Designing a Digital Library System Using the Zachman Framework: A Case Study at Gajayana University

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Abstract

Abstract- Digital libraries are one alternative to conventional libraries. This design offers digital-based library services. In its development, the digital library information system faces several challenges common in the context of user knowledge. This study aims to design an enterprise architecture for a digital library information system using the Zachman Framework as a systematic approach that accommodates various stakeholder perspectives. The method involves mapping six perspectives (from Planner to Subcontractor) against the six aspects of 5W+1H. The design results show that the Zachman approach can provide a comprehensive overview of the system's data structure, network, actors, operational time, and motivation in a structured and integrated manner. As a result, this design can be used as a reference for the development of digital library information systems in the future and improve operational effectiveness with other users.

This design aims to increase transparency in the distribution of functional responsibilities so that users with interests can understand their roles more clearly in the digital library work system. In addition, the proposed system contributes to optimizing operational processes, reducing problems that previously occurred in conventional libraries, and enabling faster, more efficient, and integrated information and service management.

Keyword: Digital Library, Zachman Framework, Enterprise Architecture, Information System

1. Introduction

Gajayana University Malang, as one of the private educational institutions located in the city of Malang, which is still running a library system in a conventional way, the author would like to provide a proposal to adopt modern technology in improving the quality of educational services. One of the initial steps taken by the author is the development of a digital library, which serves as an alternative to digitization of conventional libraries (Prajapat et al., 2022). With the digital library, Gajayana University Malang can improve in terms of more efficient services for students and lecturers, thus supporting the process in the interests of teaching and learning (Kiran, 2010); (Witten, 2010).

In today's digital era, digital transformation is a must for educational institutions to keep up with technological advances (Sulaiman & Wibowo 2018). One important aspect that requires attention is the management of knowledge owned by users in terms of libraries (Lankes, 2016); (Opoku, D., & Dadzie, 2021). Conventional libraries tend to have limitations in terms of reach, efficiency, and real-time

availability of information. This phenomenon leads to the need for information systems that are able to facilitate users' information needs quickly and precisely (Pratama et al., 2025). The main variables in digital library development include Services, Databases, and Users, where these three aspects must be well developed and integrated to achieve system effectiveness.

Although various studies have discussed library digitization, a comprehensive information systems architecture approach is still rarely used (Bass et al., 2012). According to Pearlson & Saunders (2016), information system design should consider the alignment between technology and organizational strategy. Meanwhile, Zachman (1987) emphasizes the importance of an enterprise architecture framework in understanding the needs and goals from various stakeholder perspectives. In the context of digital libraries (Nurhayati & Adi, 2020), Prasetyo et al. (2020) pointed

out that many institutions have failed in digital implementation due to the absence of careful system architecture planning. Therefore, systematic approaches such as the Zachman Framework are considered capable of overcoming this gap by providing a clear structure in system development. This research aims to design the enterprise architecture of the digital library information system at Gajayana University Malang using the Zachman Framework.

Seeing these conditions, this research aims to design a digital library information system that is in accordance with the operational needs of Gajayana University Malang using the Zachman Framework approach (Saha, 2006). This research also aims to identify the roles of each stakeholder, the ongoing business processes, and the information needs that need to be modeled systematically in order to support the management of existing book data accurately. The structure of the discussion in this research starts from theoretical studies and previous research, followed by data collection and analysis methods, system design results based on the Zachman framework, as well as conclusions and suggestions for future system development.

2. The Art of Research

In developing an effective and structured information system, understanding key concepts such as inventory information systems, system design, and architectural frameworks is very important (Babu & O'Brien, 2013); (Dey, 2014); (Nurhayati & Adi, 2020). The following literature review provides the conceptual basis for this research.

Digital Library Information System is a modern form of library that utilizes technology to store and access information online (Kusumaningrum & Sarno, 2017). This system makes it easier for students and lecturers to find references without having to come directly to the library. However, many institutions still have difficulty developing digital libraries due to limited planning and lack of integration between systems (Prasetyo et al., 2020).

Enterprise Architecture (EA) is used to design information systems to fit the needs of the organization (Jayanto et al., 2025); (Fawazzie et al., 2025). One method that is often used is the Zachman Framework, which divides system design into several points of view, ranging from planners to technicians (Alzoubi & Gill, 2020). Zachman helps organizations see the system from various sides, such as what data is used, who the users are, and how the process runs (Zachman, 1987; Pearlson & Saunders, 2016).

To produce a comprehensive system design that meets the needs of the organization, the Zachman Framework approach is used. This framework was first introduced by John A. Zachman in 1987 as a tool

in the development of enterprise architecture. The Zachman Framework maps the system design process into a 6x6 matrix, which combines six perspectives (Planner, Owner, Designer, Builder, Subcontractor, and System (Zachman, 2003). In Operation with six fundamental questions (What, How, Where, Who, When, and Why). Each cell in the matrix represents a specific architectural artifact that must be developed to ensure the completeness and consistency of the information system (Ningtyas et al., 2025) (Pratama et al., 2025).

The use of Zachman Framework in this research aims to accommodate the point of view of all stakeholders at Gajayana University Malang, ranging from librarians, lecturers, and students. With this approach, the information system designed is expected to answer the actual business needs and minimize the gap between users and system developers. A more detailed explanation of the implementation of this framework in the research will be discussed in the methods section.

3. Method

1. Type of Research

Research The type of research used in this study is descriptive qualitative research with a case study approach. This research aims to describe and map the elements of the digital library information system in the Zachman framework (Rouse, 2013); (Suryanto, M. A., & Nugroho, 2019). Descriptive research was chosen because it is able to provide a detailed description of the structure and relationships between information system components as a whole.

2. Data Collection Technique

In this research, the data collection techniques used are as follows:

a. Observation

Observation is done by direct interaction with users who have an interest, namely librarians. What is seen is how the librarian performs in carrying out his daily activities with a conventional library

system.

b. Interview

Interviews are conducted to add incomplete information from the results of observations, therefore the author will ask several questions related to system needs to complete information data which will later be developed into a new system.

3. Development Framework

This system development framework uses the Zachman Framework, which is an approach that divides the system design process into six perspectives: Planner, Owner, Designer, Builder, Subcontractor, and System in Operation (IEEE, 2000). Each perspective sees the system from a different point of view, starting from the initial planning until the system is actually used. In addition, this framework also considers six important aspects: what is needed (What), how it works (How), where the system is used (Where), who is involved (Who), when the activity is carried out (When), and why the system is needed (Why).

- In the context of the Conventional Library of Gajayana University Malang, this framework is used to describe the needs and workflows in inventory management in a step-by-step and structured manner.
- In the Planner perspective, the direction and purpose of the system is determined, namely to make book data management more organized and efficient.
- The Owner's perspective reflects the needs of library managers, such as the availability of book loan reports, book data searches.
- In the Designer section, the system begins to be designed technically through Entitiy Relationship Diagram (ERD) modeling, use cases, and activity diagrams to describe how the system will flow.
- The Builder Perspective explains the selection of technology that will be applied to this system such as, PHP for Back-End purposes, MYSQL as a database, and additionally about the existing network on campus, namely both LAN and WIFI.
- Subcontractors at this stage as subcontractors will start designing for coding purposes, creating UI/UX, and testing the system as a whole in terms of functionality and specifications that are designed according to expectations and run normally without any error constraints.
- Finally, System in Operation evaluates whether the system runs as needed through direct trials by users (Librarians, Lecturers, Students).

With this framework, the entire process can be organized clearly and systematically, making it easier for stakeholders to understand. This approach also ensures that the system is aligned with real needs and supports library digitization effectively.

4. Result

1. Object of Research

The object of this research is a conventional library at Gajayana University Malang, which until now still runs part of the service process manually, such as recording book loans and returns, managing book catalog data, and searching for books by users. This limitation is the background for the need to adapt to technological advances regarding the development of an integrated digital library system

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whose function is to improve service efficiency, accurate data, and ease of accessing information for students and lecturers.

2. Object Characteristics

Gajayana University Library currently has the following operational characteristics:

- Manual service process, Most of the running activities such as borrowing, returning, and recording book catalog data are still done manually using ledgers or spreadsheets.
- Limited Information Access, Students and lecturers must come and search for books manually due to the absence of digital information access provided.
- Lack of Technology Utilization, there is no integrated system available, which is one of the utilization of digital technology to assist in data management, reporting, and interaction with users online.

3. Framework Explanation

The system development framework in this research uses the Zachman Framework, which presents an enterprise architecture approach in the form of a two-dimensional matrix. This framework consists of:

A. Planner's Perspective

The Planner perspective in the Zachman Framework aims to formulate the initial context, scope, and vision of the digital library system to be designed. This perspective is important because it provides an overview of the system conceptually before going into a deeper technical design stage.

1. What (Data)

The data that became the main focus at this stage related to the main factors in the library management process, including:

- Book Data: Information about the book such as book code, book title, author, publisher, year of publication, ISBN.
- Member Data: Information about library members such as member number, name, address, study program, and membership status.
- Catalog Data: Classification of books based on subject, genre, or other categories.
- Borrowing Data: Records of book borrowing by members, including borrow date, return date, and return status.
- Return Data: Records of book returns by members, including the date of return, and the condition of the book.

2. How (Process)

Conceptually, the main processes designed

include:

- Library member registration.
- Recording Inputting new book data into the system.
- Search for books by title, author, or subject.
- The process of borrowing books by members
- The process of returning books by members.
- Recording of late return penalties.
- Preparation of statistical reports on book borrowing and returning.

3. Where

The main location of the system is at the library of Gajayana University Malang which is located at Jl. Mertojoyo Blk. I, Merjosari, Kec. Lowokwaru, Malang City, East Java 65144. All activities run at the bottom of the main hall which later students will fill in their data manually, therefore it will be made web-based and can be accessed by students/lecturers online (McGovern et al., 2003).

4. Who.

The parties involved in the library management process are:

- Librarian: In charge of managing book data, serving loans and returns, and providing information to users.
- Library members (students and lecturers): Use the system to search, borrow, and return books.
- System Administrator: In charge of managing the system, maintaining the database, and providing technical support.

5. When

Library management activities are dynamic, depending on the daily conditions of library operations:

- Determine the time limit for borrowing books (e.g. 1 week, 2 weeks) and the consequences of lateness (fines).
- Determine the frequency of new book procurement (e.g. monthly, quarterly) and the book selection process.
- Determine a regular schedule for system maintenance, such as data backups, software updates, and bug fixes.
- Library opening and closing hours, and availability of online services.

6. Why (Motivation)

The motivation behind developing a digital library system is:

- Reduce the time needed for borrowing, returning, and searching books.
- Allows students and lecturers to access book and catalog information from anywhere and at any time.
- Ensure book, member and transaction data is recorded accurately.
- Provide better services to library users through a modern and user friendly system.

B. Owner's Perspective

The Owner perspective in the Zachman Framework focuses on the business needs and goals to be achieved by the digital library system. It bridges the gap between strategic vision and technical implementation.

1. What (Data)

From the owner's perspective, the data of primary concern is:

- Book Data: Information on books or digital collections available in the library, including book code, title, author, category, and access status.
- Book Receipt Transaction Data: Recording every book collection received by the librarian, either from asset purchases, grants. As a basis for updating the collection inventory.
- Book Loan Transaction Data: Records book borrowing activities by library members, used for circulation control, late fees, and analysis of the most frequently borrowed books.
- Book Request Data: History of book requests from members, lecturers that show the actual need to update the procurement of new collections.
- All these data are used by the library manager or head librarian to determine the status of the collection, evaluate borrowing, plan procurement, and develop more efficient digital literacy services.

2. How (Process)

The system process from the owner's point

of view includes:

- Access daily, weekly, or monthly recaps of active collections.
- Monitoring collection addition and borrowing activities on a regular basis.
- Approve the addition of new collections based on availability or user requests.
- Evaluate the effectiveness of collection usage by referring to demand patterns and borrowing history.

The system must be able to present clear, easy-to-understand, and real-time reports so that the owner can make decisions quickly.

3. Where

From the perspective of the head librarian or owner, the collection management platform must be supported by a network infrastructure that is flexible, easily accessible, and able to support all operational activities of the digital library. The system is also designed in the form of a web-based application so that it can be accessed through various devices connected to the internet network.

4. Who.

The parties involved and interacting with the system from the owner's point of view are:

- Librarian: Serves as a decision-maker, evaluating availability, and determining budget allocations. Also responsible for all activities that occur.
- Admin: In charge of recording collection data entered into the system, both in physical and digital form, and also updating the status of book availability.

5. When

This column describes the timing of library system design and development activities as follows:

No.	Nama Kegiatan	Target	Juni			
			M1	M2	M3	M4
1.	System requirements analysis	Identification of functional, data, and user needs of digital library systems.	■			
2.	Stakeholder interviews	Digging up information from owners and users	■			
3.	Preparation of scope and objectives	Determining the scope and objectives of the system		■		
4.	Review existing business processes	Mapping the running processes for the new system		■	■	
5.	Initial design approval	Owner approval of the initial system scheme				■

6. Why (Motivation)

The owner's goals and expectations for this inventory system include:

- Improve efficiency in Collection management and library services.
- Ensure real-time availability of information and references for students and lecturers.
- Reduce the risk of data loss and errors in recording loan transactions.
- Support more accurate decision-making based on real-time data.
- Increase transparency and control over library operations.

C. Designer's Perspective

The Designer's Perspective describes how the system will be logically designed before going into the technical development phase. Here are the main points of the designer's perspective:

1. What (Data)

At this stage, the main data is designed in the form of a relational model between entities that describes the structure of information in the digital library system.

The main entities include:

- Book: includes data such as book code, title, author, publisher, year of publication, and category.
- Members: data on students, lecturers, and librarians who use the service.
- Borrowing: A record of who borrowed a book, the date of borrowing, and the status of return.
- Returns: return data including return date and lateness.
- Admin/Librarian: as the manager and controller of system activities.

2. How (Process)

The system process is described in detail through Use Case Diagrams and Activity Diagrams that explain the flow of the main functions, such as:

- User login process.
- Search for books by title or author.
- Borrowing and returning books.
- Creation of loan report.
- Collection management by librarians.

The goal is that every system workflow can be understood and implemented technically.

3. Where

The system will be web-based and can be accessed through the campus internet or intranet

network. The server will be located on campus, but access is open to students and lecturers from anywhere using their respective devices.

4. Who.

Parties involved with the system include:

- Admin/librarian: manages collections, member data, and the loan and return process.
- Students and Lecturers: search, borrow, and view usage history.
- System Administrator: performs technical setup and maintenance of the system.

5. When

The design is carried out in stages starting from analyzing needs, designing data models, preparing process diagrams, making interface prototypes, to the initial validation process of the system design by stakeholders.

6. Why (Motivation)

The motivation from the designer's side is to develop a system that is logical, easy to understand, and ready to be translated into technical form by developers. The design is also intended to be flexible in development and adaptable in case of changing needs in the future.

D. Builder's Perspective

The Builder perspective in the Zachman Framework describes how the digital library system is actually built technically based on the design that has been created by the designer. The main focus is the application of technology and the implementation of the system in a tangible form that can be accessed and used.

1. What (Data)

The data was designed in physical form using a database management system such as MySQL. The main tables built include:

- Database: db_inventory_rajawali
- Table structure and physical relationships:
    - tb_book: stores book collection information.
    - tb_member: stores user data (students and lecturers).
    - tb_loan: records book borrowing activities.
    - tb_return: records the book return process.
    - tb_admin: stores librarian data as the system manager.

Each table is connected with a foreign key to maintain data consistency and enable accurate transaction tracking.

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2. How (Process)

Business processes are converted into system modules using specific programming languages and frameworks, such as: Business processes are transformed into system modules using specific programming languages and frameworks, such as:

- PHP for the backend.
- HTML, CSS, and Bootstrap for the interface (frontend).
- JavaScript for dynamic interaction. Modules built include login, registration, book search, borrowing, returning, and reports.

3. Where

The application will be stored on the campus server and accessed through the campus library domain. The system is designed to be responsive and can be accessed from various devices, both on campus and from outside (online).

4. Who.

The team responsible for the development process includes:

- Programmer: create and implement the program code from the existing design.
- Database Administrator: build and maintain databases.
- Web Developer: in charge of designing and building the user interface.

5. When

The construction of the system was done in several stages:
- Week 1-2: development installation and database setup. environment
- Week 3-4: construction of login, borrowing, returning modules.
- Week 5: report and dashboard feature creation.
- Week 6: initial testing and bug fixing.

6. When (Motivation)

The main motivation of the builder perspective is to ensure that the system:

- Can run stably and according to its function.
- Secure from data errors and access violations.
- Ready to be used by end users with minimal technical issues.
- The builder is responsible for getting the system ready for use according to the technical specifications and functional expectations set by the owner and designer.

E. Builder Implementation Perspective

This perspective describes how all elements of the system that have been designed and built are tested and configured so that they are ready to be used by end users. The main focus is on

installation, component configuration, security, and system stability.

1. What (Data)

At this stage, test data and system initial data are entered into the database, such as:

- Early book collection.
- List of student and lecturer members.
- Simulated loan and return transactions. All of this data is used to ensure that the system functions normally before it is widely used.

2. How (Process)

System modules are organized and thoroughly tested one by one. This activity includes:

- Installation of the application on the server.
- Configure the database connection.
- Testing the login, borrowing, return, and report modules.
- Automatic backup settings to keep data safe.
- User account creation and authorization testing.

3. Where

System files and databases are placed on the main campus server, and can be accessed through the library's official domain. Folders and files are organized in a neat and secure structure. Server placement should consider physical and network security.

4. Who.

The parties involved in this stage are:

- Network Technician: ensures connectivity between devices and stable network access.
- System Administrator: manage installation, server configuration, and system security.
- Data Security Specialist: conducts access audits and ensures the protection of critical data.

5. When

Configuration and testing is done after the build process is complete. Timings include:

- Testing of basic functions and system performance.
- Simulation of system usage by different actors (students, lecturers, librarians).
- Customization and debugging before the system is officially deployed.

6. Why (Motivation)

The main motivation for this perspective is:

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- Ensure the system is ready to use without technical errors.
- Provides a stable and secure user experience.
- Ensure the system runs according to design and stakeholder expectations. This stage is key to refining the system before it is fully launched, as well as ensuring the system is able to handle real useon an ongoing basis.

F. Participant (Sub-Contractor) Perspective

The Participant perspective describes how the system is actually used by users after it has been built and implemented. The main focus is on daily interactions with the system, ease of use, as well as direct experiences from students, lecturers, and librarians.

1. What (Data)

The data used and displayed by the system directly to the user includes:
- Information on the latest and popular book collections.
- Borrowing and returning status of book.
- History of borrowing activity by members.
- Membership information and maturity notification.

2. How (Process)

End users access the system to carry out library activities independently, such as:

- Login to the system using your respective account.
- Search and select books through the search feature.
- Checking out and returning books.
- Access personal reports such as borrowing history.
- Receive automatic notifications of fines or delays.

3. Where

The system can be accessed from anywhere through a desktop, laptop, or smartphone device, as long as it is connected to the internet. For some activities such as account validation or physical book retrieval, users still need to come to the library.

4. Who
The parties involved in using the system directly are:

- Students and Lecturers: use the system to search, borrow, and return books.
- Librarians: manage collection data, verify transactions, and assist users if there are problems.

5. When (System Test Implementation Time)

The system runs 24 hours for digital services such as search and history, but physical services such as book retrieval still follow library operating hours (Monday-Friday, campus working hours).

6. Why (Motivation)

The motivations for using the system from the participant's perspective include:

- Facilitate access to information and references without having to come in person.
- Increase convenience and time efficiency in searching and borrowing books.
- Provide transparency to users on their loan activity and status.
- Encouraging a culture of digital literacy on campus.

With the system in place, user experience becomes an important benchmark for evaluation and further development to keep the system relevant and effective.

5. Discussion

The design of the digital library information system using the Zachman Framework provides a comprehensive overview of the system architecture from multiple stakeholder perspectives. This section discusses the findings of the research, the development approach, the expected impact on the library, and implementation considerations.

5.1 Findings and Interpretation
The structured approach offered by the Zachman Framework allowed the mapping of essential library activities such as cataloging, borrowing, returning, and data reporting in a systematic and integrated manner. The framework's six perspectives—from Planner to Participant—ensured that both managerial and technical aspects were taken into account. Each perspective contributed to the identification of functional requirements, user roles, data needs, system processes, and implementation strategies (Singh & Sanaman, 2012).

The key finding is that Gajayana University Library's current manual operations can be significantly enhanced through digital transformation, not only improving efficiency but also increasing transparency and data accuracy (Kiran, 2010). By addressing operational pain points through automation and centralized data management, the design aligns with the needs of students, lecturers, and librarians.

5.2 Development Approach
This study adopted a Research and Development (R&D) approach, using the Zachman Framework as a reference model. The development began with identifying functional and data requirements through observation and interviews, followed by mapping them to the Zachman matrix. Each cell of the matrix was used to describe system artifacts including data models, process workflows, technical components, and user interaction mechanisms.

The architectural outputs such as Entity Relationship Diagrams (ERD), use case diagrams, and activity diagrams provide a strong foundation for the system's future technical development.

5.3 Implementation Considerations
While the system design has been completed, its implementation requires careful planning. Key implementation stages include:

- Preparing infrastructure (server setup, database configuration)
- Developing application modules (login, catalog search, borrowing/return, reporting)

- Testing system functionalities and user acceptance
- Training librarians and system administrators

The system is intended to be deployed as a web-based platform that supports access from both internal and external users.

5.4 Research Limitations

This research is limited to the design phase and does not include actual implementation or usability testing. Furthermore, the findings are based on a single case study, which may not fully represent other institutions with different library management structures.

5.5 Implications

The proposed design can serve as a blueprint for other educational institutions aiming to digitize their library systems using enterprise architecture. It demonstrates how the Zachman Framework can bridge communication gaps between technical developers and non-technical stakeholders by providing a shared design structure

6. Conclusion

The This study presents the design of a digital library information system at Gajayana University Malang using the Zachman Framework as an enterprise architecture approach. By dividing the system into six perspectives—Planner, Owner, Designer, Builder, Subcontractor, and Participant—the design process accommodates the needs of various stakeholders, from strategic decision-makers to end users.

The results show that the Zachman Framework effectively structures system development, providing clarity in data management, process flow, stakeholder roles, and technological requirements. Each component of the library's operations, such as book borrowing, catalog search, and reporting, is modeled in a way that supports transparency, efficiency, and ease of use.

Although the system has not yet been implemented, this architectural design serves as a strong foundation for future development. It provides actionable insights for system developers and institutional decision-makers to adopt a digital solution tailored to the university's operational needs.

Future research can focus on system implementation, user acceptance testing, and performance evaluation to ensure successful adoption. Additionally, this design has the potential to be adapted for other academic libraries seeking digital transformation.

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