Expert Systems with Applications xxx (2012) xxx–xxx

Contents lists available at SciVerse ScienceDirect

Expert Systems with Applications

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

Supply chain management with lean production and RFID application: A case study

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ARTICLE INFO

Keywords:
RFID
Lean production
Supply chain management

ABSTRACT

This study applies lean production and radio frequency identification (RFID) technologies to improve the efficiency and effectiveness of supply chain management. In this study, a three-tier spare parts supply chain with inefficient transportation, storage and retrieval operations is investigated. Value Stream Mapping (VSM) is used to draw current state mapping and future state mapping (with lean production and RFID) with material, information, and time flows. Preliminary experiments showed that the total operation time can be saved by 81% from current stage to future stage with the integration of RFID and lean. Moreover, the saving in total operation time can be enhanced to 89% with cross docking. In addition, utilizing RFID technology, the cost of labors can be significantly reduced while maintaining current service capacity at the members in the studied supply chain. Return-on-investment (ROI) analysis shows that the proposed method is both effective and feasible.

1. Introduction

Substantial competition force companies to ensure customers' demands can be satisfied as much as possible at the lowest cost. Therefore, companies attempt to develop new solutions to improve the quality of their supply chains and simultaneously reduce their operational costs. In the past decades, radio frequency identification (RFID) technologies have attracted considerable attentions (Sarac, Absi, & Dauzère-Pérès, 2008). Currently, RFID is emerging as an important technology for revolutionizing a wide range of applications including supply chain management. Numerous organizations are planning to, or have already adopted RFID in their operations in order to take advantage of a more automated and efficient business processes (Sheng, Zeadally, Mitrokotsa, & Maamar, 2011).

Lean production was introduced by Toyota under the names "Toyota production system (TPS)" or "just-in-time (JIT)" manufacturing in the 1960s (Bruun & Mefford, 2004; Reichhart & Holweg, 2007; Taj, 2008; Wu, 2003). JIT manufacturing aims to eliminate waste and to improve their productions by using a continuous improvement approach, including maintaining the only required inventory and reducing setup times to decrease lead times, queue lengths, and lot sizes to reach minimum cost. Lean production enables the integration of various tools in the production system and supply chain and focuses on waste elimination to reduce costs, improve quality, and decrease lead time, inventory, and equipment downtime. Numerous enterprises have applied lean production to improve their productivity and competitiveness over the past decades.

This study explores the application of lean production and RFID technology for improving the logistics efficiency in a three-tier spare parts supply chain. This supply chain consists of a head quarter (HQ), one central distribution center (CDC), 10 local distribution centers (LDCs), and repair shops (RSs). HQ and CDC are responsible for supplying spare parts to ten LDC on a daily basis, and these LDC in turn supply spare parts to more than 400 local RS. HQ has an Information System (IS) and each CDC, LDC, and RS has a Warehouse Management System (WMS). There exist space for improvement in current operations with both information flow and material flow among the members in the studies supply chain, and therefore this research adopts lean production and RFID to increase the effectiveness and efficiency.

Preliminary experiments show that about 99.5% average reading rate was achieved with a fixed Ultra-High Frequency (UHF) RFID reader and four antennas installed in CDC and LDC receiving/shipping docks and UHF passive tags mounted on cartons or pallets. The benefit and cost of using RFID in the supply chain management are analyzed and promoted, e.g., increasing the whole supply chain efficiency and decreasing labor cost. Furthermore, this study uses return-on-investment (ROI) analyses to show that RFID implementation is effective and feasible.

The remainder of the paper is organized as follows. Section 2 presents a review of relevant literature, and Section 3 analyses the supply chain operations without RFID. Section 4 redesigns a new supply chain process with lean and RFID, and Section 5

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0957-4174/$ - see front matter © 2012 Published by Elsevier Ltd.
http://dx.doi.org/10.1016/j.eswa.2012.12.047

evaluates the efficiency improvement and provides ROI analysis. Finally, Section 6 draws conclusions and proposes future research directions.

2. Literature review

In this section, literature related to RFID technology in supply chain applications, lean production and Value Stream Mapping (VSM), and ROI is reviewed.

2.1. RFID application in supply chain

RFID technologies offer several contributions to supply chain through their advanced properties such as unique identification of products, easiness of communication and real-time information (Michael & McCathie, 2005; Saygin, Sarangapani, & Grasman, 2007). The progress through RFID can be observed in different types of supply chains such as warehouse management, transportation management, production scheduling, order management, inventory management and asset management systems (Banks, Hanny, Pachano, & Thompson, 2007).

RFID can ameliorate the traceability of products and the visibility throughout the entire supply chain, and also can make reliable and speed up operational processes such as tracking, shipping, checkout and counting processes, leading to advanced inventory flows and more accurate information (Chow, Choy, Lee, & Lau, 2006; Sarac, Absi, & Dauzère-Pérès, 2010; Tajima, 2007). Companies can achieve better supply chain planning and management by integrating and storing more accurate data obtained through RFID technologies in their information technology systems (Whitaker, Mithas, & Krishnan, 2007). There is thus a strong link between IT applications and RFID technologies.

Bottani and Rizzi (2008) indicated that reengineering models increased possible benefits gained through RFID for all processes of distribution centers and retailers. Pigni and Ravarini (2008) analyzed the effects of RFID technologies in the fashion industry. They showed that RFID technology integration improved the system business process and provided an inter-organizational information system that promoted the efficiency and effectiveness of the entire supply chain. Ferrer, Dew, and Apte (2010) studied 21 RFID applications across a wide variety of industries. Their conclusion was that there were four common benefits: replacement of labor through automation, cycle time reduction, enabling self-service, and loss of prevention. Through these numerous benefits, RFID technologies can provide cost reduction, increased revenue, process improvement, service quality, etc. Lee, Ho, Ho, and Lau (2011) discussed demand and supply chain management and examined how RFID technology can enhance the responsiveness of the logistics workflow. They concluded that the synergy of using a combination of advanced technologies to form an integrated system can help achieve lean and agile logistics workflow. Lao et al. (2012) proposed an RFID-based system to help a distribution center to facilitate the food safety control activities. A real-time food management system was developed that integrated RFID technology and case-based reasoning technique for the distribution center operators in launching a food safety plan. The study concluded that the real time data capturing nature of RFID technology further improved the efficiency and timeframe requested for the actions.

An RFID-based system can provide real-time information to operators, manages, and supervisors in order to control actual situation in the supply chain. Therefore, they can manage customers' demands and timely adjust the production plan to improve the whole supply chain efficiency and effectiveness (Cheung, Cheung, & Kwok, 2012; Ko, Kwak, Cho, & Kim, 2011; Poon et al., 2011).

2.2. Lean production and VSM

Seth and Gupta (2005) presented that the goal of lean manufacturing is to reduce waste in human effort, inventory, time to market and manufacturing space to become highly responsive to customer demand while producing quality products in the most efficient and economical manner. This approach focused on the elimination of waste. Waste took many forms and can be found at any time and in any place. It may be found hidden in policies, procedures, process and product designs, and in operations. Waste consumes resources but does not add any value to the product.

Taj (2008) indicated lean thinking started off in manufacturing representing the meaning of 'manufacturing without waste', and waste can be anything other than the minimum amount of equipment, materials, parts, and working time that are essential to production. So and Sun (2010) emphasized that lean production was proved to be an effective tool for companies to improve continuously. Becoming a lean enterprise enabled manufacturers to improve throughput, reduce costs, and deliver shipment with shorter lead times.

Lasa, Castro, and Laburu (2009) pointed that one of the latest contributions of the lean production movement is the development of the VSM technique. It was introduced as a functional method to help practitioners rearrange manufacturing systems according to a lean perspective and was based on applying the different tools explained above in a systemic or holistic way (Pavnaskar, Gershenson, & Jambekar, 2003; Rother & Shook, 1998; Womack, Womack, & Jones, 2002). Abdulmalek and Rajgopal (2007) presented that a value stream is a collection of all actions (value added as well as non-value-added) that were required to bring a product (or a group of products that use the same resources) through the main flows, starting with raw material and ending with the customer. These actions considered the flow of both information and materials within the overall supply chain. As regards the real-world application of the technique, different practices have been developed and disseminated since VSM was created. Lasa et al. (2009) concluded that VSM was a suitable guide for the application of different lean techniques at a dock-to-dock level in serial production companies.

2.3. ROI analyses of RFID implementation in supply chains

Fleisch and Tellkamp (2005) indicated that there are several significant costs and benefits of RFID implementations. Thus, companies must decide whether to invest or not to acquire RFID technologies. Hence, ROI analyses are helpful to support decisions on the feasibility of RFID deployments. Sarac et al. (2008) showed RFID technologies can provide important benefits to companies. However, because of their high costs, integrating RFID technologies in companies still require important investigations. Furthermore, every company should perform its own ROI analysis, because an RFID technology can be more beneficial for a company than another technology and/or for another company's environment. In addition, the ROI analyses have often been studied through analytical models, simulations, case studies and experiments (Sarac et al., 2010).

Ustundag, Kılınç, and Cevikcan (2010) presented that for managers and professionals, it was very important to accurately measure the benefits of an RFID project in the planning phase. Using the most proper investment evaluation methods, the managers can take the accurate decisions on RFID implementation projects. Lee and Lee (2011) reported that net present value and ROI were commonly used to evaluate investment in new technologies. As there existed RFID technology uncertainties and risks such as global standardization, chip price, security and privacy and high

Please cite this article in press as: Chen, J. C., et al. Supply chain management with lean production and RFID application: A case study. *Expert Systems with Applications* (2012), http://dx.doi.org/10.1016/j.eswa.2012.12.047