Review Article

An Automated Warehouse Management System

Abstract: The impact of a warehouse management system on supply chain performance is investigated in this study, with the goal of creating a less resource-intensive, more efficient, and dependable inventory management system. Before designing software to manage the required transactions, the warehouse's supply chain operations were analyzed. The software was evaluated for its ability to optimize work flow 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, labelling, 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 industry 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 in order to encourage academics to create and tailor innovative supply chain disruption mitigation solutions.

Keywords: bundling, labeling, repackaging., software inventory management, software inventory management, traditional manual system, warehouse management system

1. Introduction

A warehousing management system should be installed in every warehouse (WMS). An automated warehousing system needs less work, 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. Advanced warehouse operations such as zone and bin management, directed picks and put-away, and automated data collecting systems are all possible with the WMS granule. The warehouse must be split into zones and bins in order to perform directed pick and put away [1-2]. Each zone can include one or more bins and can be used for either receiving or stocking. This paper is about a telecommunications firm. It just has two product categories and a modest warehouse. The goal of the project is to automate the warehouse management system and build up a small production line within the warehouse for product labelling. The need for warehouse automation stems from the risk 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 reengineer the processes and procedures employed in the warehouse, followed by identifying the operations that could be automated. You can view the entire process by modelling business processes and workflows. Finally, a software programmed must be chosen in accordance with the warehouse's needs. One of the most important criteria in our case was that the software programmed could manage large volumes of data and sort serial numbers by expiry, receipt, and activation dates before releasing them to the dealer.

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 a number of sources.

Supply chain design: Warehouse units must evaluate the entire supply chain, from suppliers to final customers, while making decisions. This necessitates a thorough grasp of the various components and activities' linkages.

Financial considerations: Storage costs are generally determined during the design and implementation phases, and 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 technical capacity, which necessitates a thorough grasp of the products and orders. Warehouse capacity and processing/throughput 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.

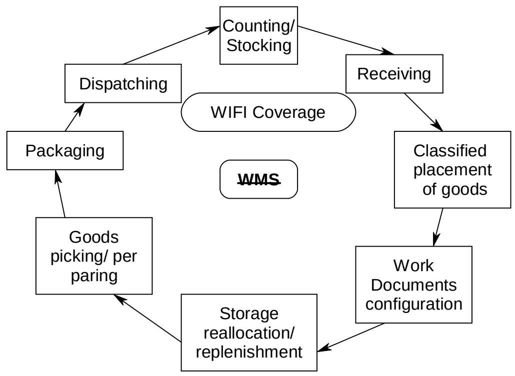

Figure 1. Overall preformation of WMS

Layout: According to Ligger, site layout difficulties are linked to the allocation of activities in the spaces, and in 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.

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, which will have a substantial impact on the entire system. 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, such as the use of warehouse equipment and the degree of automation.

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. It's easier to provide cross-unit coordination, remove waste, and make faster and better decisions with the correct system. Because 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 intended 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 at any given time. To guarantee efficient warehouse use, a small labelling line for SIM cards will be placed in the warehouse. This article will describe how to label and arrange SIM cards utilizing scanners, barcode printers, and labelling equipment using time and motion studies. The WMS improves warehouse automation and real-time data gathering. Warehouse management software can be as simple as a Warehouse Management System (WMS) or as complex as an ERP system with barcode scanners, printers, and labelling equipment. The WMS improves warehouse automation and real-time data gathering. To save time and money, all of the routine warehouse tasks can be enhanced. Research on facility layout, time and motion studies, and cost analyses will be used to verify the applicability of this approach.

This paper presents a thorough review of the warehouse design literature. It requires employing a method of analysis that combines the findings of several published studies on a certain topic. A systematic review, under this approach, aids in the mapping, consolidation, and development of a theory, as well as the discovery of new trends' structural forms, fostering knowledge progression in a research topic.

Multiple research meetings and workshops with the organisation, including live interviews and practical visits to operational warehouse sites, as well as attracting multiple experts from the company to participate in the research collaboration work, were organised to effectively get a holistic review from the point of view into the framework. Because 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 authors hypothesised that this research could not be approached with a survey study or other similar phone calls/skype distance interviews. It's an essential part of the warehousing planning process. The emphasis is on defining the operation's strategy, which will have a major impact on the system. Receiving, stocking, order fulfillment, and cross-docking are the four basic activities of warehouse installations. The goal is to lower total stocking costs while maintaining processing levels by combining all aspects, such as the utilization of warehouse equipment and the degree of automation. This paper presents a thorough review of the warehouse design literature. 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, as well as the discovery of new trends' structural shapes, all of which contribute to the advancement of knowledge in a research field. The fast rise of globalization makes supply chain management more difficult, requiring more sophisticated logistic planning, including warehouse operations. To help achieve this goal, a warehouse system is necessary, and its major function 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, enabling for the dynamic response to order demand that is necessary for agile supply chains, as well as cost savings through accurate data.

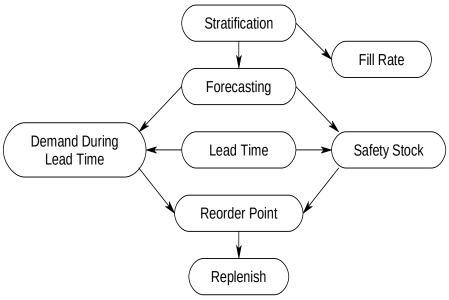

Figure 2- Inventory Management

1. Existing Reviews

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 technical 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. [34], 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 the aforementioned evaluations on SF risks 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 [30,37]. The roles of machine learning [15–21] and artificial intelligence [39] in WMS have gotten a lot of attention. Furthermore, some studies have included 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 [48], which takes an empirical approach to identifying cyber-security concerns in WMS.

However, the publications focused on risks to WMS are the most relevant to the subject of this paper. Among these, we can point to 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.

Table 1. Characteristics of the existing reviews in WMS

Sr. no	Objective	Technology
[2]	Study an Intelligent Warehouse Management System.	IoT, Wireless Sensor Network (WSN), Blockchain, AI, Machine Learning (ML)
[3]	Use of RFID technology in 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
[15]	Design of a real-world optimization system for warehouse order picking.	AI, ML
[21]	Evolution and future directions in supply chain management.	AI, ML
[28]	Using a genetic algorithm, batch orders in warehouses while minimizing trip distance.	WSN, ML
[30]	Internet benchmarking on a large scale: technology and applications in warehousing operations.	IoT, WSM
[37]	The multiple-level warehouse layout design challenge is solved using a particle swarm optimization algorithm.	IoT, WSN
[49]	Analyzing and conceptualizing grain warehouse monitoring and analytics as a service.	WSN, AI, ML
[50]	Smart refrigerator with artificial intelligence to reduce food waste.	IoT, WSN

3. WMS and other Technology

Automation for order picking procedures in warehouses is only used to a limited extent, according to. Some factors contribute to this: the necessity for big and long-term investments; dynamic market demand necessitates increasing system adaptability; and product features such as size and/or weight may alter dramatically over time. As a result, the bulk of order picking systems are still operated manually. Despite the manual nature of warehouse operations, the author emphasizes the relevance of order picking procedures as a basic WMS feature is not opposed to the use of technology in warehouse operations, but he points out that there are no conditions in which routing heuristics can be used in storage areas. The author recommended using Line Sequence Optimization (LSO), which estimates the line sequence with the shortest travel time, in circumstances where routing heuristics are used. During the essay, he gave a case study demonstrating how the LSO will be implemented as a supplemental functionality into a supplier's existing WMS.

With the goal of boosting warehouse management efficiency, a proposed interface between WMS and QR code was developed. They demonstrated how to use the WMS capability with a QR code. They present a simple architecture of a WMS based on QR codes, highlight several critical issues in the process, and provide several answers and appropriate code 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 this, as well as how to choose software using FEAHP while taking into account administrative features of the product. They picked software quality assurance (SQA) and demonstrated how to use it to implement the FEAHP. Even though WMS is an information technology that transforms a simple internal inventory management system into a Supply Chain Management (SCM) tool, it has flaws situation, and history can be saved and retrieved in real time, giving decision makers improved visibility.

It is possible to reengineer and change operation processes when WMS is combined with lean and RFID, resulting in benefits to warehouse logistics operations such as a reduction in data transmission time to WMS at receiving and shipping docks, as well as a reduction in total operation time from current to future stages. 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 linking with the Internet of Things (IoT), a technological revolution in the future of computers and communication based on the concept of anytime, everywhere connectivity for anything. The solution domains touched include smart grid, supply chain management, smart cities, and smart homes. Enabling network and communication technologies include IPv6, online services, RFID, and 4G networks.

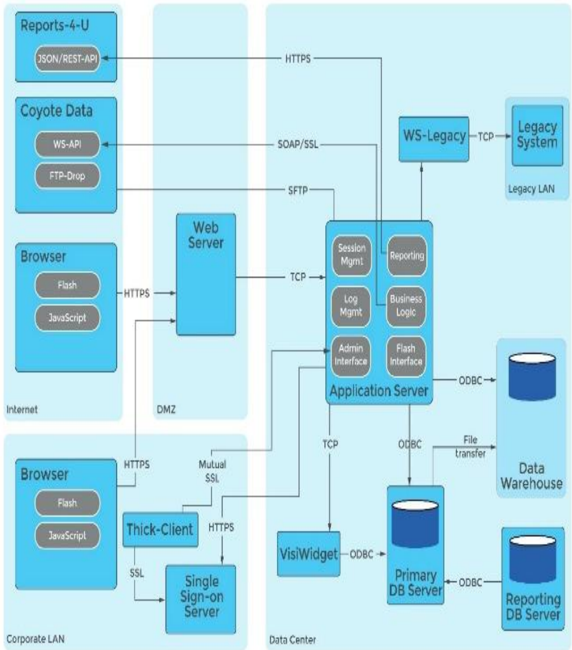

Figure 3: Working Procedure of WMS

Source: https://www.synopsys.com/glossary/what-is-threat-modeling.html .

These are some issues-

- Inaccuracy of inventory information, difficulties;
- Inaccuracy of inventory information challenges;
- Inaccuracy of inventory information;
- Difficulties determining the balance location;
- 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 are examples of smart labels that can enhance these capabilities.

4. Results

After selecting the major papers (there were 998 papers located in Scopus), 153 were 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.

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

Table 2 -Number of papers by countries

By combining the papers by continent, we can notice a concentration in Asia and Europe, which account for about 72 percent of the studies in this sample. 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 different, we can observe that the number of publications decreased from 2010 to 2013, and then grew from 2013 to 2015. From 2007 to 2010, there was an increase in publication, followed by increases from 2011 to 2013, and 2015 to 2016. 2006, 2010, 2013, and 2016 were the years with the most publications. A year with reduced contribution follows a year with a large contribution. In a prior paper, we predicted that donations would increase in 2016 and 2017, but that contributions would decline in 2018, and this is exactly what has happened, as seen in Table 2.

Table 3: Papers by years

Year	Numbers of papers	Percentages (%)
2016	11	26.19
2013	9	21.43
2015	4	9.52
2010	4	9.52
2009	3	7.14
2006	3	7.14
2008	2	4.76
2014	2	4.76
2012	2	4.76
2011	1	2.38
2007	1	2.38
Total:	42	100.00

5. Future Roadmap

The first section looks at how to use analytical and simulation models to assess the trade-offs between transportation, warehousing, and inventory management. Before researchers can replicate these trade-offs, they must first make an assumption about the current inventory control regime. In the logistics literature, a large number of inventory management models presuppose the adoption of a (Q, r) approach, whereas periodic review (S, T) inventory control models have received far less attention. The second topic examines how collaborative inventory plans can boost inventory commitment efficiency while simultaneously improving customer service. Leading by example according to a recent examination of the future of the discipline of logistics and logistics research, visionaries believe that one area in which logistics researchers must focus is coordination and collaboration, and as a result, the inventory management literature published in logistics journals has evolved in recent years in that direction. In the logistics literature, collaborative initiatives like as CRP, ECR, QR, and VMI have been popular research topics. Several chances for logistics academics to contribute to the literature were discovered after assessing and categorizing the existing inventory management literature published in major logistics journals into the above-mentioned categories. First, by adapting the approach used to incorporate extra logistical operations into inventory decisions to more modern collaborative inventory models, the inventory management literature 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 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 as a single inventory storage place in the literature.

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, this distinction may become more essential, albeit more difficult to measure. Large merchants' recent embrace of radio frequency identification (RFID) technology is an example of technical 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 study could benefit inventory management by including behavioural challenges into new and existing models. Models for inventory management and logistics-related business activities in general don't take managerial judgement and decision-making into consideration. As a result, such models' forecast accuracy may be limited. To incorporate behavioural difficulties into inventory control systems, researchers must first analyse the behavioural assumptions that these models employ through empirical tests before adding the results back into the models. Many aspects of inventory control would almost surely improve, but replenishment management, which frequently requires significant human judgement and decision-making, as well as models of collaborative supply chain interactions, would almost certainly benefit.

Because technological advancements like 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 this failure could be attributable to a lack of business processes to incorporate the additional data offered by such programmers into decision-making processes. WMS stands for warehouse 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 the organization's goals. The system improves the quality of warehouse activities (receiving, inspection, address, storage, separation, package, shipment, and document sending), and it registers, warehouses, and communicates accurate information to other IS systems, minimizing errors and costs. As a result of the increased productivity, this system results in better customer service. This IT must integrate with other ITs, such as software FEAHP, QR Code, 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 this work, this 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. This problem demonstrates that the subject is still worth investing time and resources to produce papers and research proposals on. Anomaly detection is used to discover inconsistencies in information concerning customer orders, such as input or computation errors. At the moment, every anomaly spotted by the system is double-checked by corporate employees.

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 this 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 into 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 warehouse design was analyzed using a framework that contained groups of the most important judgments within the scope of 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 arise during a successful warehouse installation. There are fewer publications dealing directly with receiving and/or expedition in operations plans, either at a strategic level, such as port layout decisions, or at an operational level, such as truck allocation on docks**.** Cross-docking activities are experiencing the same problem. As a result, more research on this topic is proposed.

6. Conclusions

One of the most significant aspects of a distribution company's operations is the warehouse management system. Process improvement can help you save time and money while also making your 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.

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