Expert Systems with Applications 39 (2012) 7015–7028

Contents lists available at SciVerse ScienceDirect

Expert Systems with Applications

journal homepage: www.elsevier.com/locate/eswa

A hybrid case-GA-based decision support model for warehouse operation in fulfilling cross-border orders

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ARTICLE INFO

Keywords:
Warehouse operation planning
Case-based reasoning
Case retrieval
Genetic algorithm-based clustering

ABSTRACT

The decision-making process is one of the complicated processes involved in warehouse operation for efficiently fulfilling various specific customer orders. This is especially true if the orders require cross-border delivery activities, such as palletization of the delivery goods according to regulation requirements. Case-based reasoning is an intelligent method for complex problem solving that uses past cases to find a solution to new problems. To achieve an appropriate solution, retrieving useful prior cases effectively for the problem is essential. However, current case retrieval methods are mainly based on a fixed set of attributes for different type of orders in which specific order features for case groups are neglected. In this paper a hybrid approach called the case-genetic algorithm-based decision support model (C-GADS), is proposed in classifying new customer orders into case groups with the highest similarity value, allowing for effectively selecting the most similar cases among the group. The proposed model also suggests the types of features considered in each case group. It helps enhance the effectiveness of formulating warehouse order operations based on grouping similar cases. To validate the feasibility of the proposed model, a case study is conducted and the results show that planning effectiveness is enhanced.

1. Introduction

With sustained development in information and communication technology, business and markets are no longer confined to geographical borders. They are linked to form a complex international network; therefore, cross-border trading occurs across the supply chain. Several parts of business processes, such as sourcing of raw materials, manufacturing, and storage, are outsourced to have lower operation costs and increased profit. To minimize downstream inventory that will increase their storage costs, most companies consider applying the pull-based strategy in cross-border supply chain. The delivery process is demand driven and depends on actual customer requirements. Generally, raw materials and semi-finished goods supplied by various companies are stored in a warehouse temporarily. Once the demand from manufacturing plants and end-customers is received, warehouse operation starts to process the order and delivers to cross-border inspection points. However, cross-border supply chains, present barriers that cause significant time and cost inefficiencies, which may result in delivery delays and material shortages. These inefficiencies are due to legal restrictions and complicated inspection procedures imposed by different places along the supply chain, leading to excessive transport flow interruption and increasing the risk of cargo damage and loss (Haralambides & Londono-Kent, 2004). In inspection points, the goods delivered across regional boundaries are required to undergo cross-border inspection processes, including product examination and delivery document validation. Diverse regulations across borders, longer lead times, and increased transportation costs exacerbate the difficulties in managing warehouse operation activities (Mentzer, Myers, & Cheung, 2004). To reduce the barrier effects of cross-border supply chain, ensuring that delivery products comply with inspection regulations is important.

A typical cross-border supply chain between two different locations is shown in Fig. 1. The warehouse is a transshipment center connecting suppliers and cross-border inspection points before goods are delivered to customers. It performs four major functions: receiving, storage, order picking, and shipping. In addition to fulfilling customer requirements within a limited period of time, warehouse operation planning should also consider inspection regulations to polish the cross-border process. Given that cross-border inspection points are located in the downstream of the cross-border supply chain, warehouse delivery process should be emphasized. Delivery time, operation costs, and chance of delay can be reduced if specific warehouse order-picking and delivery operations are arranged to suit any given situation.

Among warehouse delivery activities, sequential order picking for palletization is a challenge for increasing the picking and packing efficiency of certain types of delivery goods in the same pallet before delivery. As shown in Fig. 1, the decision making process

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doi:10.1016/j.eswa.2012.01.046

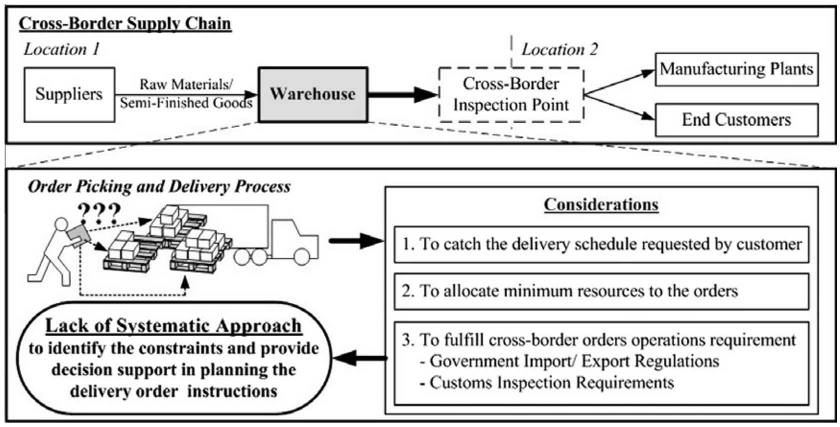

Fig. 1. Warehouse order-picking and delivery process in the cross-border supply chain.

depends on three considerations: customer perspective, warehouse operations arrangement, and regulatory policies. These considerations include the following:

(i) to catch the delivery schedule requested by the customer,
(ii) to allocate minimum warehouse resources to the orders, and
(iii) to fulfill cross-border order inspection requirements.

However, current decision-making processes depend primarily on the knowledge of warehouse manager. A systematic approach is lacking to identify the constraints and provide decision support in planning delivery-order instructions. With limited time and resources, the pressure for the warehouse manager to provide an effective and systematic delivery order handling instruction plan is increasing. Therefore, a decision-making model should be developed to assist the planning process with similar past experience and explicit knowledge.

In this paper, a hybrid approach called the case-genetic algorithm-based decision support model (C-GADS) is proposed in classifying new customer orders into case groups with the highest similarity value, allowing for effectively selecting the most similar cases among the group. The proposed model suggests the types of features considered in each case group. It helps enhance the effectiveness of formulating warehouse order operations based on grouping similar cases. A case study is conducted to validate the feasibility of the model. The results show that planning efficiency is enhanced. This paper is organized as follows. Section 2 provides a review of related literature. The C-GADS model design is presented in Section 3. In Section 4, a case study is presented to demonstrate the implementation procedures of the model. The results and findings are discussed in Section 5. The conclusion is drawn in Section 6.

2. Literature review

Generally, cross-border supply chain refers to the logistics flow of goods across international borders between separate geographical locations within a supply chain. There are a number of typical cross-border supply chains worldwide, such as (i) Indonesia–Malaysia–Singapore (Shen, 2003), (ii) US–Mexico (Hausman & Haytko, 2003), and (iii) Hong Kong–China Pearl River Delta region (Yang, 2006). The existence of the cross-border supply chain is due to unique geographic characteristics and the close connection between two places with frequent cross-border trading activities (Leung, Wu, & Lai, 2006). According to the Word Bank (2007), cross-border trading is defined as "the flow of goods and services across international land borders within a reach of up to 30 kilometers." It usually occurs when products are significantly cheaper in one place than another. The products obtained are usually located in a place separate from the manufacturing plants or retailers. The products are consolidated and stored in the same place before delivery arrangements are made. Many companies have realized that integrating inventory control and delivery policies can save a significant amount in costs (Cha, Moon, & Park, 2008). As a buffer in cross-border supply chain for storage, a warehouse can be used to provide temporary storage before receiving the delivery order from customers, consolidate products from different sources of suppliers, and provide value-added services such as packing/repacking and palletization (Gu, Goetschalckx, & McGinnis, 2007). Therefore, various operations can be done in the warehouse to suit customer delivery requirements and cross-border policies. Among the four major functions of a warehouse, order picking has been identified as the most labor-intensive and costly activity in operations (De-Koster, Kees, & Roodbergen, 2007).

To increase order-picking efficiency in a warehouse, researchers have focused on batching, routing, and facility planning and design, which can better utilize space and increase the material flow in the warehouse (Baker & Canessa, 2009; Gu, Goetschalckx, & McGinnis, 2010). According to Chan and Chan (2011), the storage assignment problem is a major task faced by the warehouse manager for order picking in a warehouse design. Ho et al. (2008a) developed order-batching methods, such as the seed-order selection rule and the accompanying order selection rule for order picking in the warehouse, to minimize the travel distance of the pickers. Rim and Park (2008) defined order-picking plan as a decision-making process for deciding which orders should be picked to maximize the order fill rate subjected to the availability of the inventory. Therefore, order picking in a warehouse plays an important role in improving delivery efficiency. Coming up with an effective plan in the order delivery process with the appropriate product palletization is a challenge for warehouse managers in decision making. With limited time to respond to the operations arrangement and to meet the tight delivery schedule requested by customers, decision makers are hard put to provide appropriate planning after considering both government regulatory policy requirements and customers' specific delivery needs. Thus, past records and explicit knowledge become important in providing references for solving a current problem.

Case-based reasoning (CBR) is one of the well-known knowledge repository and learning techniques widely adopted in decision making based on previous experience. It is an artificial intelligence technique that makes use of a similar previous experience to provide decision support to a new problem instead of an intuitive estimation approach (Kolodner, 1993; Madhusudan,