

Integrating Koha With Automated Gate Register Systems For Real-Time Library Access Logging

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Abstract—Library access management often relies on manual entry systems that are error-prone and inefficient. An automated gate register system integrated with the Koha integrated library management system has been developed to address these challenges. The system employs real-time barcode scanning to accurately record patron entry and exit events, ensuring that physical access data is seamlessly synchronized with digital records. A modular, layered architecture supports a user-friendly web interface, robust business logic for data validation and error handling, and a dedicated data layer for storing detailed access logs. Extensive testing under high-concurrency conditions has demonstrated rapid response times and high logging accuracy, while user acceptance trials have confirmed the system's ease of use and reliability. The accurate, real-time data facilitates proactive management of library occupancy and enhances security by providing a precise audit trail of access events. Additionally, the rich dataset generated by the system offers valuable insights that can inform operational decisions and resource allocation. Future enhancements will focus on improving scalability and integrating advanced analytics to forecast usage trends, thereby further transforming library operations toward a more dynamic, data-driven model.

Index Terms—Library Access Management, Koha Integration, Real-Time Data Logging, Information Systems, User Behavior Analytics

I. INTRODUCTION

The digitization of academic libraries has necessitated the development of sophisticated, automated systems that optimize resource management, user engagement, and security. Traditional gate register methods, which rely on manual log entries, often result in inefficiencies related to patron tracking, security enforcement, and data analytics. While Library Management Systems (LMS) such as Koha have enhanced cataloging and circulation processes, the absence of real-time entry-exit tracking mechanisms continues to hinder data-driven decision-making and operational effectiveness in academic libraries.

Incorporating multimedia information retrieval techniques within library systems facilitates the seamless exploration and analysis of user interaction data. Effective retrieval systems extend beyond bibliographic record management to include real-time synchronization, intelligent access control, and analytical tools that support strategic decision-making in library administration. By leveraging data-driven methodologies, an integrated gate register system can enhance security, optimize occupancy management, and provide actionable insights that contribute to institutional efficiency.

To address these challenges, a Koha-Integrated Library Gate Register System has been conceptualized to automate access control, synchronize patron logs in real time, and provide an advanced analytics module for library administrators. The proposed system strengthens real-time patron tracking, reinforces security measures, and supports scalability within institutional frameworks, thereby advancing the modernization of library operations. Through alignment with contemporary developments in information retrieval and library automation, this approach presents a scalable framework that improves access control, enhances security, and fosters a data-centric paradigm in library management.

II. RELATED WORK

A substantial body of work has examined the role of open-source software in modern library services. For instance, Barve and Dahibhate provided an early overview of open-source tools, emphasizing cost-effectiveness and adaptability—a foundation that has encouraged further exploration of open-source solutions in libraries [1]. In a more focused study, Hazarika and Ravikumar introduced a gate register tool integrated with the Koha system, demonstrating how automated entry and exit logging can enhance security and operational efficiency in library environments [2].

The adoption and user perceptions of Koha have also been rigorously investigated. Vimal and Jasimudeen explored the implementation of Koha in India, reporting favorable user perceptions while also noting areas

for improvement in real-time tracking capabilities [3]. Complementing these findings, comparative studies by Pruett and Choi and Singh and Sanaman provide a balanced assessment of open source versus proprietary integrated library systems, with a particular focus on customization, scalability, and community support—attributes in which Koha tends to excel [4,5].

Recent deployments further underscore the practical challenges and enhancements in Koha-based systems. Madu, Wada, and Digma detail the technical requirements and deployment experiences of Koha in Nigerian university libraries, highlighting both the system's robustness and the challenges inherent in real-world environments [6]. Similarly, Neupane investigates interface customizations aimed at improving usability, which is critical for ensuring that such systems meet the evolving needs of library staff and patrons [7]. In parallel, Padmavathi and Mohan focus on the acquisition module within Koha, offering insights into streamlining processes and enhancing operational workflows [8].

Beyond traditional library management, the domain of multimedia information retrieval (MIR) has gained prominence as digital libraries increasingly handle diverse media types. Raieli argues for a paradigm shift from text-centric retrieval to content-based approaches that effectively process visual, audio, and video data [9,10]. In support of this view, Gasser, Rossetto, and Schuldt present an integrated system—vitivr—that performs similarity searches across multiple media types [11], while Almunawar proposes a unified model for the retrieval of both images and video clips within digital libraries [12]. These studies demonstrate that advancements in MIR are crucial for enriching user search experiences in modern digital libraries.

Practical implementations also play a key role in bridging theory and practice. Online guides such as those by Lib Power Tech and LibAuto provide detailed instructions for deploying and managing gate register functionalities in Koha, illustrating real-world applications of the research [13,14]. Additionally, composite works summarized by Prasad capture a broader spectrum of research in digital libraries and metadata management, highlighting ongoing efforts to integrate advanced technologies—such as AI and multimedia retrieval—into library automation systems [15].

Together, these studies not only outline the evolution of open-source library management systems and multimedia retrieval techniques but also inform the present work by identifying both the strengths and gaps in existing systems. The insights derived from this literature serve as a guide for the design and implementation of integrated solutions aimed at enhancing operational efficiency and user experience in digital libraries.

III. SYSTEM OVERVIEW AND DESIGN

The gate register system is conceived as a transformative solution to address the limitations of traditional manual library access control methods. Modern academic libraries require accurate, real-time tracking of patron movements to enhance security, optimize resource allocation, and support data-driven decision-making. While the Koha Integrated Library Management System (LMS) has automated many core library functions such as circulation and cataloguing, physical access management remains largely manual. The proposed system extends Koha by integrating an automated module that records entry and exit events using barcode scanning, thereby providing a seamless bridge between physical access and digital records.

Context and Motivation

Historically, library entry systems relied on paper-based logs that were error-prone and inefficient. Recent research has underscored the need for automated solutions that minimize human intervention and improve data accuracy [2,16]. Studies on Koha's adoption have demonstrated its robustness in handling various library processes; however, the gap in automating physical access control persists [3,6]. Moreover, the increasing demand for real-time operational data has driven the need for a system capable of integrating directly with existing LMS infrastructures. This module is designed not only to enhance security by providing a reliable audit trail of patron movements but also to generate actionable insights for library administrators.

Conceptual Architecture

The system is architected with a layered design that emphasizes modularity, scalability, and seamless integration with the Koha LMS. Its conceptual architecture comprises three primary layers:

1. **Presentation Layer:** A web-based interface optimized for both the barcode scanning operation at library entry points and for administrative tasks. This interface is designed for ease of use, ensuring rapid data entry and minimal training requirements.
2. **Application Layer:** This layer encapsulates the business logic. It processes the scanned data, validates patron details by interfacing with the Koha API, and logs access events. Core functionalities include error detection, duplicate entry handling, and precise timestamping.

3. **Data Layer:** The data layer manages interactions with the Koha database. A dedicated table is introduced to store access logs, including fields for patron identifiers, timestamps, access type (entry/exit), and location metadata. This ensures that the module maintains data consistency with the main Koha system.

Design Principles and Integration Strategy

Several design principles have driven the development of the gate register system:

- **Modularity:** The system is designed as an add-on module that enhances Koha's functionality without disrupting its core operations. This modularity supports future updates and the integration of additional features [17].
- **Real-Time Synchronization:** Ensuring near real-time data exchange between the gate register module and the Koha LMS is central to the design. This enables administrators to monitor library occupancy and security continuously [18].
- **User-Centric Interface:** Both patron-facing and administrative interfaces are developed with simplicity in mind, allowing staff with minimal technical expertise to operate the system effectively.
- **Scalability and Extensibility:** The layered architecture ensures that the system can handle increased patron volumes and can be extended with new functionalities as library needs evolve [16].

Integration with Koha LMS

A critical component of the design is the seamless integration with the Koha LMS. Rather than replacing existing functionalities, the gate register module complements Koha by introducing a new data stream for access control. The system retrieves patron information via Koha's API and logs entry/exit events directly into a new table within the Koha database. This tight integration ensures that updates to patron records in Koha are immediately reflected in the access logs, thereby maintaining high data integrity and consistency.

IV. IMPLEMENTATION AND DEPLOYMENT

The practical realization of the gate register system involved transforming design concepts into a robust, production-ready module that integrates directly with the Koha LMS. This section describes the development environment, coding practices, deployment procedures, testing strategies, and how recent studies have influenced the approach taken while designing this system.

Development Environment and Tools

The system was developed on a Linux (Debian/Ubuntu) platform with Apache serving as the web server, and PHP as the primary programming language. MySQL—already in use by Koha—was employed for database operations. Table 1 summarizes the key components of the development environment.

Table 1 Development Environment and Tools

Component	Specification/Tool
Operating System	Linux (Debian/Ubuntu)
Web Server	Apache HTTP Server
Programming Languages	PHP, HTML, CSS, JavaScript
Database System	MySQL (integrated with Koha LMS)
Barcode Scanner	USB-based

Coding and Integration Strategy

The module was implemented as an independent add-on to extend Koha's capabilities without modifying its core functions. The coding strategy emphasized:

- **Modular Architecture:** The codebase was segmented into modules for user interface, business logic, and database operations. This separation of concerns facilitates easier maintenance and future feature extensions.
- **Robust API Interfacing:** By leveraging Koha's APIs, the system fetches real-time patron data. This approach is informed by recent research that stresses the importance of seamless integration between legacy systems and new modules [19].
- **Dedicated Data Handling:** A new table was incorporated into the Koha database to log access events. Careful schema design and indexing ensure efficient query performance even during high-usage periods [18].

- **Error Handling and Resilience:** Comprehensive error-checking routines were developed to handle duplicate scans, invalid entries, and transient connectivity issues, thereby ensuring data integrity.

Deployment Procedures and Testing

Deployment was executed in a series of controlled stages to minimize operational disruptions:

1. **Server Preparation:** The target server was fully updated, and all required software packages were installed. Security hardening was applied to protect the system against vulnerabilities.
2. **Module Installation:** The gate register module was installed within the Koha OPAC directory. Configuration files were modified to reflect the correct database credentials and network settings.
3. **Database Augmentation:** Dedicated tables were created in the database, complete with appropriate indexing to support real-time data retrieval.
4. **Integration Testing:** Rigorous unit and integration tests were conducted to ensure that patron data was correctly fetched from Koha and that access events were logged accurately. These tests were performed under simulated high-load conditions to validate performance.
5. **User Acceptance Testing (UAT):** Library staff participated in testing sessions, providing feedback that led to refinements in both the interface and overall system performance. This user-centric approach echoes deployment strategies suggested by Miller and Lee [20].

The iterative testing and gradual roll-out process not only ensured compatibility across different Koha versions but also allowed for performance tuning based on real-world usage patterns. As highlighted by Kumar and Zhang et al., optimizing database operations and refining error management are crucial for maintaining system reliability—a principle that guided the development process [16,18].

Challenges and Their Resolution

During the implementation and deployment phases, several challenges were encountered:

- **Compatibility Issues:** Variability across Koha versions necessitated conditional integration code. Extensive cross-version testing helped overcome these challenges, ensuring broad compatibility.
- **Performance Bottlenecks:** Early load testing revealed delays under high concurrency. SQL query optimizations and the strategic use of database indexing substantially improved system responsiveness [18].
- **Data Integrity:** Managing duplicate scans and transient errors required robust error-handling mechanisms. These were refined iteratively based on feedback from integration tests and UAT sessions.

In summary, the Implementation and Deployment phase was carried out through a meticulous, multi-stage process that balanced technical rigor with practical requirements. Insights from recent studies were instrumental in refining the integration and deployment strategies, ultimately leading to a reliable and scalable gate register system.

V. EVALUATION AND DISCUSSION

A thorough evaluation of the gate register system was conducted to ensure that it met the high standards required for modern library access management. The evaluation was performed through a combination of technical performance testing, user feedback sessions, and data integrity analyses. This multifaceted approach provided insight into the system's operational strengths as well as areas for future improvement.

Performance Evaluation

The system was subjected to extensive load testing to simulate peak usage conditions within a busy library environment. Key performance metrics such as response time, logging accuracy, and database query efficiency were measured. Under high-concurrency scenarios, the system maintained near real-time data synchronization, with response times averaging under a second per transaction. Table 2 summarizes the performance outcomes.

Table 2 Evaluation Metrics for System Performance

Metric	Outcome
Logging Accuracy	> 98%
Average Response Time	~ 1 second
Error Rate (duplicate scans)	< 1%
Database Query Optimization	15-20% improvement over baseline
System Uptime (6-month period)	99.2%

The improvements in database performance are consistent with strategies outlined by Zhang et al., and the low error rates confirm that the error-handling mechanisms are effective [18].

User Insights

Structured testing involving library staff and select patrons provided rich insights into the system's usability. The intuitive, web-based interface required minimal training, enabling rapid adoption even among users with limited technical expertise. Staff reported that clear navigation and an unambiguous audit trail facilitated quick verification of access events. Real-time occupancy feedback empowered administrators to proactively manage crowding and address security concerns promptly. Feedback also highlighted that the simplicity of the design reduced errors in daily operations and increased overall confidence in digital access control. These observations underscore the importance of user-centric design in library automation, demonstrating that even straightforward interfaces can drive significant operational improvements.

Data Integrity

Maintaining robust data integrity is fundamental to ensuring reliable library access control. The system incorporates comprehensive error-checking routines to detect and resolve issues such as duplicate scans and transient connectivity lapses. Frequent audits of the access logs have shown that events are recorded consistently and accurately, even under high concurrency. Optimized SQL queries and a well-structured data schema contribute to efficient data processing and synchronization with the primary Koha database. This high level of data consistency not only reinforces the reliability of real-time reporting but also ensures that the audit trail remains a trustworthy source for operational analysis and long-term planning. The focus on data integrity aligns with best practices in digital library management and supports the system's overall robustness.

Discussion and Future Work

Evaluation results confirm that the gate register system not only enhances operational efficiency and security in library access management but also consistently delivers reliable performance across multi-branch libraries. The system's real-time synchronization, high logging accuracy, and intuitive interface have substantially reduced administrative burdens while supporting informed, data-driven decision-making.

Looking ahead, several opportunities for further refinement and expansion have been identified:

- **Advanced Analytics:** There is potential to integrate predictive modelling and machine learning techniques that can forecast usage trends, enabling proactive resource allocation and more effective security monitoring.
- **Deeper Integration:** Expanding interoperability with additional components of the Koha system—such as circulation, acquisitions, and inventory management—can lead to a more comprehensive and unified library management ecosystem.
- **User Interface Enhancements:** Ongoing feedback from library staff and patrons suggests that further refining the interface could improve usability and accessibility, making the system even more intuitive.
- **Enhanced Scalability and Flexibility:** Although the system already performs well in multi-branch environments, exploring dynamic load balancing and distributed architectures will ensure robust performance as library networks continue to grow.
- **Emerging Technologies:** Integrating mobile devices and Internet-of-Things (IoT) sensors could further enrich data collection and streamline user interactions, opening new avenues for real-time library management.

These future directions aim to build on the system's current success and ensure it remains adaptable to evolving library needs and technological advancements.

VI. CONCLUSION

The automated gate register integrated with the Koha library management system represents a significant leap forward in reconciling physical access control with digital record management. By utilizing real-time barcode scanning and robust data synchronization, the system has effectively streamlined library operations, reduced manual errors, and alleviated administrative burdens. Its proven performance across multi-branch environments confirms that accurate and consistent logging of patron movements can be achieved without disrupting existing library workflows.

The detailed exploration of the system's design, implementation, and deployment phases underscores the value of a modular architecture and seamless API integration. A well-structured development process, from initial requirement analysis through rigorous testing and user acceptance trials, ensured that the solution meets the diverse needs of library environments. Furthermore, the incorporation of an intuitive web interface has not only enhanced usability for staff and patrons but also established a reliable audit trail for security monitoring and operational analysis.

In summary, the integration of automated access control within an established digital library framework offers a robust, scalable, and adaptable solution for modern library management. The system lays a strong foundation for future enhancements, including advanced analytics and deeper integration with other library functions, thereby continuing to drive the evolution of digital library operations.

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