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A RFID case-based logistics resource management system for managing order-picking operations in warehouses

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ABSTRACT

In the supply chain, a warehouse is an essential component for linking the chain partners. It is necessary to allocate warehouse resources efficiently and effectively to enhance the productivity and reduce the operation costs of the warehouse. Therefore, warehouse management systems (WMSs) have been developed for handling warehouse resources and monitoring warehouse operations. However, it is difficult to update daily operations of inventory level, locations of forklifts and stock keeping units (SKUs) in real-time by using the bar-code-based or manual-based warehouse management systems. In this paper, RFID technology is adopted to facilitate the collection and sharing of data in a warehouse. Tests are performed for evaluating the reading performance of both the active and passive RFID apparatus. With the help of the testing results, the efficient radio frequency cover ranges of the readers are examined for formulating a radio frequency identification case-based logistics resource management system (R-LRMS). The capabilities of R-LRMS are demonstrated in GSL Limited. Three objectives are achieved: (i) a simplification of RFID adoption procedure, (ii) an improvement in the visibility of warehouse operations and (iii) an enhancement of the productivity of the warehouse. The successful case example proved the feasibility of R-LRMS in real working practice.

1. Introduction

Due to the effects of globalization, current supply chain networks are increasingly complex. Logisticians have to deal with numerous channel partners who may be located a great distance apart and who request a greater than ever diversity of products, and who need to deal with more statutory requirements and documentation than ever before (Vogt, Pienaar, & De Wit, 2005). Therefore, the fulfillment of customers' demands with good quality products, on time product delivery and superior logistics services becomes difficult to achieve. In general, enterprises have adopted different approaches for managing the supply chain activities which include material sourcing, production scheduling, warehousing and product distribution. Logistics resource management (LRM) is one of the approaches for managing the activities of the whole supply chain efficiently. It facilitates the allocation of logistics resources to appropriate logistics functions and controls the movement of raw materials, work-in-progress and finished goods, from suppliers to customers in an efficient manner. In doing this, supply chain partners are kept satisfied.

A warehouse is an essential link between the upstream (production) and downstream (distribution) entities, and most of the warehouse operations are either labour- or capital-intensive. The performance of these operations not only affects the productivity and operation costs of a warehouse, but also the whole supply chain. Thus, information systems such as warehouse management systems (WMSs) were adopted for collecting data of warehouse operations in order to solve various problems in a warehouse, such as material handling problems. However, the current WMSs are incapable of providing timely and accurately warehouse operations information because they contain no feature of real-time and automatic data retrieval. Instead, the systems rely heavily on warehouse staff members to input operational information manually or through bar-code systems. Hence, incorrect information is unavoidably input from time to time as human error is inevitable (Sexton, Thomas, & Helmreich, 2000). Moreover, it is difficult to

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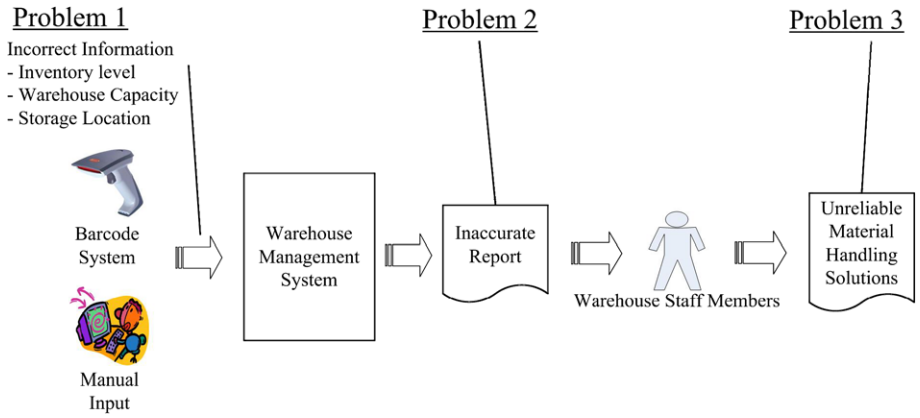

Fig. 1. Common problems frequently occur in a warehouse.

formulate reliable material handling solutions to handle different orders either by warehouse staff members (who may be biased) or through WMSs (Chow, Choy, Lee, & Lau, 2006). Therefore, it is essential to propose an intelligent system with real-time and automatic data retrieval features for solving material handling problems. Fig. 1 shows the common problems which frequently occur in a warehouse due to human error and out-of-date information. Based on the input of incorrect information in inventory level, warehouse capacity and storage location, inaccurate reports are generated from WMSs for warehouse staff members to make unreliable material handling solutions for managing the daily warehouse operations.

In this paper, a set of RFID reading performance tests is performed. The tags are placed in different positions and attached to different materials for evaluating the reading performance of the active and the passive RFID devices. Based on the test results, the efficient radio frequency cover ranges of the readers are examined and the most suitable locations for the installation of the RFID devices are determined. Besides, a RFID case-based logistics resource management system (R-LRMS) is proposed to improve the efficiency and effectiveness of order-picking operations in a warehouse by means of formulating a reliable RFID technology implementation plan. This will enable warehouse resources to be located on a real-time basis and instant material handling solutions will be suggested for handling the customer orders automatically. The feature of real-time and automatic data retrieval in the proposed system is support by the RFID technology, which also facilitates constructing an effective triangular localization scheme to determine the exact locations of warehouse resources. The collected data is then compared with the attributes stored in an embedded case-based engine to determine the appropriate material handling equipment to handle the order-picking operations. Moreover, a material handling solution formulation model is constructed by mathematic algorithms to generate the shortest pick-up sequence for the appropriate material handling equipment. In doing this, the objectives of maximizing the productivity of warehouse and minimizing the operation costs in a warehouse are achieved.

The paper is divided into six sections. Section 1 is the introduction. Section 2 presents related literature reviews on logistics resource management and the technologies of tracking items and the management of such data. Section 3 explains the design methodology of R-LRMS, while in Section 4, a case study is presented to illustrate the improvement in productivity in Group Sense Limited (GSL) with the help of R-LRMS. In Section 5, an analysis of the findings will be discussed. Finally, a conclusion about the use of R-LRMS is drawn and suggestions for future work are made in Section 6.

2. Literature review

2.1. Current approach in managing logistics resources

According to Kaihara (2003) and Liu et al. (2005), a supply chain is a valuable information sharing channel among the suppliers, manufacturing and storage facilities, distributors and customers for facilitating the key business activities of the sale, production and delivery of a particular product. Thus, the main principle of supply chain management (SCM) is to integrate effectively the material flows and related information within the demand and supply processes (Soroor & Tarokh, 2006). However, due to the global extension of supply chain networks, enterprises need to collaborate with suppliers, customers, or even competitors in different time zones, across numerous organizational boundaries, and in a variety of cultures. Under these circumstances, the challenge of allocating production, transportation, and inventory resources to satisfy demand is daunting (Simchi-Levi, Kaminsky, & Simchi-Levi, 2004). Recent trends towards the management of logistics resources have the potential to minimize the impact of the physical dispersion of supply chain members. The objective of logistics resources management (LRM) is to determine the most effective approach for allocating the appropriate logistics resources to different logistics functions, facilitate information flow and share knowledge through a supply pipeline, provide feasible collaborative channels for supply chain partners to provide superior customer services (Ross, 2003). In LRM, five logistics operations areas are covered in a supply chain network. These are: (i) freight cost and service management, (ii) fleet management, (iii) load planning, (iv) routing and scheduling, and, (v) warehouse management (Poirier & Bauer, 2000). Within these logistics operations areas, warehouse management is the most important function for linking the supply chain partners to formulate the seamless integration of the whole supply chain and for ensuring the smooth flow of products inside the network (Gu, Goetschalckx, & McGinnis, 2007). With such an arrangement, it is essential to handle the warehouse resources, such as stock keeping units (SKUs), pallets and racks, pallet trucks and forklifts, and warehouse staff members, efficiently and effectively in order to have smooth manufacturing operations, to reduce inventory, lower processing, storage, and transshipment costs, and increase productivity within facilities (Vogt et al., 2005). Within the chain, currently, warehouse management systems (WMSs) are adopted to handle the warehouse resources and operations. However, these systems are lacking in real-time information sharing ability as the data collection technique is either manual-based or bar-code based. Therefore, WMSs are incapable of capturing real-time information or of