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Design and development of logistics workflow systems for demand management with RFID

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ABSTRACT

This paper discusses demand and supply chain management and examines how artificial intelligence techniques and RFID technology can enhance the responsiveness of the logistics workflow. This proposed system is expected to have a significant impact on the performance of logistics networks by virtue of its capabilities to adapt unexpected supply and demand changes in the volatile marketplace with the unique feature of responsiveness with the advanced technology, Radio Frequency Identification (RFID). Recent studies have found that RFID and artificial intelligence techniques drive the development of total solution in logistics industry. Apart from tracking the movement of the goods, RFID is able to play an important role to reflect the inventory level of various distribution areas. In today's globalized industrial environment, the physical logistics operations and the associated flow of information are the essential elements for companies to realize an efficient logistics workflow scenario. Basically, a flexible logistics workflow, which is characterized by its fast responsiveness in dealing with customer requirements through the integration of various value chain activities, is fundamental to leverage business performance of enterprises. The significance of this research is the demonstration of the synergy of using a combination of advanced technologies to form an integrated system that helps achieve lean and agile logistics workflow.

1. Introduction

The logistics and supply chain environment is characterized by aggressive global competition, rapidly changing technologies and increasingly complex markets, all of which have prompted the development of information systems to facilitate the exchange and update of relevant data transactions. In general, decisions are made by logistics services providers, normally based on personal experience and knowledge. However, recent reviews on logistics systems indicate that inadequate attention has been given related to the development of a logistics workflow system which can respond rapidly to outside changes in an effective manner (Goutsos & Karacapilidis, 2004; Liu, Zhang, & Hu, 2005). With advert of RFID technology, information of moving objects can be obtained in a quick manner and easier way. Identification of demand pattern, market trend, and customer behaviour requires real time information and formulation of replenishment strategy needs both explicit and implicit knowledge. Since knowledge is captured by human experts and the turnover of the experienced staff may lead to loss of valuable corporate asset. This research aims to develop a responsive logistics workflow system featured with a combination of emerging technologies for capturing update information and deploying relevant knowledge, thus facilitating effective demand management (Lee, Lau, & Ho, 2005).

2. Related studies

To stay competitiveness in today's turbulent market, not only supply chain management but also demand chain management attracts the researchers' attention so as to respond to customers' needs quickly. Supply chain management is the integration of key business process for end users through original suppliers who add values on products, services, and information (Tan, 2001) while demand chain management is the whole manufacturing and distribution process may be seen as a sequence of events with one end in view; it exists to serve the ultimate consumers (Brace, 1989). If supply chain is regarded as a push strategy to the upstream operations driven by the downstream operations; demand chain is regarded as a pull strategy to meet customer needs with satisfactory quality in a profitable way. Demand chain management puts emphasis on the needs of the marketplace and

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designing the chain to satisfy these needs of downstream operations which is triggered by the suppliers/manufacturers and working backward (Vollmann & Cordon, 1998). The main components of demand management are demand creation, communication, supply planning and order management which is in strategic, tactical and operational level (Thomas, 2004). To achieve effective demand chain management, the organizations need to consider the supply chain cost, product profitability, sales volume and customer value proposition. One of the prepositions of demand chain management model proposed by Heikkilä (2002) is reliable information flows which contribute to high efficiency in value chain. An integrated framework for the development of focused demand chains suggested by Childerhouse, Aitken, and Towill (2002) realized that information about the competitive situation can be interpreted; analyzed and represented in the form of key order winner and order qualifier. It cannot be denied that information plays a pivotal role in supply chain and demand chain to attain the goal of quick response.

With advent of new technology like Radio Frequency Identification (RFID), which is an automatic identification method, keeps track and trace of the moving objects within the logistics network. Both bar-code and RFID have its distinct strength in data collection and application areas. InLogic (2008) has done the comprehensive comparison between RFID and barcode in terms of line of sight, read range, read rate, identification, read/write operation, interference and automation and authors have include the data related to read rate, data capacity, communication protocol, cost, and summarized in Table 1. Bar codes has lower cost, easy tagging for different material and comparable accuracy rates due to the mature technology with large installed base. Comparing with bar-code, RFID has advantages of small tag size, longer lifespan, readable in harsh environments; support for nonstatic data, reprogrammable and traceable and those benefits are verified by the study of Jones, Wyld, and Totten (2005). RFID will gradually replace bar code based on condition of the dropping price of tag and hardware, international standard of common frequency of operation, advocates of large retailers and advance technical development of the tag and hardware. RFID is used for physical distribution and planning including inventory control (Jedermann, Behrens, Westphal, & Lang, 2006), warehousing (Chow, Choy, Lee, & Lau, 2006), material handling (Huang, Zhang, & Jiang, 2007) and order processing (Philips, 2004). RFID is advocated by Wal-Mart for promoting the use of electronic code to streamline the supply chain and Wal-Mart requests suppliers to attach tag to each pallet of goods in distribution center and warehouse. The invention of smart-shelf alerts practitioners to replenish the goods instantly when the goods are out of stock. This invention system can greatly reduce the error between the inventory record and physical record so as to reduce the number of cycle count and increase the effectiveness of inventory management. RFID, which is applied to manage the movement of material handling equipment such as fork-truck, results in increasing efficiency of picking processes by 15–20% (Chow et al., 2006). The application of RFID for point of sales can greatly reduce the processing time at cashiers and further reduce the queuing time. In short, RFID has been prompted to have strategic implementation with concerned of data management, system integration and security.

Cross-platform supply chain information system was proposed to enable data exchange among various data object over geographically isolated regions (Lau & Lee, 2000). Demand chain management solutions put much emphasis on collaborative forecasting processes between manufacturers, suppliers and customers to attain the goal of inventory optimization. However, it is difficult to have an accurate forecasting due to many uncertainty factors in the dynamic market. As a result, logistics information system is proposed to facilitate information exchange though the logistics workflow for just-in-time replenishment rather than putting too much emphasis on forecasting. In summary, this review of contemporary publications indicates that while many research studies have been conducted using various approaches to improve demand and supply chain, the research related to apply machine learning for demand pattern recognition has not received the attention it deserves. This issue is addressed in this paper with the introduction of a logistics workflow system for demand management, which is fully described in the following sections.

3. Proposed methodology

In order to keep inventory at reasonable level that is sufficient to provide supplies on demand continuously but avoid overstocking, distributors, manufacturers and retailers need effective information sharing among each other. The structural framework of responsive logistics workflow system (RLWS) is formulated and shown in Fig. 1. In particular, the focus of development is on

Table 1
Comparison of RFID and barcode.

	RFID	Barcode
Line of sight	Not required (in most cases)	Required
Data capacity	100's–1000's of characters	<20 characters with linear
Read range	Passive RFID: Up to 25 feet Active RFID: up to 100's of feet or more	Several inches up to 30 feet
Read rate	10's, 100's or 1000's simultaneously	Only one at a time
Read accuracy	90% depends on relative orientations of reader and tag antennas and their polarizations)	90% or higher
Identification	Can uniquely identify each item/asset tagged	Can typically only identify the type of item (UPC code) but not uniquely
Read/write	Many RFID tags are Read/Write	Read only
Technology	RF (Radio Frequency)	Optical (Laser)
Interference	Like the TSA (Transportation Security Administration), some RFID frequencies do not like metal and liquids They can cause interfere with certain RF frequencies	Obstructed barcodes cannot be read (dirt covering barcode, torn barcode, etc.)
Communication protocol	ISO 18000	RS232
Automation	Most "fixed" readers do not require human involvement to collect data (automated)	Most barcode scanners require a human to operate (labor intensive)
Cost	Tag 5¢ RFID startup kit with RFID reader, antennas, alien gateway software, startup kit tag and power supply/ power cable USD 2595	Barcode label near zero Barcode scanner USD 120–1500 Barcode printer USD 240–7500