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Design of an integrated warehouse management system at Politeknik Astra using the scrum method

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Abstract

This study addresses the problem of fragmented, manual, and low-visibility warehouse management in the Technical Service Units (UPT) at Politeknik Astra, which has led to operational inefficiencies and the emergence of dead stock. The objective of this research is to design and implement an integrated Warehouse Management System (WMS) to improve inventory transparency, data accuracy, and operational efficiency. The system was developed using the Scrum methodology through five iterative sprints, each lasting two weeks, involving requirement analysis, system design, implementation, and evaluation. Functional and non-functional testing is performed using Black-box Testing, Integration Testing, and User Acceptance Testing. The results indicate that the developed WMS successfully integrates purchasing requests, goods receiving, picking, borrowing, stock monitoring, and reporting processes into a standardized and real-time system. The system improves inventory visibility, reduces recording errors and duplicate purchasing, and supports faster and more accurate operational decision-making. In addition, the implementation of the WMS generates measurable financial benefits through cost savings in system procurement, training, materials, and warehouse space utilization. This study demonstrates that an integrated WMS developed using Scrum can effectively enhance warehouse management performance in vocational education institutions.

Keywords*:* Inventory; Scrum; Vocational Education; Warehouse integration; Warehouse Management *System*

1. Introduction

One of the most crucial elements in the supply chain is the warehouse [1]. The activities carried out within it, as well as the costs incurred, significantly affect the overall performance of the supply chain [2]. The warehouse is a key component of the logistics system that supports a company's operational activities, particularly in product storage, consolidation, and distribution [3]. The planning of warehouse layout and material handling systems is also one of the key aspects of warehouse operational efficiency [4]. Many companies strive to improve their warehouse systems to become more efficient, reduce costs, and accelerate work processes. However, warehouse operational management is not a simple task. Its complexity requires effective management, as inefficiencies in the warehouse have the potential to disrupt the entire production process [5]. Therefore, such inefficiencies can lead to various forms of waste, namely activities that do not add value to the value stream [6].

In the context of vocational education, Politeknik Astra plays an active role not only in academic activities but also in production activities carried out by the Technical Service Unit (UPT). The production activities in the UPT require inventory to support material storage. However, the material storage area is still located in a separate warehouse area, resulting in stock recording being conducted manually and independently and being known only by the related unit. This condition creates a risk of waste due to the lack of overall stock data visibility. The results of observations indicate the presence of dead stock, which occurs due to inventory purchases made without considering existing stock levels. The total value of the dead stock amounts to IDR 162,500,000.

Based on these issues, the implementation of a Warehouse Management System (WMS) is a highly necessary strategic step. This study develops a multi-unit integrated WMS that provides real-time stock visibility using the Scrum approach. The WMS helps organizations address warehouse management challenges, reduce waste, and improve inventory data transparency [7].

2. Method

This study adopts the Scrum method, which is part of the Agile methodology, and is designed for the development of systems that are complex, dynamic, and subject to changing requirements throughout the development process. Scrum is selected because it supports iterative and adaptive system development and actively involves users through continuous feedback in each development cycle. In this study, Scrum is implemented for the development of the Warehouse Management System (WMS) at Politeknik Astra, using React.js as the frontend programming framework and ASP.NET API as the backend service. The development process is carried out through several iterations called sprints, in which each sprint produces a system increment that satisfies the Definition of Done [8].

Scrum stages

The Scrum stages applied in this study include product backlog, sprint planning, sprint implementation, daily scrum, sprint review, and sprint retrospective. These stages are carried out iteratively until the system fulfills all user requirements.

a. Product Backlog
The product backlog is a list of system requirements formulated as user stories, which describe system features from the users' perspectives. The product backlog is developed based on observations of warehouse business processes, interviews with relevant stakeholders, and system requirements analysis. Each user story is then prioritized according to its level of urgency and its impact on the UPT warehouse business processes. This product backlog serves as the primary basis for planning and executing subsequent sprints.

b. Sprint Planning
Sprint planning is conducted at the beginning of each sprint and involves the development team and the Scrum Master. At this stage, the prioritized product backlog is selected and decomposed into more detailed tasks in the form of a sprint backlog. Each item in the sprint backlog is assigned story points as an estimate of the effort level and implementation complexity. The outputs of sprint planning are the sprint goal and the sprint planning document, which serve as references for development activities during the sprint period.

c. Sprint Implementation
Sprint implementation is the stage in which system development is carried out in accordance with the agreed sprint backlog. At this stage, the development team performs system design, coding, and unit testing of the developed features. During the sprint, progress is monitored using project management tools, allowing the status of each task to be tracked transparently. Task statuses are categorized into several stages, namely *To Do*, *In Progress*, *In Review*, and *Done*. The duration of each sprint in this study is two weeks, or approximately ten working days, which is considered effective for producing features that can be tested and evaluated.

d. Daily Scrum
The daily scrum is a short meeting conducted every day during the sprint. This meeting aims to monitor sprint progress, identify obstacles, and align the team's daily work plans. In the daily scrum, each team member reports the tasks that have been completed, the plans for the current day, and any impediments encountered. This information is used by the Scrum Master to ensure that the sprint proceeds as planned and that obstacles can be addressed promptly.

e. Sprint Review
The sprint review is conducted at the end of each sprint and involves the development team, the Scrum Master, and system users. At this stage, the completed features are presented and

demonstrated. User feedback is collected to evaluate the alignment of the system with warehouse operational needs. The outcomes of the sprint review may include feature approval, proposed improvements, or additional requirements that are then added to the product backlog for the next sprint.

f. Sprint Retrospective
The sprint retrospective is conducted after the sprint review to evaluate the team's working process during the sprint. At this stage, the team discusses what went well, the challenges encountered, and the improvements needed for the next sprint. This evaluation aims to continuously improve team performance and the quality of the development process.

In this study, the development of the Warehouse Management System (WMS) was carried out through five sprints, each with a duration of two weeks. Each sprint had a different development focus, ranging from item data management, goods receiving, picking and borrowing of UPT items, to the presentation of an integrated stock monitoring dashboard. This iterative approach allows the system to be developed incrementally and adapted to user needs based on the evaluation results of each sprint.

System testing was conducted to ensure that all developed functions operate according to the defined requirements and specifications. The testing methods used in this study include:

a. Black-box Testing which focuses on verifying that system functions meet user requirements without examining the internal code structure. This testing was applied to each developed feature to ensure that system outputs correspond to the given inputs.
b. Integration Testing to ensure that system modules operate in an integrated manner without errors, particularly in warehouse transaction processes and stock data updates.
c. User Acceptance Testing (UAT) which was conducted with users to assess whether the system meets UPT warehouse operational needs and is ready for use in a real environment.

The results of these tests were used as the basis for system improvements in subsequent sprints until the system was declared to meet the Definition of Done and be ready for implementation.

3. Result and Discussion

Business process analysis

Based on the results of direct observation of warehouse management activities, a comprehensive understanding of the business process flow was obtained, starting from requirement requests to the registration of materials in the system and their storage in the respective UPT warehouses. This business process analysis serves as the initial output of the Scrum implementation and is used as the basis for developing the product backlog and determining system development priorities in subsequent sprints. In Figure 1, the process begins with the submission of material requirements by users, which is then administratively verified to ensure the completeness and clarity of the documentation. After the initial verification, the system searches the existing material database to determine whether the request concerns a new material or an already registered one. If the material has not yet been recorded, the administrator enters the data by completing the technical specifications and supporting documents. The entered information is then validated by the relevant parties to ensure technical compliance and data accuracy. If any discrepancies are found, the documents are returned for correction; however, if all information meets the required standards, the material is approved and registered in the system to support procurement and operational processes. This stage reflects a control mechanism that ensures material data quality before it is used in procurement and operational activities.

Entity Relationship Diagram (ERD)

The Entity Relationship Diagram (ERD) and the class diagram were developed as outputs of the sprint implementation stage, aiming to translate the system's functional requirements into an integrated data structure and system logic. The ERD in this system illustrates the data management flow starting from purchase request processing, ordering from suppliers, goods receipt in the warehouse, and distribution through picking and borrowing activities in Figure 2. The process begins with the purchase request entity, which is associated with employee and department data as the requesting parties.

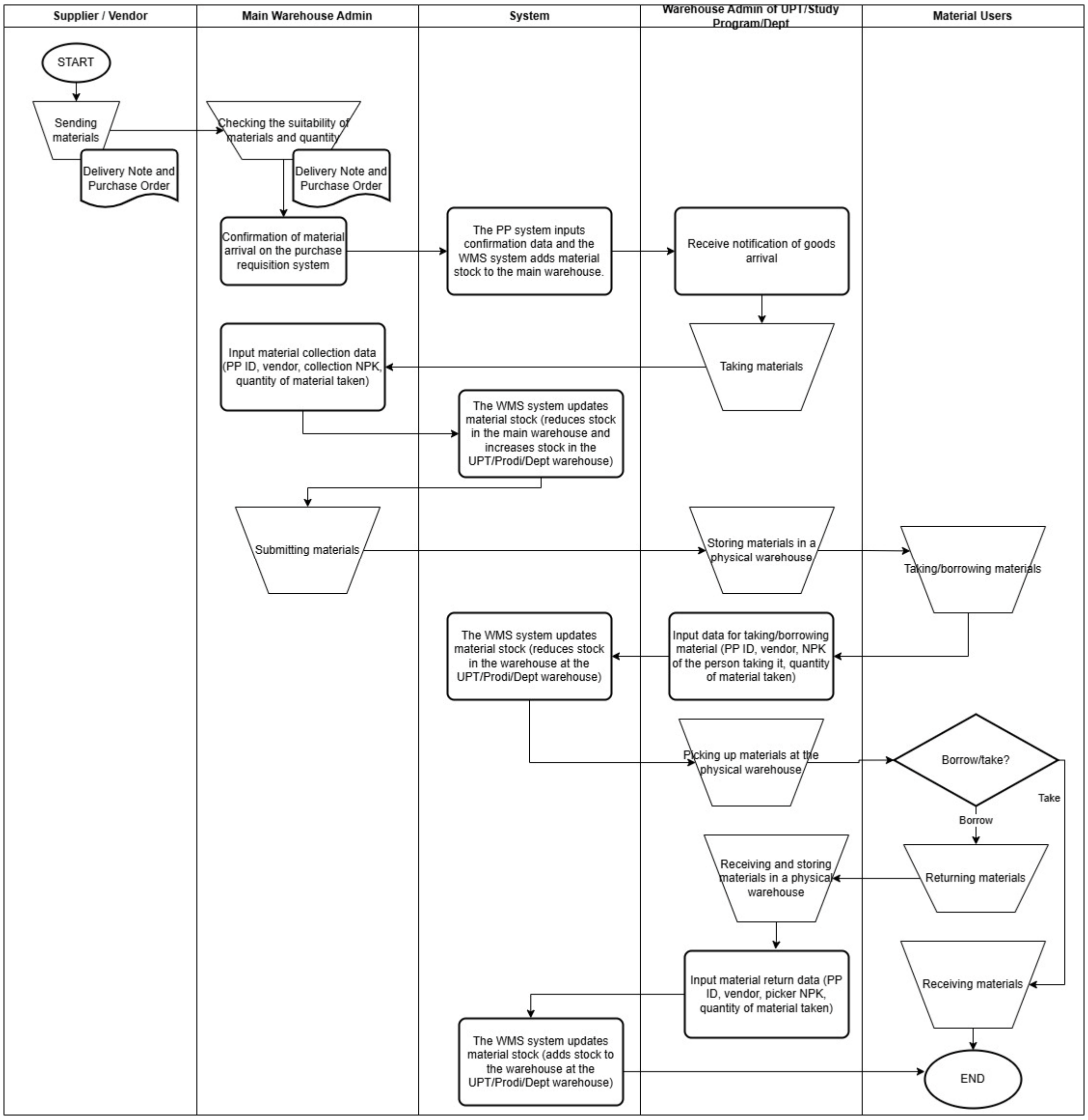

Figure 1. Business process flow

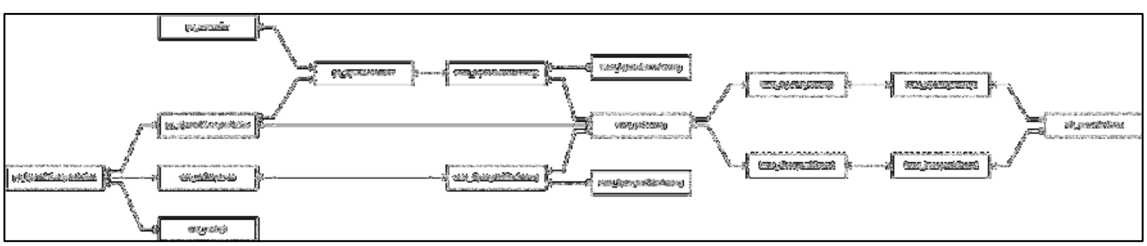
Figure 2. Entity relationship diagram

The relationships among these entities indicate system integration that enables consistent item tracking from the initial request to final usage, thereby supporting data accuracy and operational efficiency.

Backlog development

Actor identification aims to determine the stakeholders who will be involved in the system. This can be seen in the use case diagram presented in Table 1.

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Table 1. Use Case Diagram WMS

<table>
<tr><th>Use Case Types</th><th>Diagram</th></tr>
<tr><td>

Use Case: Manage Item Data

In this use case, the central warehouse administrator can manage the item master data, where the central warehouse administrator can view the item list, view item details, and view item distribution data. In addition, the UPT warehouse administrator can manage the UPT item master data, where the UPT warehouse administrator can view the item data list and view item details.

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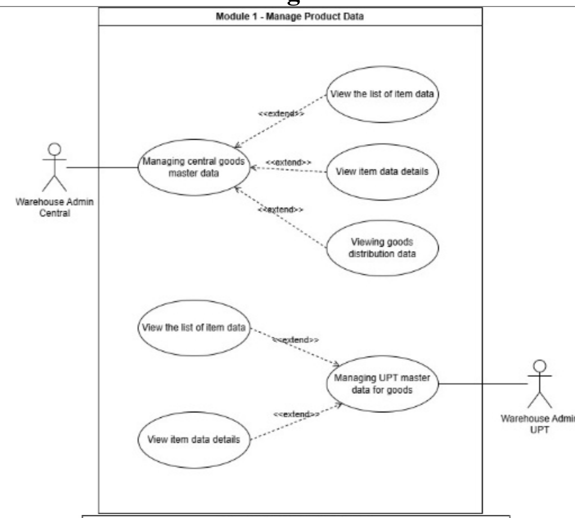

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Use Case: Goods Receipt

In this use case, the central warehouse administrator can manage central goods receipt, where the central warehouse administrator can view the goods receipt history and view the details of each goods receipt. In addition, the UPT warehouse administrator can manage UPT goods receipt, where the UPT warehouse administrator can view the goods receipt history and view the details of each goods receipt.

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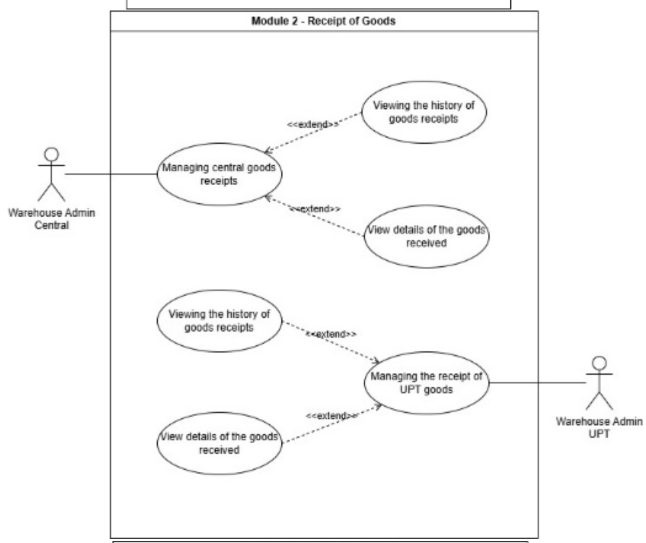

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Use Case: Goods Picking

In this use case, the central warehouse administrator can manage goods picking, where the central warehouse administrator can view the picking history, view picking details, and approve picking requests. In addition, the UPT warehouse administrator can manage goods picking, where the UPT warehouse administrator can view the picking history, view picking details, and submit picking requests.

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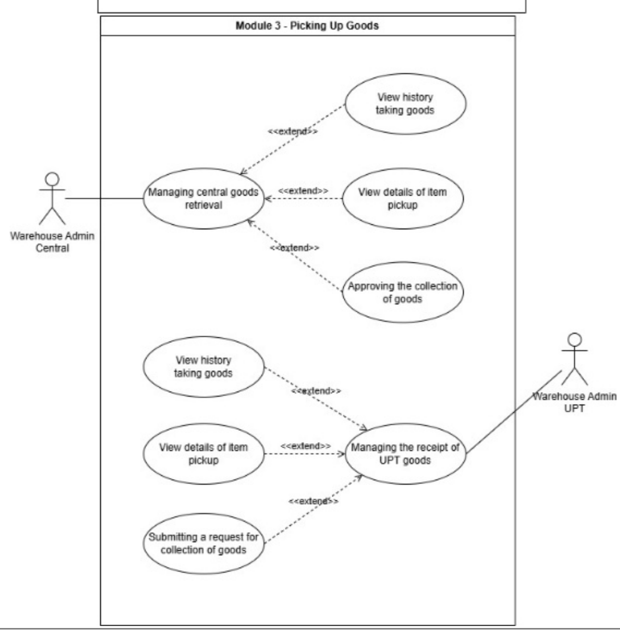

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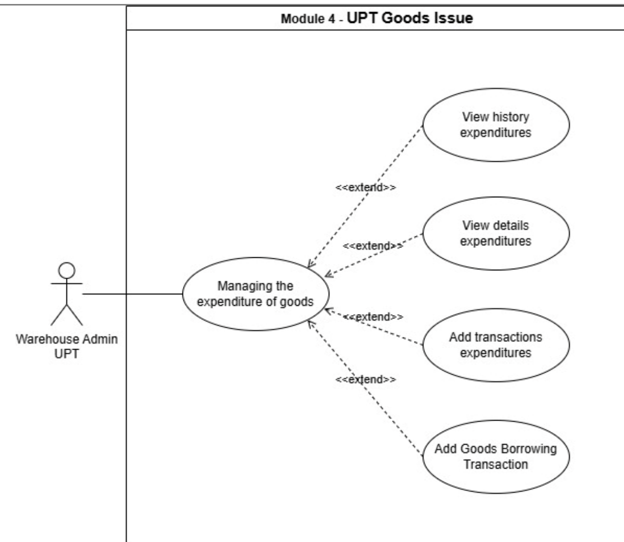
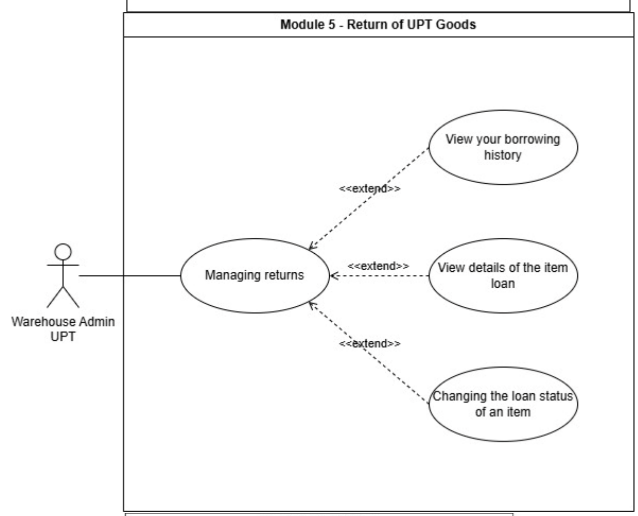
Use Case: UPT Goods Issue

In this use case, the UPT warehouse administrator can manage goods issue transactions, where the UPT warehouse administrator can view the goods issue history, view goods issue details, add goods issue transactions, and add goods borrowing transactions.



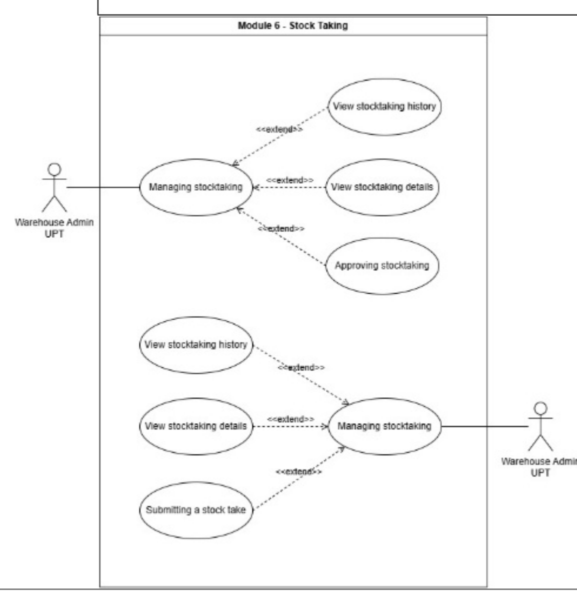
Use Case: UPT Goods Return

In this use case, the UPT warehouse administrator can manage goods returns, where the UPT warehouse administrator can view the borrowing history, view borrowing details, and update the borrowing status



Use Case: Stock Taking

In this use case, the central warehouse administrator can manage stock taking, where the central warehouse administrator can view the stock taking history, view stock taking details, and approve stock taking activities. In addition, the UPT warehouse administrator can manage stock taking, where the UPT warehouse administrator can view the stock taking history, view stock taking details, and submit stock taking requests.



Determining system functions

Determining system functions is necessary to ensure that the design process is carried out more effectively, efficiently, and in a structured manner, so that the developed system can meet the defined requirements. This diagram in Figure 3. illustrates the relationships among entities that represent the main business processes, starting from purchase requests, goods receipt, and inventory recording, to picking and borrowing activities carried out by the related units. Each table is designed with interconnected attributes to ensure consistent and integrated data flow. Entities such as purchase request lists, vendors, purchase orders, goods receipt, and item master data are interrelated, facilitating information tracking from the request stage to the storage of items in the warehouse. In addition, there are entities that handle transaction processes at the UPT level, including goods picking and borrowing, which are directly linked to inventory data.

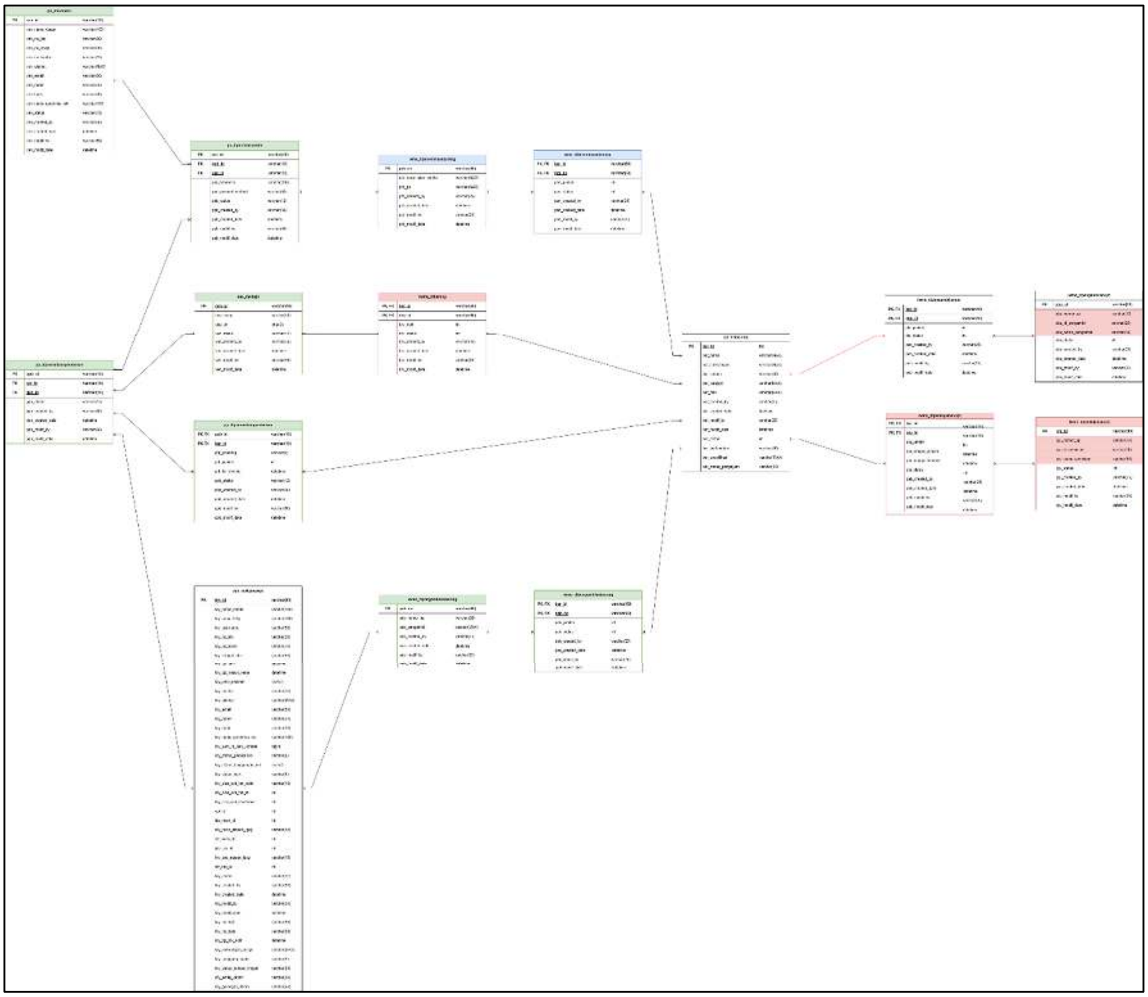
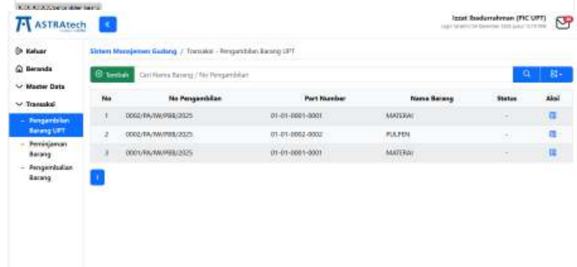
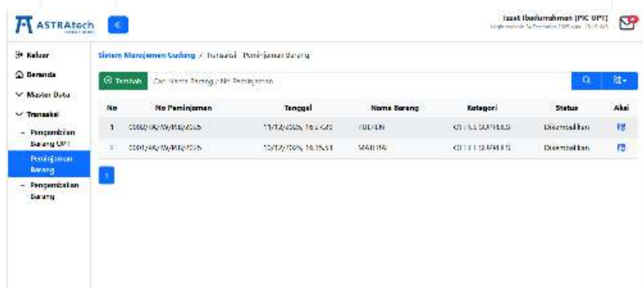
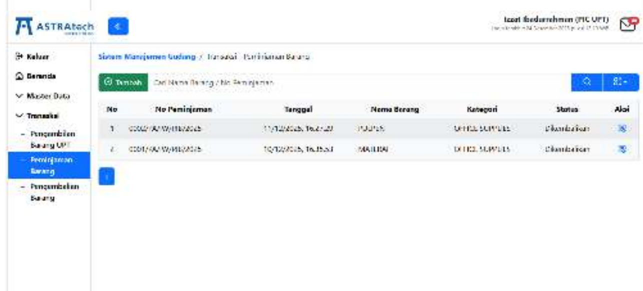
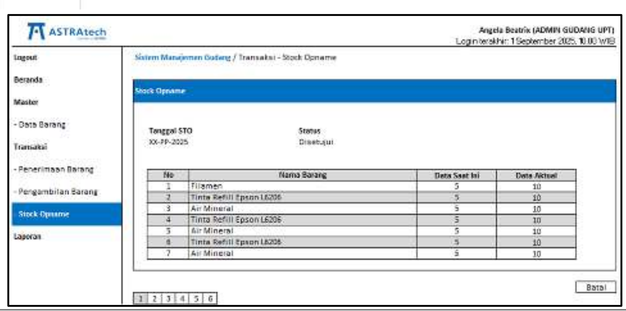


Figure 3. Class diagram WMS

Warehouse management system development

Based on the results of the requirements analysis, the Dashboard use case diagram not only displays a list of goods picking and receiving transactions but also presents comprehensive stock information for all UPT warehouses in a single integrated view. The WMS interface in Table 2. was developed incrementally as outputs of several sprints and was evaluated through sprint reviews to ensure alignment with user requirements. This integration enables faster and more accurate monitoring processes, thereby minimizing potential errors in stock recording. One of the main benefit of implementing a WMS is the improvement of stock accuracy [9]. In addition, users can access information in real time, which improves responsiveness in fulfilling item requests. Overall, the system successfully addresses the need for warehouse management that is more transparent, efficient, and easier to control compared to the previous manual system. With optimal warehouse management, organizations can reduce costs, shorten processing times, improve order accuracy, and enhance customer satisfaction [10].

Table 2. WMS dashboard display design

Function	WMS Dashboard View
Central Warehouse Goods Picking User Interface	
UPT Goods Collection User Interface	
User Interface UPT Item Loan	
User Interface UPT Returns	
User Interface Stock Taking Design	

Testing

The developed WMS was subjected to both functional and non-functional testing using Black Box Testing and User Acceptance Testing (UAT). These tests were conducted from the users' perspective to ensure that the functional and non-functional requirements of the system were met. During the testing process, the development team conducted demonstrations using various types of input, including empty data, valid data, and invalid data, in accordance with the detailed testing documentation. Based on these demonstrations, users were able to provide input and feedback to the development team. The results of these tests determine whether the software is ready for release or requires further improvement. Based on the development and testing results, the Warehouse Management System was proven to be capable of addressing the main issues of warehouse management that were previously fragmented, manual, and lacked visibility. The system successfully integrates inventory, receiving, picking, and stock monitoring processes in a standardized and real-time manner, supported by comprehensive transaction recording. The results of functional testing and User Acceptance Testing indicate that the system meets user requirements and is ready for operational use.

Potential cost saving

In addition to process improvements, the Warehouse Management System also provides financial value. In tangible terms, the benefits include cost savings from system and tool procurement amounting to IDR 275,109,370, training cost savings of IDR 3,250,000, material cost savings of IDR 35,990,220, and a reduction in depreciation or warehouse area rental costs amounting to IDR 15,877,500. Thus, the total tangible benefits amount to IDR 330,227,090.

4. Conclusion

The main problem identified in this study was the manual, fragmented, and low-visibility warehouse management system that resulted in inefficiencies, data inconsistencies, and the accumulation of dead stock. To address this issue, an integrated web-based Warehouse Management System was developed using the Scrum methodology, enabling real-time integration of purchasing, receiving, picking, borrowing, stock monitoring, and reporting processes. The results show that the system improves data transparency, accuracy, and operational efficiency while also producing tangible cost savings of IDR 330,227,090 from reduced system procurement, training, material waste, and warehouse area costs. Functional testing and User Acceptance Testing confirmed that the system meets user requirements and is ready for operational implementation. For future development, it is recommended to integrate the WMS with financial and procurement systems, enhance analytical features for demand forecasting and inventory optimization, and expand the system's implementation to other institutions to increase its scalability and impact

Acknowledgements

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