Design of a RFID case-based resource management system for warehouse operations

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Abstract

In the past, the selection of resources to execute various warehouse operation services was done solely by experts. In this paper, a RFID-based Resource Management System (RFID-RMS) is designed to help users to select the most suitable resource usage packages for handling warehouse operation orders by retrieving and analysing useful knowledge from a case-based data warehouse for solutions in both time saving and cost effective manner. In addition, a pure integral-linear programming model using a branch and bound algorithm to define the optimum travel distance of forklifts is also developed and embedded in the proposed system. The proposed system, which is suitable for usage in a warehouse operation environment, enhances the effectiveness in formulating resource usage package and managing resource operation by integrating the Radio Frequency Identification (RFID), case-based reasoning (CBR) technologies and the programming model for forklift route optimization. Through applying RFID-RMS in the GENCO Distribution System, a multinational logistics company, the utilization of warehouse resources is expected to be maximized while work efficiency will be greatly enhanced.
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1. Introduction

In the past decade, the change in the global economy has significantly redefined the way enterprises are operated. One of the major changes is that the core activity of warehousing in supply chain is no longer confined to keeping a large amount of stock. Instead, small quantities of goods are delivered promptly from a significantly wide variety of stock keeping unit (SKU) throughout its supply chain (Berg & zijm, 1999). Planning and control of warehouse facilities and systems are therefore made even more complex. In general, most warehouse managers lack timely and quality information derived from accurate monitoring and measurement of resources. They usually rely on their knowledge to formulate material handling solutions to handle different orders. In doing so, bias judgment easily occurs. In such sense, it seems that a systematic approach should be adapted

and developed to make sure that the material handling solutions are formulated with out bias.

In this paper, an RFID-based resource management system (RFID-RMS) is presented. This is a case-based system incorporating the RFID technology to explore important customer attributes for case retrieval and matching process. With the help of RFID technology, a flexible and timely resource data accessing and collection framework for the system is achieved. In addition, a new customized route optimizing programming model, using real time data of an RFID tag to solve the order picking problems of material handling equipment is developed and installed at the route allocation optimizer, a sub module of resource management engine in the proposed system. The aim of this system is to maximize both the efficient use and productive allocation of warehouse material handling equipment at the lowest operating cost.

The paper presents the supportive literature in Section 2. A generic model is developed to integrate the case-based reasoning technology and an advanced automatic data identification technique (RFID), and to embed a branch and bound route optimization programming model. The purpose is to formulate an optimum material handling solution, which is illustrated in Section 3. In Section 4, a case study is

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presented to show how RFID-RMS is used in improving the warehouse operating performance in GENCO; a US based multi-national logistics company. The results and a discussion on the findings are listed out in Section 5. Finally, the overall conclusion about the use of RFID-RMS is made in Section 6.

2. Reviews of related studies

2.1. Current warehouse operation environment

Since 1990 s, the mode of production in enterprises has changed from the traditional mass production mode led by products into the mass customization production mode to facilitate increasing global market competition. Hence, the supply chain activity has been reformulated to achieve its competitive advantage. Harmon (1993) noted that warehouses should be redesigned and automated to achieve high throughput rate and high productivity, thereby reducing the order processing cost. In such sense, warehouse operation does no longer serve as a large-stock keeping; instead, it has become a critical activity in the supply chain to outperform competitors on customer service, lead times and costs (Koster, 1998).

The changes outlined above have had a dramatic challenge on warehouse management. Warehousing is often needed to perform routine logistics operations such as inventory storage, order product mixing, cross docking and customer service (Coyle, Bardi, & Langley, 2003). When performing such operations, valuable company resources such as storage space, material handling equipment and operators are engaged. Ballard (1996) addressed that efficient utilization of space and resources in a warehouse will result in higher accuracy and better customer service. In order to achieve high performance warehouse operation required in today's marketplace, a variety of research activities focusing on the use of warehouse management system (Hokey & Sean, 1994; Berg & Zijm, 1999; Nynke, De koster, & Van de Velde, 2002), order picking time reduction (Gibson & Sharp, 1992; Peterson, 2000; De Koster, Van der Poort, & Wolters, 1999), and design of job scheduling system (Park, Kang, & Lee, 1996) have been widely examined. However, the attention paid by researchers in resource management in warehouse operation is relatively limited.

In order to balance the operating cost against the requirements on different logistics operations, one must make a number of critical resource management decisions such as warehouse layout design, stock storage location, material handling equipment selection, scheduling operators' job, employee training and so on. Thus, it is a challenge for warehouse managers to make decisions on resource usage package for each other in a short response time. In order to speed up the decision making process, an integrated case-based RFID automatic data identification technique is adopted for retrieving useful cases of resource selection.

2.2. Case-based reasoning (CBR)

CBR is an artificial intelligence (AI) problem-solving approach which has widely been applied in software reuse, logistics, process planning and assessment (Spalazzi, 2001; Carswell, Wilson, & Bertolotto, 2002). The wide adaptation of CBR is due to its self learning capability by acquiring the 'memory' of human beings. Baumeister, Atzmuller, and Puppe (2002) stated that CBR systems promote the natural knowledge acquisition process, so that cases can be used for decision support. According to Choy, Lee, and Lo (2003), CBR is a problem-solving technique, which complements the solution, acting as a memory of past cases which can be consulted in order to identify similar cases for the new problem. Aamodt and Plaza (1994) proposed that CBR operation is subdivided into four tasks: retrieve, reuse, revise and retain, and it forms a cycle which leads to continual improvement by storing more and more cases. In general, two common case retrieval methods, namely nearest neighbour method and inductive indexing method, are widely adopted. Wess, Althoff, and Derwand (1993) proposed a retrieved mechanism named k–d tree integrating the niches of two case retrieval techniques in order to enhance the efficiency and accuracy of case retrieval.

Although CBR technique can help warehouse managers to select appropriate sets of resources in different warehouse operations, the availability of selected resources to perform orders still remains a problem. In general, it is difficult to track the real time resource location and status, which prevents warehouse managers from selecting resources to perform warehouse activities. In such a case, the newly emerging wireless technology, namely, radio frequency identification (RFID), plays an important role in this application.

2.3. RFID technology

RFID is a generic technology concept that refers to the use of radio waves to identify objects (Auto-ID centre, 2002). This technology has been widely applied in numerous areas in the supply chain activities such as manufacturing and distribution of physical goods (Mintchell, 2002), shipping and port operations (D'Amico, 2002; Dornheim, 2002) and inventory management (Smaros & Holmstrom, 2000). Moreover, such an emerging technology has also been further extended to the application domain of warehouse operations in the supply chain. Three cases are summarized below to illustrate the warehousing resource management applications and the resulting benefits using RFID technology.

(i) Case 1-Kitchens, Inc. (Chappell, Durdan, Gibert, Ginsburg, & Tobolski, 2002) is a specialty retailer in home furnishing in the United States which adopted