Improving Performance in the Institute of Health Sciences through an Automated Warehouse Management System

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***Abstract*— Effective management of items within a warehouse environment is crucial for optimizing operations, maintaining accurate inventory, and maximizing productivity. A well-designed warehouse management system (WMS) plays a vital role in achieving these objectives. This research paper focuses on the development of a warehouse management system (WMS) that efficiently controls and manages items within a warehouse setting. The study employs both interview and prototype methodologies to gather requirements and design a practical solution. By conducting in-depth interviews with warehouse managers and staff, valuable insights into their pain points, existing systems, and desired features for an improved WMS were obtained. A prototype WMS was created using a user-centered design approach, incorporating functionalities such as automated data capture, inventory tracking, order fulfillment, and reporting features. The developed WMS prototype was tested and refined through feedback sessions and usability testing with warehouse personnel, leading to improved operational efficiency, inventory accuracy, and user satisfaction. Overall, this research contributes to the field of warehouse management by providing a user-centric approach to designing and implementing an effective WMS.**

Keywords— warehouse management system, automated inventory management, inventory management, user-centered design, interviews, prototype, operational efficiency..

I. Introduction

Product and material handling and transportation systems have been used in manufacturing companies for many years (Amato et al., 2005). The level of automation employed in industry has continuously grown as electronic and computer technologies have improved in terms of functionality, ease of use, integration with other devices, and affordability (Amato et al., 2005). This progress has resulted in a significant increase in the complexity and interactivity between different types of systems (Amato et al., 2005). International interest in innovating and sharing advances in these systems is driven by the need for collaboration on projects desire to enhance global competitiveness (Amato et al., 2005). It is important to note that mechanical, physical, electrical, and software components cannot be isolated and do not function independently (Amato et al., 2005).

Over the past fifteen years, substantial efforts have been made to identify optimal strategies for planning and controlling warehouse systems (Atieh et al., 2016). Effective warehouse management and efficient resource allocation have become crucial as a result (Atieh et al., 2016).

The need for automating warehouses arises from the fact that manual handling can lead to human errors, which in turn may impact warehouse utilization (Bhor et al., 1980). Conducting a comprehensive study of the system is necessary to automate the process (Bhor et al., 1980). The initial step towards implementing an automated warehousing system involves identifying and reengineering the processes and procedures carried out in the warehouse, followed by determining which processes can be automated (Bhor et al., 1980).

The Warehouse Management System (WMS) offers a range of computerized and automated procedures to enhance efficiency and minimize costs at organizations (Atieh et al., 2016). Efficient management of all operational warehouse activities is achieved through the WMS, resulting in reduced costs associated with warehouse management (Atieh et al., 2016).

The previous studies had several shortcomings. The statements regarding the growth of automation and the limited discussion on the challenges of integrating various technologies in warehouse automation lack empirical data or case studies to support them. Furthermore, it fails to mention the usage of data analytics in warehouse management systems.

II. Literature Review

Warehousing takes up to between 2% and 5% of the cost of sales for corporations, and with today's highly competitive global business environment, organizations are emphasizing return on assets (Chen et al., 2018). Minimizing warehousing costs has become an important business issue. Many firms are automating their basic warehousing functions to achieve the increase in throughput rates or inventory turns required for their warehousing operations to be cost-effective (Chen et al., 2018).

When a warehouse management system (WMS) is implemented, it will inevitably lead to an improvement in accuracy, a decrease in labor costs, and an improved capacity to serve customers by shortening cycle times (Chen et al., 2018). WMS will take the lead in both increased storage capacity and inventory reduction. The amount of safety stock needed might be reduced if the receiving process becomes more accurate and efficient (Chen et al., 2018). However, the impact of this reduction on inventory levels as a whole will be minimal. The variables (lot sizing, lead times, and demand variations) regulating inventory levels may simply be unaffected by WMS (Chen et al., 2018). WMS, however, helps make things more organized and efficient, which results in increased storage capacity (Chen et al., 2018).

A. Literature Review References:

M	Researcher Name	Research Objective	Methodology	Methods
1	(Bhor et al., 1980)	Reduce time , eases the work for workers, keep records of goods	This paper is using Applied methodology	The methods used is Prototype
2	(Chen et al., 2018)	Realize the real-time tracking, automatic access to warehouse, speeding up the automation process	This paper an applied methodology	Systematic analysis, design, development
3	(Deng et al., 2018)	Combination of stacking and loading, reduces the cost of renovation	This paper is using Experimental and applied methodology	Using Client-server architecture by Analysis
4	(Custodio & Machado, 2020)	Identified and discussed to clarify future research opportunities	This paper is a comprehensive literature review	Using material collection, descriptive analysis
5	(Atieh et al., 2016)	Supply chain performance that offers an inventory management system that is more dependable, efficient, and uses less resources	This paper is using Experimental and prototyping	Using interview and observation.
6	(Emir Žunić et al., 2018)	Smart WMS optimizes processes to save resources and to create a more	This paper is using descriptive methodology.	Using analysis and data collection.
7	(Mostafa et al., 2018)	WMS to achieve more control and monitoring of the operations in real time	Systematic review	A comprehensive Literature Search and Study Selection

We gain valuable insights into the challenges faced by warehouse managers and staff, their desired functionalities for a warehouse management system, and their expectations for integration and collaboration. These insights will inform the development of the prototype system and subsequent iterations.

III. Problem of Research

The primary challenge encountered in warehouse management at the Institute of Health Sciences in Mualla Aden revolves around the intricate nature of manually recording and monitoring inventory. Presently, materials and equipment are documented using paper records, which introduces the possibility of errors and hampers efficient information updating and tracking. Moreover, this conventional system leads to delays in addressing requests and distributing materials, thereby adversely impacting workflow. Hence, implementing an automated warehouse management system has the potential to enhance performance at the Institute of Health Sciences.

IV. Research Objective

The main Objectives of this Research are listed below:

- To develop a prototype for a user-centric warehouse management system (WMS) that efficiently controls and manages items within a warehouse environment.

- To identify pain points in existing systems, and understand desired features for an improved WMS.
- To test, refine, and validate the developed WMS prototype through feedback sessions.

V. METHODOLOGY

This research employs a mixed-methods approach, incorporating qualitative interviews and prototype development. investigation entails conducting interviews with warehouse managers and staff members to gather valuable insights and feedback. Subsequently, an iterative prototyping process is implemented to enhance the system based on their specific requirements.

To ensure a comprehensive understanding of warehouse management practices and requirements, a representative sample of warehouse managers and staff members is carefully selected to participate in the study.

A. DATA COLLECTION:

Interview Phase:

To conduct effective interviews, it is important to develop a structured interview protocol. The interview protocol should include a set of questions designed to gather detailed information from participants. Here's an example of interview questions for the warehouse management system research.

• Can you describe the current warehouse management practices in your organization?
• How do you handle inventory management, order processing, and tracking in your warehouse?
• What are the key steps involved in your order fulfillment process?
• What functionalities and features do you expect in a warehouse management system to address your specific needs?
• Are there any specific requirements for inventory tracking, order processing, or reporting that you would like to see in a new system?
• How do you envision the integration of the warehouse management system with other existing systems or technologies in your organization?

Once the interviews are completed, transcribe the interview recordings and analyze the data using qualitative analysis techniques such as thematic analysis. Thematic analysis involves identifying common themes, patterns, and key findings from the interviews. The table below will show an example of potential themes that may emerge from the interview data:

Table 1: Summary of the benefits identified through the interview data.

No.	Features of the WMS	Ref.	Sample Evidence
1	Inefficient inventory tracking and management processes	2	In our warehouse, we use the old method of using paper orders for items […] . […]It is also hard to track the items in the warehouse […] . Its hard for us to know the items left in the warehouse to order more items in the future […] .
2	Lack of real-time visibility into inventory levels and stock outs.	2	[…] when I want to know how many tables or chairs in the warehouse so I need to count them […] . […] and it hard to order some items because I don't have list in my hand[…] .
3	Manual and time-consuming order processing procedures	1	I use paper and pen to consume items and count them in the paper[…] . […] taking from me a lot of time for this process[…].
4	Real-time reporting and analytics for better decision-making.	1	[…] and for report in the end of the year when the manager want from me a report, I want for weak to count the remain items[…] . […] and sometime I recount again because of the mistakes that's happened […] .
5	Delay responding to requests and distributing materials	1	[…] that will me delay in time to distribute items for the departments […]. […] because I need to make some paper record[…] .

system and subsequent iterations.

B. SYSTEM ARCHITECTURE:

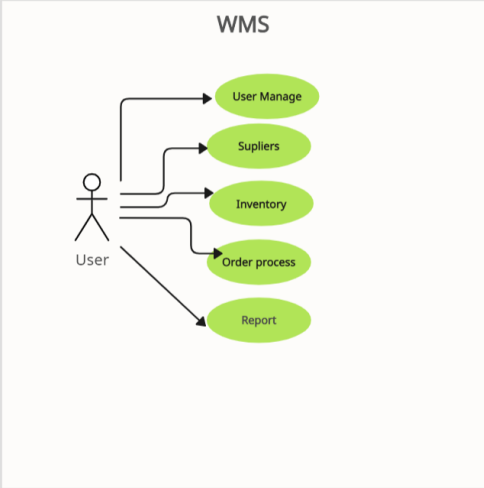
Develop a warehouse management system by utilizing Windows Forms for creating user-friendly UI components, including forms for data entry, search functionality, data grids, and generating reports. For hardware we need minimum of an Intel i3 processor, RAM capacity of at least 4GB, Hard disk capacity of at least 512GB. Implement the business logic layer using C# classes to encapsulate core functionalities such as inventory management, order processing, and tracking. Utilize Microsoft Access as the database to store and manage relevant data, including

products, orders, suppliers, and inventory information. Establish a connection between the C# application and the Microsoft Access database to facilitate seamless data interaction. Implement a robust user authentication mechanism to secure system access by defining user roles, permissions, storing user credentials securely, and enforcing password policies.

C. USE CASE DIAGRAM OF THE INITIAL DESIGN:

In use case diagram representation of the interactions between actors (users, systems, or external entities) and the system being developed. In the case of your warehouse management system (WMS), here's a description of the key elements you can include in the use case diagram:

- User Manage: This use case covers the ability to add, update, delete, and make permissions for users.
- Suppliers: This use case covers the ability to add new suppliers and update the information about suppliers.
- Manage Inventory: This use case represents the ability to track and manage the warehouse inventory, including adding new items, updating quantities, and monitoring stock levels.
- Process Orders: This use case involves the order fulfillment process, including receiving and processing customer orders, picking and packing items, and generating shipping labels or invoices.
- Generate Reports: This use case allows users to generate various reports related to inventory levels, order history, and warehouse performance.



D. PROTOTYPE EVALUATION PHASE:

Based on the insights gained from the interview phase, an initial prototype of the warehouse management system is developed. The prototype should incorporate the functionalities, features, and requirements identified during the interviews. using C# as a programming language and Microsoft Access as a database. The prototype should have a user-friendly interface that is intuitive and easy to navigate. The design should consider the specific needs and preferences of warehouse managers and staff. For example, the user interface should have clear and visually appealing graphics, well-organized menus, and easy-to-access functionalities. Here's an example of the initial prototype design:

1. *User Management Module:*

This prototype should have a user management system that has two types of permissions: a normal user and an admin user. The admin user can create and update the user's details, like their full name, username, and password. can also manage suppliers, inventory items, order processing, tracking, and reporting. The normal user cannot manage user details like create user, update user, delete user. Can only manage the suppliers, inventory items, order processing, tracking, and reporting. Prototype interface for the users shown in figure 1.

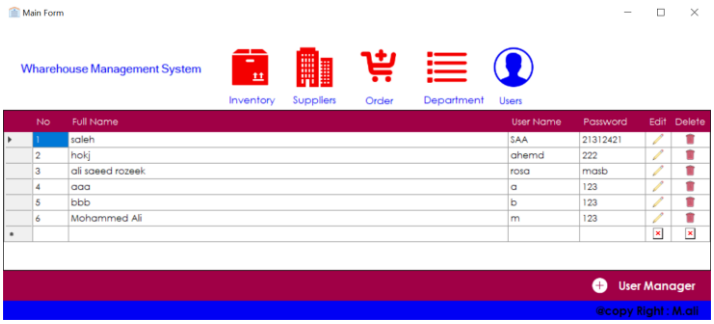


Figure 1. Prototype for Users interface

2. *Suppliers Management Module:*

In this prototype, you should enter the names of suppliers, their phone numbers, information about them, and modify them. and can delete or add a new supplier. A prototype for the supplier interface is shown in figure 2.

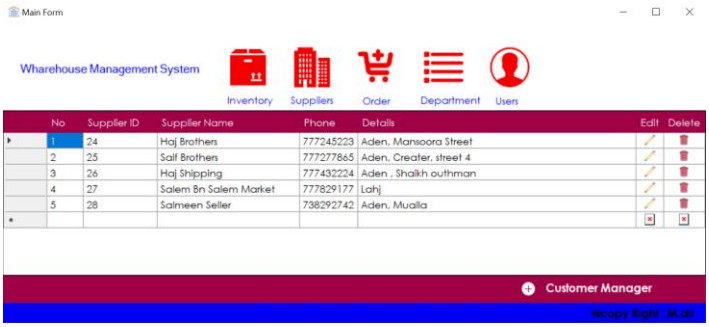


Figure 2. Prototype for Suppliers interface

3. *Inventory Module:*

This prototype has a user-friendly interface to view and manage inventory levels with a real-time update on inventory stock levels. You should enter the name of items, quantity, price, and who is the supplier for that item.

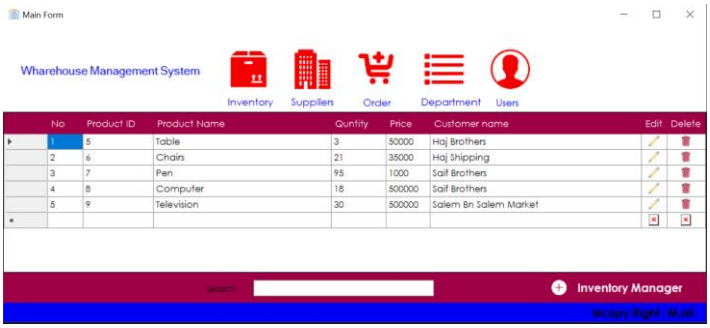


Figure 3. Prototype for Inventory Management interface

4. Department Module:

In this prototype, you can enter, edit, update, and delete the department. In this interface, you can enter only the name of the department. The prototype for the department module is shown in Figure 4.

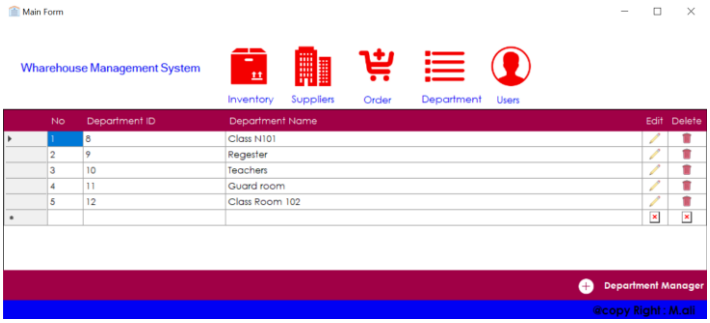


Figure 4. Prototype for Department interface

5. Order processing Module:

This prototype has a user-friendly interface to manage a streamlined order entry and processing workflow, integration with the inventory management module for accurate stock availability checks, automated order status updates and notifications to stakeholders, and tracking and logging of order fulfillment activities. You can order by selecting the department, the item name, the quantity you want, and the total price for those items. You just click on the department name and the item name and click save to complete the order process. Prototype for the Order Processing module shown in Figure 5

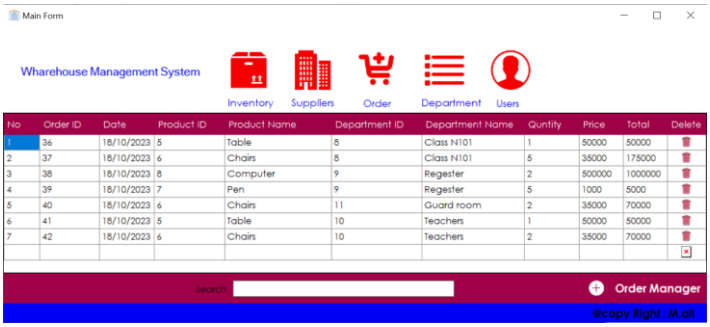


Figure 5. Prototype for Order Processing interface

E. FINAL PROTOTYPE AND TESTING PHASE:

Conduct follow-up interviews or focus group sessions to gather feedback from participants. Ask specific questions about their experience using the prototype, any usability issues, and suggestions for improvement. Based on the feedback received, make the necessary refinements and adjustments to the prototype. This may involve modifying the user interface, enhancing functionalities, or incorporating additional features requested by participants. Once the refinements are made, conduct testing to ensure the prototype functions as expected and meets the desired objectives. This testing may involve simulating different warehouse scenarios to evaluate the system's performance and identify any issues or bugs.

Throughout the prototype development process, it is important to involve stakeholders, including warehouse managers, staff, and other relevant parties, in the decision-making and feedback loops. This ensures that the prototype aligns with their needs and requirements and increases the likelihood of successful implementation and adoption.

After multiple iterations of gathering feedback, refining, and testing, the final prototype of the warehouse management system is developed. The final prototype should reflect the desired functionalities and address the identified challenges and requirements. The final prototype is subjected to validation and acceptance testing to ensure that it meets the stakeholders' expectations and performs as intended. This testing involves a thorough evaluation of the system's functionality, performance, and usability. Feedback from stakeholders during this phase is valuable for making any final adjustments before the implementation stage.

VI. CONCLUSION:

The objective of implementing a warehouse management system (WMS) is to automate the existing manual system by utilizing computerized equipment and comprehensive software solutions. This allows for the preservation of valuable data and information over extended periods while ensuring easy access and manipulation. The necessary software and hardware for implementing a WMS are readily available and user-friendly. By implementing a WMS, the warehouse in the Institute of Health Sciences can achieve a secure, reliable, and efficient management system without errors. It enables users to focus on other tasks instead of keeping track of records manually. Additionally, a WMS helps optimize their resources, as computerized records eliminate the need for repetitive data entry. This means users can access the necessary information without being distracted by non-essential details.

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