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Potential of Streamlining Warehouse Processes and IT integration to Increase Implementation of Automation

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Abstract – **Warehouses are located all around the world, and they are getting bigger and handle more and more material every day. This has increased the need to implement automation in warehouses. To be able to implement automation beneficially, at multiple warehouses with multiple customers owned by the same company, the processes, and the IT systems at the warehouses need to be streamlined and standardized. For this purpose, we suggest modeling an explicit architecture of the warehouses, and study which possible impact to reach from applying the architecture to standardize processes, IT systems, and in the end increase the implementation of automatization solutions. A case study of a logistics company with multiple warehouses around the world shows a big financial and growth potential to implement such an architecture. Based on previous implementations of product architecture the estimated potential of financial savings is up to 400.000 euros for a medium-large size warehouse. Streamlined processes agreed between the different departments and the implementation of similar automation will enable the company to share data and automation parts between the different warehouses.**

Keywords – **Operation Management, Warehouse, Automation, Robots, Warehouse Management System, Modularization, Architecture, Process Flow**

I. INTRODUCTION

Implementation of automation in warehouses is becoming more and more important to stay competitive. Warehouses that store goods are located all around the world. Most warehouses are built up around the following: processes, warehouse equipment, cost of employees, IT systems, data, products, and customers. Each of these things affects the warehouse and its possibilities to implement automation. This paper will describe the important parameters, the implemented automation solutions, and their performance, and look at the findings from a case study that implemented an architecture to streamline warehouses processes.

Processes in a warehouse can be split into three overall processes, which are inbound, storage, and outbound. Each of these processes consists of subprocesses that can vary depending on the products and customers. The inbound phase is where the warehouse workers move the goods from the arriving truck to the storage racks in the warehouse. The storage phase is the period where the goods are stored at the warehouse and different cycle counts take place to ensure the warehouse management system (WMS) has the correct amount of each stock keeping unit (SKU) in the system. The outbound process consists of the picking and moving of ordered goods from the storage racks to the outbound trucks. Depending on the customer the picking, moving, and packing will be done as requested. The outbound goods can be either full pallets, boxes, or single items.

To store and move goods in the warehouse, **warehouse equipment** is used. The equipment in the warehouse will affect the processes and material handling processes in the warehouses. To be able to get the full output of the automation solutions in the warehouses streamlining the equipment is a necessity.

With the implementation of automation, the **IT systems**, and the integration with IT becomes more and more important. The main system that controls the warehouses are a WMS system. The WMS system integrates with the customers' enterprise resource planning (ERP) system. Implementing different automation solutions requires the IT systems to be able to integrate and control the automation. Setting up an integration from the software of the automation solution often referred to as the Warehouse Control System (WCS) and the WMS will enable the automation to be an integrated part of the warehouse. There is a potential to streamline this integration among the different automation solutions and the different warehouses using the same WMS. In the future, this can enable more warehouses to implement automation as a plug-and-play solution.

More automation solutions increase the amount of collected **data** from the warehouse. The increased amount of data can optimize the processes in the warehouse and more data can show the potential bottlenecks in peak seasons and how it will affect the key performance indicators (KPI's).

Each warehouse stores various products for different **customers**. Depending on the products and customers in the warehouse, the processes will be different and the automation solutions that fit each warehouse will therefore also differ. The increasing amount of e-commerce requests a higher automation degree as it

enables faster handling and therefore it results in a shorter delivery time for the end customers.

The location of the warehouse can also affect whether it is beneficial for at warehouse to implement automation. Depending on the country and the **cost of a blue-collar** worker it can be important to decide when it is more beneficial to have automation solutions implemented.

The changing market makes it necessary to ensure that the warehouses are competitive. Implementing automation is risky and costly, but also necessary if the warehouses should stay competitive with the increasing demand for e-commerce and short delivery times. Doing it right and ensuring a streamlined implementation of automation for multiple warehouses can save the company money. A big advantage of streamlining the processes and the automation solutions is also to gain profit from having multiple different warehouses operated by the same company. This enables the warehouses to use the same data to investigate where, when and what automation to implement. As the solutions have already been tested in a similar setting it will enable implementation of the automation solutions to be faster and less risky.

II. LITERATURE REVIEW

The literature review will focus on the available literature that is relevant for the development of the architecture and the automatization of warehouses. It will also investigate the current literature on streamlining IT integration at warehouses.

A. Modularization and Architecture

The theory and use of modularization and architecture for a product program have been described in multiple articles and books [1]. The architecture used in the case study is based on the framework presented in the book in reference [2]. The overall idea of the framework is an architecture that consists of four different views. Figure 1 shows the four views of the architecture. The first view describes the current situation and its performance. The second view describes the goal and prioritization of the modularization. The third view focus on the future architecture of the product. The last view focus on how to execute the plan and to continue to use the finding in bigger projects.

Fig. 1. The four views of the product architecture.

Figure 2 shows the potential of implementing an architecture for a product program. The focus of rationalization is to optimize and streamline sales, development, production, and supply and delivery. The growth suggests that a more streamlined architecture will ensure growth by getting new customers and new markets because modularized products increase the development of new products. A paper describes how the theory behind modularization can be used within the service and the IT industry. [3]

Using architecture to streamline and optimize the processes, IT systems, and equipment in a warehouse is the identified gap in the literature. Investigating the use of an architecture to increase the implementation of automation is also identified as a gap in the literature. Different literature has described the need for identification of parameters and streamlined processes when looking to implement automation in warehouses [4].

Fig. 2. The dimensions of the modularization and architecture theory for a product program. [2]

B. Warehouse Automation

Reference [5] describes how a flexible automated warehouse should be build up around three main components: automated equipment, data collection technologies, and management solutions. A model-driven approach to implement automation has been tested and assessed [4]. Two sources have described the difference between several different automation solutions and each of their advantages and disadvantages [6], [7].

C. IT Integration

The IT systems at warehouses are becoming more complex with different IT systems controlling and managing various aspects of the warehouse. Including the communication with customers and clients, a Power BI platform to manage data analysis, the warehouse management system (WMS) that controls the materials way through the warehouse, the ERP system from the clients, etc. Integrating the WMS with the WCS of each automation solution will ensure that the automation solution can receive data from the WMS. [8], [9].

II. METHODOLOGY

Limited literature within streamlining of warehouse processes was found, and it was decided to do a single case study of a logistic company to test the potential of using the architecture and modularization theory at multiple warehouses owned by the same company.

Applying a Design Research Methodology allowed the project to consist of multiple iterations to ensure that the developed concept was useful in the actual industry. The study was consisted of collection of both qualitative and quantitative data. Conducting interviews with employees at the company are used to understand the challenges with implementation of automation and to investigate the current processes in the warehouses. The findings in the interviews are supported by looking at data and systems from one of the warehouses to increase the knowledge about the processes taking place in the warehouses.

Discussing the findings with appropriate people working at the management level for the company lead to interesting findings of the actual challenges in the warehouses. Employees of the company provided the data used in the project. The data used to analyze the current performance and status of the warehouses included year-to-date financial data, process data, future project data, meetings, interviews, and site visits. Analyzing actual warehouse data gave a better understanding of the process times and the differences and similarities between the clients in the warehouses. Investigation of the different automation solutions already implemented by the case company to understand the potential and the specific processes that each solution can replace in the warehouse.

III. CASE STUDY RESULTS

The case study identified the potential of the modeling of an explicit architecture that will streamline processes, IT integration and identify which automation solutions can increase the efficiency of the different phases in the warehouses. The case study analyzed a transport and logistics company with many different warehouses with different customers and products to handle.

A. Parameters

Parameters described in the introduction will be used to assess when and where to implement automation. Table 1 describes the parameters and how each parameter is important when implementing standardization and automation.

TABLE I
PARAMETERS FOR WAREHOUSES

Parameter Name	Description	Standardization and automation potential
Processes	The processes depend on the clients and their products.	Based on time and frequency the most interesting processes can be identified
Warehouse Equipment	The equipment is used to move and store the goods in the warehouse. The type of equipment will affect the processes and the process times in the warehouses.	Standardizing the equipment used in the warehouses will streamline the processes
IT Systems	The main IT systems that control the warehouses are the WMS. The automation solutions need to be able to integrate with the WMS system used in the warehouse.	The focus will both be on the normal WMS integration for each warehouse and ensure that it is streamlined. However, it will also aim to streamline the integration of automation to ensure integration as plug-and-play solutions.
Products and customers	Characteristics of products and customers being handled in the warehouse.	By splitting the products and customers into different categorize, the goal is to be able to identify which categorize fit which automation solutions.
Data	Increased amount of automation can give huge amounts of data that can optimize the warehouse flows and the forecasting in the warehouses. It also enables the automation solutions to learn from each other.	The increased amount of data can be shared between the warehouse, and it can benefit both the warehouses and the customers to increase sales, customer satisfaction, etc.
Blue-collar salary	The average salary to a blue-collar worker in the country where the warehouse is located.	Calculating if it is beneficial to replace blue-collar workers with automation will use the salary of the blue-collar workers in the respective countries.

B. Automation Solutions

The case company has a list of standard automation and mechanization products already in use at the different warehouses. Table 2 shows the list of the most relevant solutions. There are three levels of automation. Ground level, semi-automated, and fully automated. The list gives an overview of the different solutions and which processes each of them can replace in a warehouse.

TABLE 2
AUTOMATION SOLUTIONS

Name of automation solution	Description	Processes	Level of automation
CubiScan	Can be used to measure the size and weight of a product	Inbound, outbound	Ground
AGV	The AVG transports pallets to and from the storage racks.	Inbound, outbound	Ground
Vertical lift	Storage with automated put-away and pick	Inbound, storage, outbound	Semi
Locus	Helps a person to transport picked products	Outbound	Ground
Caja	Transport of either put-away or picked items	Inbound, outbound	Ground
Puttwall	Light-directed sorting. Used to sort batch picked orders	Outbound	Ground
Pick-by-light/ Pick-to-light	Helps the employees pick an order faster.	Outbound	Ground
Autobag	Automated opening and closing of the shipping bag	Outbound	Ground
Carton on demand	Measures the order and folds a carton around it	Outbound	Ground
AutoStore	Fully automated storage, where goods are stored in boxes. Products need to be manually	Inbound, storage, outbound	Semi

inserted and picked from a box

C. *Warehouse Architecture to Streamline Processes*

The developed architecture for the case study consisted of four views that present the current state of the warehouses and suggest the future of more streamlined warehouses. The four views were client and market view and warehouse capabilities, warehouse processes and operations, IT infrastructure, and realization. The architecture identified which warehouses processes would benefit the most from automation. It also looked at the financial performance of different warehouses for different clients and compared the performance. Moreover, it identified the clients that gained the biggest benefits from different automation solutions. The architecture also analyzed the current IT systems and their integration, and it identified requirements for future warehouses with increased automation. An implementation plan for how automation should be implemented in the different warehouses concluded the architecture in the fourth view.

D. *Potential of the Warehouse Architecture*

The architecture can help the case company to standardize their warehouses both within the processes and within the IT integration. The architecture can ensure that the processes that are offered for handling the customers product are similar for a big amount of the warehouses own by the case company. This will not just optimize the flow in the warehouse it will also enable the company to implement more automation. The architecture can check if the warehouse fulfills the parameters for a specific automation solution. All the above should enable them to implement automation solutions as plug-and-play with a shorter implementation time.

There are two financial perspectives in the project. The first is the possibility to increase the efficiency of the processes by using modularization. The implementation of sharing of key principles in a production context has shown the potential to reduce the cost base up to 15 % for 80 % of the portfolio [1]. This finding shows a potential to be able to work with a more module-based approach in the warehouses. Using the numbers from the product program, with a potential of optimizing 50 % of the processes with 15 % savings, and the gross profit of handling for one of the bigger warehouses owned by the case company they will be able to save up to 400.000 euro in one medium-large size warehouse. Each warehouse is different and handles different clients and products, and the case company will most likely not be able to increase the efficiency in all the warehouses. The second financial perspective is the ability to implement more and similar automation solutions at the different warehouses. It is described in different literature how automation solutions can optimize warehouses with less use of floor space, lower number of blue-collar workers, faster delivery time, fewer errors, fewer accidents, and so on [7], [10], [11].

IV. DISCUSSION AND CONCLUSION

The analysis and the development of the architecture for a case company were done as a proof of concept to evaluate if the product architecture could be changed and adapted to be used for warehouses to streamline the processes and improve the implementation of automation solutions.

Based on the product program figure 3 describes the possible advantages of a warehouse architecture. The architecture can increase the implementation of automation, which can also attract new clients to the warehouse, helping the warehouses to grow in the future. Discussing the findings of the case study with top management and warehouse project managers at the case company increased the knowledge about the actual application of the project in the case company. Based on the findings in the case study is it expected that the architecture can rationalize and streamline the equipment, processes, IT, and make the warehouses more scalable.

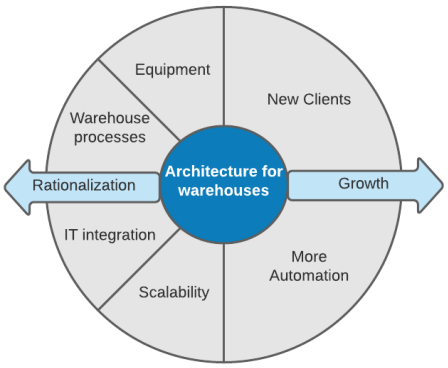

Fig. 3. The dimensions of the modularization and architecture theory for the architecture of warehouses. [12]

A. *Future Work*

So far, a proof of concept with a limited number of warehouses were used to build an architecture. The architecture showed that there is a potential to optimize and streamline the processes in the warehouses. Warehouses that are more streamlined indicates that there is a potential to implement automation in a more standardized way based on different parameters. Parameters and automation solutions are part of the first step of building a model that will be able to find the best fit in warehouses for automation solutions. The next step is to build the model based on data from warehouses and previous automation projects at the case company.

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