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Procedia CIRP 41 (2016) 568 – 572

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48th CIRP Conference on MANUFACTURING SYSTEMS - CIRP CMS 2015

Performance improvement of inventory management system processes by an automated warehouse management system

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Abstract

This study investigates the impact of a warehouse management system on supply chain performance that provides less resources effort, more efficient, and reliable inventory management system. The supply chain procedures carried out in the warehouse were reviewed before customizing a software that can handle the necessary transactions. The software was tested for enhancing the work flow and providing a timely and efficient handling. Data was collected from the warehouse of a leading telecommunications service provider in Jordan. Furthermore, the facility layout was studied and we introduced a production station within the warehouse, which resulted in better space optimization/utilization of the warehouse. The production station consists of three steps: bundling, labelling, and repackaging. The system handles three phases of product lifecycle: receiving, processing, and distribution of SIM and prepaid scratch cards. Each phase of the product lifecycle was discussed in detail and the process/procedure gaps were identified. This work can serve both as a practical guide and industrial example for some researchers to compare the software inventory management system with the traditional manual system in the telecommunications sector in Jordan. It also highlights the gap between theory and practice; to motivate researchers to develop and customize new systems for mitigating supply chain disruptions.

Peer-review under responsibility of the scientific committee of 48th CIRP Conference on MANUFACTURING SYSTEMS - CIRP CMS 2015

Keywords: Supply Chain; Warehouse Management, Inventory System, ERP

1. Introduction

Warehousing management system (WMS) is a necessary approach for every warehouse. An automated warehousing system provides less effort, more efficient, and reliable results compared to manual handled system. WMS is designed to help reduce costs through effective warehouse processes [1]. The WMS granule provides functionality for handling advanced warehouse processes that involve so called zones and bins, directed picks and put-away., as well as automated data capture systems. To perform directed pick and put away, it is necessary to divide the warehouse into zones and bins. A zone could be a receiving zone or a stocking zone, and each zone can consist of one or several bins [1]. This paper is based on a telecommunication company. It has a small warehouse where only two types of scratch cards and simcards are stored as safety stock and handled/distributed to dealers. The previous WMS status include the process from receiving the goods to product dispatching to dealers, were conducted using manual entry excel sheets. The goal of this work is to automate the warehouse management system, along with implementing a mini-size production line for product labeling within warehouse.

The need for automating the warehouse arises from the fact that manual handling may cause human errors which may affect the warehouse utilization [2]. In order to automate the process, a thorough study on the system should be conducted.

The first step towards an automated warehousing system is identifying and reengineering the processes and procedures carried out in the warehouse, followed by identifying the processes that could be automated. Modeling the business processes and workflows helps seeing the process as a whole. Business Process Modelling and Notation (BPMN) would be a feasible solution for this situation since the primary goal of BPMN is to provide a notation that is easily understood by all users within the organization. Basically BPMN is a method of illustrating business processes in the form of a

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doi:10.1016/j.procir.2015.12.122

diagram similar to a flowchart. BPMN can also help to ensure that XML(Extensible Markup Language) documents were designed for the execution of diverse business processes can be visualized with a common notation.Thus, BPMN creates a standardized bridge for the gap between business process design and process implementation [3].

Ultimately, a software program must be chosen depending on the needs of the warehouse. In our case for example, one of the most important requirements was that the software program must be able to withstand large capacity of data and it also has to be able to sort out the serial numbers according to expiry, receiving, and activation date then releasing it to the dealer.

Many researchers have found that a system may be automated, by using an Enterprise Resource Planning (ERP) system. ERP is a business management software that a company can use to collect, store, manage and interpret data from many business activities. It also provides an integrated view of core business processes, using common databases maintained by a database management system [5].

Choosing a suitable ERP system that is applicable to the necessary requirements is a critical process. An ERP system, which integrates all of the units within an organization at the information level, plays an important role for a successful enterprise. With a right system, it is easier to provide coordination between units, eliminate waste, and make faster and better decisions. Adopting an ERP system is a significant investment decision for a firm, therefore a great deal of attention should be given to the selection of the right system [6].

Despite their benefits, ERP systems are known for their implementation challenges which can include system complexities, required organizational changes, and need skilled IT staff. The literature identifies that approximately 66 to 70 percent of ERP implementation projects were reported to have failed to achieve their implementation objectives in some way [4]. Finally, ERP literature has suggested several critical ERP selection factors, but very few studies have tested their applicability in real-life context [5].

The primary goal of a warehouse is to manage the movement and storage of the goods in the most efficient way. WMS is designed to help reduce costs through effective warehouse processes. It is aimed to those companies that need to receive and ship goods, while maintaining an optimum utilization of space and knowing specifically where all goods are stored at any given time [1]. In order to maintain an optimum utilization of the warehouse a small labelling line for simcards will be implemented in the warehouse. This paper will show the optimal way for labeling and arranging the SIM cards, using time and motion studies. Software driven warehouse management systems could be simply a Warehouse Management System (WMS) or it could be integrated to the actual ERP system of the company along with barcode scanners, barcode printers, and labelling equipment. The WMS enhances real-time data capture, and the automation of warehouse. The common warehouse tasks can all be optimized to save time to make for greater profits. Benefiting from studies on facility layout, time and motion studies and cost analysis will verify the applicability of this approach.

2. Methodology

2.1 Software

To create a software, there will be two main stages, first creating the database, secondly customizing the system by programming it and writing some codes.

The implementation of the software began by studying the existing system and the processes within it. After studying the current system, we identified three main processes; receiving an order from the supplier, activating a certain quantity of scratch cards according to their serial number as first in first out (FIFO), and finally preparing the dealer order. Due to the fact that scratch cards have monetary value, only a predetermined amount of the scratch cards are activated. This amount is the order quantity and the safety stock level. This procedure is more secure.

In order to ensure precision, Business Process Model and Notation (BPMN) flow charts were created for each individual process (see figure 1). In this step, an free online BPMN charting, Lucidchart.com was used for creating flow charts. This website is user friendly; BPMN flowcharts are drawn by dragging and dropping the objects from the toolbar onto the working area.

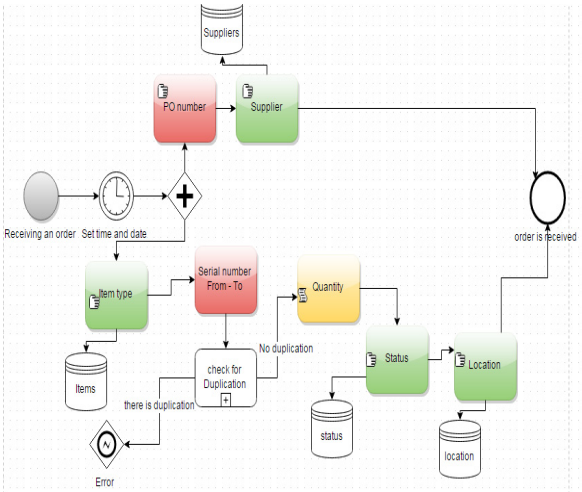

Fig.1 Process map sample (Receiving order process)

In order to select the correct software, all the available software programs should undergo a comparative analysis. Moreover, the software program should comply with pre-set requirements, namely, it should be able to withstand a significantly large amount of data, be able to sort serial numbers in a FIFO order, and it should be reliable with a high level of security. After analysing the existing software programs, the optimum software will be chosen; in this paper Microsoft Visual Studio Express was used.

The starting point of creating a local database is creating a list of tables and defining the relationships between them. The project data; classes and relationships were implemented in database tables using Visual studio Express. Tables, a primary key in each table, and a rows of sample data were created (see figure 2). A foreign key was added to specify how records on one table might correspond to records in the other table. In the next step, the application that was developed in Visual Studio

was connected to one of the local database files; in this case the database was connected to SQL Server Express database files (.mdf).

Figure 2, shows a sample of a table in the system, which has a primary key with few rows of: *Username*, *Action Type*, *Action Date* and *Serial From To*, where each row has a certain data type. The *Username* and *Action Type* rows correspond to records in other tables; they are foreign keys and have the same data type as the primary key of the reference table. In order to set the primary key, the following code must be written:

CONSTRAINT Fk_ActionType FOREIGN KEY (ActionType) REFERENCES Actions (Id),

FK_ActionType--> Sets the name of the foreign key

ActionType--> The name of the column that the foreign key represents

Actions--> To which table it refers to

Id--> Primary key of the reference table

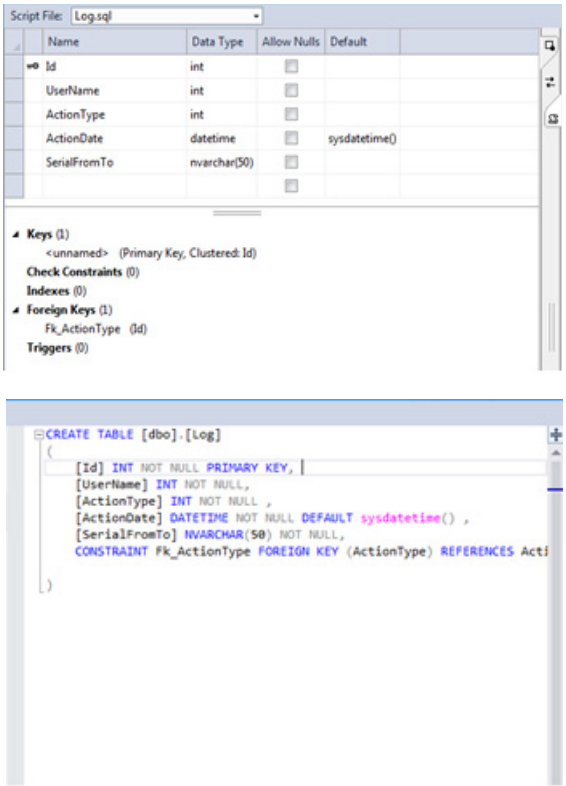

Fig. 2 Log table sample

After creating all the required tables, along with its primary and foreign keys, a relationship between the tables was established as shown in fig.3. The next step after creating the foreign keys is to populate the tables with data. Then it was found that transforming the software into a web based application was more appropriate. A web application provides an interface to the existing database which was created earlier. A web application can be generated by using a combination of the new ASP.NET Web Application, MVC template and Entity framework 6.

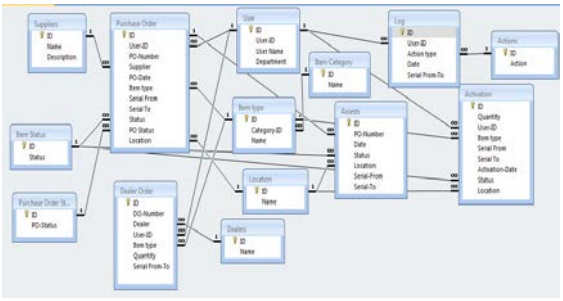

Fig.3 Relationships between tables

After creating the web application, the data models and the codes were generated. These codes provide standard data operations for the model classes. The generated code provides a good starting point for an application but it does not necessarily provide all of the functionality that is required in the application [7]. Therefore the programming stage was needed; in order to customize the code to meet the particular requirements of our project and to make it more efficient, by using ASP.NET as a computer programming language.

2.2 Labelling Line

This part consists of two main actions, the machinery and the manual labor. Enhancement to WMS can be obtained by studies on facility layout, time and motion studies and cost analysis.

The machinery part is all about the selection of an Barcode printer, there are a number of barcode printing technologies, we selected a Thermal based barcode printers because compared to other printers they require less maintenance, have less expensive media, and print faster while maintaining excellent print quality. The next concern was what type of thermal printer we should choose; the biggest difference between them is how heavy of a print volume they can handle, so we needed to choose one with a heavy print volume a one that will print from a couple thousand labels per day. Once we knew what type of thermal printer we needed, the next big concern is what print method we were going to use, Thermal printers are capable of printing in two different ways - direct thermal (DT) and thermal transfer (TT), depending on how long we needed the label to last and the material it's made of, we have found that the thermal transfer is more effective our application

The Manual Labor part:

This part consists basically of three main processes in which the labeling process will occur:

- Unpacking and Arranging
- Labeling and Inspection
- Packing

The first manual labor step is that an operator should unpack a specified number of simcards and arrange them on the workstation to start working on them. After performing a time and motion study, we have found that the best method to unpack the box of simcards would be by arranging them on the workstation. The first simcard, having the newest serial number should be the furthest away from the labeling and inspection part. Meaning that it would be the last to be worked on, i.e., last

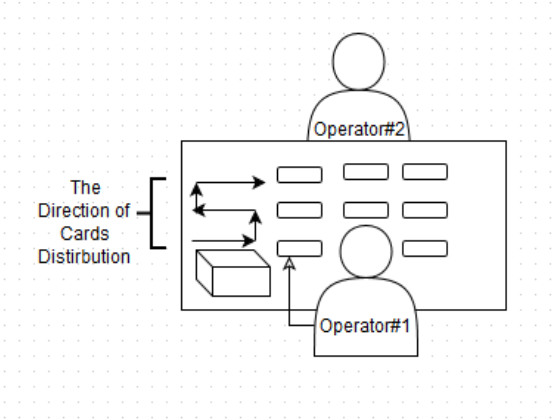

Fig.4 labeling workstation

in First out (LIFO), and the last simcard (being the oldest serial) would be the first to be labeled.

The labeling and inspection was found to be quicker when the cards will be displayed in rows from left to right according to the serial number. Where the labels will be stickered on each card in correlation with the order of the printed stickers. Consequently, the inspection needs to take place before repackaging. The cards will be collected in the same arrangement and piled up for the inspection using the barcode reader. The barcode reader will check whether the codes are similar on the actual card and the sticker. If an error occurs, the system will give a notice to the operator where he will need to do a manual inspection to solve the problem. Errors would be either no matching between both the card and sticker, or if the cards are not in sequence i.e., card number 38, then card number 40, an error will occur that there is a missing serial number, 39.

The third and last step is repacking. Where simcards should be put back inside the box. Resulting in the oldest being at the bottom of the box and the newest at the top, this will be of benefit when sorting them on the shelves meaning that the newest would be allocated furthest inside. It was concluded that the most important steps to focus on would be; first conducting a time and motion study, to determine the optimum, easiest and fastest way workers can complete the process from A to Z and this also helped in determining the optimum number of workers taking into consideration the cost of manual labor and the production rate per day too. Then, the facility layout, the most important objective of the facility layout of our workstation is minimizing the material handling as much as possible so we have studied all possible locations pros and cons and some safety conditions.

3. Results and Discussion

3.1 Software

Regarding the software implementation, the software program illustrated the basic principles of an automated warehouse system. This system governs the whole process starting with receiving the orders, up until the dealer order is handed. Our software can basically handle a significantly large amount of data, which is instantly stored on the server for backup. Accordingly the serial numbers are sorted FIFO as mentioned in the methodology. Each small process in the program is interrelated with the other, so that a perfect sequence occurs with no duplication and no mistakes occur throughout the entire process. As the order first enters the warehouse, the serial numbers and type of each product is recorded in the system, this is where the chain of processes begins. The data is rearranged automatically by the new modified software, in a way that a single click is able to provide the employee with any data required. More importantly, by simply entering the quantity needed for activation in the new modified software, it will automatically generate the serial range according to the FIFO method. This displays the amount of stock available in sequence from the oldest to the latest. This is done with optimum security and guarantees no duplication.

Nonetheless, after activating the serial numbers are excluded from the list of inactive data then the employer can hand in the active material to the dealers on the due date. The software can also allocate the stock in the warehouse, which facilitates reference and security reasons, to ensure that the specific active products are handed to the dealer.

All in all, our web application can carry out the general important requirements of an automated warehouse management system which are customized briefly according to the demands of a telecommunications warehouse. The automated software generates reports about the received items; when an order is received each item will have a certain serial number, status and location, the software can show the quantity of each item type, date of receiving, status either active or inactive, the user who received the item and location. The data is guaranteed to be secure, and the software is guaranteed to work efficiently with the least amount of human error, no duplication and no mistakes compared to the previous manual handling system.

3.2 Labelling Line

After performing time and motion studies, examining the facility layout and studying the case in detail, the results of our study indicated that implementing a labelling line in the warehouse would be of a great advantage to the company. The company would therefore be able to dispose of its third party services, and thereby greatly reduce the costs of the labelling process in-house.

The labelling line makes use of the extra space in the warehouse. As mentioned before WMS are not limited to effective warehouse processes but also optimize the utilization of space.

The best practice process from unpacking each individual good in sequence, labelling them and repacking them in the same order, was found and implemented in that manner, thereby assuring the minimum amount of errors and the optimal solution for a fast and reliable performance.

To improve accuracy of the labelling process an inspection process will be made. At this stage the operator will check if there is an error with the labelling stage, since there error percentage is 0%. as mentioned before, errors would be either no matching between both the card and sticker, or if the cards are not in sequence. While performing studies for optimal processes, the type of the label printer was also taken into account in a way that will help reducing the cost, while choosing the printer a certain specifications were taken into

account; maintenance and row material requirements (ink and paper), printing speed and quality.
Finally, we now have an automated warehouse management system capable of organizing, handling, sorting and storing large amounts of data efficiently, along with a labelling line within the warehouse facility that takes advantage of the extra space in a way that helps optimize the performance of the company as a whole.

4. Conclusion

To conclude, an automated warehouse management system is an essential replacement for a manual management system. The main purpose of automating the warehouse system is to control the movement and storage of the products, together with the benefit of enhanced security and quicker handling. The newly created software upgraded the capabilities of the warehouse management system. Currently, the stored data can be organized according to serial number, activated easily assuring the FIFO concept, and handed to the dealers accurately with the least amount of possible errors. The implementation of a labelling and packaging line inside the warehouse was also an additional function in our study, in which labelling of cards is performed followed by repackaging. All in all, the warehouse system has become more reliable and efficient after the automation, simplifying the process for the operators, the supplier and the dealers.

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