policy shifts—such as those experienced during the COVID-19 pandemic—have introduced new complexities in service continuity and user access [15][16]. Furthermore, disparities in digital literacy among users pose significant barriers to the effective utilization of digital library services [10]. The adequacy and quality of digital content also remain central to the success of such systems, with insufficient content availability undermining their perceived value and utility [17].

In response to these challenges and in recognition of the library's evolving role within the academic ecosystem, this study seeks to: (1) identify the core needs and systemic challenges associated with library service automation; (2) design a responsive and scalable automation system tailored to address these needs; (3) rigorously test and evaluate the system's effectiveness; and (4) develop comprehensive user guidelines and a functional prototype to support institutional implementation and adoption.

Methods

This study employed a qualitative descriptive approach combined with system development methodology to design and evaluate an ICT-based library automation system at Universitas Negeri Semarang. Data were collected through literature analysis, interviews with librarians, IT staff, and students, as well as direct observation of library workflows. A needs analysis was conducted using thematic coding to identify critical system requirements.

The system was developed using the Waterfall model, incorporating PHP and MySQL for backend development, and was structured to include key services such as digital catalog access, online borrowing and returning, reservation tracking, and administrative reporting. Usability testing was conducted using the System Usability Scale (SUS) alongside qualitative feedback to evaluate user experience and functionality. Ethical clearance was obtained, and participants' confidentiality was maintained throughout the study.

Discussion

1. Needs Analysis

The UNNES Library, also known as Rumah Ilmu, serves as the intellectual heart of the Universitas Negeri Semarang academic community. This facility provides a wide range of printed and digital collections that support academic activities. It also features user-friendly services such as comfortable reading rooms, access to online journals, and multimedia facilities. UNNES Library continues to innovate to meet user needs, including the implementation of increasingly sophisticated digital services. Users can access updated information regarding library hours, collections, and ongoing programs through the official website or social media channels.

The management system at UNNES Library already incorporates RFID technology, representing a significant advancement in collection management. The next logical step is integrating this technology further with other digital services such as a mobile application for user convenience and developing analytical features to monitor collection usage and user needs. This integration can enhance operational efficiency and user satisfaction.

RFID technology has revolutionized library management by increasing efficiency, accuracy, and user experience. RFID systems enable automated tracking and management of library resources, substantially reducing manual labor and errors. RFID tags attached to library items allow rapid identification and tracking through strategically placed RFID readers throughout the library [21], [22]. This system automates processes like check-outs and returns, enabling simultaneous processing of multiple items, which is a considerable improvement over traditional barcode systems [23].

Studies show that RFID system performance may be influenced by environmental factors such as the presence of metal bookshelves, which can result in signal loss. Models have been developed to predict signal loss and optimize antenna placement for improved performance. Additionally, the reader angle plays a crucial role in reading efficiency, with optimal angles significantly enhancing tag read success rates [24].

The benefits of RFID in libraries include time-saving, improved inventory management, and enhanced security against theft [21], [23]. However, challenges like signal interference and the need for robust system design still exist [24]. To realize its full potential, RFID systems must address these limitations and be optimally designed.

2. RFID Service Cycle and Automation

RFID technology automates book lending and return processes, minimizing human intervention and errors. This leads to faster transaction processing and increased circulation rates [23]. RFID tags can store extensive data, enabling libraries to manage due dates, renewals, and fines electronically, thereby simplifying administrative tasks [23]. The RFID system streamlines book circulation, allowing simultaneous item processing, speeding up transactions and reducing staff workload [25], [22].

The use of autonomous robots equipped with RFID technology can automate shelving and retrieval tasks, overcoming challenges such as misplaced items and labor-intensive searches. These robots can interact with users through a web interface, enhancing accessibility and user engagement in library services.

Combining RFID with wireless sensor networks creates a smart library environment, enabling real-time tracking and management of library resources. This integration supports advanced features such as automatic notifications for returns and inventory control, fostering a more efficient library system. Enhanced security features, like automated alerts for unreturned items, provide peace of mind for users and library staff [25].

Implementing RFID-based self-service systems in libraries significantly enhances operational efficiency and user experience. This technology automates various library processes, enabling users to check out and return materials quickly, reducing wait times, and improving resource access. Despite its many advantages, challenges such as initial implementation costs and user training requirements may arise, potentially affecting the overall transition to this technology.

3. System Implementation

Circulation services involve the movement of library materials outside the premises. These services allow users to borrow materials effectively. At UNNES Rumah Ilmu Library, circulation services include borrowing, renewing, and returning books. Users can access these services through Self-Check and Automatic Book Return machines, enabling independent use without librarian assistance.
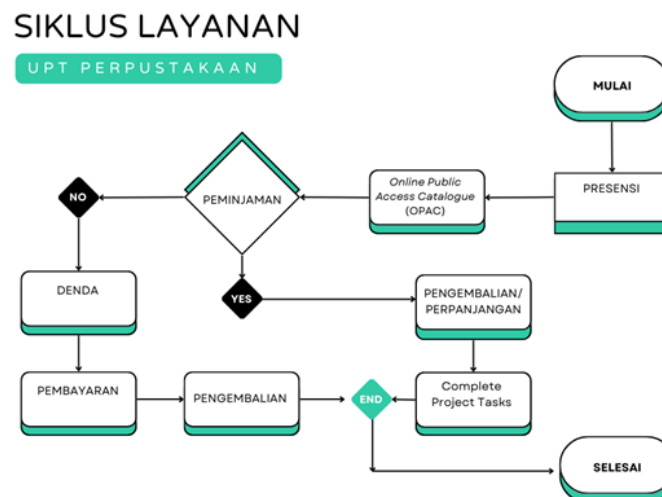

Figure 1: Service Cycle Diagram

The diagram outlines the Service Cycle at UPT Library, starting from user presence, followed by borrowing via OPAC (Online Public Access Catalogue). Successful transactions lead to options for return or renewal. In case of overdue items, users must pay fines before returning books. The cycle ends once all related tasks are completed. This is elaborated in the RFID-Based Circulation Services User Guide.

4. RFID-Based Library Automation Development

Radio Frequency Identification (RFID) is widely used across various sectors, including library management. RFID-based library service automation represents a recent innovation that allows for more efficient and integrated management and service processes. RFID operates by using radio waves to identify and track objects tagged with RFID chips, offering speed and accuracy advantages over conventional barcode systems.

In libraries, RFID replaces barcode systems in managing book collections. Each book is tagged with an RFID chip containing its ID, title, and author. This enables quick, contactless transactions. Users simply place books on an RFID reader, and the system automatically records the transaction. This reduces transaction times and minimizes queues.

RFID also enhances security. Libraries can track books in real-time. If an item exits the premises without proper check-out, an alarm sounds to prevent theft. RFID facilitates efficient inventory tracking: staff can scan shelves with portable RFID readers to check availability and location instantly.

RFID implementation improves user experience by enabling self-service kiosks, letting users borrow and return books independently. This boosts convenience and allows staff to focus on complex tasks like collection management and information services.
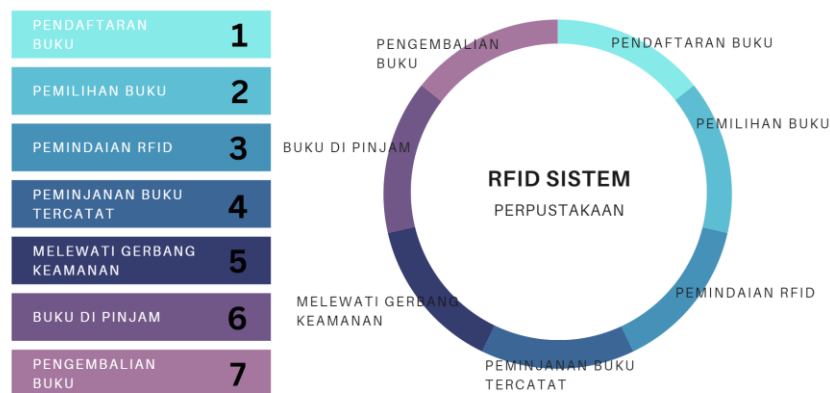

Figure 2: RFID System Flow

The RFID system operates through several steps. First, books are tagged with RFID chips containing detailed metadata, which is stored in a library database. When a user selects a book to borrow, they place it on an RFID scanner. The scanner's antenna reads the tag, and the system verifies the data with the database. If the match is successful and the user is registered, the loan is processed.

As users exit, gate-mounted RFID systems verify transaction completion. If a book hasn't been officially borrowed, alarms are triggered. For returns, users place the book on an RFID scanner, and the system logs the return, allowing it to be shelved or quarantined. Inventory audits are simplified using portable RFID scanners that automatically read tags during shelf walkthroughs.

Conclusion

RFID systems significantly enhance library operations by automating borrowing, returning, and inventory processes. Users benefit from quick, staff-free transactions, while real-time tracking boosts accuracy and efficiency. Enhanced security features prevent theft, and staff workload is reduced, allowing better service delivery. This technology contributes to an improved library experience for all users.

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