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Development of a Web-Based Internship Licensing System Using the Waterfall Model at the Ministry of Law and Human Rights

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Abstract: The internship licensing process at the Ministry of Law and Human Rights (Kemenkumham) was previously managed through manual procedures, leading to inefficiencies such as delayed processing, data redundancy, and lack of real-time status tracking. This study aimed to develop a web-based internship licensing system to improve administrative efficiency, transparency, and user experience. The development process employed the waterfall model, covering five stages: requirement analysis, design, development, testing, and maintenance. The system was implemented using Laravel for the backend, Flutter for the frontend, and MySQL for the database. Key features include digital permit submission, weekly and final report uploads, role-based dashboards, and real-time status notifications. System validation involved black-box testing and expert evaluation using a 5-point Likert scale, yielding a 94.66% feasibility score categorized as very feasible. The results demonstrate that the application fulfills core functional requirements and addresses the previously identified administrative limitations. The study concludes that the system is effective for managing internship processes in public institutions. Future improvements include broader system integration with academic information systems and enhanced mobile compatibility.

Keywords: Internship Licensing System; Web Application; Waterfall Model; Laravel; Public Sector Digitalization.

1. Introduction

The acceleration of digital transformation has driven organizations, particularly in the public sector, to adopt information and communication technology (ICT) to enhance service delivery and operational efficiency [1], [2]. Web-based information systems are essential for automating administrative tasks, reducing human error, and improving transparency and responsiveness in public services [3]–[5]. In the education sector, particularly in internship and licensing processes, digital solutions are increasingly being adopted to support more efficient and accountable administrative workflows [6], [7].

The Ministry of Law and Human Rights (Kemenkumham) plays a central role in providing legal, immigration, and correctional services in Indonesia. One of its initiatives includes organizing internship programs that offer students the opportunity to gain practical experience in public legal institutions. These programs not only enrich students' knowledge of real-world legal administration but also contribute to the development of qualified human resources in the legal sector.

However, the existing internship licensing process within Kemenkumham's regional offices remains predominantly manual. The management of internship data still relies on spreadsheets such as Microsoft Excel and requires physical submission of documents. This manual approach introduces several inefficiencies, including data redundancy, the risk of data loss, delays in application processing, and difficulties in tracking application statuses in real time [8]–[10]. Moreover, the internship evaluation process is conducted using printed rubrics, which can result in inconsistencies, lack of objectivity, and vulnerability to loss or damage [11].

The absence of an integrated digital system hampers communication between applicants, supervisors, and administrative staff. This can lead to uncertainty in the approval process, reduced satisfaction among users, and administrative errors that affect service quality. Addressing these issues requires the implementation of a centralized, user-oriented system that supports digital submission, online verification, secure data storage, and real-time monitoring.

This study aims to develop a web-based internship licensing system using the Laravel framework and a waterfall development approach. The system includes features such as digital application submission, automated notifications, real-time tracking, and secure document handling. Through this initiative, the study seeks to increase administrative effectiveness, reduce manual workload, and support the ongoing digital transformation within public service institutions.

2. Material and methods

The development of this internship permit application uses the waterfall method which consists of five stages, namely Requirement Analysis, Design, Development, Testing, and Maintenance [12], [13].

Figure 1. Waterfall Method

2.1 Requirement Definition

At this stage, developers must know information about all software needs such as the usefulness of the software desired by users and software limitations. This information is usually obtained from interviews, surveys, or discussions. After that, the information is analyzed to obtain complete data about user needs for the software to be developed.

2.1.1 Identification

The internship permit system involves multiple users, each with specific roles and responsibilities. Admins manage student data, verify applications, update statuses, and upload internship permits. Students submit applications, upload required documents, track their application status, and fill in internship logbooks. Internship supervisors assess logbooks, monitor student progress, and provide feedback on internship reports. Operators handle administrative tasks and process applications, while Division Heads oversee student progress and generate annual internship reports. This structured division of tasks ensures that the internship process runs efficiently and in an organized manner.

2.1.2 Functinal Requirements

The system must support user management for account access, internship permit management for applications and approvals, weekly report management for student submissions and supervisor reviews, and internship report management for final report assessment and feedback. These features ensure an efficient and organized internship permit process.

2.1.3 Non-Functional Requirment

The system must have a user-friendly interface that is intuitive and easy to navigate. It should offer online accessibility, allowing users to access it from anywhere via the internet. Additionally, the system must ensure performance efficiency by processing requests quickly for a smooth and seamless user experience.

2.1.4 Proposed System Flow Map

At this stage, the design is done quickly and represents all known aspects of the software, and this design becomes the basis for making the application. System planning is arranged by considering the data that has been obtained which is collected at the requirement analysis stage. This stage will produce a flow map which is a representation of all the needs in making the system. The following is the flow map:

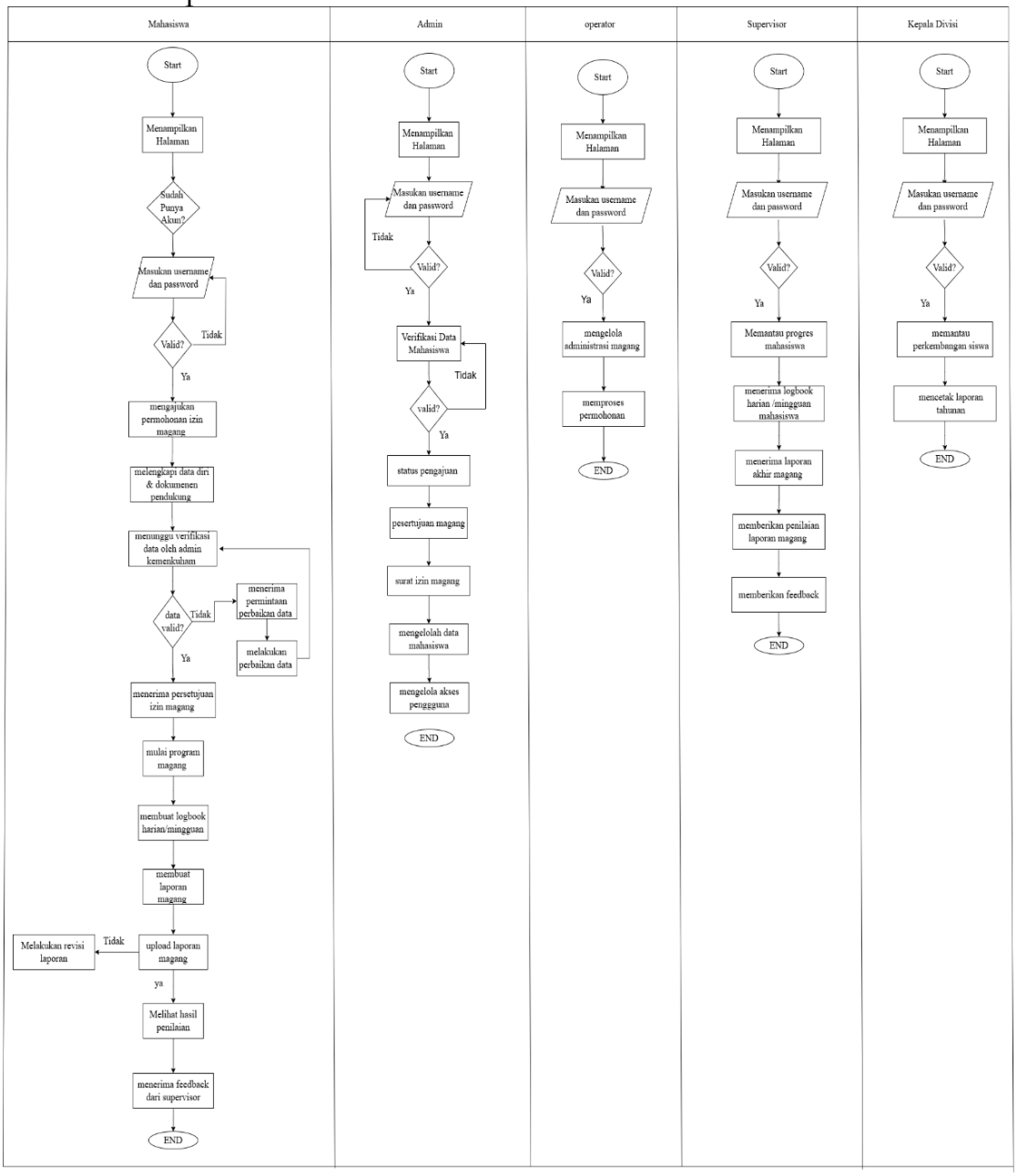

Figure 2. Proposed System Flow Map

Figure 2 shows a system flow map that illustrates the process flow for various users, namely admin, students, operators, supervisors and division heads. Each

user after logging in will be directed to the dashboard page, and can access menus that are adjusted to their respective access rights and needs.

2.2 Design

After the system requirements analysis is complete and all requirements have been clearly defined, the next step is the system design process. This process aims to get an idea of how the information will be implemented in the system. The process in System and Software Design is as follows:

2.2.1 Use Case Diagram

Use Case diagram is a model of the results of system design analysis that aims to describe system needs. The system needs will be implemented by the user so that the system design can be described [14], [15]. Here is the design of the Use Case Diagram that can be seen in the image below:

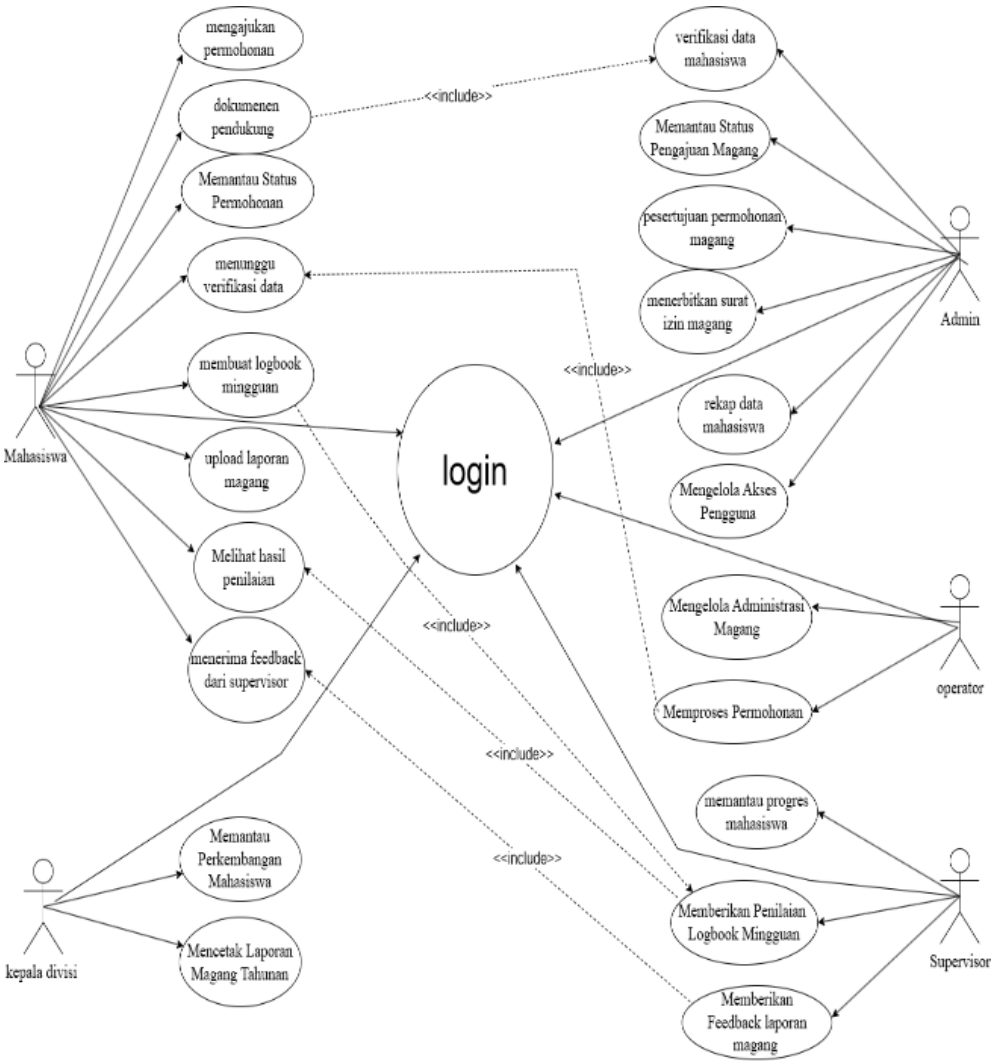

Figure 3. Use Case Diagram

Figure 3 Use Case Diagram illustrates five actors in the internship system: Admin, Students, Internship Supervisor, Operator, and Division Head. Admin manages data and verification of applications, Students submit applications and fill in the logbook, Internship Supervisor assesses and provides feedback, Operators manage administration, and Division Heads monitor and print reports. Each actor plays a role in the smooth running of the internship process from registration to final evaluation.

2.2.2 Activity Diagram

Activity diagrams describe the various processes of activities in a system that is being created, how each process begins, the decisions that may occur, and how the process ends. Activity diagrams also describe parallel processes or stages that may occur in several parts of the execution [16], [17]. The following is an Activity Diagram in the internship permit application:

2.2.2.1 Login Activity Diagram

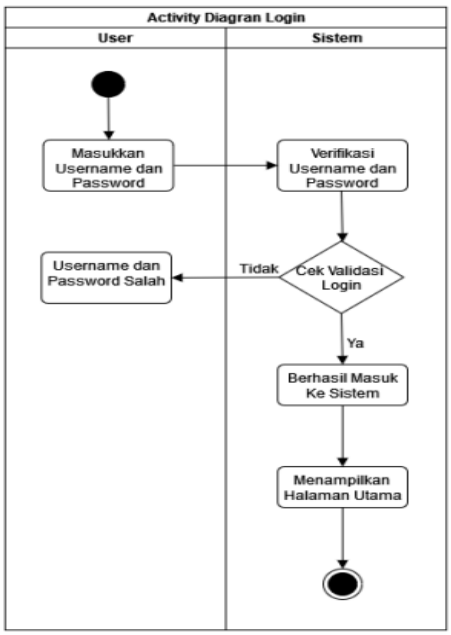

Figure 4. Login Activity Diagram

Figure 4 explains that to login, the user must first fill in the username and password. After that the system verifies whether the username and password are correct or not. If correct then the login is successful and enters the application, if wrong the system will notify that the username or password is incorrect and then will return to the user activity entering the username and password.

2.2.2.2 Admin Activity Diagram

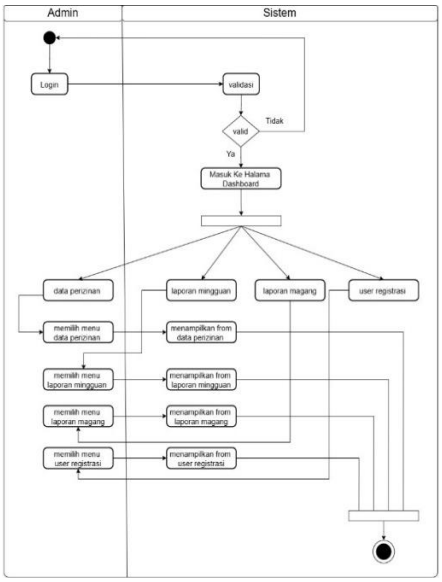

Figure 5. Admin Activity Diagram

In Figure 5 Activity diagram, the activity diagram that can be done by the admin in the system is depicted. To enter the system, the admin must first log in using a username and password. If the input entered is valid, the system will display the home page. The admin home page has several submenus, namely licensing data, weekly reports, internship reports, and user registration. Each selected submenu will display a form to manage data. As well as doing a recapitulation.

2.2.2.3 Student Activity Diagram

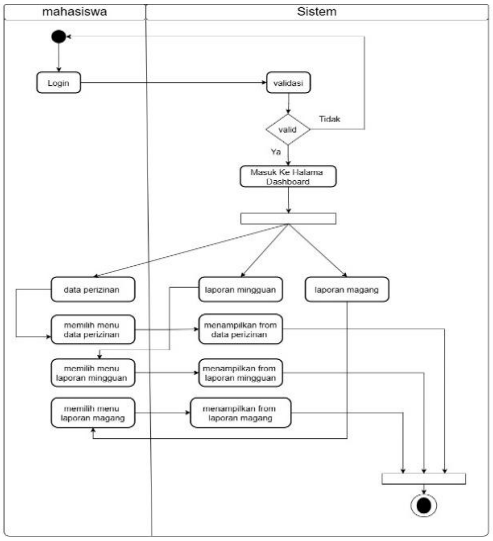

Figure 6. Student Activity Diagram

In Activity Diagram Figure 6, students must log in with a username and password. If valid, the system displays the home page with the Permit Data

submenu. After filling out the permit form and the application is accepted, the Weekly Report submenu will appear to manage the activity logbook and the Internship Report to manage the final internship report.

2.2.2.4 Operator Activity Diagram

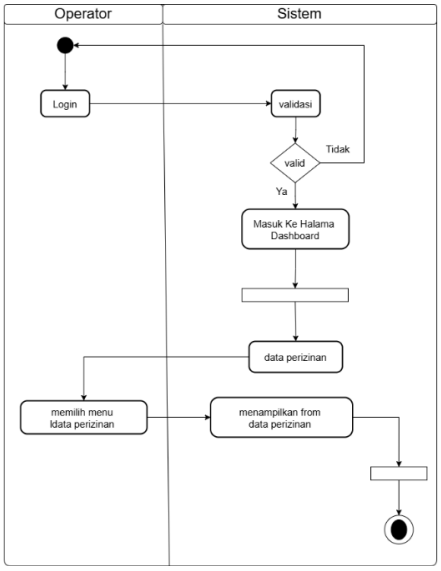

Figure 7. Operator Activity Diagram

In Activity Diagram Figure 7, the operator must log in with a username and password. If valid, the system displays the home page with the Internship Permit Data submenu, where the operator can set the internship application status as Processed, Accepted, or Rejected.

2.2.2.5 Supervisor Activity Diagram

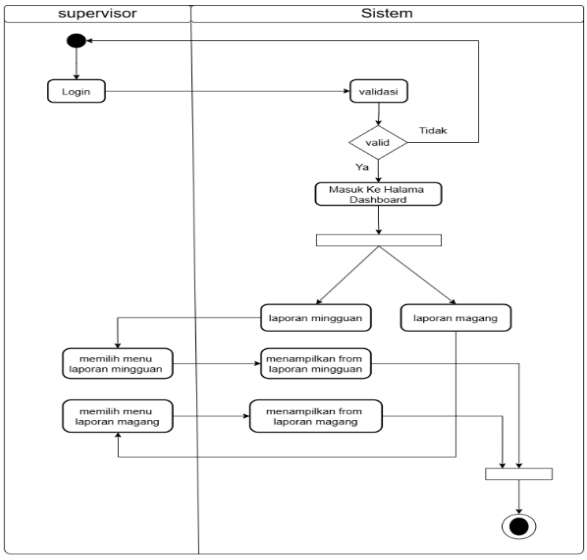

Figure 8. Supervisor Activity Diagram

In Activity Diagram Figure 8, the supervisor must log in with a username and password. If valid, the system displays the home page with the Weekly Report and Internship Report submenus. The Weekly Report is used to provide assessments and determine the examination status (Process or Examined). The Internship Report allows the supervisor to provide feedback in the form of comments and determine the assessment status (Process or Examined).

2.2.2.6 Activity Diagram Head of Division

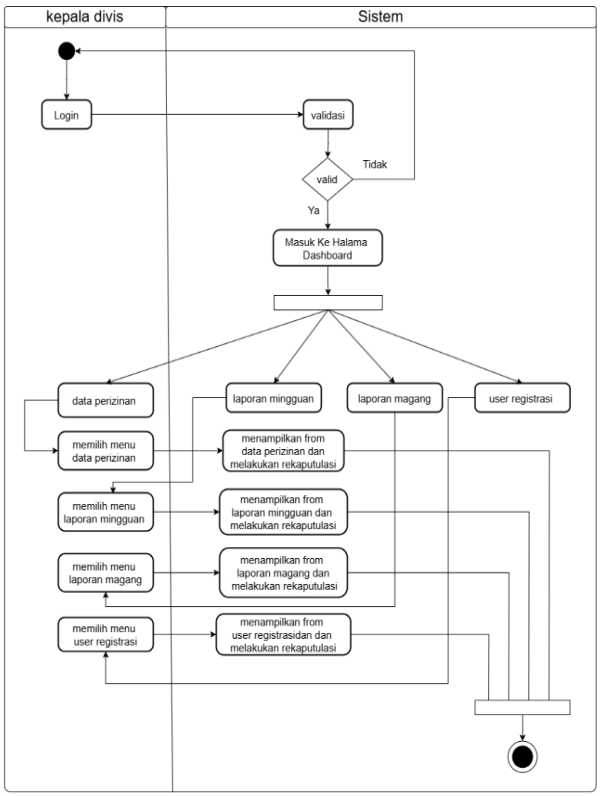

Figure 9. Activity Diagram Head of Division

In Activity Diagram Figure 9, the division head must first log in with a username and password. If valid, the system displays the home page with access rights such as admin. There are several submenus, namely Licensing Data, Weekly Reports, Internship Reports, and User Registration. Each submenu displays a form for annual recapitulation and monitoring student progress.

2.2.3 Sequence Diagram

Sequence diagram is a UML technique used to describe the interaction between objects in and around a system, such as users, displays, and so on, with messages depicted temporally [18], [19]. The following is a sequence diagram contained in the student violation point information system:

2.2.3.1 Sequence Diagram Admin

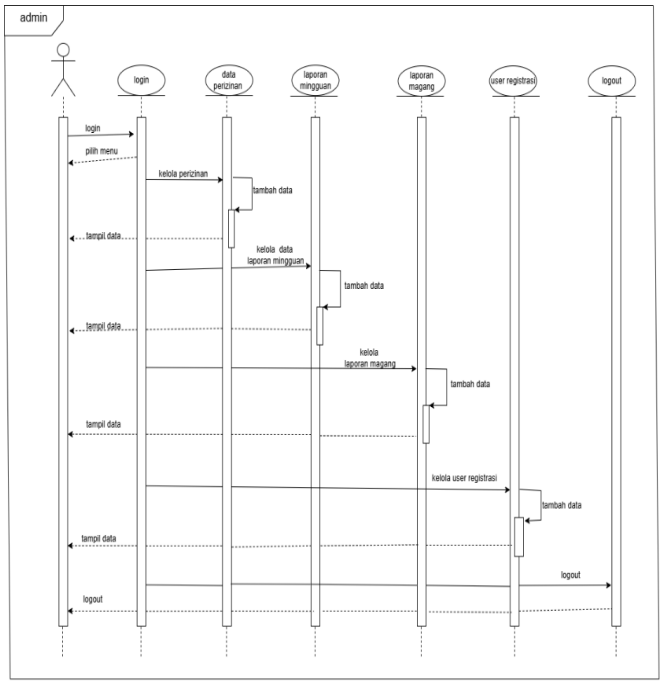

Figure 10. Sequence Diagram Admin

Figure 10 shows the interaction between the admin and the objects in the system. The admin can access the menus, namely, licensing data, weekly reports, internship reports, and user registration.

2.2.3.2 Student Sequence Diagram

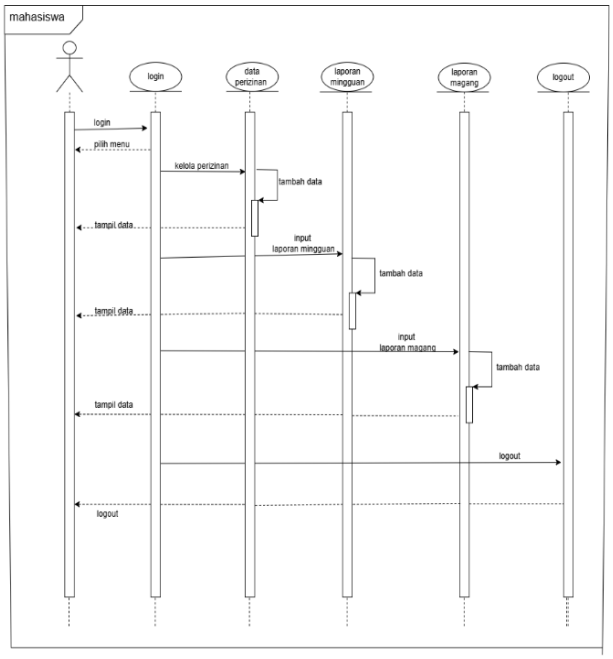

Figure 11. Student Sequence Diagram

Figure 11 shows the interaction between students and objects in the system. Students can access menus, namely, licensing data, weekly reports and internship reports.

2.2.3.3 Operator Sequence Diagram

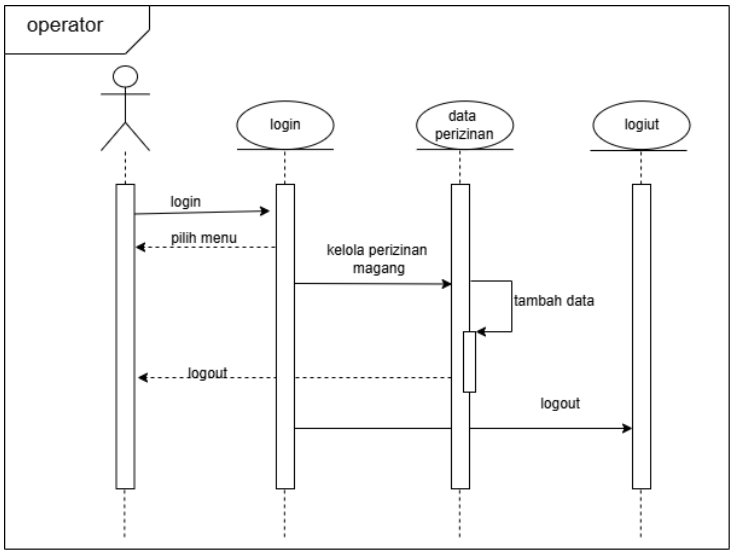

Figure 12. Operator Sequence Diagram

Figure 12 shows the interaction between operators and objects in the system. Operators can access the menu, namely, licensing data.

2.2.3.4 Sequence Diagram Supervisor

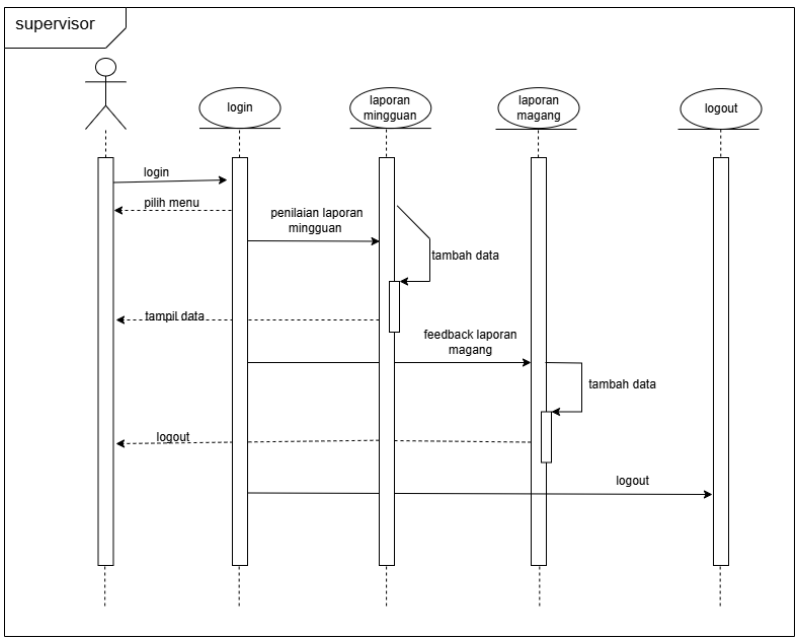

Figure 13. Sequence Diagram Supervisor

Figure 13 shows the interaction between the admin and the objects in the system. The supervisor can access the menu, namely, weekly reports and internship reports.

2.2.3.5 Sequence Diagram for Head of division

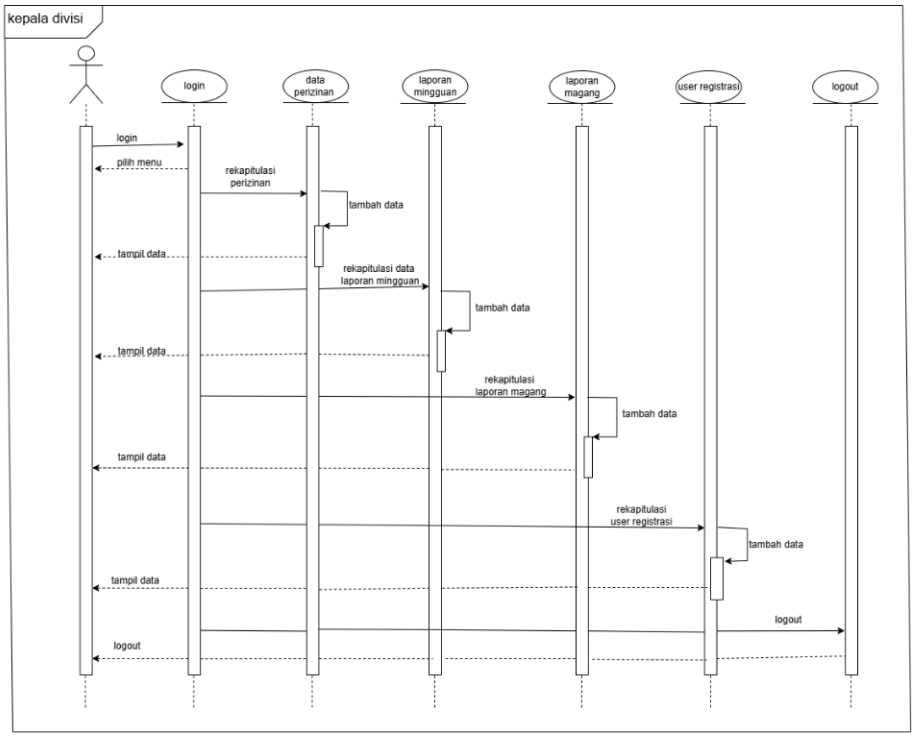

Figure 14. Sequence Diagram for Head of division

Figure 14 shows the interaction between the division head and the objects in the system. The division head can access the menus, namely, licensing data, weekly reports, internship reports, and user registration.

2.3 Development

In the implementation and unit testing phase, the previously outlined plan is executed through programming. For the backend, PHP is used with the Laravel framework, which provides a robust and efficient environment for developing information systems. The mobile frontend is developed using Dart and Flutter, which offer a smooth and responsive user experience. The database is managed using MySQL, which was chosen for its reliability and performance as a Database Management System (DBMS)

2.4 Testing

At this stage, the completed application will undergo a testing process to assess the extent of the application's performance. In this study, application testing was carried out using the black-box testing method using an expert validation

questionnaire. The data generated from the expert validation questionnaire is a description of the criteria for the application for developing a recommendation system for selecting a final assignment supervisor that was developed. The data generated from the validity questionnaire was summed up and explained using criteria with a scale of 5, to interpret the measurement results or also called assessments.

2.5 Maintenance

Maintenance is the final stage of the waterfall method. Software that has been used and maintained. Maintenance includes fixing errors that were not found in the previous steps. In the maintenance stage, the goal is to maintain, update, and improve the system over time. The maintenance process can involve steps similar to initial development, starting from analyzing specifications to making changes to existing software, but does not include creating new software [20], [21].

3. Results and discussion

This section presents the implementation outcomes of the internship licensing application and discusses the alignment between the development process and the initial objectives using the waterfall model. Each phase—requirement analysis, system design, development, testing, and maintenance—is evaluated to demonstrate the system's functionality, performance, and impact.

3.1 Requirement Fulfillment

Based on the requirement analysis phase, several key needs were identified: role-based access, digital submission, real-time status tracking, centralized logbook/report management, and secure authentication. These requirements were translated into system features such as student application forms, admin dashboards for verification and data recapitulation, weekly and final report uploads, and supervisor feedback interfaces.

The system successfully supports five user roles: Admin, Student, Operator, Supervisor, and Division Head. Each role is provided access to features relevant to their responsibilities. For instance, students can upload logbooks and final reports, while supervisors can assess those entries directly via the system. This fulfills the requirements gathered through initial stakeholder interviews and observations.

3.2 System Design Implementation

The system's structure was defined through Unified Modeling Language (UML) diagrams, including use case diagrams, activity diagrams, and sequence diagrams. These models served as essential guides for the functional

development of the application. The use case diagrams outlined the specific tasks assigned to each user role, ensuring that all functionalities aligned with the requirements identified during the analysis phase. Activity diagrams were used to model the workflows of various user interactions, such as login validation, permit data processing, and report uploads, allowing developers to visualize the decision points and process flows clearly. Meanwhile, sequence diagrams mapped the interactions between system components and users over time, helping to establish the temporal logic of operations and communication between objects. Collectively, these design elements contributed to a coherent user experience, reduced ambiguity during implementation, and ensured that the system's final structure closely followed the architectural plans established during the design phase.

3.3 System Development

The application was developed using the Laravel framework for backend functionality, applying the MVC (Model-View-Controller) architecture to separate logic, interface, and data layers. The frontend, developed using Flutter, provides a responsive interface accessible on both web and mobile platforms.

The database uses MySQL, selected for its relational model, speed, and ease of integration with Laravel. The system's backend includes APIs for handling form submissions, report uploads, and user authentication, while the frontend offers intuitive navigation through dashboards and forms.

3.4 System Testing and Validation

System testing was conducted to ensure that each developed feature met the specified functional requirements and worked as intended. The testing process adopted the black-box testing method, which focuses on examining the system's external behavior without evaluating its internal code structure. Each critical function—such as login, user registration, permit submission, weekly report uploads, final report management, and supervisor evaluations—was tested to verify its accuracy in handling input data, producing expected outputs, and managing incorrect or incomplete inputs with appropriate error messaging. All tested modules passed this stage, confirming the system’s operational integrity.

To evaluate the usability and readiness of the system for real-world implementation, a validation process was carried out by involving domain experts, including lecturers in information systems and internship program coordinators. The experts were asked to assess the system based on several aspects using a questionnaire with a 5-point Likert scale, where 1 indicates strongly disagree and 5 indicates strongly agree.

The evaluation focused on four key aspects: usability, clarity, performance, and system completeness. The results of this expert validation are summarized in the following table:

Table 1. Expert Validation Results

No	Validation Aspect	Average Score	Category
1	Usability	4.70	Very Good
2	Clarity of Features	4.65	Very Good
3	System Performance	4.75	Very Good
4	Completeness of Features	4.60	Very Good
Overall Average		**4.67**	**Very Feasible**

The overall average score of 4.67 (or 94.66%) places the system in the "very feasible" category. This suggests that the application is well-suited for actual implementation in internship administration processes, especially in public institutions like the Ministry of Law and Human Rights.

The qualitative feedback from experts highlighted several important points. First, the simplicity of the interface was praised for enabling users, especially students and administrators, to navigate and operate the system with minimal training. Second, the real-time tracking of permit status was considered a strong improvement over the previous manual methods, as it reduces uncertainty and improves communication between parties. However, the experts also provided constructive suggestions, such as enhancing the document upload process by including confirmation prompts and incorporating user guidance pop-ups to assist first-time users.

These results indicate that the developed system not only fulfills the technical requirements but also successfully addresses the core problems identified during the requirement analysis phase—namely, manual data entry, slow communication, and lack of transparency. The testing and validation process confirms that the system can provide an efficient, user-friendly, and scalable solution for managing internship permits in institutional settings.

3.5 System Implementation Overview

The following is a brief overview of the system's main interface components and functionalities based on implementation:

3.5.1 Website Main Page Appearance

This image shows the interface of the Kemenkumham e-Magang platform, a web system for managing internship programs at the Ministry of Law and Human Rights. The platform aims to provide valuable internship experiences for students and improve skills in the legal field. The site navigation provides the Home, About, Features, Services, and Contact menus, indicating the

existence of supporting features for interns. Overall, this platform is in line with the internship permit digitalization project that you are developing at the West Sumatra Kemenkumham.

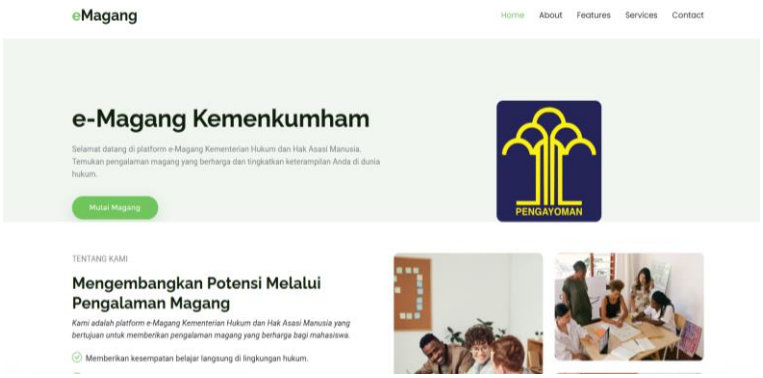

Figure 15. Website Main Page Appearance

3.5.2 Login Page display

The login page is displayed after the user clicks the start internship menu on the main page of the application. This page functions as a login access for users who have user and password access rights. After successfully logging in, the user is directed to the dashboard page. The following is a display of the login page for this application:

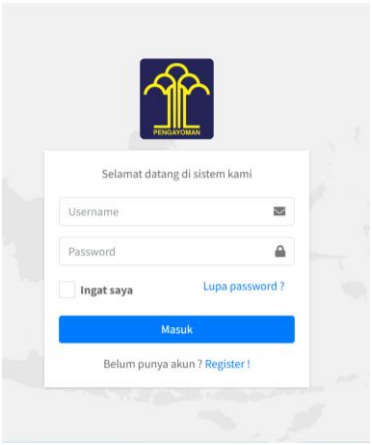

Figure 16. Login Page

3.5.3 Registration Page Display

The login page is displayed after the user clicks the start internship menu on the main page of the application. This page functions as a registration access for users who do not yet have user and password access rights. After successfully registering, they will enter the login page, the user is directed to the dashboard page. The following is a display of the registration page for this application:

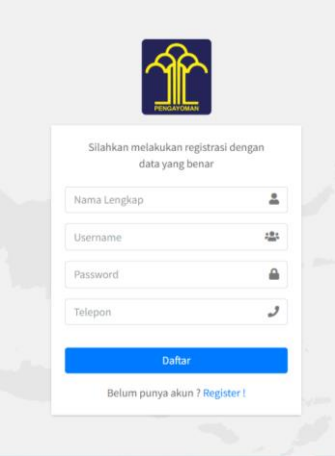

Figure 17. Registration Page Display

3.5.4 Admin Dashboard Page

This dashboard contains a summary of data such as the number of weekly reports, internship reports, user registrations, and internship permits. Side navigation provides access to various features, including Permit Data, Weekly Reports, and User Registration. In addition, there are graphs to visualize the number of internship permits. With a clear and informative display, this system helps admins in unifying and managing internship programs more efficiently.

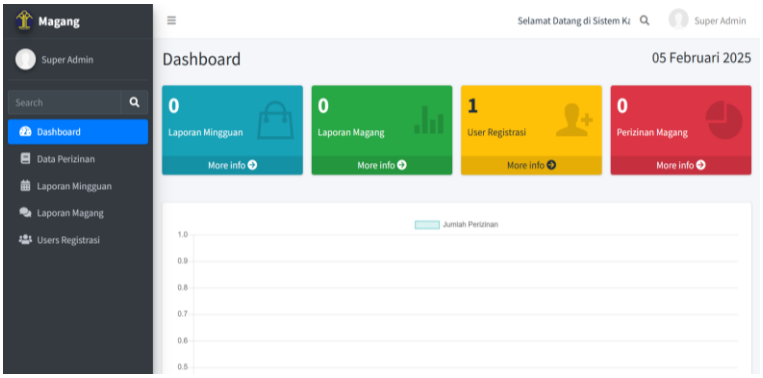

Figure 18. Admin Dashboard Page

3.5.5 Student Permit Data Page

This page displays the internship registration form in the Kemenkumham e-Internship system. This form allows users to enter Full Name, Place of Birth, Date of Birth, Gender, Telephone, University, Address, and upload an Application Letter. There is a Save Data button to save the inputted information. This feature makes it easier for students to apply for internships digitally. After the internship application is accepted, a weekly report and internship report will appear.

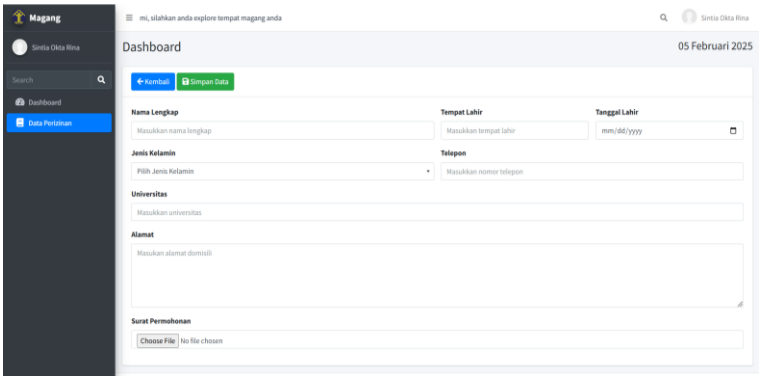

Figure 19. Student Permit Data Page

3.5.6 Student Weekly Report Page

This page shows the weekly report upload page in the Kemenkumham e-Internship system. Users can select the report date and upload the logbook file as evidence of internship activities. There is a Save Data button to save the report. This feature makes it easier for students to document their internship activities digitally

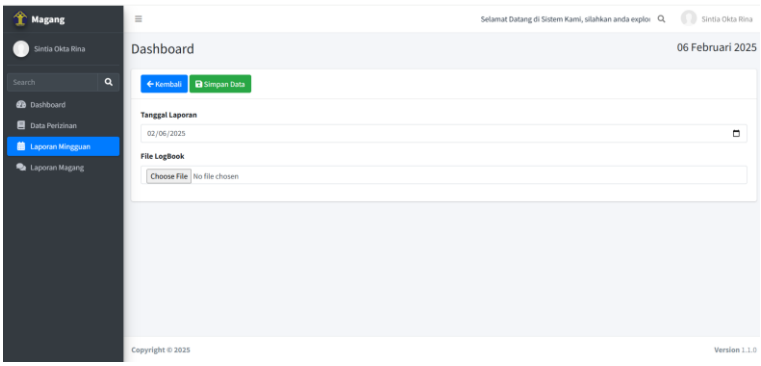

Figure 20. Student Weekly Report Page

3.5.7 Student Internship Report Page

This page shows the internship report upload page in the Kemenkumham e-Internship system. Users can select the report date and upload internship files as evidence of activities. There is a Save Data button to save the report. This feature helps in the digitalization of internship administration, facilitating tracking and management of reports.

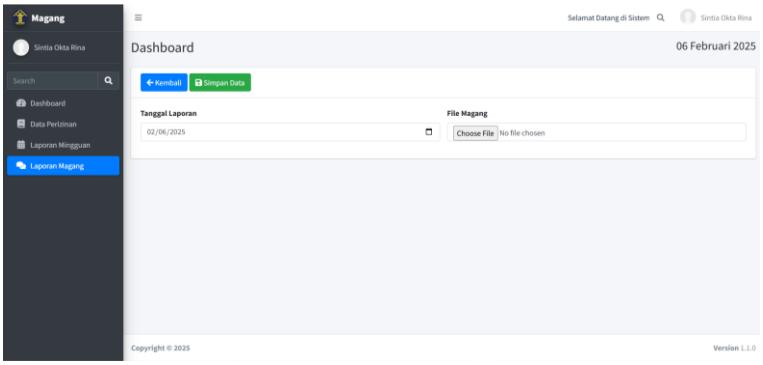

Figure 21. Student Internship Report Page

3.5.8 User Registration Page

The user registration page in the Kemenkumham e-Magang system allows admins to add new users by filling in their Full Name, Username, Password, Telephone, and selecting User Status such as Admin, Student, Operator, Supervisor, or Head. This feature supports efficient management of user accounts in the system.

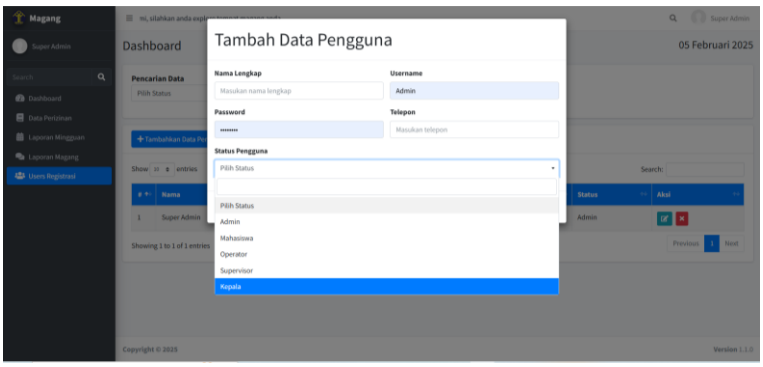

Figure 22. User Registration Page

3.6 Maintenance Plan and Future Enhancements

As the final phase of the waterfall development model, maintenance plays a critical role in ensuring that the system remains functional, reliable, and adaptable to evolving user needs. After the system is deployed, ongoing maintenance activities are planned to address both technical and usability-related issues. Initial maintenance efforts will focus on fixing bugs reported during user onboarding and early usage, particularly issues related to login errors, data submission inconsistencies, or interface responsiveness. These early fixes are crucial for stabilizing the system before broader adoption.

In addition to corrective maintenance, adaptive maintenance is planned to ensure the system remains compatible with updated software environments. This includes upgrading the Laravel and Flutter frameworks periodically to

align with their latest stable versions, thereby improving performance, security, and support for newer features.

Based on expert feedback and user suggestions, several enhancements are proposed for future development. These include the addition of push notification features to inform users about permit status updates in real time, broader mobile compatibility across different user roles to support increased flexibility, and the development of analytics dashboards to provide high-level reporting for internship program coordinators and institutional administrators.

Looking ahead, the system is also expected to be integrated with existing academic information systems used by universities and government APIs, such as those managing student databases or institutional verification. This would significantly streamline the data validation process, minimize redundancy in document submission, and further improve the transparency and accuracy of internship administration.

Overall, the maintenance plan and proposed enhancements aim to ensure that the system continues to deliver long-term value, scales effectively across different institutional environments, and evolves in response to user demands and technological advancements.

3.7 Discussion

The development and implementation of the internship licensing application addressed several critical challenges identified during the requirement analysis phase. Manual processes such as physical document submission, delayed status updates, and fragmented communication were replaced by an integrated, role-based digital system. Through the waterfall model stages—analysis, design, development, testing, and maintenance—each aspect of the system was aligned with stakeholder expectations, ensuring that functionality met institutional workflow demands [22].

From the requirement fulfillment, it is evident that the system managed to accommodate five distinct user roles with tailored access and features. This structure not only streamlines administrative processes but also enhances accountability by clearly separating responsibilities between students, supervisors, administrators, and program coordinators. The seamless transition from paper-based operations to a digital platform reflects the system's success in adapting to the complexity of real-world institutional dynamics.

The design implementation, grounded in UML modeling techniques, ensured a clear architectural foundation. The use of use case, activity, and sequence diagrams facilitated accurate translation of user stories into workflows, improving the efficiency of development and reducing the risk of misinterpretation. These diagrams played a vital role in enabling developers to

simulate real-time interactions and identify dependencies before actual coding began—an essential step in reducing development errors and optimizing performance.

During the development phase, the combination of Laravel for backend and Flutter for frontend allowed for responsive, secure, and maintainable implementation. The use of MySQL as the database ensured robust data integrity and supported the scalability needed for deployment in institutional settings. The decision to implement the system on a web-based platform with mobile adaptability reflects current trends in government digital transformation and education technology [23]–[25].

System testing and validation further affirmed the application's readiness. Black-box testing confirmed that all functional components behaved as expected, handling various inputs and system states appropriately. More importantly, expert validation provided qualitative and quantitative evidence of the system's viability. With a mean score of 4.67 (94.66%) across usability, clarity, performance, and completeness dimensions, the system was deemed "very feasible" for institutional use. This result exceeds common thresholds for pilot deployment and indicates strong acceptance among target users.

Positive feedback emphasized the intuitive interface and real-time status tracking—features directly tied to the core problems the system aimed to resolve. Meanwhile, constructive suggestions regarding confirmation dialogs and onboarding guidance offer valuable insights for iterative improvements. This highlights the importance of maintaining an adaptive development outlook, even after primary implementation is complete [26], [27].

The system interface and dashboard reviews also reflect a strong user-centered design. By enabling direct access to relevant functions—such as student report uploads, admin verifications, and supervisor assessments—the interface minimizes cognitive load and supports task completion with minimal training. Visual elements, such as summary dashboards and progress graphs, enhance transparency and support decision-making for administrators.

The maintenance and enhancement plan provides evidence of long-term sustainability. It outlines corrective and adaptive strategies, including framework upgrades, feature expansion (e.g., push notifications, analytics dashboards), and integration with external APIs [28], [29]. These enhancements will not only future-proof the system but also expand its interoperability within broader digital ecosystems, such as academic information systems and government portals [30].

Overall, this study demonstrates that applying a structured software development approach—like the waterfall model—combined with rigorous validation and stakeholder involvement, results in a practical and scalable

solution. The system not only digitizes internship licensing efficiently but also sets a foundation for future innovation in managing academic-government partnerships. It offers a reference model for other public institutions seeking to improve administrative transparency and operational efficiency through technology [31].

4. Conclusion

This study successfully developed a web-based internship licensing system using the waterfall development model, with Laravel for backend implementation and Flutter for frontend interfaces. The system addresses key administrative challenges previously faced by the Ministry of Law and Human Rights, particularly inefficiencies in manual processing, lack of real-time status tracking, and the absence of centralized data management. Through structured analysis, design, implementation, and validation, the application proved to be functionally robust, user-friendly, and institutionally appropriate, receiving a 94.66% feasibility score from expert validation.

The system enables role-based access for five user types—Admin, Student, Operator, Supervisor, and Division Head—ensuring that each actor can perform their tasks efficiently and in line with organizational workflows. Additionally, features such as digital report submission, automated status updates, and real-time feedback mechanisms significantly improved the transparency and traceability of the internship process.

However, this research has several limitations. First, the evaluation was conducted in a controlled environment with a limited number of expert respondents, which may not fully reflect end-user perspectives, especially students with diverse technological competencies. Second, the system has not yet been integrated with national academic portals or government data services, which limits its current scalability and interoperability. Furthermore, the mobile version is still under optimization for full responsiveness across all user types.

Future research should focus on broader field testing involving end-users from multiple institutions to gather more representative usability data. Additionally, integration with government APIs—such as university student databases or electronic document verification systems—should be explored to automate validation processes and reduce administrative redundancy. Further enhancement of the analytics module for internship monitoring and outcome reporting is also recommended to support data-driven decision-making at the institutional level.

In conclusion, the system lays a strong foundation for modernizing internship management in public institutions and serves as a scalable model for similar digital transformations in academic-government collaborations.

Author's declaration

Author contribution

Sintia Okta Rina was responsible for conceptualization, methodology, software development, data curation, original draft writing, as well as review and editing of the manuscript. **Resmi Darni** contributed to supervision and validation. **Vera Irma Delianti** participated in data analysis and interpretation. **Rizkayeni Marta** contributed to literature review and final manuscript proofreading. All authors have read and approved the final version of the manuscript.

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Competing interest

The authors declare no conflict of interest related to this research.

Ethical clearance

This study did not involve any experiments with human participants or animals that require ethical approval. All activities conducted in this research, including system testing and expert validation, were carried out in accordance with institutional and national research ethics standards. Informed consent was obtained from all participants involved in the validation process.

AI statement

This manuscript was prepared by the authors. Generative AI tools, including large language models, were only used to support language refinement, formatting, and structure enhancement under the full supervision of the authors. The intellectual content, interpretation of results, and final conclusions are entirely the responsibility of the authors.

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