International Journal of Information Engineering and Science

E-ISSN: 3048-1953
P-ISSN: 3048-1902

Research Article

Implementation of IT Governance in the Design of Expert Systems for Improving Library User Services

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Abstract: The integration of IT Governance and expert system design offers transformative benefits for enhancing library user services. This research employs the COBIT 5.0 framework to align IT strategies with library objectives while developing an expert system tailored for personalized recommendations. The findings indicate that the expert system significantly improves operational efficiency, service accuracy, and user satisfaction by using user profiles to recommend relevant materials and streamline the borrowing process. Testing revealed high user satisfaction levels, with 96.6% finding the system effective and 100% confirming its efficiency. Additionally, IT Governance ensures strategic integration between technological infrastructure and service quality objectives, enabling data-driven decision-making. The study also highlights challenges, such as the need for robust data management and user training, suggesting areas for future improvement. Recommendations include incorporating machine learning to enhance system intelligence, conducting regular evaluations to maintain system relevance, and testing the scalability of this approach across various types of libraries. By integrating IT Governance with an expert system, this research sets a strong foundation for modernizing library services to better meet user expectations in the digital era.

Keywords: : IT Governance; COBIT; IT Service Management; Expert System; Collaborative Filtering

1. Introduction

Information technology (IT) has become a fundamental component in modern organizational management, including in academic and public libraries. In the digital transformation era, libraries are no longer merely repositories of printed collections but have evolved into information service centers that rely heavily on integrated information systems to support cataloging, circulation, data management, and user interaction. The effective utilization of IT enables libraries to enhance operational efficiency, improve data accuracy, accelerate information retrieval processes, and deliver higher service quality to users (Prakom Banjarmasin City, 2020; Alloy Software, n.d.). However, the successful implementation of IT systems does not solely depend on technological infrastructure; it also requires structured governance mechanisms to ensure that IT initiatives are aligned with institutional objectives and stakeholder needs.

IT governance plays a strategic role in ensuring that information systems generate value, manage risks effectively, and support sustainable organizational performance. In library environments, proper IT governance can significantly improve service reliability, responsiveness, and transparency (Nova & Dompak, 2024). Governance frameworks such as ISO standards, TOGAF, ITIL, and COBIT provide structured guidance for aligning IT strategy with organizational goals, managing risks, and monitoring performance (ITGD, n.d.; Rexy, n.d.). Among these frameworks, COBIT 5.0 is widely adopted due to its comprehensive approach in integrating governance and management processes, ensuring accountability, and optimizing IT-related investments. Through structured governance, libraries can ensure that their digital services are not only functional but also strategically aligned with long-term development objectives.

Received: September 05, 2024
Revised: October 19, 2024
Accepted: November 19, 2024
Published: November 21, 2024
Curr. Ver.: November 21, 2024

One of the most critical implementations of IT in libraries is the Online Public Access Catalogue (OPAC) and other digital service platforms that facilitate information access and borrowing processes (Taher et al., 2019). While these systems have improved accessibility and efficiency, practical challenges remain, such as limited personalization features, manual verification processes, and insufficient integration between user data and recommendation mechanisms. In many cases, existing systems focus primarily on operational functionality without fully leveraging intelligent technologies or embedding governance frameworks into system design and evaluation (Seppewali et al., 2023). As a result, there is a need for a more integrated approach that combines IT governance principles with intelligent information systems to enhance service effectiveness and user satisfaction.

Based on these considerations, this study aims to analyze the role of IT governance in improving library services and strengthening data management systems. Specifically, this research examines how governance frameworks can support the design and implementation of intelligent systems that enhance operational efficiency and service quality (Muliani, 2023). The findings are expected to provide strategic recommendations for optimizing IT governance in libraries and to contribute to the development of governance-based digital transformation models in academic service institutions. Ultimately, this study seeks to strengthen the overall functionality, accountability, and sustainability of library information systems in the digital era.

2. Literature Review

Information technology (IT) governance has increasingly been recognized as a strategic instrument to ensure alignment between technological initiatives and organizational objectives, particularly in public service institutions. Recent studies emphasize that frameworks such as COBIT and ISO/IEC 20000 enhance accountability, service quality, and risk management in IT-driven environments (Evani & W, 2022; Muliani, 2023; Nova & Dompak, 2024). In academic and public institutions, effective IT governance supports data-driven decision-making and strengthens digital transformation strategies (Kurniawan Ritonga & Firdaus, 2024).

At the operational level, expert systems have been widely implemented to support decision-making processes through rule-based reasoning and structured knowledge representation (Seppewali et al., 2023). Meanwhile, web-based recommendation systems, particularly those employing collaborative filtering approaches, have demonstrated effectiveness in personalizing user experiences by analyzing user profiles and behavioral data (Kulkarni & Rodd, 2020). These intelligent systems improve service efficiency and user satisfaction by providing adaptive and relevant recommendations.

However, recent literature shows that studies on IT governance primarily focus on managerial alignment, service standards, and infrastructure evaluation without integrating intelligent decision-support mechanisms into governance frameworks (Evani & W, 2022; Nova & Dompak, 2024). Conversely, research on expert systems and recommendation systems emphasizes algorithmic development and personalization performance but rarely discusses how governance structures guide their implementation, control, and evaluation (Seppewali et al., 2023; Kulkarni & Rodd, 2020). In library contexts specifically, digital service improvements tend to concentrate on system usability and operational efficiency, while the integration of formal IT governance frameworks such as COBIT into intelligent system design remains limited.

Therefore, a significant research gap exists in the integration of IT governance frameworks with expert system–based recommendation systems in library services. There is still limited empirical evidence demonstrating how governance principles can systematically guide the development and deployment of intelligent systems to ensure strategic alignment, operational effectiveness, and sustainable service quality. This study addresses that gap by integrating COBIT-based IT governance with a collaborative expert system design to enhance library user services, contributing to both governance research and intelligent system implementation in academic library environments.

3. Method

The research was conducted using qualitative methodology, and the findings will be presented in the form of various research approaches. The information studies used in the research can be traced back to a number of previous studies.

3.1. IT Governance

IT Governance, first introduced in the early 1990s, refers to a set of mechanisms that enable organizations to leverage their IT capabilities effectively to support strategic objectives. In a contemporary context, IT governance is understood as a structured system that ensures information technology resources are aligned with organizational goals and deliver measurable value (Kurniawan Ritonga & Firdaus, 2024). IT governance emphasizes the strategic relationship between organizational management and the IT function, particularly in ensuring that IT operations contribute directly to business value creation and sustainability (Wibowo, 2021). The primary objective of IT governance is to enhance operational accountability and transparency through structured IT management practices, supported by standardized service management and quality assurance frameworks (Evani & W, 2022).

Furthermore, IT governance establishes clear boundaries of responsibility and accountability in managing information systems and technology infrastructure. It integrates strategic alignment, performance measurement, risk management, regulatory compliance, and defined roles within IT management structures. Effective governance ensures that IT services operate efficiently while maintaining service quality and security standards (Wijaya, 2021). In this regard, governance mechanisms are not limited to operational control but extend to continuous evaluation and performance improvement, enabling organizations to optimize IT investments and strengthen institutional performance (Kurniawan Ritonga & Firdaus, 2024).

3.2. International Standards and Framework for IT Governance and Management

By 2024, IT businesses can improve accountability, governance, and management by implementing IT frameworks and standards such as COBIT, ISO/IEC 27001, ITIL, and CMMI. These frameworks drive better risk management, information security, and IT service efficiency. COBIT, developed by ISACA, focuses on IT governance and management, ensuring alignment between business and IT strategies and maximum business value from IT investments.

1. In the areas of planning and organizing, procurement and implementation, delivery and support, and monitoring, COBIT defines thirty-four IT process frameworks and over 300 control objectives. Optimal service delivery is ensured through planning and organizing, which manages strategic and tactical issues; monitoring addresses control process issues and independent audits; and acquisition and implementation addresses IT development and integration (Turel et al., 2021).
2. The IT Infrastructure Library (ITIL) is a UK-based documentation offering best practice for IT service management, established in 1989 by the Centre for Computing and Telecommunications. Managed by the UK Office of Government Commerce and supported by the IT Service Management Forum, ITIL was revised in 2000 in Prakom Banjarmasin City. (2020).

Replacing the previous BS15000 standard, the BSI management overview now provides a comprehensive introduction to ITIL, with ITIL books building on that material and providing advice on best practice for IT service management. By 2024, the two-part standard known as ISO/IEC 20000 will improve service quality and user happiness thanks to its emphasis on efficient, high-quality IT service management, its support for strong IT governance, and its alignment of IT services with business objectives. Rexy. (n.d.)The ITIL document, in its third iteration, uses a lifecycle-based approach, providing a code of practice and standards for IT service management. ITGID. (n.d.).

3.3. Expert system

Computer software that imitates the decision-making process of a human expert or experts is called an expert system. This group of specialists provides the expert system with its basic knowledge, which then determines its capabilities (Durkin, 2020). Expert systems are defined as software that can make judgments that are usually made by humans in relevant subjects using scientific knowledge, facts, and thinking skills. Computer-based systems that integrate inference rules with a specialized knowledge base curated by subject matter experts are known as expert systems. This combination is used in decision-making to address specific challenges, consisting of three main modules (Liao, 2021), that is :

1. Knowledge Acquisition Mode
   As the system learns new things from specialists, it enters this module. To build the system, relevant information needs to be gathered, and this is where a knowledge engineer comes in. A knowledge engineer acts as an intermediary

between the expert system and the people who really understand the subject matter.

2. Consultation Mode
   An expert system is said to be in consultation mode when it can respond to problems raised by the user. In this section, the user interacts with the system by responding to its questions.
3. Explanation Mode Module
   This lesson discusses the system's decision-making process, specifically outlining the steps to conclude.

An expert system mainly consists of:

1) Knowledge Base
   The knowledge base, which is a representation of expert knowledge, is a key component of an expert system. A collection of information and rules forms the knowledge base. Things, events, or circumstances can be explained using facts. Applying rules allows one to derive new facts from existing facts. The knowledge base is a representation of an expert. This representation can then be incorporated into an expert system framework, such as EXSYS, PC-PLUS, CRYSTAL, or a specific programming language for artificial intelligence, such as PROLOG or LISP.
2) Inference Engine
   The central processing unit (CPU) of an expert system is the inference engine. The job of the inference engine is to use the existing knowledge base to direct the reasoning process for a given situation. To find a solution or conclusion, the inference engine manipulates and directs the rules, models, and facts contained in the knowledge base. In doing so, the inference engine uses control methods and reasoning processes. Overall, there are two types of reasoning strategies: accurate and imprecise. When all the information necessary to conclude is readily available, we use accurate reasoning; when this is not the case, we use imprecise reasoning. The reasoning process can be facilitated by using control approaches. Forward chaining, backward chaining, and a combination of the two are the three most common control strategies.
3) Database
   To meet the regulatory requirements of the system, the database contains all relevant information. All data, both entered at the start and taken during the conclusion process, are stored in the database. Data collected from observations, along with additional information required for processing, are stored in the database.
4) User Interface
   This facility is used as a communication intermediary between the user and the system.

Knowledge representation is a method for organizing acquired information into a particular schema or diagram for the purpose of understanding the interconnections between different pieces of data. Knowledge engineers can better understand the knowledge structure required to build an expert system by using this method. Expert systems development often uses the following knowledge representation techniques:

1. *Rule-Based Knowledge*
   Facts and rules are physical manifestations of knowledge. Representations in this style consist of premises and conclusions.
2. *Frame-Based Knowledge*
   A network framework or hierarchical structure is used to describe knowledge.
3. *Object-Based Knowledge*
   Object-based networks are used to describe knowledge. An object is a piece of data that has data and procedures, or processes.
4. *Case-Based Reasoning*
   The conclusion drawn from the case constitutes knowledge.

The following are several types of expert system problems:

- Interpretation, or drawing meaning from an unstructured body of material through description or inference.
- Forecasting, in particular, involves speculating about possible outcomes in a particular scenario.
- Diagnosis, especially considering symptoms, to determine the root cause of errors in complex scenarios.
- Design, in particular, is selecting the parts of a system to assemble in such a way that they achieve your performance goals within the parameters you have set.
- Making a plan, more specifically, a series of steps to be followed to achieve some goal with a certain starting point and constraints.
- Fixing and debugging, which involves finding and understanding solutions to problems.
- Educate, particularly by identifying and resolving gaps in subject area knowledge.
- Management, especially controlling the actions of a multifaceted environment.
- The ninth step is selection, which is choosing the best option from a list.
- Modeling the interactions between system parts through simulation.
- Monitoring, especially comparing visible data with predetermined standards.

3.4. Stages of Creating an Expert System

Although expert systems are more complex than ordinary systems, they can still be designed and built. The creation of several programs shows that anything is possible, regardless of how difficult it may seem. There are several factors to consider when developing expert system software, as follows :

a. Identify problems and requirements.
b. Assess the suitability of the problem.
c. Evaluate options.
d. Calculating return on investment.
e. Selecting manufacturing instruments.
f. Implementing knowledge engineering.

3.5. Web-Based Recommendation System

Web-based recommendation systems are intelligent tools that analyze current data to determine visitor interests and then make recommendations to increase conversion rates and customer loyalty. There are two main types of user profiles that form the basis of the functionality of recommendation systems: profiles that deal with profile creation and management, and profiles that deal with profile usage and recommendations. The main functions of these systems are profile creation and maintenance, data processing, and suggestion generation (Zhang et al., 2021).

3.6. Collaborative-Based

Collaborative filtering is a method in Figure 1 that uses market segmentation to predict user preferences by comparing the current user profile with other users' profiles. This helps identify users who may have similar needs, infer their interests from similar users, and make recommendations based on these findings (Li, 2023). This approach helps in enhancing the user experience and improving the overall user experience.

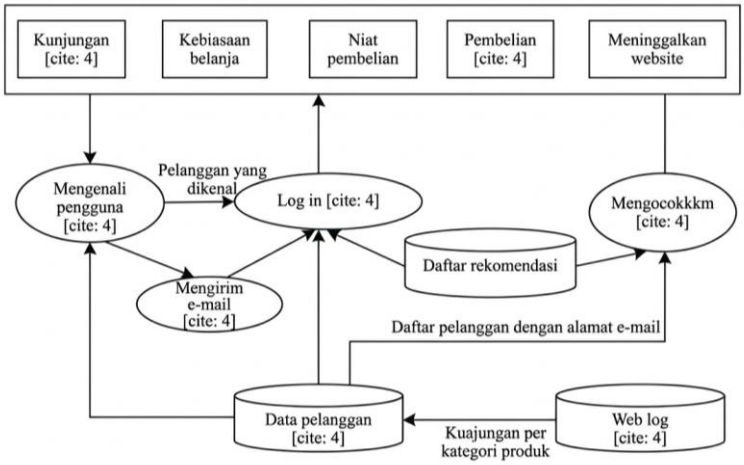

Figure 1. Collaborative Recommendation System Architecture On An E-Commerce Web

Collaborative filtering systems use a two-dimensional user-product matrix to collect data, which represents users and products. However, this data organization can cause scalability issues and poor performance if the data set is large, such as millions of users and products. The user-product matrix also becomes inefficient and lean if customers do not buy many items or do not want to provide product reviews. Clustering and principal component analysis are dimensionality reduction methods that can be used to address these issues. Collaborative filtering methods take into account the degree of connection when predicting user preferences based on the aggregate preferences of others in their subgroups. Unfortunately, there are several drawbacks to this technique. First, it does not provide sufficient justification for recommendations, which can lead to poor results for people with diverse interests. Second, it cannot promote new items that have not been tried or reviewed by anyone. For example, most collaborative filtering algorithms cannot tell a user whether a new book is a good book because they only work when the database contains preference data for a particular item.

4. Results and Discussion

4.1. System Design

Admin and user are the two main components of this system. Logging in as admin gives access to the system and the ability to process data, including system user and book data, using the admin menu. Users have the option to refine the suggestion results by providing personal data, preferences, and comments.

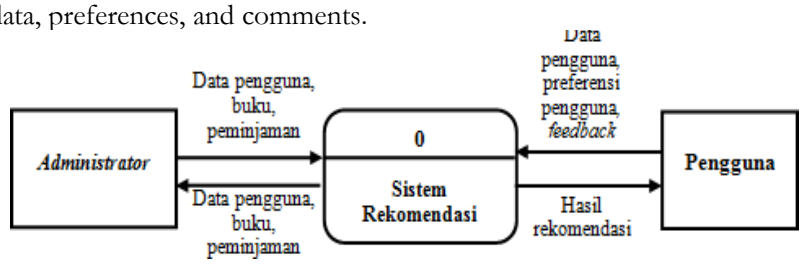

Figure 2. Context diagram of a book lending recommendation system

a. DAD Level 1

The first of the four system steps is data processing, which involves manipulating the database by adding, viewing, updating, or deleting records, just like in Figure 3. The second step is displaying book information, which is viewed by general system users; the third step is borrowing a book, which is completed by users entering the book title; and the fourth step is processing user data, which includes adding new users and providing comments. While all users can access the other processes, the first process requires administrator permission. Contacting the administrator is necessary if problems arise or if users wish to change their personal data.

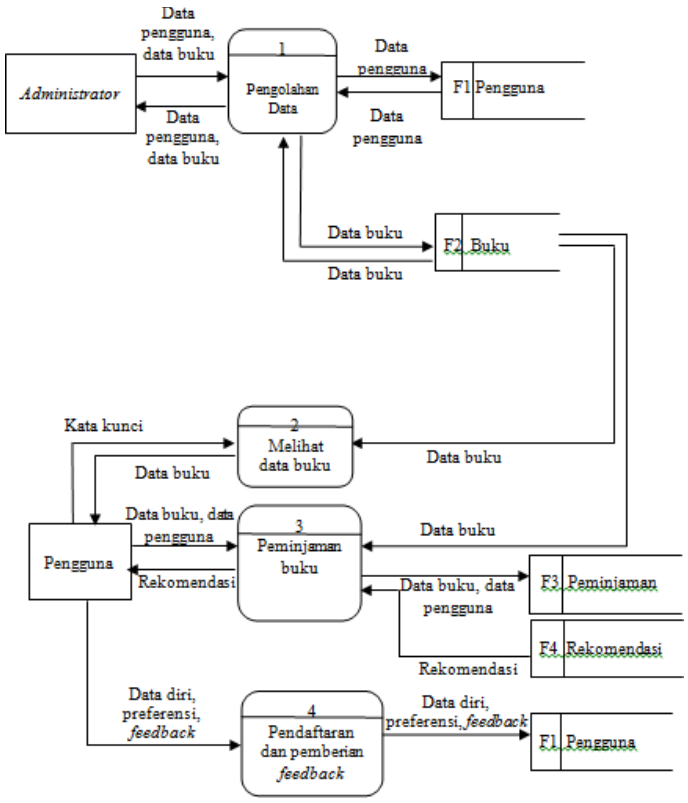

Figure 3. DAD Level 1

b. DAD Level 2 Process 1

Only confirmed admins have access to the database and can make changes to all data in Figure 4.

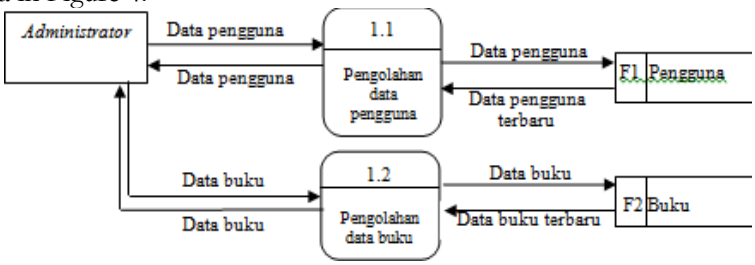

Figure 4. DAD Level 2 Process 1

c. DAD Level 2 Process 2

Users can obtain book data by entering keywords based on book title, author name, or publisher (Figure 4). This function in Figure 5 is part of the Level 2 DAD Process 2.

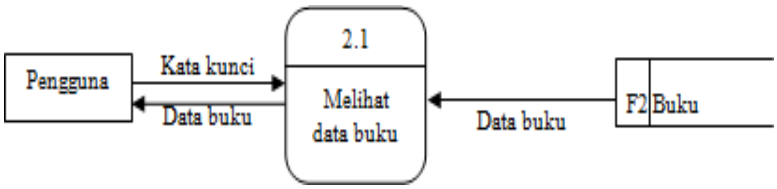

Figure 5. DAD Level 2 Process 2

d. DAD Level 2 Process 3

Users can borrow books from the library by providing personal data and book data. If you borrow two books, the suggestion table will record both. The system makes suggestions based on the data in the recommendation table when a user borrows one book.

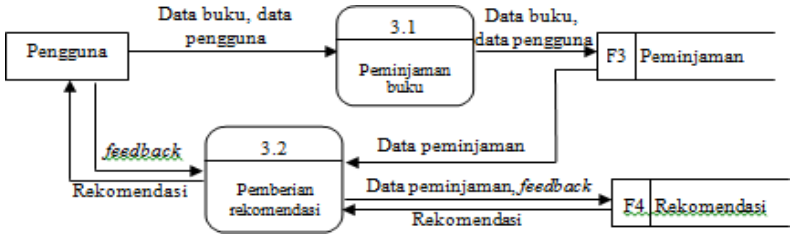

Figure 6. DAD Level 2 Process 3

e. DAD Level 2 Process 4

To keep up with the growth in the number of users, the library system must be able to accept new users who provide personal information such as name, gender, religion, address, phone number, place, date of birth, major, and preferred reading materials. If users need to make changes to their data, they must contact the system administrator. They can also provide suggestions to improve recommendations and report any problems they encounter.

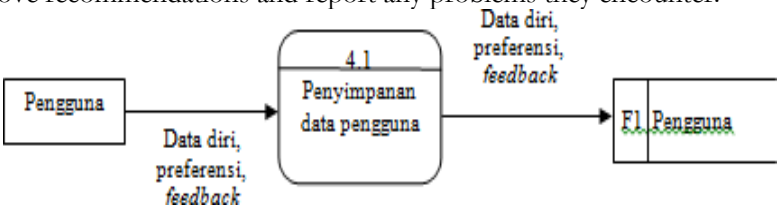

Figure 7. DAD Level 2 Process 4

4.3. Database Design

The goal of the database design phase is to accommodate processing demands, perform various performance items, provide a natural structure, and satisfy the information needs of users and the system. Figure 8 shows how the Entity Relationship Design (ERD) style simplifies the understanding of table connections.

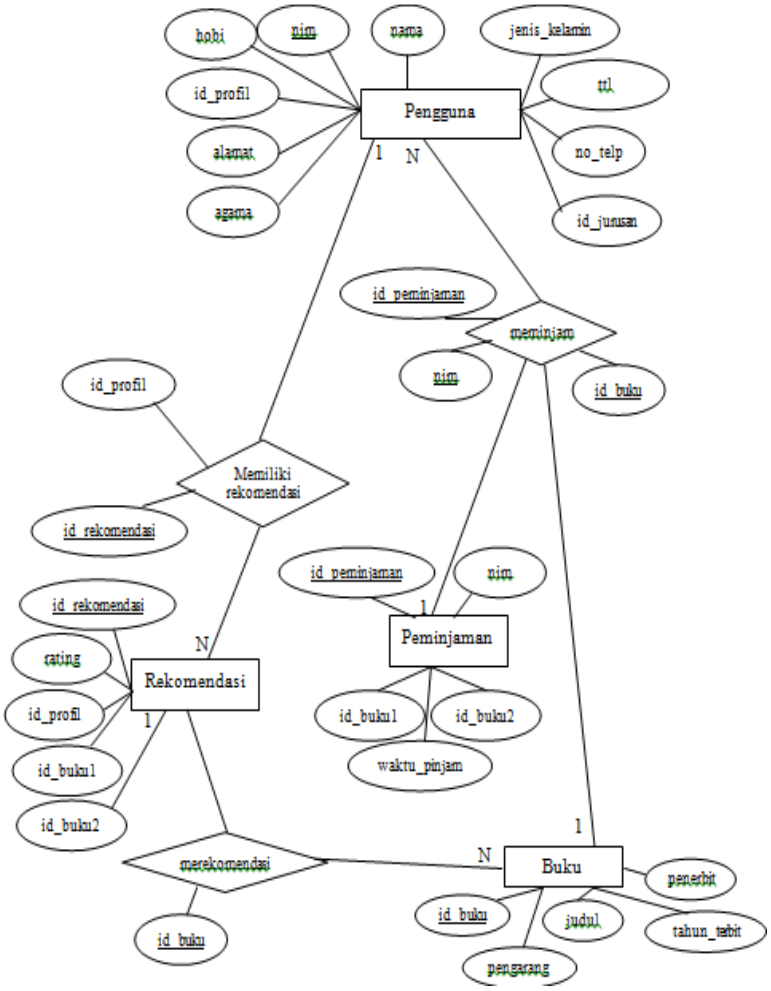

Figure 8. ERD System

4.4. System Flow Diagram Design

As shown in Figure 9, the Library's book borrowing recommendation system implements a flow diagram, which is a systematic depiction of the problem-solving process.

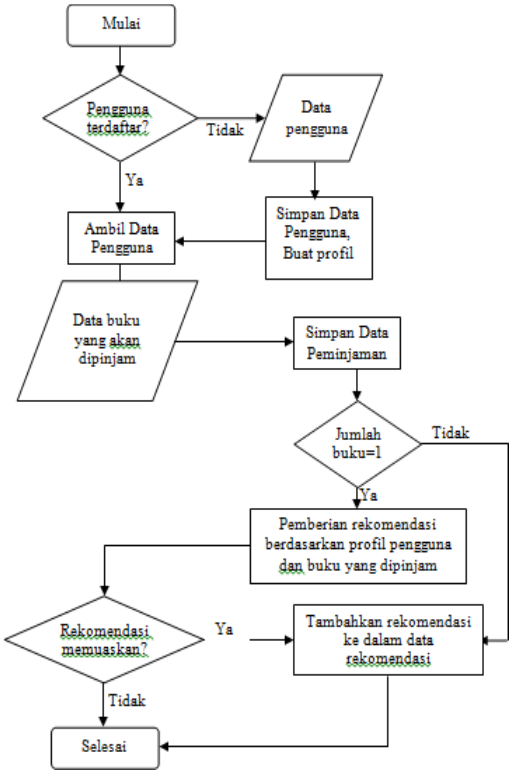

Figure 9. System flow diagram

4.5. Drafting Rules

Designing with Rules in Mind: Expert systems are rule-based processes for solving problems. In 1986, Gondran published... When recommending books to borrow, libraries use a collaborative approach. Based on user profiles and the books they borrow, the system creates profiles for them using rules and then makes suggestions. A set of rules is applied by the system when user groups are created.

```
Rule 1: IF hobi baca teknologi informasi dan
        telekomunikasi AND jurusan teknik
        informatika atau teknik elektro THEN
        profil 1.
Rule 2: IF hobi baca teknologi informasi dan
        telekomunikasi AND jurusan teknik
        penerbangan atau teknik mesin THEN
        profil 2.
Rule 3: IF hobi baca teknologi informasi dan
        telekomunikasi AND jurusan teknik
        industry THEN profil 3.
Rule 4: IF hobi baca kedirgantaraan AND jurusan
        teknik informatika atau teknik
        elektro THEN profil 2.
Rule 5: IF hobi baca kedirgantaraan AND jurusan
        teknik penerbangan atau teknik mesin
        THEN profil 4.
Rule 6: IF hobi baca kedirgantaraan AND jurusan
        teknik industri THEN profil 5. Rule
        7: IF hobi baca dunia perindustrian
        dan perdagangan AND jurusan teknik
        informatika atau teknik elektro THEN
        profil 3.
Rule 8: IF hobi baca dunia perindustrian dan
        perdagangan AND jurusan teknik
        penerbangan atau teknik mesin THEN
        profil 5.
Rule 9: IF hobi baca dunia perindustrian dan
        perdagangan AND jurusan teknik
        industri THEN profil 6.
Compiler
Rule 10: IF hobi baca musik dan kesenian AND
        jurusan teknik informatika atau
        teknik elektro THEN profil 7.
Rule 11: IF hobi baca musik dan kesenian AND
        jurusan teknik penerbangan atau
        teknik mesin THEN profil 8.
Rule 12: IF hobi baca musik dan kesenian
        AND jurusan teknik industri THEN
        profil 9.
Rule 13: IF hobi baca lainnya THEN profil 10.
```

Figure 10. Rule-Based Process

Userclassified into profile group 1, which includes students majoring in informatics engineering and reading books on information technology and telecommunications. The system applies the following rules to generate recommendations based on the data in Table 1.

Table 1. Example Table of User Grouping

Jenis Data	Nilai Data
NIM	06030013
Nama Mahasiswa	Piniel Romulia Hasibuan
Jenis Kelamin	Laki – Laki
Tempat, Tanggal Lahir	Mataram, 01 April 1988
Agama	Kristen Protestan
Alamat	Jl. Pelem Lor No.8, Banguntapan
No. Telepon	085640444476
Hobi Baca	Teknologi Informasi dan Telekomunikasi
Jurusan	Teknik Informastika

```
Rule 1: IF buku pertama dengan kelompok profil
        user ada dalam daftar rekomendasi THEN
        rekomendasi buku adalah maksimum tiga
        buah buku kedua dengan rating
        tertinggi dalam daftar rekomendasi.
Rule 2: IF buku pertama dengan kelompok profil
        user tidak ada dalam daftar
        rekomendasi THENIF buku kedua dengan
        kelompok profil user ada dalam daftar
        rekomendasi THEN rekomendasi buku
        adalah maksimum tiga buah buku pertama
        dengan rating tertinggi dalam daftar
        rekomendasi.
Rule 3: IF buku kedua dengan profil user tidak
        ada dalam daftar rekomendasi THEN
        rekomendasi adalah maksimum tiga buah
        buku dengan rating tertinggi untuk
        kelompok profil user.
```

Figure 11. Following the rules to Generate Recommendations

The system uses techniques to group users, such as users with profile group 1 and book recommendation data, as shown in Table 2.

Table 2. Book Recommendation Data Table

Id_buku1	Id_buku2	Rating
45	43	5
45	44	6
45	46	8
50	45	4
119	45	3

The existing rule will display recommendations for users with profile group 1 who borrow books with book codes 46, 44, and 43.

4.6. System Implementation and Analysis

Once the system is completed, it will go through two stages of testing: theoretical and practical. Practical testing involves testing the system with a sample of XYZ students who will use it in the future. To estimate how users will rate unexplored objects, the recommendation system evaluates user profiles with reference attributes. The system processes user data after registration and groups users based on rules. If a user borrows a book, the system uses historical data and profile data to make book recommendations based on the user's profile and the book borrowed. This collaborative filtering method is unique because of its long learning curve, as the initial recommendations are of low quality when there are few users. As the number of users increases, the quality of the recommendations gradually improves, leading to higher quality recommendations as the number of users and book borrowings increases.

a. Practical Testing

The level of detail in the suggestion list is closely related to the accuracy of the system's recommendation output. During the live system testing phase, a representative sample of 10 students (representing approximately 10% of the total student body) was drawn from the user pool. Interviews with faculty members corroborated this picture. A flowchart illustrating the user testing procedure is shown in Figure 12.

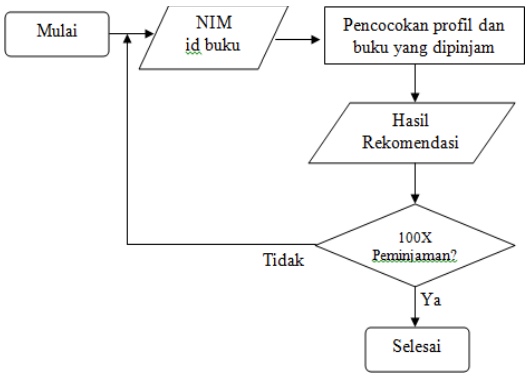

Figure 12. Flowchart of the system testing process

b. Test Results

Figure 14 shows the results of a survey asking users of the system how effective the system was when used at the XYZ library; 96.6% of respondents said the system was effective, while 3.6% said it was not. This graph shows the level of system effectiveness obtained from all the data collected. Based on the same test, we know that the XYZ library system is very efficient because all respondents agree that the system is efficient. This is shown in Figure 16. Figure 18 shows the results of the same test, showing the level of user satisfaction with the system. Specifically, 39.1% of users are very happy, 50.6% are somewhat satisfied, 1.1% are less satisfied, and 1.1% are dissatisfied with the performance of the system.

5. Conclusion

This study shows that the implementation of COBIT 5.0-based IT Governance in designing an expert system can significantly improve library user services. The system offers personalized recommendations based on user profiles, improving operational efficiency, service speed, and accuracy in borrowing and searching books. The high level of user satisfaction (96.6% and 100%) indicates the feasibility of the system at various library scales. The implementation also benefits strategic alignment between information technology and library needs, supports data-driven decision making, and improves the overall user experience.

Expert systems should be developed with AI to enhance capabilities, including user need prediction and advanced search features. User training should be provided to enhance system usability. Regular evaluation and cross-context testing should be conducted to ensure system consistency across different types of libraries. Multi-platform integration should be ensured to enhance user accessibility, ensuring the system is compatible with a variety of devices, including desktops and mobile phones.

Author Contributions: M.W. and D.N. contributed to the conceptualization of the study. M.W. was responsible for the methodology design and software development. Validation was conducted by D.N. Formal analysis was carried out by M.W. and D.N. Investigation and data curation were performed by M.W. The original draft of the manuscript was prepared by M.W., while review and editing were conducted by D.N. Visualization was completed by M.W. Supervision, project administration, and funding acquisition were managed by D.N. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding

Data Availability Statement: The data supporting the findings of this study are not publicly available due to the nature of the research and confidentiality considerations.

Acknowledgments: The authors would like to thank all participants who took part in the usability testing process. The authors also acknowledge the support provided by the academic environment that facilitated this research.

Conflicts of Interest: The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript; or in the decision to publish the results.

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