



An Automated Warehouse Management System

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/JSRR/2022/v28i730534

Open Peer Review History:

This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: <https://www.sdiarticle5.com/review-history/87813>

Review Article

Received 25 March 2022
Accepted 04 June 2022
Published 20 June 2022

ABSTRACT

The impact of a warehouse management system on supply chain performance is investigated in this study, to create a less resource-intensive, more efficient, and dependable inventory management system. Before designing the software to manage the required transactions, the warehouse's supply chain operations were analyzed. The software was evaluated for its ability to optimize workflow and provide timely and effective service. The data was collected from a Jordanian telecoms service provider's warehouse. Furthermore, the facility layout was assessed, and a manufacturing station was built within the warehouse, resulting in improved warehouse area optimization and use. Bundling, labeling, and repackaging are the three procedures of the production station. Product receipt, processing, and delivery are all handled by the system. Each stage of the product lifecycle was thoroughly investigated, and defects in the process and procedure were discovered. Some scholars may use this work as a practical reference and an example to compare Jordan's telecoms sector's software inventory management system to the traditional manual system. It also draws attention to the gap between theory and reality to encourage academics to create and tailor innovative supply chain disruption mitigation solutions.

Keywords: *Bundling; labeling; repackaging; software inventory management; traditional manual system; warehouse management system.*

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1. INTRODUCTION

A warehousing management system (WMS) should be installed in every warehouse. An automated warehousing system needs less work and is more efficient, and generates more consistent results than a human-handling system. WMS is designed to save money by assisting with effective warehousing operations. The warehouse must be split into zones which perform directed pick and put away [1-2]. It just has two product categories. The goal of the project is to automate the warehouse management system and build up a small production line within the warehouse for product labeling. The need for warehouse automation that manual handling will lead to human errors, resulting in lower warehouse utilization. To automate the procedure, a thorough study of the system is required. The first step toward an automated warehousing system is to identify and re-engineer the processes. Procedures employed in the warehouse, followed by identifying the operations that could be automated. The entire process can be reviewed by modeling business processes and workflows. One of the most important criteria in our case was that the software program could manage large volumes of data. And sort serial numbers by expiry, receipt, and activation dates before releasing them to the dealer [1-10].

Many researchers have identified how to automate a system using an Enterprise Resource Planning (ERP) system. ERP software enables a firm to collect, store, manage and interpret data from several sources.

Supply Chain Design: A warehouse unit must evaluate the entire supply chain, from suppliers to final customers, while making decisions. This necessitates a through grasp of the various components and activities' linkages.

Financial Considerations: Storage costs are generally determined during the design and implementation phases. They should be predicted as accurately as possible with the least amount of investment and operational costs.

Operational Factors: Before deciding on the design of an installation, it is vital to determine its technological capacity, which necessitates a through grasp of the products and orders. A warehouse capacity and processing capacity are two factors to consider. The order picking/fulfillment methods are directly linked to the processing rate, which is an important system productivity measure. The effective total space usage must be precisely established before the design phase can begin.

Layout: According to site layout difficulties are linked to the allocation of activities in the spaces. The case of reallocating space in an existing building, a design solution may be required.

Information and Control Technology: Assert that information and control technology enable warehouse activities to be gauged, regulated, and optimized, making them critical components of supply chain flow integration.

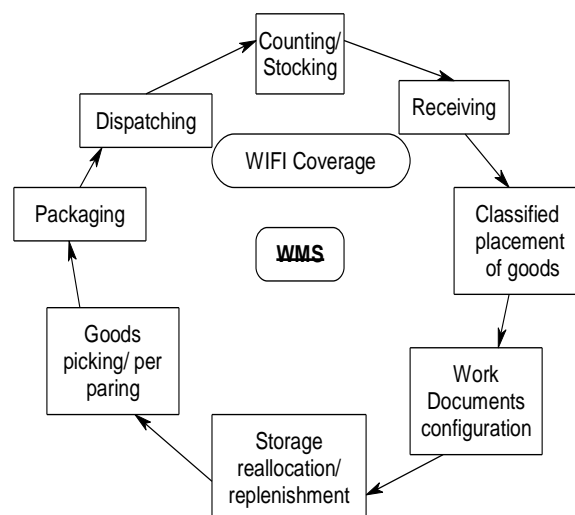


Fig. 1. Overall preformation of WMS

Measuring and Monitoring Performance: Performance criteria must be explicitly and precisely stated for long-term design evaluation.

Operation's Plan: It's an essential part of the warehousing planning process. The emphasis is on defining the operation's strategy. This subclass includes the four core functions of warehouse installations: receiving/expediting, stocking, order picking/fulfillment, and cross-docking.

Resource Dimensioning: The goal is to lower total stocking costs while maintaining processing levels by combining all variables.

The selection of an ERP system that meets the required standards is a crucial step. An ERP system is critical to a company's performance because it integrates all of an organization's units at the information level. Because of implementing an ERP system is such a significant financial investment, it should be carefully chosen. The primary purpose of a warehouse is to maximize the efficiency of item movement and storage. WMS is used to reduce costs by supporting efficient warehousing operations. It's designed for companies who need to collect and deliver commodities. While maximizing space efficiency and knowing exactly where everything is present at any given time. To guarantee efficient warehouse use a small labeling line for SIM cards will be placed in the warehouse. The WMS improves warehouse automation and real-time data gathering. Warehouse management software can be as simple as Warehouse Management System (WMS). The WMS improves warehouse automation and real-time data gathering to save time and money. Research on facility layout, time and motion studies, and cost analysis will be used to verify the applicability of this approach.

This paper presents a thorough review of the warehouse design literature. A systematic review, under this approach, aids in the mapping, consolidation, and development of a theory.

Attracting multiple experts from the company to participate in the research collaboration work, were organized to effectively get a holistic review from the point of view in the framework. The framework itself takes 15 to 30 minutes of face-to-face explanations to fully explain to people who have not been exposed to its context previously. The emphasis is on defining the operation's strategy, which will have a major impact on the system. The four basic activities of

warehouse installations are receiving, stocking, order fulfillment, and cross-docking. This paper presents a thorough review of the warehouse design. A method for combining the findings of several published studies on a single topic. A systematic review aids in the mapping, consolidation, and refinement of a theory. The fast rise of globalization makes supply chain management more difficult. Requiring more sophisticated logistic planning, including warehouse operations. Major function of WMS is to collect products, store resources until they are needed, and then extract products from inventory and distribute them in answer to requests. WMS also keeps track of job order information and displays the status, such as whether the job is complete or not, as well as the information. This IT serves as a link between a company's strategic and operational levels.

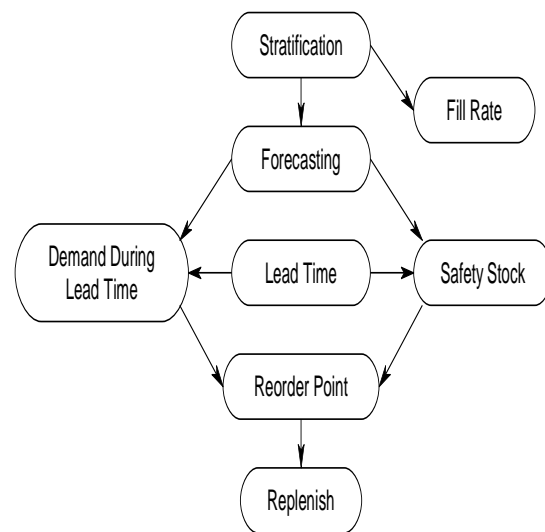


Fig. 2. Inventory management

2. LITERATURE SURVEY

Several studies have been undertaken on various elements of WMS. Some of these studies focus on AI-based WMS applications [2–3], the design of sensors and sensor networks to enable WMS, the use of educational hardware like the Raspberry Pi, and technological issues like imaging techniques and routing protocols [11]. Few academics have examined the literature on threats to WMS in particular. Lambert, D. M., and Cooper, M. C. [12], for example, have offered a study of WMS vulnerabilities and related risks, as well as some limited threat mitigation measures. Window [9] has published another research on RFID cyber-security concerns. However, none of

Table 1. Characteristics of the existing reviews in WMS

Sr. no	Objective	Technology
[2]	Studies an Intelligent A warehouse Management System.	IoT, Wireless Sensor Network (WSN), Blockchain, AI, Machine Learning (ML)
[3]	Use of RFID technology in A warehouse Management System.	IoT, AI, ML
[11]	In a smart warehouse, an IoT-based data transmission system using a UWB and RFID technology is used.	IoT, AI, ML
[16]	Design of a real-world optimization system for warehouse order picking.	AI, ML
[21]	Evolution and future directions in supply chain management.	AI, ML
[24]	Using a genetic algorithm, batch orders in a warehouse while minimizing trip distance.	WSN, ML
[13]	Internet benchmarking on a large scale: technology and applications in warehousing operations.	IoT, WSM
[14]	The multiple-level warehouse layout design challenge is solved using a particle swarm optimization algorithm.	IoT, WSN
[25]	Analyzing and conceptualizing grain warehouse monitoring and analytics as a service.	WSN, AI, ML
[26]	Smart refrigerators with artificial intelligence to reduce food waste.	IoT, WSN

the aforementioned evaluations on SF risks to include a taxonomy or a plan for future research in this area. In recent years, however, some academics have been interested in surveys on IoT and associated technologies [13,14]. The roles of machine learning [15–21] and artificial intelligence [22] in WMS have gotten a lot of attention. Furthermore, some studies have to include security-related features of WMS as a topic. For instance, consider R. Pulungan's research [2], in which some challenges related to the security and privacy of WMS were investigated without presenting a threat taxonomy. Another example is a review by Y. Zhao [23], which takes an empirical approach to identify cyber-security concerns in WMS.

However, the publications focuses on risks to WMS are the most relevant to the subject of this paper. Among these, main issue of M. Xiaosheng's [3] report, which fails to provide a taxonomy or a future roadmap. Table 1 shows the characteristics and technology of existing surveys in the WMS domain.

3. WMS AND OTHER TECHNOLOGY

Automation for order picking procedures in a warehouse is only used to a limited extent. Dynamic market demand necessitates increasing system adaptability, and product features such as size and weight may alter dramatically over time. As a result, the bulk of order picking systems is still operated manually. Despite the

manual nature of warehouse operations, the author emphasizes the relevance of order picking procedures as a basic WMS feature. The author recommended using Line Sequence Optimization (LSO), which estimates the line sequence with the shortest travel time. Circumstances where routing heuristics are used. Demonstrating how the LSO will be implemented as a supplemental functionality in a supplier's existing WMS. To boost warehouse management efficiency, a proposed interface between WMS and QR codes was developed. They demonstrated how to use the WMS capability with QR codes. They present a simple architecture of a WMS based on QR codes. Several critical issues in the process, and provide several answers and appropriate codes to these challenges. Concentrating on selecting the suitable WMS based on the type of items can be more beneficial to them. The authors employed a fuzzy extended analytical hierarchy (FEAHP) and describe how the approach of FEAHP can accomplish. They picked the software quality assurance (SQA) and demonstrated how to use it to implement the FEAHP.

It is possible to re-engineer and change operation processes when WMS is combined with lean and RFID. RFID's ability to organize inventory in the petroleum industry was demonstrated. In two months, the efficiency improves and the errors reduce. WMS and other ITs are linked with the Internet of Things (IoT), a technological revolution in the future of

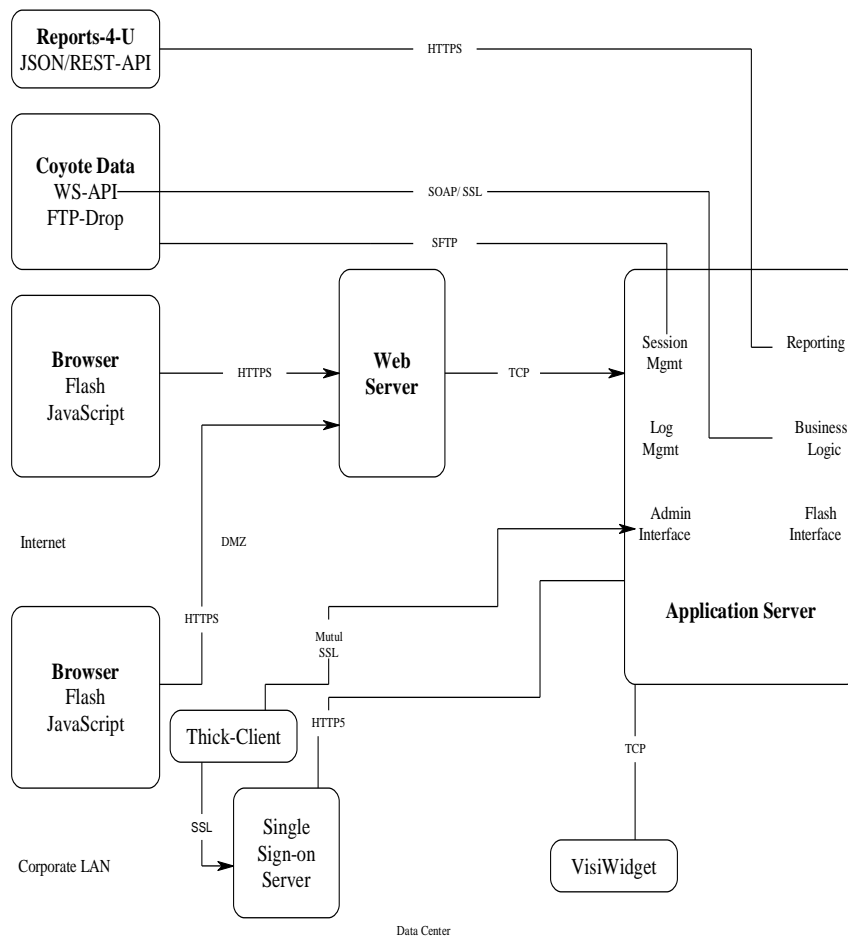


Fig. 3. Working procedure of WMS

computers and communication. The solution domains touched to include smart grid, supply chain management, smart cities, and smart homes [27-35].

These are some issues-

- Inaccuracy of inventory information, difficulties;
- Inaccuracy of inventory information challenges;
- Inaccuracy of inventory information;
- Difficulties determining the balance location;
- A warehouse space inefficiency;
- Miscarriage when releasing;
- Checking out-of-stock before the release;
- Inability to conduct actual checks on commodity

Inventory control, reaction time, and SKU diversity have all improved significantly as a result of the implementation and integration of fast-expanding IT systems (stock-keeping units).

RFID tags, automated identification (Auto-ID) sensors, wireless communication networks, and interior warehouse management systems.

4. RESULTS

After selecting the major papers (there are 998 papers located in Scopus), 153 are chosen, and 42 studies were close to the paper proposal. The following nations are represented in 45 issues: USA (4), China (5), South Korea (5), France (1), Mexico (2), Colombia (3), Germany (5), UK (3), Italy (2), India (1), Brazil (3), Malesia (1), Netherlands (1), Poland (1), Taiwan (6), Turkey (6). (2). Because some writers are from various nations and write the same work, the total number of authors exceeds 42, culminating in 45 [36-42].

By combining the papers by continent, an increase in the concentration in Asia and Europe, which account for about 72 percent of the studies in a sample can be easily noticed. Asia has 40 percent of the papers, Europe has 33 percent,

South America has 18 percent, and North America has 9 percent.

From 2006 to 2016, the writers noticed an oscillation in the subject published. The biggest number of publications was published in 2016, followed by 2013 and 2015/2010. Even if the numbers are high, major academician to contribute to the literature are discovered. After assessing and categorizing the inventory management systems in major logistics journals, extra logistical operations are much needed in inventory decisions. Again, going for more modern collaborative inventory models, the inventory management systems can be enhanced.

Because collaborative models are built on the sharing of knowledge, stochastic demand becomes more important as inventory management models advance. Furthermore, in a collaborative inventory management programmer, the basic stock out the assumption of backorders or missed sales may not be sufficient. Another area of research in the inventory management literature that has yet to be addressed is how inventory models approach the retail shop. The retail store is now considered a single inventory storage place in the literature [43-50].

Products can be kept in numerous locations within a retail store, as Angulo et al. (2004) point out (i.e., backroom and shelf). As retail supply chain technologies and information transfer improve and is distinction may become more

essential, albeit more difficult to measure. Large merchants' recent embrace of radio frequency identification (RFID) technology is an example of technological advancement. The adoption of RFID in the retail supply chain allows for far more detailed inventory data to be captured within the store. Finally, future studies could benefit inventory management by including behavioral challenges in new and existing models. Models for inventory management and logistics-related business activities, in general, don't take managerial judgment and decision-making into consideration. As a result, such models' forecast accuracy may be limited. To incorporate behavioral difficulties in inventory control systems, researchers must first analyze the behavioral assumptions that these models employ through empirical tests before adding the results back in the models.

RFID and collaborative programmers like CRP and VMI provide additional information for better inventory management. Logistics researchers have the opportunity to develop business processes that effectively use the additional information to improve decision-making. VMI and other collaborative inventory management programmers have shown to be more difficult to adopt than expected. And failure could be attributable to a lack of business processes to incorporate the additional data offered by such programmers in decision-making processes. WMS stands for a management system, and it is a type of information technology used in logistics to solve operational and strategic issues. The programmer simplifies the process of reaching

Table 2. Number of papers by countries

Countries	Number of papers Per country	Percentage (%)
Taiwan	6	12.33
China	5	11.11
Germany	5	11.11
South Korea	5	11.11
USA	4	8.89
Brazil	3	6.67
Colombia	3	6.67
UK	3	6.67
Italy	2	4.44
Mexico	2	4.44
Turkey	2	4.44
France	1	2.22
India	1	2.22
Malaysia	1	2.22
Netherlands	1	2.22
Poland	1	2.22
Total:	45	100.00

the organization's goals. The system improves the quality of warehouse activities (receiving, inspection, address, storage, separation, package, shipment, and document sending). As a result of the increased productivity, and its system results in better customer service. And its IT must integrate with other ITs, such as the software FEHP, QR Codes, ERP, and certain hardware because the volume of data is enormous and the quality of the logistic service must be high (RFID).

In the sample of work, is a stream of research has a wide range of countries and authors, with Asia and Europe accounting for roughly 72 percent of the topics. The quantity of publications fluctuates from year to year. Although there is no trend by year, more papers were published in 2016. Problem demonstrates that the subject is still worth investing time and resources to produce papers and research proposals on.

The system identified around 3.55 percent of the total number of orders as abnormalities. The firm workers identified 67 percent of those as being correct. After phase and algorithm modification, it will be used in other parts of the WMS that have user inputs or calculations. The next step is to integrate optimization algorithms in more crucial distribution procedures. Customers will be able to use a website to place orders and obtain recommendations based on their preferences. To be employed in various warehouse procedures, the anomaly detection system will be adjusted and developed. The literature on a warehouse design was analyzed using a framework that contained groups of the most important judgments within the scope of a warehouse design and execution from 1999 to 2015. The majority of the papers examined (48%) are theoretical and quantitative, according to the report. There are still few papers that offer a valid model that can be applied to real-world scenarios to identify the primary challenges that during a successful a warehouse installation. As a result, more research on topic and is proposed.

5. CONCLUSIONS

One of the most significant aspects of a distribution company's operations is the warehouse management system. Process improvement can help to save time and money while also making the workplace more efficient. More critical distribution strategies will incorporate optimization methods. A website will

allow customers to place orders and obtain recommendations based on their preferences.

The anomaly detection system will be tweaked and developed to be used in various warehouse procedures. The order selection algorithm will contain additional constraints such as weight, fragility, volume, and other real-world constraints.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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