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OInvCons: Odoo-based Inventory Management for Construction Projects: A Design Initialization

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Abstract

The construction industry has considerable difficulties in managing a large number of materials an equipments to afford the growing reliance on subcontractors. This new are of outsourcing paradigm brought hierarchical management complications and inter-site control problem to aggregate all the sub-contractor resource. This work proposes a system design and an initialized implementation of a subsystem integrated to Odoo ERP framework to manage inventory and provide the support of customization report. Our proposed system provide three arrows in a pillar to tackle the warehouse operation, the hybrid access control and the different customization degree in both unified and consolidated analytic strategies. To ensure and benchmark the work, we also conducted a set of ten or more demonstration scripts as a basis for evaluating the performance of the developed system. The demonstration of Python-based module confirms the feasibility of our design and implementation, which can be accessed on the app market.This module will be available on the Odoo app store for easy access and integration. People can find it at `https://apps.odoo.com/apps/modules/17.0/huy_inventory_management` where it will support many inventory management and reporting functions within the Odoo framework.
I certify that I have the right to deposit this contribution with MPRA.

1 Introduction

Enterprise Resource Planning (ERP) framework [1] serve as fundamental tools for integrating and streamlining business processes across organizations. Customization is essential to align ERP systems with specific operational needs. Beside its usefulness, the technique comes with challenging due to its costs increasing and potential risks to software quality. Many considerable factors include scala-

bility, and configurability play crucial roles in determining the success implementations this type of software framework [2].

The construction industry, traditionally slower than manufacturing in adopting new technologies, suffers from inefficiencies in material management, leading to delays and cost overruns. As the construction sector transitions to Construction 4.0, the integration of modern technologies such as IoT, AI, and data analytics highlights the limitations of traditional ERP systems [3]. Addressing these gaps requires innovative approaches tailored to the unique needs of this industry [4].

This study introduces three main works to address these challenges.

- Warehouse Import/Export Optimization: A streamlined process for managing material flows, including receiving, storing, and dispatching, designed to improve accuracy and reduce delays.

- Hybrid Access Control Lists (H-ACL): A robust multi-site access management framework that ensures secure and decentralized resource control while maintaining centralized oversight.

- Customizable Warehouse Reports: Real-time data-driven reporting tools that support decision making by providing insight into inventory levels, material usage, and operational efficiency.

By combining centralized and decentralized management approaches, the proposed UML-based model integrates real-time tracking and dynamic dashboards. This approach enhances material management, reduces waste, and supports sustainability goals. The study also introduces a quantification framework to evaluate customization trade-offs, enabling informed decision-making in ERP implementations. Through theoretical analysis and empirical validation, this research aims to provide the construction industry with a scalable and practical ERP solution, aligning with both operational efficiency and sustainability objectives.

Feature	**Custom module**	**Basic module**
Inventory import/export	Yes	Yes
Multi-level and distributed user permissions	Yes, with site-specific distribution	Admin and user only
Inventory reporting	Flexible customization solution developed	Fixed reports

Table 1: Comparison of custom and basic modules for inventory management in construction ERP

2 Paper organization

The remainder of this work is structured as follows:

- **Section 3: Literature Review** provides an overview of existing research and technologies related to the system's design and n. It is divided into two main sections: the first evaluates various ERP systems, the context of multiple site outsourcing and the taxonomy of customization degree measurement.
- **Section 4: System Design** descibe the design of the system components, including warehouse import/-export functionality, distributed access control lists (ACL), and customizable warehouse report generation. It also introduces the test plans and demonstration scripts used to validate system functionality.
- **Section 5: Results and findings of the initial implementation** discusses the results of the initial system implementation and provide a set of script to evaluate and assess the system's effectiveness in order to further improvement.

3 Literature Review

3.1 ERP software

Evaluating existing ERP applications is a crucial preliminary step in ensuring the chosen solution aligns with the specific needs of the project. This evaluation not only helps mitigate potential risks but also highlights relevant features that support the research objectives.

IFS Cloud [5] offers advanced warehouse and inventory lifecycle management tools, integrated subcontractor management, and equipment tracking. Its ability to handle fragmented projects with multi-site operations makes it highly scalable for complex construction needs. This system aligns with the research topic by providing multi-site integration and subcontractor management features, though its complexity might not be ideal for smaller projects.

Acumatica [6] excels in warehouse automation with real-time analytics and AI-powered forecasting. It provides seamless integration with project and subcontractor management while enabling robust budget and cost tracking. This system demonstrates the potential for applying AI-driven predictions and real-time data processing, which can enhance the flexibility and efficiency of warehouse workflows in the research topic.

Oracle Fusion Cloud [7] delivers comprehensive inventory and logistics management tailored for large-scale construction operations. Its high scalability and extensive customization capabilities align with the goals of the research topic. However, its implementation may require significant financial and technical investment, making it less suitable for smaller-scale projects.

SAP ERP [8] is a reliable solution for optimizing warehouse operations and supply chains, with additional tools for subcontractor and vendor management. It is particularly suited for enterprises managing multiple fragmented construction sites. The system's focus on supply chain optimization provides valuable insights for multi-site material coordination in the proposed project.

Procore [9] integrates strong project management tools with inventory tracking, focusing on real-time field operations and subcontractor management. Its emphasis on material usage tracking at construction sites closely aligns with the research topic's goals. However, its limited customization options might not fully support specialized workflows.

CMiC [10] integrates inventory, procurement, and project management capabilities, including tools for material transfers and cost control. Its ability to handle concurrent construction projects offers valuable insights for managing inventory across multiple locations in the research topic. However, it may lack the flexibility required for non-standardized processes.

Jonas Enterprise [11] combines inventory management, equipment tracking, and subcontractor coordination within an intuitive project management dashboard. It is particularly suited for small to mid-sized firms focusing on material efficiency. The system's simplicity and focus on project-level tracking provide a practical reference for the research topic.

Sage 300 [12] Construction balances functionality and usability by providing efficient tools for warehouse management, material procurement, and supplier collaboration. It is ideal for growing firms managing multi-site operations. Its capabilities in supplier integration and inventory planning can be adapted to the research topic for efficient material handling.

Epicor [13] provides detailed warehouse management features, including inventory aging and landed cost tracking. Its real-time analytics for material allocation and equipment usage align with the research topic's focus on cost and material tracking. However, its financial orientation may require adaptation to operational workflows.

Odoo [14] stands out for its open-source flexibility, allowing customized workflows for warehouse management. Its integration with subcontractor and project management modules makes it a cost-effective solution for smaller construction projects. The research topic can leverage Odoo's adaptability to develop specialized workflows and integrations.

Each reviewed ERP system offers unique strengths relevant to the management of construction materials and warehouses. While premium systems like Oracle Fusion Cloud and SAP ERP emphasize scalability and advanced supply chain capabilities, flexible solutions such as Odoo and Jonas Enterprise offer cost-effective options for customized workflows. The research topic can draw inspiration from these systems to develop a tailored solution that integrates subcontractor management,

multi-site coordination, and advanced inventory tracking.

3.2 Multi-site access control to empower external subcontractor resource

The new paradigm of dynamic nature of construction projects creates significant challenges in managing inventory [15] and the large-scale organisation [1]. Materials often require specialized storage conditions, and unpredictable project schedules lead to fluctuating demands. Additionally, fragmented workflows between subcontractors and suppliers exacerbate delays and miscommunication. The work in BIM based construction [16] emphasizes that effective inter-trade is critical for reducing costs and meeting project deadlines, yet it remains underdeveloped in many construction firms. Addressing these challenges necessitates adopting advanced inventory systems capable of real-time tracking, multi-site integration and collaboration [17] and predictive planning. Predictable subsystem and inter-component collaboration are the key factor toward the next generation of industrial organization [18].

Industry 4.0 offers several key technologies that can be applied to enhance inventory management in construction projects. These systems enable the creation of digital twins, providing real-time monitoring and simulation of inventory processes [19]. The inter-trade optimize resource allocation and minimize waste by predicting material needs and tracking usage across fragmented sites. The rigorous innovation raises a construction system upgrading theme [4] to enable the outsourcing of sub-contractor where the contribution to role of 28.1% of respondents . The job migration help adapt the predictor of project successfullness which has a long history from application level [20] to service orientation [21] and integration business process [22].

The software system design leverages Unified Modeling Language (UML) to provides a structured approach to designing inventory systems. Other advanced analytics and artificial intelligence (AI) techniques further enhance decision-making by enabling predictive planning. These tools can forecast material requirements, optimize procurement schedules, and identify inefficiencies in the supply chain [23]. By standardizing these workflows and integrating with machine learning models, the system operations facilitates improved communication among stakeholders. The recent federated clouds encourages the cooperative inter-accessing among multi-site especially in construction industry [24]. Thanks to the advancement of network virtualization migration [25], the technique can select different members of the construction project to migrate the subtask and establish a contract under subcontractor role [26].

3.3 Customization degree measurement

Sustainable practices in material management are increasingly emphasized in construction. Hermann, Pentek, & Otto (2016) [27] advocate for lean construction principles that focus on minimizing waste and optimizing workflows. ERP customization is essential for aligning systems with business goals, though it introduces risks. Customization involves modifying ERP software to meet specific customer requirements [28][29].

The customization of ERP involves modifications to the software to meet specific customer requirements that are not supported as standard features. These changes can range from simple report generation to developing complex add-ons. According to Brehm et al. (2001) [30] and Light [31], customization often includes adjustments to modules, databases, user interfaces, or application interfaces to align the ERP system with unique organizational needs. Dittrich et al. (2009) [32] further emphasize that such customizations are source-code-based adaptations essential for achieving alignment between the ERP system and the organization's business processes.

However, customizing erp has both advantages and disadvantages.Aslam et al. (2012) [33] and Luo and Strong (2004) [34] note that it can add significant value to ERP projects by enabling competitive advantages, differentiation, and innovation while achieving organization-specific savings. Excessive customization can result in high maintenance costs and complicate future upgrades[32]. It is therefore crucial for organizations to balance the business value of customization against the associated risks.

Quantitative Approach to Customization Estimation Parthasarathy and Daneva (2016)[35] present a quantitative method for estimating ERP customization using the PRCE (Prioritized Requirements-Based Customization Estimation) algorithm based on ERPCE (Parthasarathy, 2008[36]). This method utilizes customer-prioritized requirements and applies traceability matrices along with a ranking system to assess the fit between customer needs and ERP features. The algorithm estimates the minimum and maximum customization required by comparing customer-prioritized requirements (PR-SRS) with ERP vendor specifications (SRS). The algorithm calculates the mismatch as a percentage, which determines the changes required in either customer requirements or ERP software to achieve a successful implementation.

The case study also demonstrates the feasibility of the PRCE algorithm. The study shows that the method is cost-effective, aligns customizations with business goals, and supports decision making by quantifying customization efforts ([35]).

4 System Design

This section provides an overview of the system and introduces the three primary objectives of this study. The system is designed to address key challenges in material management for the construction industry, leveraging the flexibility and capabilities of an ERP solution developed on the Odoo platform.

The system is built around the ERP platform, which serves as the backbone for inventory management, reporting, and approval workflows. In the design, we also embed the model of modern construction workflow, as in Construction 4.0, by enabling outsourcing management and subcontractor integration through its modularization and only-scalability deployment.

The architecture diagram (Figure 1) outlines the main components and workflows of the proposed system:

1. **Warehouse management:** this module is responsible for managing inventory import and export processes.
2. **ERP core system:** this module is placed at the central hub, the ERP integrates with the warehouse module to provide synchronized data and process automation.
3. **Hybrid approval process:** this process utilizes Hybrid Access Control Lists (H-ACLs) to ensure distributed and role-based approval mechanism.
4. **Reporting tools:** this module create overview document of the system data info in various report types, it also offers dynamic analytics and visualization tools.
5. **Subcontractor integration:** this module provides connectivity mechanism to multi-source subcontractor and integrating construction 4.0 outsourcing components.

In the remain of this section, we describe the detailed design of the three project' objectives :
Objective 1: is in the section 4.1, it implements inventory import and export functionalities, focusing on optimizing stock transfer strategies and ensuring accurate tracking across multiple locations.
Objective 2: is in the section 4.2, it emphasizes Hybrid Access Control Lists (H-ACLs) to ensure secure and efficient system usage matching the diverse roles. This subsystem includes a hybrid approval process, combining both automated and manual approval mechanisms. This ensures flexibility in handling complex workflows, such as managing subcontractor-related tasks or project milestones.
Objective 3: is in the section 4.3), it focuses on the design of customizing warehouse reporting tools. Data is consolidated within the ERP to generate unified reports and strategic or predictive customized report. These report variants provide both operational visibility and predictive analytics to support decision-making in construction management. The design alos enables real-time insights through dynamic data visualization and export capabilities.

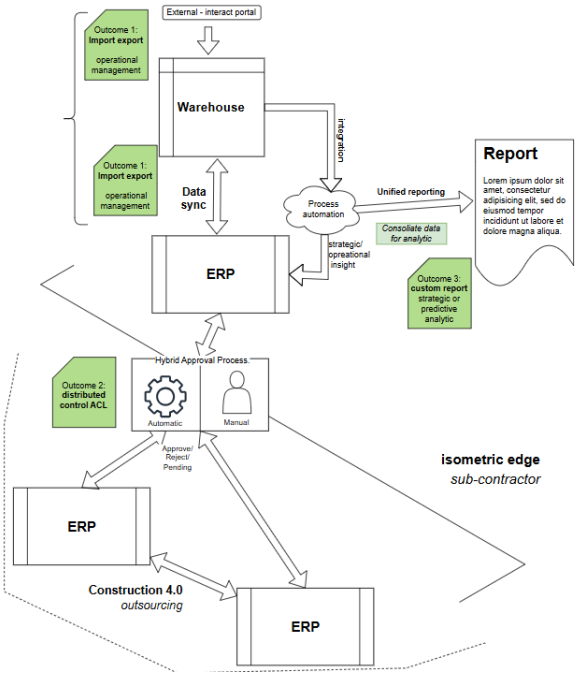

Figure 1: System architecture overview

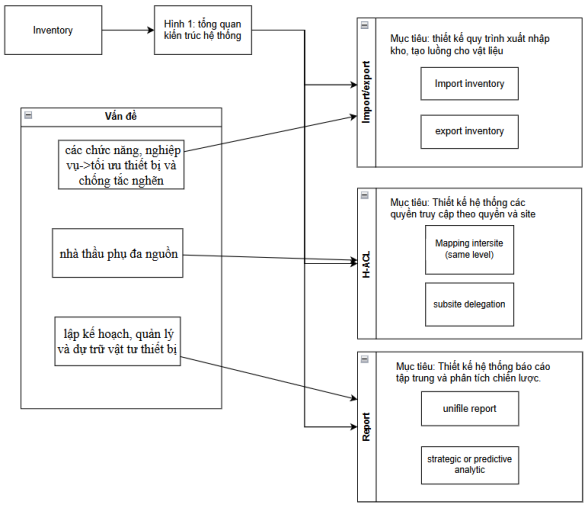

Figure 2: System overview

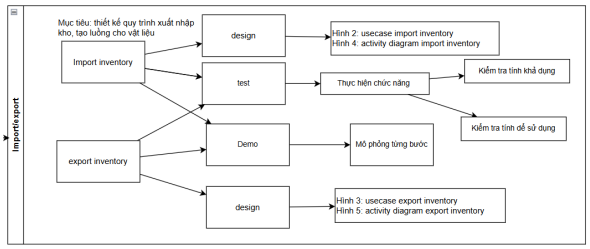

Figure 3: Object 1 overview

4.1 Objective 1: warehouse import/export

Warehouse import/export focuses on the design and implementation of the inbound and outbound processes, which are core activities in warehouse management.
The details of objectives 1 are organized into the following sections. The section 4.1.1 outlines the design of the module, including its functions and use case diagrams. The section 4.1.2 presents the testing plan with scenarios for functional and error-handling tests.

4.1.1 Design warehouse import/export basic

This section presents the list of functions in Table 4.1.1 and a set of use case diagrams.

Function	Module Interface
Create import note	stock.picking
Create export note	stock.picking
Confirm inventory export note	stock.picking
Update delivery status	stock.move
Identify destination warehouse	stock.picking
Identify source warehouse	stock.picking
Update transaction records	stock.picking
Update stock levels	stock.quant
Notify	base

Table 2: List of functions for warehouse import/export module

The usecase of inventory import The Figure 4 called *Inventory import usecase* shows the process of and manage the import process of goods into a warehouse. The primary actor in this system is the **inventory worker** who is responsible for initiating import requests, tracking shipping, checking inventory and confirm and update stock. The detailed four steps of inventory importing progress, included:

i. Create import request: the Inventory Worker submits a request for importing inventory.

ii. Track shipping: the system enables the worker to monitor the progress of incoming goods and confirm their arrival.

iii. Receiving inspection: the Inventory Worker verifies the quantity and quality of the goods to ensure compliance with requirements.

iv. Confirm and update stock levels: a imported inventory completed raise a request to processes the confirmation, and update stock levels in the warehouse.

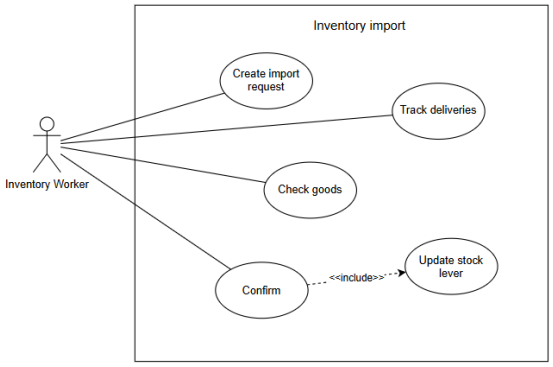

Figure 4: Use case 1.1 inventory import

The usecase of inventory export The Figure 5 called *Inventory export usecase* shows the

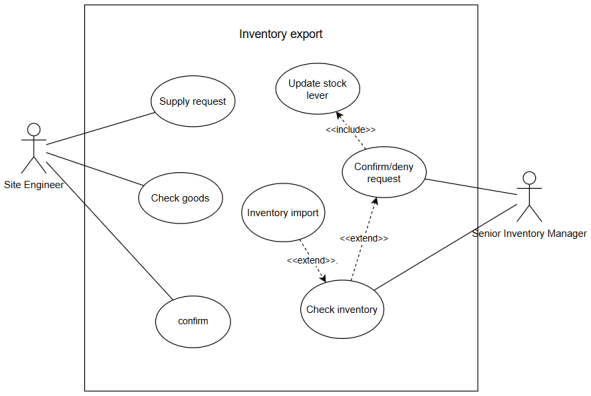

Figure 5: Use Case 1.2: Inventory export

The primary actors in this system are site engineer and senior inventory manager. **Site Engineer** initiates the supply requests, verifies goods quality, and ensures the export of inventory. **Senior inventory manager** follows up the progress of inventory export, the verification step of stock availability, and the approval process supply requests. The four key actions in the export process include:

i. Supply request: The Site Engineer submits a formal request for materials required on-site, specifying details such as type, quantity, and urgency.

ii. Receiving inspection: Upon receiving the goods, the Site Engineer verifies the quality and quantity to ensure they meet the requirements.

iii. Confirm: After inspection, the Site Engineer confirms the export process, ensuring the goods are ready for dispatch.

iv. Confirm/Deny Request: The Senior Inventory Manager evaluates the supply request, checks stock availability, and either approves or denies the request.

Activity diagrams An activity diagram illustrates the flow of activities and decisions within a process or workflow in the two operation of inventory importing and exporting.

Inventory import activity diagram The Figure 6 outlines the sequential process of importing goods into the warehouse, illustrating the interaction between the Inventory Worker and the System. The five steps in the import process include:

i. Login: The Inventory Worker logs into the system.

ii. Create Import Request: The Inventory Worker submits an import request, which generates an Import Note.

iii. Track Deliveries: The Inventory Worker tracks incoming goods.

iv. Check Goods: The Inventory Worker inspects the quality and quantity of the goods.

v. Confirm: The Inventory Worker confirms the import, prompting the system to update stock levels.

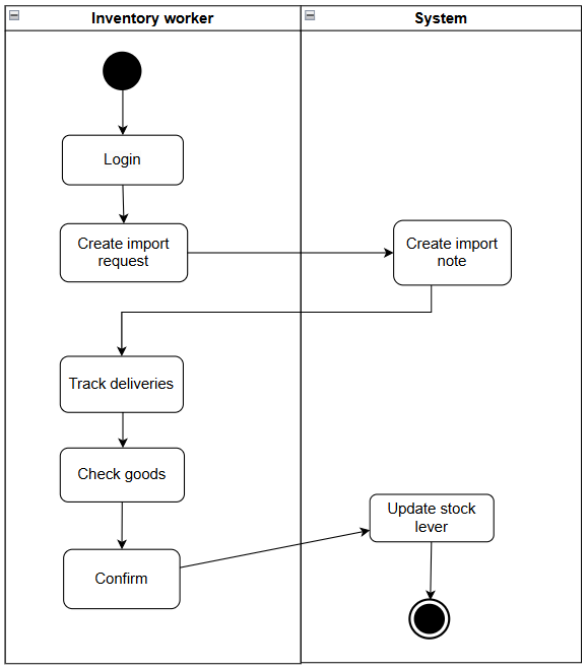

Figure 6: Inventory Import Activity Diagram

Inventory export activity diagram The Figure 7 outlines the sequential process of exporting inventories. This progress spans over the three phases, which include:

i. Phase inventory worker: Site engineers create supply requests, track deliveries, inspect goods and confirm completion

ii. Phase of centralized core hub: The system generates export notes after the construction engineer requests materials, notifies senior managers, site engineers and automatically updates inventory levels.

iii. Phase of senior inventory manager Deliveries: Managers check inventory, confirm requests, and decide to either deliver available products or import new ones.

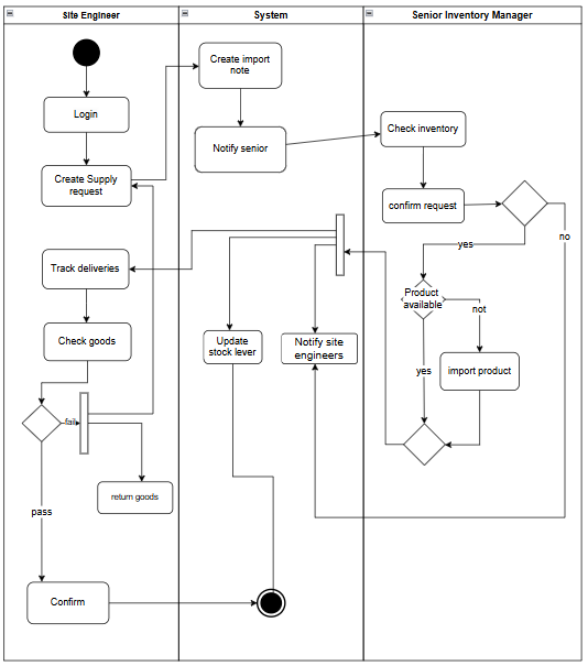

Figure 7: Inventory Export Activity Diagram

Proposed system vs. current Odoo implementation The current inventory management system perform locally at construction sites where each inventory worker has no management from senior manager. We propose a multi-phase that enable the automation from submit orders and trigger the confirmation to inventory manager which includes the system inventory checking. These improvement results the benefits listing below:

i. Efficiency: Eliminates the need for phone calls and paperwork. The system automatically creates import and export orders and notifies you when changes occur.

ii. Real-time inventory tracking: Site engineers can view current stock levels and make informed decisions about material requests. All inventory information and issues will be saved in the system in real-time, site engineers can track promptly and accurately.

The proposed system improves operational efficiency, and decision-making, offering potential for future integration with advanced technologies like IoT and AI.

4.1.2 Test plan of inventory importing/exporting

This test plan is designed to test the functionality of the import and export operations. It includes validation of core system

functions, error handling, data integrity. Below are the details for each test scenario.

Test 1: Inventory importing/exporting This test helps evaluate the system's ability to handle inventory transactions, including both inventory imports and exports. The test covers various scenarios to ensure that inventory stocking levels are updated correctly and that the related processes are performed properly.

Scenario 1.1.1: Successful import: The Inventory Worker navigates to the "Inventory Import" module, creates a new import entry, and enters product details such as product codes and quantities. The system should update inventory levels accurately. Any discrepancies, such as invalid product codes, should be highlighted for correction.

Scenario 1.1.2: Successful export: A inventory export request is created and processed. Once completed, the system updates the inventory level, confirming that the release operation is complete and inventory has been updated correctly.y.

Scenario 1.1.3: Lacking stock: A material export request has a quantity exceeding available stock. The system check the available amount if it out of the current limitation then the system display a warning, "Insufficient stock. Reduce quantity or check stock levels".

Test 2: Error handling in importing/-exporting This test evaluates the error management during inventory transactions of import or export. It includes scenarios to ensure proper validation and prevent incorrect data processing:

Scenario 2.1: Missing fields in import file: An import file with missing mandatory fields (e.g., product codes or quantities) is submitted. The system should reject the file and highlight the missing fields, ensuring that data integrity is maintained through proper validation.

Scenario 2.2: Export without confirmation and notification: The user attempts to process an export request without confirming the related material request. The system should block the export and display the warning: "Material request must be confirmed before exporting," preventing unauthorized exports.

Scenario 2.3: Duplicate entries: An import file with duplicate product entries is submitted. The system should detect the duplicates and either merge them or prompt the user to correct the file, preventing duplicate data from entering the inventory system.

Error	**Handler work**
Missing fields	Reject the input
Operation missing notification	Block and display warning
Duplicate entry	Detect and block input

Table 3: List of error handling test

Test 3: Data integrity ensures that inventory data remains accurate and trace-

able throughout all operations:

Scenario 3.1: Validation of updated inventory: After completing a series of imports and exports, the updated inventory levels should accurately reflect the cumulative changes made. This ensures that inventory records are always in sync with actual stock levels.

Scenario 3.2: Audit log generation: All inventory operations (imports, exports, and changes) should be logged properly for auditing. The system's audit logs should capture necessary details, including timestamps, users, and the changes made, ensuring traceability and transparency.

Data integrity test	**Expected result**
Inventory updating	Verify the number of record changing
Audit	Loging the tracking of changing operation

Table 4: List of data integrity test

4.2 Objectives 2: Hybrid access control list (H-ACL)

Hybrid access control list focuses on designing a flexible and distributed mechanism for managing permissions, combining automated and manual approval processes to ensure both security and adaptability across multiple systems or sites

The details of objectives 2 are organized into the following sections. The

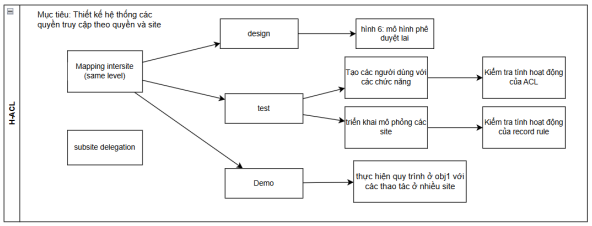

Figure 8: Object 2 overview

section 1.2.1 focus on designing the user access control module, configuring user roles, ACL settings, and record rules to ensure precise access management. The section 1.2.2 presents the test plan to validate the functionality and effectiveness of the system.

4.2.1 Design of distributed ACL

This section presents the design for a system that starts with 5, which is a list of group roles. Column 1 is the group name, and column 2 lists the rights associated with that group.

Group Name	**Rights**
Inventory Worker	Search Items in Store
Site Engineer	Create/Modify/Cancel MSR Request
Senior Inventory Manager	Search Items in Store

Table 5: Roles and permissions mapping for the ACL system

Hybrid approve The (Image 9) illustrates the mechanism of access control and

data access management in a distributed system, with access control rules applied at different sites. The system is divided into distinct sites, examble site 1 and site 2, where each site has its own set of users and data objects. this mechanism ensure the security of the data while providing appropriate access for each user based on their role and location.

In this system, model A represents a specific data object that requires access control. Access rights are managed based on user roles and the location of users within each site. The Admin, as the senior administrator, has full access and control over the Model A object across both sites. However, regular users like user 1 and user 2 are only allowed to access data within their respective sites and are denied access to data from other sites. These users can have temporary access when allowed by administrator

A hybrid model combining elements of centralization and decentralization offers several advantages in decision-making and operational efficiency. This model allows decisions of varying importance to be made at the appropriate levels: minor decisions can be handled by decentralized units, while more significant decisions remain centralized. This structure improves decision-making speed, as less critical issues do not need approval from higher authorities, enabling a more agile process. Hybrid model also improves coordination between departments and units. The central authority ensures that decentralized units function within a unified framework,

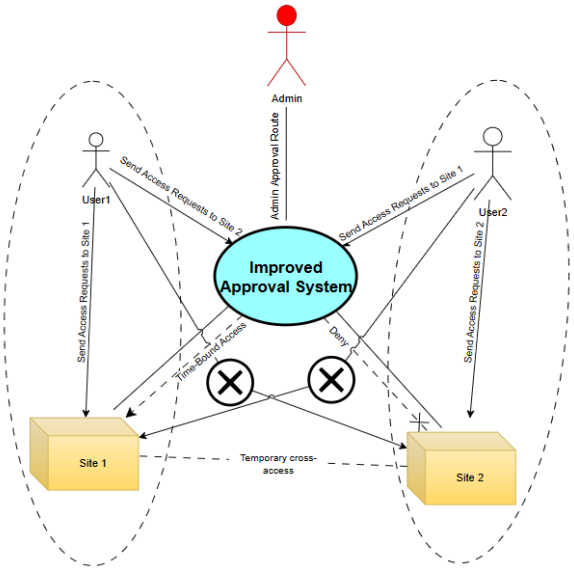

Figure 9: Hybrid approve

which enhances communication and promotes collaboration across divisions. This structure helps optimize resource allocation, improve performance, and minimize redundancies.

4.2.2 Test plan of distributed access control list

The testing for objectives 2, focusing on the implementation of the distributed access control list (ACL).It includes validation of authorization verification, accounting function, alias or mapping ACL among different subsystems.

Testing methods and measurements The testing will include three main testing methods, each with corresponding measurements:

1. **Role-based access control testing:**
    - Test prohibited actions for specific roles (e.g., Inventory Worker attempting to modify MSRs).
    - Record the number of blocked unauthorized actions.
2. **Multi-site security testing:**
    - Assign users to multiple sites and then attempt to access data from unauthorized sites.
    - Measure the response time for permission checks.
3. **Record-level access testing:**
    - Compare records displayed to the user with actual authorized records in the database.

Test 1: Authorization verification

- Scenario 2.2.2.1: Admin access to all records: Verify that an admin user can access all modules and records.
- Scenario 2.2.2.2: Employee limited access: Verify that an employee has restricted access to specific modules or records.
- Scenario 2.2.2.3: Unauthorized action prevention: Ensure that users cannot perform actions without proper permissions.
- Scenario 2.2.2.4: Verify group-based permissions: Validate that permissions based on user groups are enforced correctly.

Test 2: Accounting function

- Scenario 2.2.3.1: Record-level permissions: Verify that a user can only access records associated with their assigned site or instance.
- Scenario 2.2.3.2: Large-scale logging system: Verify that the system supports backing up the logs periodically when the size reaches a threshold.
- Scenario 2.2.3.3: Analyze the log function: perform the display and summary of the recorded log of system access.

Test 3: Alias or mapping ACL among different subsystems

- Scenario 2.2.4.1: Multi-site access control: ensure that ACL works correctly across multiple sites or instances.
- Scenario 2.2.4.2: Verify the creation of new aliases for upcoming subsystems.
- Scenario 2.2.4.3: Verify permission granting and delegation among local ACL from one subsystem to another subsystem.

4.3 Objectives 3: Unified and customized warehouse report

Unified reporting is a centralized system that integrates data from multiple sources (such as ERP, warehouse, CRM, etc.) and presents the information in a standardized format. Its goal is to provide real-time reports that help managers make quick and informed decisions. The system supports operational reporting, uses real-time data, and creates reports, dashboards, or charts in a consistent format.

The details of objectives 3 are organized into the following sections. The section4.3.1 section outlines the design of the module, including the model and class diagram. The section 4.3.2 section presents the test plan with scenarios for functional tests. Goals of objectives 3: Design reporting system with functions:

- **Create inventory reports**: Generate real-time reports on stock levels or activities based on specific criteria.
- **Customize the report interface**: Meet the needs of different roles in the system, from warehouse staff to senior management.
- **Ensure accurate integration of data**: From various sources, providing timely and accurate information.
- **Enable data export, trend analysis, and visualization**: Support the creation of charts and report exports, providing deeper insights into inventory performance.

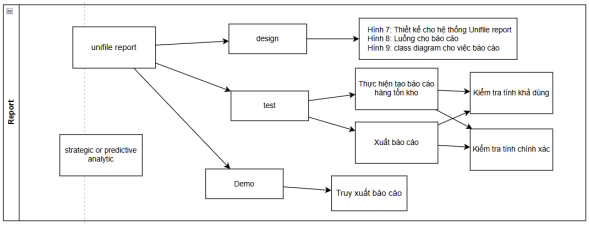

Figure 10: Object 3 overview

4.3.1 Design

Details of this objective

This section describes the design of the warehouse reporting module. In phase 1, I designed a unified reporting system in 11. The Unified Reporting system is a centralized subsystem where data from multiple sources (e.g., ERP, warehouse, etc.) is integrated and presented in a standardized format, providing immediate and timely insights into operational activities..

Report structure The report data is structured in the following manner (refer to Table 6):

Row	Content
1	Model names from which data is retrieved.
2	Key functionalities supported by the report.
3	Data fields related to the report.

Table 6: Report structure overview

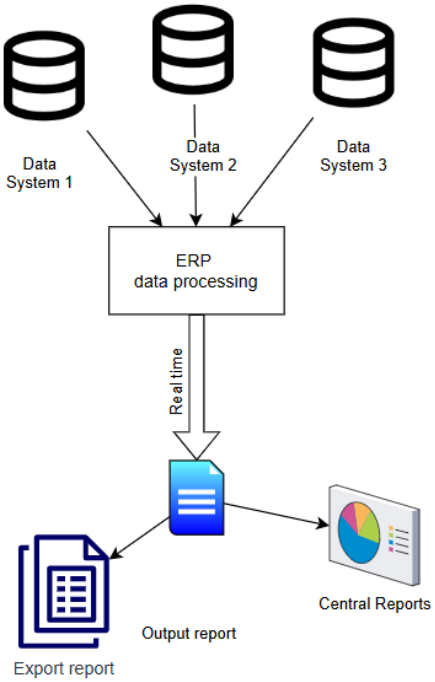

Figure 11: Unified reporting

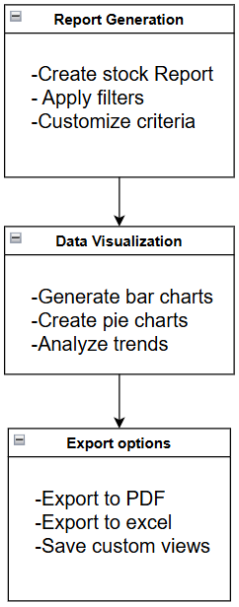

Figure 12: Execution Flow for Report

Execution flow design The execution flow for generating warehouse reports is depicted in Figure 12. This flow outlines the steps involved in retrieving data, processing metrics, and presenting the results in a user-friendly format.

Report generation: The process begins with creating a stock report, which serves as the foundation for tracking inventory levels and other relevant data. This report compiles raw data related to stock quantities, delivery statuses, and item conditions, providing a comprehensive overview of the current inventory status.

Once the initial report is generated, users can apply filters to narrow down the dataset. Filters allow for the selection of specific inventory categories, time periods, or other relevant criteria, ensuring that the report focuses on the most important data.

Data visualization After generating and customizing the report, the next step is data visualization. Visualization plays a key role in turning complex data into actionable insights. The system generates bar charts and pie charts based on the inventory data, which makes it easier for users to spot trends and patterns at a glance.

By analyzing trends, users can identify changes or patterns in inventory, such as high demand for certain products, low stock levels, or overstocking. This analysis provides the foundation for informed decision-making regarding procurement, stock management, and resource alloca-

tion.

Export options After generating and visualizing the report, users are given various export options to share or store the report in the desired format:

- **Export to PDF**: This option allows users to export the report in a standard format that is easy to share and view.
- **Export to Excel**: For users who require further analysis, the report can be exported to Excel. This format enables users to manipulate the data, perform advanced calculations, and generate additional insights through pivot tables or other Excel tools.
- **Save custom views**: Users can save their customized report settings for future use, streamlining the reporting process.

Details of warehouse reports

Information to display The warehouse reports aim to provide critical inventory-related insights through the following:

- **Inventory stocking levels**: Displaying stock quantities by product and location for real-time monitoring.
- **Inventory stocking history**: Showing historical stock movements with details such as stock picking records and movement dates.
- **Inventory cost**: Calculating and presenting the costs associated with inventory.

Process data The reporting module processes data in two main stages:

- **Data retrieval**:
  - **Models used**:
    - `stock.quant`: Retrieves current stock data.
    - `stock.picking`: Fetches stock movement history (incoming and outgoing).
    - `product.product` + `product.template`: Provides product-specific details.
    - `stock.landed.cost`: Calculates inventory costs.
  - **Data fields**: Includes stock levels, movement records, product details, and cost calculations.
- **Metric calculations**:
  - `Total stock`: Summing up the quantities across all locations.
  - `Total cost`: Aggregating inventory costs for accurate reporting.
  - `Stock trends`: Analyzing movements over time to identify patterns or anomalies.

Data visualization Presenting information in an intuitive and accessible format is critical for usability. The following methods are employed:

- **Display formats**: Reports can be generated in PDF, displayed on a web client, or visualized using a JavaScript visualization library viewer.

- **Display forms**:
  - `Tables`: Presenting a concise snapshot of inventory information organized by product or warehouse.
  - `Charts`: Highlighting trends, comparisons, or patterns in inventory data for quick decision-making.

Export options: To facilitate further analysis and integration, the reporting module supports multiple export options:

- Export formats include `.xlsx`, `.csv`, and `.pdf` for flexibility in data sharing and reporting.

By implementing the above design, the warehouse reporting system ensures accurate and actionable insights for decision-makers, enhances operational transparency, and streamlines inventory management. The integration of user-friendly visualization tools and export capabilities further adds value, enabling seamless adoption across various business functions.

Model	Function
štock.quant	Stores current inventory information for each product at each location.
`stock.picking`	Logs the history of stock movements (receipts and deliveries).
`product.product`	Stores detailed information about each product.
`stock.landed.cost`	Records inventory costs by product (value upon receipt and additional costs).
`stock.location`	Contains information about storage locations (warehouse name, address, warehouse code).

Table 7: Data models for report generation

The reporting package class diagram

The class diagram of the reporting package 13 plays a fundamental role in streamlining communication and improving decision making within the construction company. The system is designed to generate several types of reports, including inventory reports, delivery notes, damaged device reports, and equipment custody reports. These reports ensure that all relevant departments, from procurement to site management, are continuously updated with accurate and real-time information.

The relationships between different classes in the system are key to generating these reports efficiently. For instance,

the connection between the MSR (BackOrder) class and the Orders class allows the system to produce comprehensive MSR reports, reflecting current orders and backorder statuses. Similarly, the interactions with the Projects and Inventory classes ensure that the reports are populated with up-to-date project data, including inventory levels and material requirements.

The overall structure of the reporting system in this model significantly enhances the efficiency of inventory management, procurement tracking, and equipment monitoring. By automating report generation and ensuring real-time data is available, the system reduces the reliance on manual processes, improves data accuracy, and provides decision-makers with timely insights. Ultimately, this contributes to smoother project execution, better resource management, and increased operational efficiency in the construction industry.

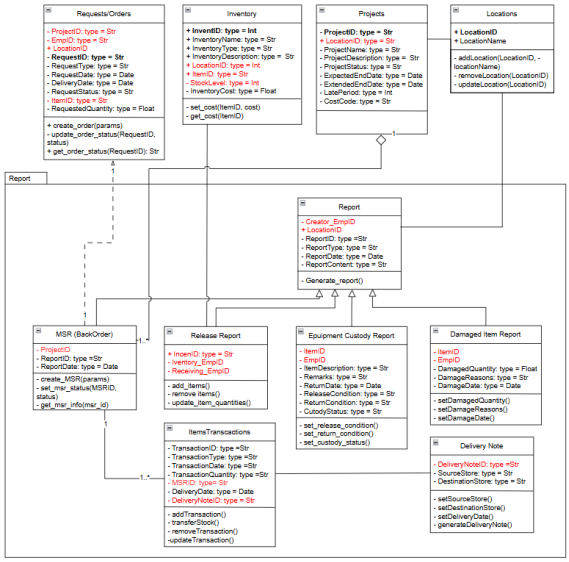

Figure 13: Class diagram for report

4.3.2 Test plan

The test plan for objective 3 outlines how to evaluate the functionality of the reporting system. Testing will be conducted by simulating users performing system functions and evaluating based on the results displayed:

Test case 1: Check report display

- Scenario 3.2.1.1: Generate a stock report: Navigate to the inventory report module, apply filters. The report should display stock levels grouped by product and location.
- Scenario 3.2.1.2: Generate charts: Access the reporting module, choose "Generate chart," and select criteria. The chart should be generated accurately based on the selected criteria.

Test Case 2: Check filtering report

- Scenario 3.2.2.1: Test filters on reports: Apply various filters (e.g., by product category, location, or date range) and verify the output. The filtered report should display data that matches the applied criteria.
- Scenario 3.2.2.2: Export stock report to Excel/PDF: Generate a stock report, then click "Export" and choose

the format (Excel/PDF). The report should be exported in the correct format with the correct data and structure.

Test Case 3: Measure the degree of customization in the report

- Scenario 3.2.3.1: Run a benchmark or rating to measure the customization degree: perform a benchmark or rating to evaluate the degree of customization the designed system supports.
- Scenario 3.2.3.2: Estimate the customization degree: Perform the algorithm PCE (Product customization estimation) and estimate the degree of customization.

5 Results and findings of initial implementation

In this section, we present some initial implementation of the three main components of our work. These include evaluation criteria in section 5.1, evaluation steps in section 5.2, evaluation results, and recommendations in section 5.3.

5.1 Evaluation criteria

Functional evaluation: Verify that the system delivers the expected functionality across all modules and workflows.

- **Accuracy:** All stock levels, material transfers, and procurement records are updated correctly in real-time.
- **Workflow completeness:** Key processes such as material supply requests (MSRs), inventory imports/exports, and approvals work seamlessly from initiation to completion.
- **Role-specific features:** Each user role (e.g., Inventory Worker, Site Engineer, Senior Manager) can only access and execute permitted actions.
- **Integration:** Modules such as stock, purchase, and reporting integrate smoothly without data inconsistencies.

Usability Evaluation: Assess how intuitive and efficient the system is for end-users.

- **Ease of navigation:** Users can easily locate and interact with features relevant to their tasks.
- **Error prevention:** The interface minimizes user errors, with clear feedback and validation messages.
- **User satisfaction:** Positive feedback from users regarding ease of use and design through surveys or interviews.
- **Heatmap analysis:** Using tools like Smartlook, determine how effectively users interact with the interface and identify potential bottlenecks.

Performance evaluation: Ensure the system performs reliably under various operational conditions.

- **System responsiveness:** Tasks such as creating MSRs, updating stock levels, and generating reports are completed within acceptable timeframes (e.g., less than 2 seconds for basic operations).
- **Load handling:** The system can process large datasets (e.g., 100,000+ inventory records) without performance degradation.
- **Uptime:** The system maintains at least 99.9% availability during peak usage.
- **Scalability:** The system supports increasing users, inventory records, and workflows without requiring significant re-engineering.

Reporting and analytics: Ensure the system provides actionable insights and accurate reporting capabilities.

- **Report accuracy:** Data in generated reports matches system records and is error-free.
- **Visual clarity:** Charts, graphs, and visualizations are easy to interpret and align with user expectations.
- **Customizability:** Users can customize reports and filters to suit specific project needs.
- **Performance:** Reports are generated quickly, even with large datasets.

Compliance: Ensure the system adheres to relevant industry standards and organizational policies.

- **Regulatory compliance:** The system aligns with construction industry standards for data handling and operational workflows.
- **Internal policies:** The system respects organizational rules regarding data privacy, security, and workflow approval processes.

5.2 Evaluation steps

5.2.1 Demo script for inventory importing/exporting

This testing plan focuses on evaluating and improving the stock in/out workflow within the Odoo inventory module. The primary goal is to assess how users interact with key inventory processes, such as receipts and delivery orders. By simulating the user's journey through each step of these processes, we can identify potential usability issues and areas for improvement. To enhance the accuracy of this evaluation, we will use Smartlook, a tool for tracking user behavior. This tool will provide valuable insights through heatmaps and session recordings, allowing us to understand user interactions better.

The testing process will be conducted step by step, focusing on both stock receipt and stock delivery processes. After

collecting data on how users engage with the interface, we will analyze the results to pinpoint common challenges and user confusion. Finally, we will compile a report that includes heatmaps, session recordings, and actionable recommendations to optimize the stock management workflow for a smoother user experience.

The script where we use the tool Smartlook (`https://app.smartlook.com/`) to monitor user interactions during stock in and stock out operations. The steps are as follows:

The Demo Script
Step 1: Integrate smartlook with the Odoo inventory module: Embed the Smartlook tracking script into the web application.
Step 2: Simulate user actions for the stock in process
Step 3: Simulate user actions for the stock out process:
Step 4: Monitor user interactions: Use Smartlook heatmaps and session recordings to track user interactions on the interface.
Step 5: Analyze collected data: Identify usability issues, such as frequently clicked buttons, areas with user confusion, or missed interactions.
Step 6: Compile a report: Include heatmaps, session recordings, and actionable recommendations to improve the stock in/out workflow.

Table 8: The Demo Script of the Objectives for Inventory Import/Export

5.2.2 Demo Script of Distributed ACL

The demo script for objectives 2 outlines the following steps, which will be followed the script in Table 9.

The described steps enhance security, scalability, and usability in a multi-site ERP system for construction. Configuring Access Control Lists (ACL) and record rules ensures users only access data relevant to their roles and assigned sites, reinforcing security while maintaining consistency. User simulations, such as inventory workers managing stock or managers approving orders, test the system's flexibility and real-world application.

Monitoring unauthorized access through logging tools highlights the system's reliability and data protection capabilities. Verifying multi-site consistency ensures seamless operations across locations, supporting scalability. Finally, reporting on user access, blocked actions, and suggested improvements helps refine the system to better meet the complex needs of construction operations.

The Demo Script
Step 1: Configure Access Control List (ACL) in Odoo for user roles. Step 2: Configure Record Rules for multi-site security. Step 3: Simulate user interactions for each role. Step 4: Monitor access attempts through Odoo's logging and audit features. Step 5: Analyze multi-site consistency. Step 6: Compile a report summarizing

Table 9: Demo script for objectives 2

5.2.3 Demonstration script for warehouse report

These steps focus on enhancing the reporting capabilities of the ERP system, directly addressing criteria like reporting, usability, and scalability. Configuring the reporting module ensures comprehensive stock insights, enabling users to analyze product levels, locations, and trends with flexible export options in PDF and Excel formats.

Simulating report generation for various scenarios tests the system's reliability under different conditions, including large datasets, ensuring it performs efficiently without compromising accuracy. Visual insights, such as pie and line charts, add usability by offering intuitive data representation. The process also identifies areas for improvement, ensuring the reporting system evolves to meet the dynamic needs of construction management and is summarized in Table 10.

Reporting and testing steps
Step 1: Configure the Reporting Module in Odoo Step 2: Simulate Report Generation for Various Scenarios Step 3: Generate Charts for Visual Insights

Table 10: Reporting and testing steps

5.3 Evaluation results and discussions

5.3.1 Objectives 1: Inventory management

The system effectively facilitated inventory importing and exporting processes. Tests demonstrated that:

- **Accuracy:** Stock levels and material records were updated in real-time during import and export operations.
- **Workflow completeness:** All key processes, including creation and validation receipts / delivery orders, were carried out seamlessly from the start to the end.
- **Usability:** The interface is user-friendly, ensuring that users can easily navigate through the system without missing any steps.

However, the process could benefit from further automation, such as automatic notifications for low stock levels and optimized stock transfer between warehouses.

The basic import and export demonstration are in Figure 14 and 15, respectively.

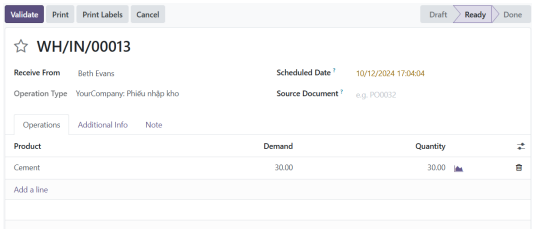

Figure 14: Import Cement

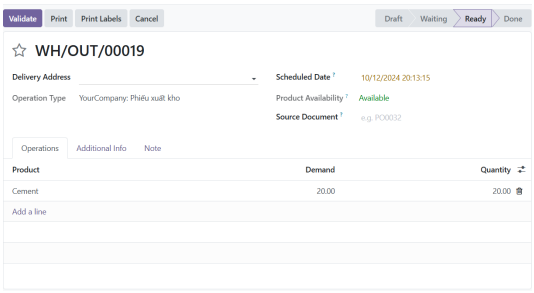

Figure 15: Export Cement

5.3.2 Objectives 2: Hybrid-ACL

The configured Access Control Lists (ACLs) and record rules ensured robust role-based permissions:

- **Security:** Unauthorized actions, such as attempting to delete stock or access restricted modules, were successfully blocked with appropriate error messages.
- **Usability:** Role-specific workflows (e.g., inventory workers managing stock levels, site engineers creating MSR requests, and managers approving transfers) were intuitive and aligned with user expectations.
- **Multi-Site consistency:** Access rules enforced data isolation for site-specific users while maintaining visibility for super admins.

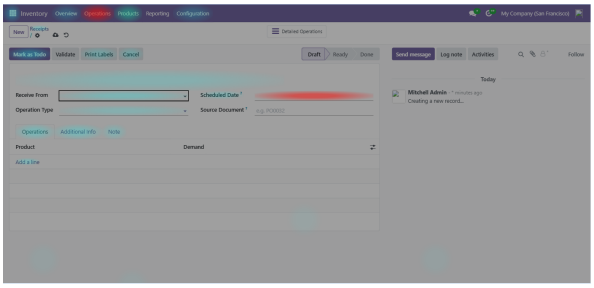

Figure 16: Enter Caption

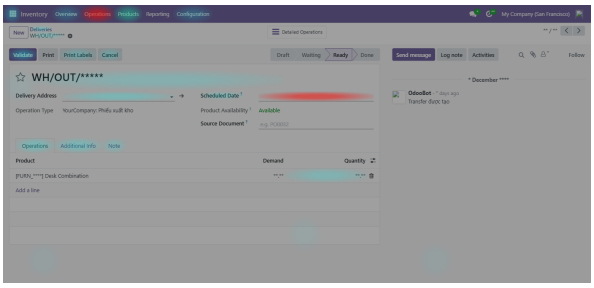

Figure 17: Enter Caption

Recommendations include enhancing the logging system to provide more detailed insights into unauthorized access attempts and automating periodic access reviews.

Expected results The results of the tests will be recorded and allow the valid operations. The invalid operation after checking ACL will be denied as expected.

5.3.3 Objectives 3: customized report

The reporting module provided accurate and customizable insights:

- **Accuracy:** data in exported reports (PDF and Excel) matched system records, with correct formatting.
- **Performance:** reports were generated efficiently, even with large datasets, and visualizations such as pie and line charts rendered correctly.
- **Customizability:** filters for product categories, date ranges, and warehouse locations enabled tailored reports.

Further improvements could include adding data visualizations, such as charts, to enhance user experience and facilitate better decision-making. The illustration of the generated report is shown in Figure 18 and the PDF version is in Figure 19.

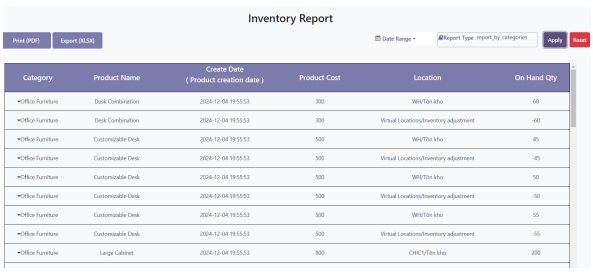

Figure 18: Generator report

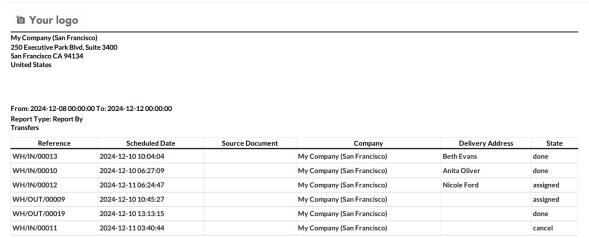

Figure 19: Export to PDF

6 Conclusion

This work initially implemented an ERP solution that tackled the problem of inventory management and operational workflows specifying for the construction project. The developed system is built on the Odoo ERP platform, which is an enterprise standard. Our proposed system effectively streamlines inventory processes, enables multi-site access control mechanisms, and improves reporting capabilities through various supporting report type and flexible customization.

The three developed subsystems including inventory management, access control configuration, and customization reporting tool exhibit a definite compliance with construction-specific requirements. Our hybrid approval workflows, and subcontractor management capabilities plays a pivotal role in integrating warehouse with ERP components. Our customization report addresses the strategic and operational insights for manager users of the developed system.

Future work will empower the system to fully incorporate advanced equipment management and subcontractor coordination. The coordination aims to opti-

mize resource allocation, tracking, and utilization of assets among multiple sites, as well as supporting multi-directional transferring of inventories and subcontractor delegation. This extension offers a unified streamline process provide a proper supplying subsystem for construction industry.

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