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Design of a Web-Mobile Based Information System for Monitoring Maintenance and Repair Reports of Electrical Substations

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Abstract— *The manual workflow for reporting maintenance and repair of electrical substations at PT Haleyora Power, which relies on WhatsApp and Microsoft Excel, creates various obstacles, such as delays, risk of data errors, and a minimal capacity for real-time monitoring. This research aims to design and implement a web-based monitoring information system to overcome these inefficiencies. The development method used is Prototyping, which emphasizes active user involvement through an iterative evaluation cycle. The system was built using PHP-MySQL and comprehensively tested based on five quality aspects from the ISO/IEC 25010 standard: functional suitability, reliability, usability, performance efficiency, and security. The research results show the system was successfully built and passed all tests, achieving 100% in functional suitability, high reliability with no data loss, and a usability score of 86%, which is categorized as 'very feasible' by users. The implemented system successfully transformed the manual reporting process into a centralized digital workflow, significantly improving efficiency, data accuracy, and providing real-time monitoring capabilities for management.*

Keywords *: Monitoring Information System, Prototyping, Software Quality, ISO/IEC*

I. INTRODUCTION

The development of information and communication technology (ICT) in the digital era has had a significant impact on supporting service quality improvements across various sectors, including energy and electricity. Digital transformation not only affects commercial and industrial aspects but has also become a key factor in operational efficiency and enhancing the reliability of the electricity system. According to Grace Tantiono & Wasito (2021), the application of ICT-based monitoring and reporting information systems can accelerate information distribution, improve data accuracy, and enhance the effectiveness of managerial decision-making.

In the context of electricity, particularly for institutions or companies providing maintenance and repair services for electrical distribution facilities, the need for an integrated monitoring and reporting information system is increasingly critical. The maintenance and repair process for power substations requires speed and accuracy of information, as delays in reporting or data processing can impact electricity service to the public. The absence of a computerized system often leads to inefficiencies, such as slow information distribution, data entry errors, and the potential loss of crucial operational data.

PT Haleyora Power Region 7 Kotabumi, a subsidiary of PT PLN (Persero) engaged in the operation and maintenance of electricity transmission and distribution networks, still faces these challenges. Based on observations, the reporting mechanism for repair and maintenance activities is still conducted manually. Initial information is conveyed via WhatsApp, manually re-recorded in a ledger, and finally inputted into Microsoft Excel. This mechanism causes various problems, including reporting delays, data redundancy, a high rate of input errors, and the risk of data loss.

Given these critical operational issues, the implementation of an information system that digitally integrates the reporting, recording, and monitoring processes is no longer just an option, but a necessity. A web-mobile based information system emerges as a highly relevant solution, offering the capability to be accessed anytime and anywhere, which is crucial for field technicians, while also facilitating real-time data synchronization among all users (staff, technicians, and managers).

While several studies have explored the development of monitoring systems [1], [4], a specific gap remains in the literature regarding the application of a user-centric development method like Prototyping within the context of electrical substation maintenance in Indonesia. Much of the existing research focuses on the final product, with less emphasis on the iterative, user-involved process required to ensure high adoption and usability in the field. Therefore, this research aims not only to design and implement a functional web-mobile based monitoring information system but also to contribute a documented case study on the application and evaluation of the Prototyping model to enhance the efficiency, effectiveness, and service quality at PT Haleyora Power Region 7.

II. RESEARCH METHODS

This section presents the results of the research, starting from a detailed analysis of the existing system, the formulation of the proposed system's functional requirements, the system's design, its implementation, and the results of a comprehensive software quality assessment.

3.1 Analysis of the Existing System

A thorough analysis of the current operational workflow at PT Haleyora Power Region 7 was conducted through direct field studies, stakeholder interviews, and a review of existing documentation. The findings confirm that the entire process for reporting maintenance and repair of electrical substations is fundamentally manual and fragmented. The established procedure begins with field technicians capturing and sending initial reports, often including images, via the WhatsApp messaging application. This information is then received by administrative staff, who must manually transcribe the details into a physical ledger or a Microsoft Excel spreadsheet for archival and tracking. This multi-step, manual mechanism creates several significant operational bottlenecks and inherent risks, confirming the urgent necessity for a digital transformation to establish a centralized, swift, and accurate reporting workflow.

3.2 System Requirements Analysis

Following the analysis of the existing system, the next step was to consolidate the findings from interviews and observations into a formal set of system requirements. Functional requirements define the specific behaviors and functions the system must perform to meet user needs and solve the identified problems. These requirements serve as the foundational blueprint for the system's design and development. The key functional requirements identified for the monitoring information system are detailed in Table 1.

As detailed in the table, the functional requirements encompass the entire operational workflow, from master data management by the Admin (F-01, F-02, F-03) to field reporting by Technicians (F-06) and high-level monitoring by Management (F-08, F-10). Each requirement is designed to directly address a weakness in the manual system. For instance, requirement F-06, "Manage Preventive Data," fully replaces the inefficient WhatsApp reporting by providing a structured input form. These documented requirements subsequently formed the basis for the system's architectural and interface design.

3.3 Data Collection Method

To establish a comprehensive understanding of the system's requirements and the operational context, a mixed-method approach to data collection was employed. This involved four complementary techniques to triangulate findings and ensure a robust analysis:

1. *Literature Review:* A systematic literature review was conducted to build a strong theoretical and empirical foundation for the research. This review covered foundational theories on web and mobile-based information systems, a comparative analysis of modern software development methodologies like Prototyping and Agile, and an examination of international standards for software quality testing, particularly ISO/IEC 25010. Furthermore, several relevant previous studies were critically analyzed to identify existing research gaps and best practices, thereby positioning the contribution of this research within the current body of knowledge.
2. *Field Study (Observation):* Direct field studies were carried out at PT Haleyora Power Region 7 Kotabumi. This observational phase was crucial for conducting an *as-is analysis* of the existing business processes. The focus was on mapping the fragmented manual reporting workflow, from the

Table 1. Summary of Previous Research

No	Author	Method	Title	Main Result
1	Priambudi et al. [1]	Extreme Programming	Apartment Payment Status Monitoring Information System	Information obtained quickly, accurately, and effectively
2	Rudi Setiyanto et al. [2]	Prototype	Goods Inventory Information System	Reduced errors in data input and reports
3	Gracetantiono et al. [3]	Extreme Programming	Implementation of Widgets Builder for Monitoring Computer System Performance	More efficient monitoring of computer resources
4	Valentina [4]	Prototype	Transformer Maintenance Information System	Reports are more accurate and user-friendly
5	Laurentinus et al. [5]	Prototyping	Design of an Android-based Electrical Substation Monitoring System	Substation data collection & real-time reporting with map integration

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initial report creation via WhatsApp by field technicians to the manual data re-entry into Excel by administrative staff. This allowed for the identification of specific bottlenecks, inefficiencies, and pain points in the current system.

3. *Interview:* Semi-structured interviews were conducted with key stakeholders across different organizational levels, including technical managers, administrative staff, and field technicians. The primary objective of these interviews was to elicit specific user requirements (*user stories*), determine essential system features from an end-user perspective, and clearly understand their expectations for the new monitoring system's functionality and interface.
4. *Documentation:* The documentation method involved collecting and analyzing relevant secondary data from the company's internal archives. This included reviewing existing damage report forms, historical maintenance logs, and Standard Operating Procedures (SOPs). This analysis helped validate the findings from interviews and observations and provided a concrete basis for designing the system's database schema and report generation modules.

3.4 Development Method (Prototyping)

The system development method utilized in this research is the Prototyping Model. This model was strategically chosen over more rigid, linear models (like Waterfall) because of its suitability for projects where user requirements are not fully known upfront and are expected to evolve. Prototyping facilitates active and continuous user involvement from the earliest stages, employing iterative cycles of design, evaluation, and refinement. This user-centric approach ensures that the final system is highly aligned with the practical needs of its users. The iterative lifecycle of the Prototyping model is illustrated in Figure 1 .

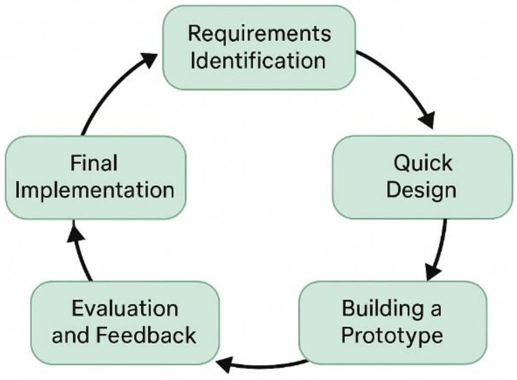

Figure 1. The Prototyping Model Lifecycle

The main stages of the Prototyping method implemented in this research were as follows:

1. *Requirements Identification:* Synthesizing all information from the data collection phase to define an initial set of system requirements.
2. *Quick Design:* Creating low-fidelity designs, such as wireframes and mockups, to provide a visual representation of the proposed system for early user feedback.
3. *Building a Prototype:* Developing a functional, interactive, but partial implementation of the system that users could test.
4. *Evaluation and Feedback:* Users test the prototype and provide feedback, which is used to identify areas for improvement and refinement.
5. *Final Implementation:* After several iterations of feedback and refinement, the approved prototype is developed into the final, complete system.

3.5 System Testing

To validate the quality and readiness of the final application, the system was comprehensively tested. The testing framework was based on the internationally recognized ISO/IEC 25010 software quality model, which defines specific quality characteristics. The evaluation focused on the following five key aspects:

1. Functional Suitability**:** To verify that the system performs its specified functions correctly. This was tested using black-box methods to ensure all features met the requirements defined during the analysis phase.
2. Reliability**:** To assess the system's ability to operate without failure under specified conditions. This included testing data integrity and error handling.
3. Usability**:** To measure the ease with which users can learn and interact with the system. This was evaluated through user testing and questionnaires.
4. Performance Efficiency**:** To test the system's responsiveness and resource utilization, which is critical for technicians who may be operating with limited internet connectivity in the field.
5. Security**:** To ensure that the system protects information from unauthorized access, confirming that the role-based access control mechanisms were implemented correctly.

III. RESULT AND ANALYSIS

3.1 Analysis of the Existing System

A thorough analysis of the current operational workflow at PT Haleyora Power Region 7 was conducted through direct field studies, stakeholder interviews, and a review of existing documentation. The findings confirm that the entire process for reporting maintenance and repair of electrical substations is fundamentally manual and fragmented. The established procedure begins with field technicians capturing and sending initial reports, often including images, via the WhatsApp messaging application. This information is then received by administrative staff, who must manually transcribe the details into a physical ledger or a Microsoft Excel spreadsheet for archival and tracking.

This multi-step, manual mechanism creates several significant operational bottlenecks and inherent risks that compromise efficiency and data integrity. Key identified issues include chronic reporting delays due to the long and asynchronous communication chain, substantial data redundancy from the repetitive recording process, and a high susceptibility to human error during manual transcription. Furthermore, this system entirely lacks a real-time monitoring capability, rendering it nearly impossible for management to track the progress of ongoing repairs, evaluate technician performance effectively, or make agile, data-driven decisions. This critical analysis underscores the urgent necessity for a digital transformation to establish a centralized, swift, and accurate reporting workflow that is systematically documented and transparent.

3.2 Proposed System Design

In direct response to the critical deficiencies identified in the existing system, a comprehensive web-based monitoring information system was designed utilizing the prototyping methodology. The design phase was initiated by translating the identified user needs and functional requirements into a structured system architecture. To visually define the system's functional scope and delineate the interactions between different users and its features, a Use Case Diagram was developed, as presented in Figure 1.

As visualized in the diagram, the proposed system architecture is built around five primary actors, each with clearly defined roles and access privileges to ensure a structured and secure workflow. The Admin is granted comprehensive control over master data, including user management, substation lists, and maintenance schedules. The Technician role is streamlined to focus on the core task of inputting preventive maintenance data and performance reports directly from the field. The Warehouse personnel manage spare parts inventory, while the Manager is provided with high-level access to view the main dashboard and generate all necessary reports. Finally, a unique feature allows the Public to submit complaints, creating a valuable feedback channel. This role-based design not only ensures a structured separation of duties but also enhances data security and integrity, forming a robust foundation for the new digital workflow.

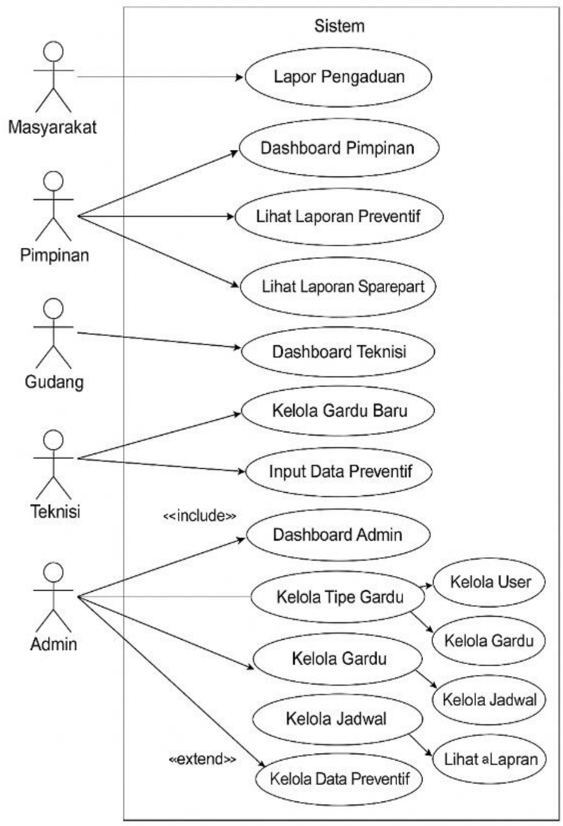

Figure 2. Use Case Diagram of the Proposed System

3.3 Implementation and System Interface

The system was developed using the PHP programming language, with MySQL as the database management system and the Bootstrap framework to ensure a responsive interface accessible on mobile devices. Below are some of the main interface views of the successfully implemented system.

The admin dashboard serves as the main control and monitoring center, presenting a visual summary of data, such as the total number of substations, substations requiring verification, number of technicians, and new complaints, as shown in Figure 3.

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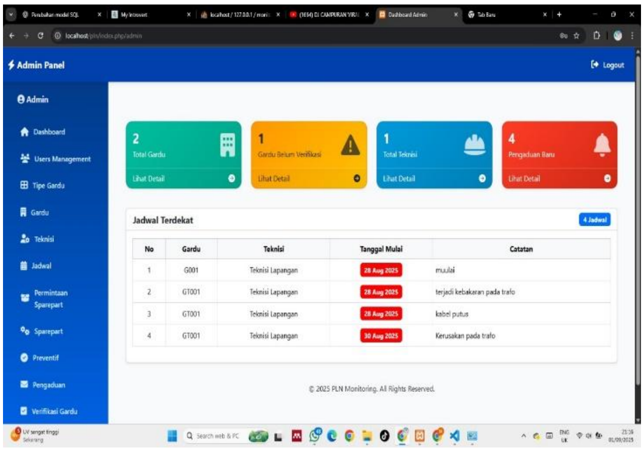

Figure 3. Admin Dashboard Interface

Figure 4 shows the technician's report input page. This feature is the core of the business process digitalization, replacing reporting via WhatsApp. Field technicians can directly input performance reports through a structured form.

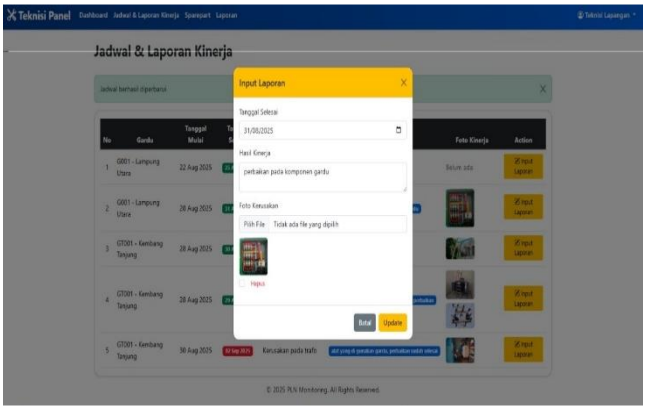

Figure 1. Manager's Dashboard Interface

For managerial needs, a special dashboard was designed for managers (Figure 4). This dashboard presents aggregate data in the form of summary cards and bar charts, allowing managers to efficiently monitor perfrmance and resource allocation.

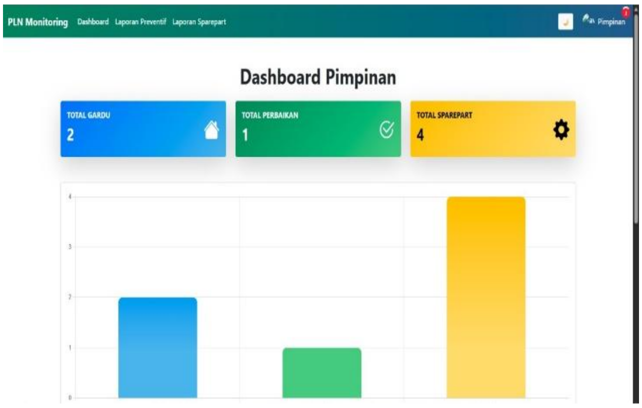

Figure 5. Manager's Dashboard Interface

The system provides an automated report generation feature that can be downloaded in PDF or Excel format. As shown in Figure 5, managers or admins can easily access data recapitulations for further analysis and official documentation.

3.4 System Quality Testing Results

The system was comprehensively tested according to the ISO/IEC 25010 software quality standard to ensure that the developed application is not only functional but also meets established quality

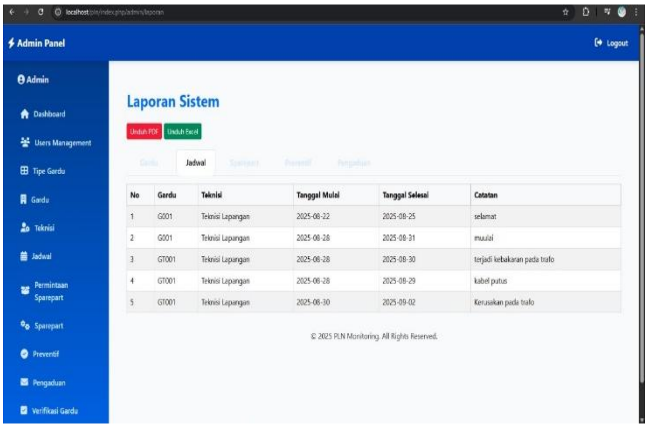

Figure 6. System Report Page with Download Feature

benchmarks. The test results, focusing on five crucial aspects, are detailed below, with a particular emphasis on the usability evaluation.

Initial tests confirmed the system's core robustness. Functional Suitability was validated using black-box testing, which resulted in 100% of the features running according to their specifications. Reliability tests, conducted through a simulation of 100 report submissions, showed high stability with 0% data loss. Performance Efficiency was deemed excellent for field operations, with average page load and data query response times ranging from 0.8 to 1.2 seconds. Finally, **Security** protocols were verified, confirming that the role-based access control mechanism effectively prevents unauthorized access.

A more in-depth analysis was conducted on the Usability aspect, as it is critical for user adoption. The usability test involved 10 respondents representing all user roles (3 admins, 5 technicians, and 2 managers). Feedback was gathered using a Likert scale questionnaire based on five standard usability metrics: Learnability, Efficiency, Memorability, Errors, and Satisfaction. The aggregated results of this evaluation are visualized in the bar chart presented in Figure 6.

Figure 6. Usability Testing Results Based on Five Sub-Criteria

As shown in Figure 6, the system achieved an overall average usability score of 86%, which falls into the "Very Feasible" category. This high score indicates strong user acceptance. A closer look at the sub-criteria reveals that the system excelled in Memorability (88%) and Satisfaction (88%), suggesting that users found the interface intuitive and were pleased with their overall experience. Efficiency (87%) also scored highly, confirming that users could complete tasks quickly. The lowest score, while still high, was for the Errors (82%) aspect, indicating that minor improvements in user guidance or input validation could further minimize potential user mistakes.

The overall findings from all testing phases are summarized in Table 2, confirming that the developed system is valid, reliable, and highly suitable for deployment.

Table 2. System Quality Testing Results

Testing Aspect	Result	Interpretation
Functional Suitability	100% functions run normally	Very Suitable
Reliability	0% data loss during simulation	Very Good
Usability	Average score of 86% (Likert Scale)	Very Feasible
Performance Efficiency	Average response time 0.8 – 1.2 seconds	Efficient
Security	Access according to user role verified	Secure

IV. CONCLUSION

This research has successfully designed and implemented a web-based information system for monitoring the reporting of maintenance and repair of electrical substations at PT Haleyora Power Region 7 using a prototyping approach. The developed system effectively addresses the problems of the manual process (WhatsApp, Excel), which previously caused delays, redundancy, and the risk of data loss. Based on the evaluation, the system is proven to be functionally suitable, reliable in data management, has a high degree of usability (86% score), and is efficient and secure for operational needs. The main contribution of this research is the digitalization of the end-to-end reporting process, which has successfully increased the efficiency of the reporting cycle significantly, from several hours to a matter of minutes, while also providing a real-time monitoring platform for management. For future research, it is recommended to add features such as automatic notifications, an offline mode for technicians, GIS integration for visual substation mapping, and to conduct advanced load and security testing.

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