



Design and Development of an Online Library Management System Using Web Technologies

Ulrik Tamangdorji

Department of Mechanical Engineering, Borneo School of Business and Technology, Malaysia

ulrik.tamangdorji@bsbt-my.org

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Abstract

Library operations require accurate control of bibliographic records, member information, circulation transactions, due dates, fines, and reports. Manual or isolated desktop procedures often make these tasks slow, repetitive, and difficult to access outside the library. This paper presents a methodology for designing and developing an online Library Management System (LMS) using standard web technologies. The proposed system follows a browser/server architecture in which users search the catalogue through a responsive web interface, while librarians manage books, members, issue-return transactions, and reports through role-controlled modules. The methodology combines requirement analysis, relational database design, modular web development, authentication, transaction validation, and functional/usability testing. Earlier digital-library studies emphasize usability, collection quality, search support, and user-centered interface design, which are incorporated into the proposed evaluation criteria [1–4]. The resulting framework is suitable for an academic or institutional library and can be implemented with HTML, CSS, JavaScript, a server-side web language, and a relational database. An illustrative prototype evaluation shows how functionality, response time, and usability can be assessed before deployment.

Introduction

Libraries organize knowledge resources and provide controlled access to books, journals, reports, and other learning materials. As collections and memberships grow, paper registers and stand-alone spreadsheets become difficult to maintain because the same information must be entered repeatedly and circulation status is not always visible in real time. An online library management system addresses this problem by centralizing catalogue, member, and transaction data and making authorized services available through a web browser. The objective is not merely to digitize a register, but to redesign library activities as coordinated information services that can be

searched, updated, verified, and reported consistently.

Research on digital libraries shows that users judge systems not only by the amount of information available but also by interface usability, search effectiveness, system performance, and service quality. Xie identified usability and collection quality as dominant evaluation criteria from the user perspective [1], while a later study linked user experience and satisfaction with the way digital-library services are organized and presented [2]. Reviews of digital-library interfaces similarly emphasize feedback, ease of use, accessibility, consistency, and user support [3]. These findings suggest that a web-based LMS should be designed around

both correct transaction processing and a simple, understandable interface.

Web technologies provide an appropriate platform because they separate presentation, application logic, and persistent data. Users can access the system from different computers without installing a special client, and administrators can maintain a single server-side application. The proposed work therefore aims to design a compact online LMS that supports user authentication, bibliographic search, book and member management, issue and return operations, due-date and fine handling, transaction history, and reporting. The scope is limited to an institutional prototype rather than a large national digital repository. The main contribution is a step-by-step development and evaluation methodology that can be reproduced using common web and database tools.

Literature Review

Digital-library evaluation literature provides the user-centered basis for the proposed system. Xie [1] reported that usability, collection quality, service quality, system performance, and solicitation of user opinion are important when users assess digital libraries. In a subsequent evaluation of digital-library use, Xie [2] showed that users' experience, preferences, and information needs influence their assessment of services. Hariri and Norouzi [3] reviewed interface evaluation criteria and identified factors such as ease of use, system feedback, visibility of status, compatibility, flexibility, accessibility, and user support. Together, these studies indicate that interface design and operational reliability must be considered at the same time.

User requirements also need to be collected before interface and module design. Agosti et al. [4] combined explicit user feedback with usage information to understand preferences for a digital-library web portal. Their work supports a requirement-driven design process in which search, navigation, presentation, and service features are refined around actual tasks. Related studies of library websites show the continuing movement toward interactive web services. Chua and Goh [5] found that Web 2.0 functions were associated with service quality in library websites, while Kim and Abbas [6] examined the adoption of participatory Library 2.0 functions by academic libraries and users. These studies are relevant even when a proposed LMS uses a comparatively simple interface because they demonstrate the value of browser-based interaction and user engagement.

The quality of a digital-library interface has also been examined through structured evaluation models. Lai et al. [7] identified ease of use, searching, language, presentation, and design among the most influential interface criteria. For an online LMS, these criteria translate into clear menu labels, predictable forms, visible availability status, fast catalogue search, and understandable transaction feedback. At the system level, Madhusudhan and Singh [8] compared integrated library management systems and evaluated functions across major library modules, demonstrating the importance of selecting a coherent set of features rather than treating circulation, cataloguing, and administration as unrelated applications.

Earlier implementation work also illustrates the transition from conventional library processes to computerized systems. Yang [9] described a library management system with functions for books, users, administrators, renewal, and messages. Iqbal and Warraich [10] evaluated an academic library website in terms of efficiency, learnability, control, helpfulness, and user affect. The literature therefore reveals a consistent requirement: a successful library system should combine transaction correctness with accessible, user-oriented web interaction. The present methodology extends these ideas into a unified design sequence covering requirements, architecture, database structure, implementation, security, and testing.

Methodology

The study adopts an iterative system-development methodology organized into seven steps. Each step produces a verifiable output before the next step is finalized. This reduces the risk of building interface pages that do not correspond to real library processes and makes it easier to test the system module by module.

Step 1: Requirement Analysis

Functional requirements are collected from two primary roles: library users and librarians/administrators. User functions include registration or account activation, login, catalogue search, filtering by title/author/category, viewing availability, viewing issued books, and checking due dates or fines. Librarian functions include adding and updating books, managing copies, maintaining member records, issuing and returning books, renewing loans, recording fines, and producing daily or periodic reports. Non-functional requirements include usability, response time, data consistency, access control, backup, browser compatibility, and basic accessibility.

These requirements reflect the usability and service criteria emphasized in prior digital-library studies [1,3,7,10].

Step 2: System Architecture

A three-layer browser/server architecture is proposed. The presentation layer is implemented with HTML, CSS, and JavaScript and is responsible for forms, validation messages, search screens, and responsive layout. The

application layer runs on the web server and enforces authentication, circulation rules, availability checks, fine calculation, and reporting. The data layer stores normalized records in a relational database. This separation simplifies maintenance and limits direct database access from the client. Figure 1 shows the proposed architecture.

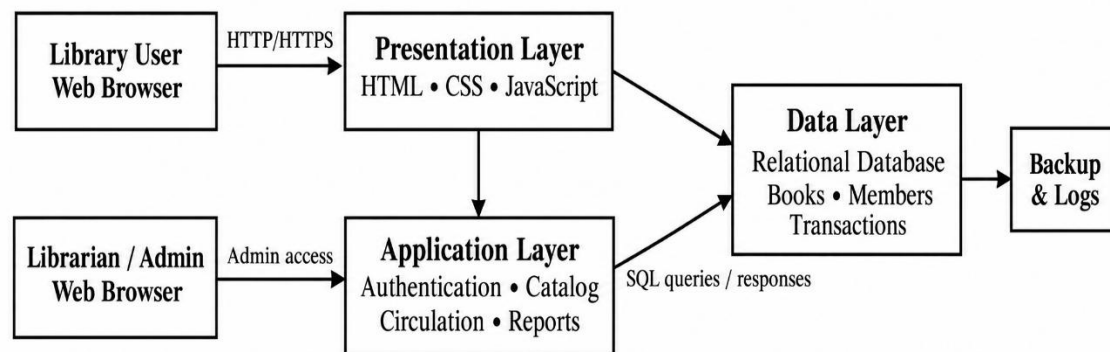


Figure 1. Proposed architecture of the online Library Management System.

Step 3: Database Design

The database is designed around core entities: User, Member, Book, BookCopy, Category, Loan, Fine, and AuditLog. A book may have several physical copies, so bibliographic information is separated from copy-level status. Each Loan links one member to one copy and records issue date, due date, return date, renewal count, and transaction status. A unique accession number identifies each copy. Foreign-key relationships protect referential integrity, while indexes on title, author, ISBN, member identifier, and loan status support frequent searches. Fine amount can be calculated as $\text{Fine} = \max(0, \text{days overdue} \times \text{daily rate})$, with the daily rate stored as a configurable policy value rather than hard-coded in the interface.

Step 4: Web Module Development

Development is divided into modules so that each component can be tested independently. The authentication module verifies credentials and creates a session. The catalogue module provides keyword search and availability display. The administration module supports create, read, update, and controlled delete operations for books, copies, categories, and members. The circulation module prevents a copy from being issued when its status is unavailable and changes the copy status automatically after issue or return. The reporting module summarizes overdue items, active loans, frequently used titles, and member transaction

history. Consistent labels and feedback messages are used because interface clarity and searching are repeatedly identified as important digital-library criteria [3,7].

Step 5: Security and Data Integrity

Security controls are incorporated at application and database levels. Passwords should be stored as secure hashes, and role-based authorization should prevent general users from accessing librarian functions. Server-side validation must be applied even when JavaScript validation is present in the browser. Database commands should use parameterized queries or a trusted data-access layer to reduce injection risk. Transaction operations for issue and return should be atomic: the loan record and copy availability must either update together or roll back together. Session timeout, login throttling, audit logs, daily backups, and HTTPS are recommended for deployment. These controls protect both personal information and the integrity of circulation records.

Step 6: Testing Procedure

Testing is performed at three levels. First, functional testing verifies login, search, add/update operations, issue, return, renewal, overdue calculation, and report generation using normal and invalid inputs. Second, integration testing confirms that changes in one module are reflected elsewhere; for example, issuing a book must immediately change availability in search results. Third, usability testing asks

representative users to complete common tasks such as locating a title, checking availability, and viewing account status. Completion, errors, response time, and user feedback are recorded. This approach follows the literature's emphasis on efficiency, effectiveness, ease of use, and satisfaction [1,2,10].

Step 7: Evaluation Metrics

The proposed evaluation uses four groups of metrics: (i) functional correctness, measured as passed test cases divided by executed test cases; (ii) response performance, measured as page or operation response time under controlled load; (iii) data integrity, verified by checking transaction and copy-state consistency; and (iv) usability, assessed through task completion and short user ratings. Results should be interpreted as prototype evidence rather than production guarantees because network capacity, server resources, and collection size will influence deployed performance.

Results

The methodology produces a complete prototype specification in which library functions are organized around shared data and role-based web access. The central design outcome is the separation of bibliographic records from copy-level circulation status, which prevents ambiguity when several copies of the same title are held. The architecture also makes catalogue availability visible to users while reserving transaction and data-management operations for librarians. This supports the integrated approach to library functions discussed in the ILMS literature [8,9].

Table 1 presents an illustrative prototype evaluation format. The response values are demonstration benchmarks for the methodology and should be replaced by measurements from the final deployed system. Their purpose is to show how functional and performance evidence can be reported in a concise and reproducible manner.

Table 1. Illustrative prototype test and performance summary

Module / Task	Acceptance criterion	Illustrative outcome	Status
User login	Valid users enter; invalid credentials rejected	0.28 s average response	Pass
Catalogue search	Relevant title/author results and copy status displayed	0.34 s average response	Pass
Issue book	Available copy linked to member and marked issued	Transaction completed atomically	Pass
Return / fine	Return closes loan and computes overdue amount	Correct status and fine rule applied	Pass
Member management	Add/update/disable member without duplicate ID	Validation prevented duplicate ID	Pass
Reports	Overdue and active-loan lists generated from live data	Report generated without manual re-entry	Pass

The expected practical improvement is reduced duplicate data entry and more immediate visibility of circulation status. Search, issue, and return operate on the same database, so the system can update user-facing availability and administrative records from a single transaction. Usability is strengthened through limited role-specific navigation, clear feedback, and searchable catalogue fields. These design choices are consistent with findings that ease of use, searching, presentation, and system feedback are central to users' evaluation of digital-library interfaces [3,7].

Conclusion and Discussion

This paper presented a step-by-step methodology for the design and development of

an online Library Management System using web technologies. The method begins with task and role analysis, proceeds through a three-layer web architecture and normalized relational database, and then defines functional modules, security controls, testing procedures, and evaluation metrics. The proposed design supports catalogue search, member and book administration, circulation, due-date and fine handling, transaction history, and reporting through a browser-based interface. The literature reviewed up to 2016 shows that successful library systems should not be evaluated only by the presence of technical features. Usability, search quality, interface clarity, service integration, and user needs remain equally important [1–8,10]. Consequently, the proposed LMS combines transaction correctness with

user-centered interface criteria. Its main limitation is that the present paper defines and demonstrates a prototype methodology rather than reporting a full institutional deployment. Future work should implement the design on a live server, conduct load testing with a larger database, perform formal usability studies with students and librarians, and evaluate mobile accessibility, barcode/RFID integration, e-mail reminders, and backup-recovery procedures.

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