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## RFID-enabled warehouse optimization: lessons from early adopters in the 3PL industry

### Abstract

This paper presents the impact of RFID technology on the picking and shipping processes of one RFID-enabled warehouse in the 3PL industry. The findings from our study confirm initial results from many studies where RFID implementation has been shown to enable business process redesign, improve data quality, real-time data collection and synchronization and enhance system integration. In this study we show that the full potential of RFID technology is dependent upon the involvement of all supply chain members involved in implementation. Moreover, firms considering implementing RFID technology need to take into account their investment in complementary assets such as employee training and knowledge development. The implication of this is that business process modeling and simulation is critical to ensure that stakeholders involved in a RFID project fully understand the impacts of integrating RFID technology on business processes.

### Keywords

RFID, TPL, Optimization, Business Process

### Disciplines

Business Administration, Management, and Operations | E-Commerce | Management Information Systems | Physical Sciences and Mathematics | Technology and Innovation

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# RFID-ENABLED WAREHOUSE OPTIMIZATION: LESSONS FROM EARLY ADOPTERS IN THE 3PL INDUSTRY

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## Abstract

*This paper presents the impact of RFID technology on the picking and shipping processes of one RFID-enabled warehouse in the 3PL industry. The findings from our study confirm initial results from many studies where RFID implementation has been shown to enable business process redesign, improve data quality, real-time data collection and synchronization and enhance system integration. In this study we show that the full potential of RFID technology is dependent upon the involvement of all supply chain members involved in implementation. Moreover, firms considering implementing RFID technology need to take into account their investment in complementary assets such as employee training and knowledge development. The implication of this is that business process modeling and simulation is critical to ensure that stakeholders involved in a RFID project fully understand the impacts of integrating RFID technology on business processes.*

**Keywords:** RFID technology, RFID project, business process optimization, supply chain management, 3PL.

## Introduction

Radio frequency identification (RFID) is currently considered to be “one of the most pervasive computing technologies in history” (Roberts, 2006 p. 18) that is capable of: (i) enabling the Mark Weiser vision of ubiquitous computing where technology is seamlessly incorporated into our daily lives (Weiser, 1991; Floerkemeier and Lampe, 2004), and (ii) improving substantially the supply chain (Turban et al., 2006; Michael and McCathie, 2005). Defined as “a wireless automatic identification and data capture (AIDC) technology” (Fosso Wamba et al., 2008 p. 615), the basic concept behind RFID technology is not new. The first industrial application of this technology dates to the World War II by

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the British Air Force to distinguish allied aircraft from enemy aircraft (Asif and Mandviwalla, 2005). However, the technology has evolved considerably in recent years and the modern RFID infrastructure consists of a tag containing an antenna and a chip with information about the tagged item or product, a reader incorporating a radio transmitter and receiver, and a host computer equipped with middleware software, in which business rules are configured. As soon as RFID tag enters the reader's reading area, a bidirectional communication is established between the tag and the reader through radio frequencies and the reader retrieves and sends the unique identification of the product to the host computer for further processing.

Driven by the major players in the retail industry such as Wal-Mart and Metro Group, as well as the U.S. Department of Defense, RFID technology has generated new attention from the scientific and practitioner communities. For example, Curtin et al. (2007) have called for additional studies to assess the real impact of RFID technology at the supply chain level. Whitaker et al. (2007) emphasize the "need to test adoption and business value, specifically in the RFID context" (p. 3), as the technology continues to encounter technical difficulties (i.e. read rates, tags collision, system integration, RFID data management). The technical challenges can introduce considerably higher variable costs when RFID tags are introduced at the supply chain level. Drawing on simulated laboratory studies Bendavid et al., (2006) and Fosso Wamba et al. (2006) show that RFID technology holds considerable potential and have subsequently called for more studies on RFID technology in real-life settings. This paper begins to partially fill this gap by presenting the results of real application of RFID technology on the picking and shipping processes of a 3PL warehouse. In particular, this paper draws on prior study on RFID research agenda (Curtin et al. 2007, p. 99) and a longitudinal case study of a third-party logistics service provider and its supply chains to examine the following research question:

***RQ: How are business processes and work systems changed due to RFID at all points in the value chain?***

Next, section 2; we position the study within the broad supply chain management and information technology domain. Then, section 3, we review the literature that relates to supply chain optimization integrating RFID technology and the various empirical work based primarily on laboratory and pilot studies. In section 4, we describe the context of the study and the methodology. Section 5, presents the basic infrastructure at the shipping dock of an RFID-enabled warehouse infrastructure. Finally, section 6, we describe the RFID-enabled picking and shipping processes before concluding the paper in section 7.

Supply Chain Management (SCM) is defined as "the integration of key business processes from end user through original suppliers that provides products, services and information that add value for customers and other stakeholders" (Lambert and Cooper, 2000 p. 66). The strategic importance of SCM is generally accepted in the academic community (Ragatz et al. 1997; Frohlich and Westbrook, 2001) and there is growing consensus that greater integration of key supply chain business processes will lead to improvement in the firm's competitive position (Frohlich and Westbrook, 2001; Smart, 2008). Information Technology (IT) is fundamental to the success of SCM and various technologies have been used to optimize operational activities. These technologies include: bar coding, Enterprise Resource Planning (ERP), Warehouse Management system (WMS), and Electronic Data Interchange (EDI). Recently, RFID technology has emerged as a new wave of IT to support greater product transparency and supply chain optimization. Moreover, there are increased numbers of firms, in various industries, that are exploring the potential of RFID to improve SCM operations. In particular, RFID is considered to be the next generation of bar coding that will increase supply chain data capture and information exchange within firms and between supply chain members (Fosso Wamba et al., 2008).

## **RFID Impacts in the Supply Chain: Empirical Results from Laboratory and Pilots Studies**

Early work on the impact of RFID in a supply chain setting has primarily focused on laboratory or pilot studies. For example, using a laboratory study Fosso Wamba et al. (2008) show that when RFID technology is linked to the EPC network it can have a major impact on mobile B2B e-commerce in a retail supply chain. Improvements in this study included: (i) business process, operational process and IT infrastructure redesign, (ii) information sharing and synchronization between all supply chain members, (iii) human and physical resource utilization, optimization, and finally, (v) strategy redefinition. Bendavid et al. (2006), using a field study conducted in the utility industry and a proof-of-concept in a laboratory setting, verified that process optimization can be achieved when integrating RFID technology into an information systems application. Vijayaraman and Osyk (2006) present an empirical study of RFID implementation in the warehousing context in order to determine whether manufacturing firms, third party logistics (3PL) providers, distributors, and retail firms intend to implement the technology. Their results indicate that very few companies are currently considering the adoption of RFID technology because scepticism remains about the potential of the technology.

In contrast, studies conducted by Loebbecke (2007), Loebbecke (2005) and Hardgrave et al. (2005) reveal more positives results. Loebbecke (2007) examined a RFID project that linked a department store chain to a fashion goods manufacturer. The author concluded that RFID technology was actually beneficial to the two project partners involved, as well as to the entire supply chain. For example, RFID technology lead to time savings in the movement of goods along the supply chain, the reduction of handling costs, the improvement of data quality, and offered new service offerings. In her previous study conducted at the Metro group in Germany, the author found that the technology contributed to a reduction of out-of-stocks from 9% to 14% as compared with the previous year; also, it optimized store space by almost 11% (Loebbecke, 2005). Finally, in an independent study conducted at “Wal-Mart RFID-enabled stores” over a period of 29 weeks, Hardgrave et al. (2005) reached the conclusion that RFID-enabled stores are at 63% more effective in replenishing out-of-stocks than stores without RFID, which can be translated into a reduction of out-of-stocks by 16%.

### **Context of the Study and Methodology**

This paper builds on the product value chain perspectives (Porter, 1985) and the business process approach (Lefebvre et al., 2006; Pavlou et al., 2005; Byrd and Davidson, 2003). Indeed, the product value chain allows the description of the supply chain network value-adding activities (Porter, 1985; Papazoglou and Ribbers, 2006) and its “provides managers with a tool to analyze and, if necessary, redesign their internal and external processes to improve efficiency and effectiveness” (Papazoglou and Ribbers, 2006 p. 78). In addition, the business process approach is a useful approach to study the sequences of different activities within the network of organizations and to assess the impact of information technology at the process level. The industry focus is on a 3PL company that is currently using RFID technology.

#### ***Context of the 3PL Industry***

The globalization of the business environment and the increasing use of outsourcing has given rise to the rapid growth of third party logistics (3PL). Third party logistics has been defined as “a relationship between a shipper and a third party which, compared with the basic services, has more customized offerings, encompasses a broad number of service functions and is characterized by a long-term, more mutually beneficial relationship” (Murphy and Poist, 1998 p. 35). The provision of 3PL services has become being increasingly popular and Langley et al. (2005) report that 82% of the respondents to a recent survey currently use 3PL services. Types of services offered by a 3PL provider include

activities such as transportation, warehousing, inventory management (ALPHA Research Consortium, 2004). Competitive pressures in this industry are strong and the major 3PL players in the market have traditionally been quick to adopt new technology in order to avoid commoditization (van Hoek, 2000). The adoption of RFID technology by the vendors in this industry follows this lead. Indeed, this industry is considered as one of the lead users of RFID technology. Based on the global RFID revenue in 2007 (Gartner, 2008).

### ***Research Sites***

The study was conducted at a 3PL provider site with a focus on those activities involved in the management of telecommunications stationary batteries (Part A, Figure 2). The product value chain perspective is particularly relevant as a theoretical framework because RFID implementation is product-driven (Bendavid et al., 2007). The focal firm under investigation is a large 3PL. It owns a large distribution center in Canada and facilities in the United States of America (USA) and provides a variety of services including storage, transport and customs clearance fees. The Montreal distribution center is used to store telecommunications batteries from various suppliers, based on the needs of the three main customers of the focal firm. This focal firm has to ship new batteries to various remote sites, collect used batteries when requested, and deliver them to the nominated recycler facilities.

### ***Data Collection***

The current project was conducted in two main phases (i) one exploratory phase using longitudinal cases study and (ii) one confirmatory phase where the expected results from phase 1 were monitored in the RFID-enabled warehouse. In the exploratory phase, longitudinal cases were used as case study is a pertinent research strategy to understand the dynamics within a supply chain (Eisenhardt, 1989). Moreover, case studies allow researchers to answer questions such as “why” and “how” things are done (Yin, 1994). As a matter of fact, they are more and more extensively used in the logistics and operation management (Stuart et al., 2002). Also, both qualitative and quantitative data were collected through multiple inquiries such as on-site observations, interviews and focus groups.

Based on the requirements by key respondents, various scenarios of business process integration using RFID were discussed and simulated through the use of a business process analysis tool called ARIS Toolset. This tool is based on the Event-driven Process Chains (EPC) formalism which allows a global definition, mapping, analysis, optimization and implementation of business processes. The EPC formalism allows a logic representation of activities within a supply chain (intra- and inter-organizational processes) and is a powerful language to allow all stakeholders involved in the RFID project to fully understand the impacts of integrating RFID technology on business processes. This modeling schema uses three types of logical connectors to indicate the workflow between activities and events, mainly the “^” (i.e. and), “v”(i.e. or) “XOR” (i.e. exclusive or), and makes it possible to assign responsibilities (i.e. employee) to a specific function, assign a system which is used to perform the function (e.g. WMS (Warehouse Management System), RFID middleware or Printer), show information inputs and outputs such as picking list, RFID tags (see Part B, figure 2) (ARIS Toolset, 2008). At the end of the exploratory phase, one optimal scenario is retained in order to be implemented in the warehouse.

## **RFID-Enabled Warehouse: Case of the Shipping Dock**

For the purposes of this paper we restrict our investigation to the transactions of the RFID-enabled shipping dock. In Figure 1, as soon as the forklift approaches the shipping dock in this case, an RFID portal ((r) in Figure 1) with enclosed reader and two antennas, an auxiliary device called “photo eye” triggers an event that activates the two antennas connected to the reader that captures the information written on the b-Tags. Based on the business rules in the middleware (the one use here is called OMS and was developed by Ship2save), a set of action could be performed (e.g. create and send an ASN (Advanced Shipping Notices), send a request to update inventory in the WMS).



Figure 1: RFID enabled-shipping dock for real-time transactions

## The RFID-Enabled Picking and Shipping Processes

In order to assess the impact of RFID technology on the picking and shipping processes, a process approach was being used after many authors demonstrated its relevance to the study of the information technology impact (Pavlou et al., 2005; Byrd and Davidson, 2003), and more recently, to that of RFID technology (Lefebvre et al., 2006). Indeed, this approach enables the study of the impact of information technology at the locus of that impact namely business process (Pavlou et al., 2005).

In the RFID-enabled picking and shipping processes (Part B, Figure 2), the picking process is triggered by the electronic picking order (e-Pick). As soon as this e-Pick is received, a set of actions is performed, namely manual actions (e.g. attach b-Tag on the battery, pick the battery, etc.) and automatic actions (e.g. print number of tag required x-b-Tag, validate the match between the b-Tag and picking order, etc.). When the picking order is over, an automatic match between all batteries tags and the picking order is performed. If there is an error, the process is immediately stopped for further verification by the picking clerk. If not, the picking clerk can drive through the shipping dock and drop the batteries in the truck. As soon as the batteries pass through the shipping dock, they are automatically read (Figure 3) and this action triggers a set of other actions such as (i) create and send an ASN to the dedicated supply chain member, (ii) update inventory in the WMS.

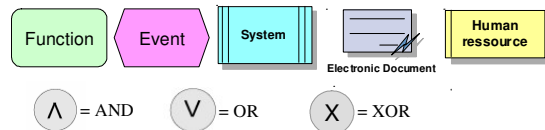
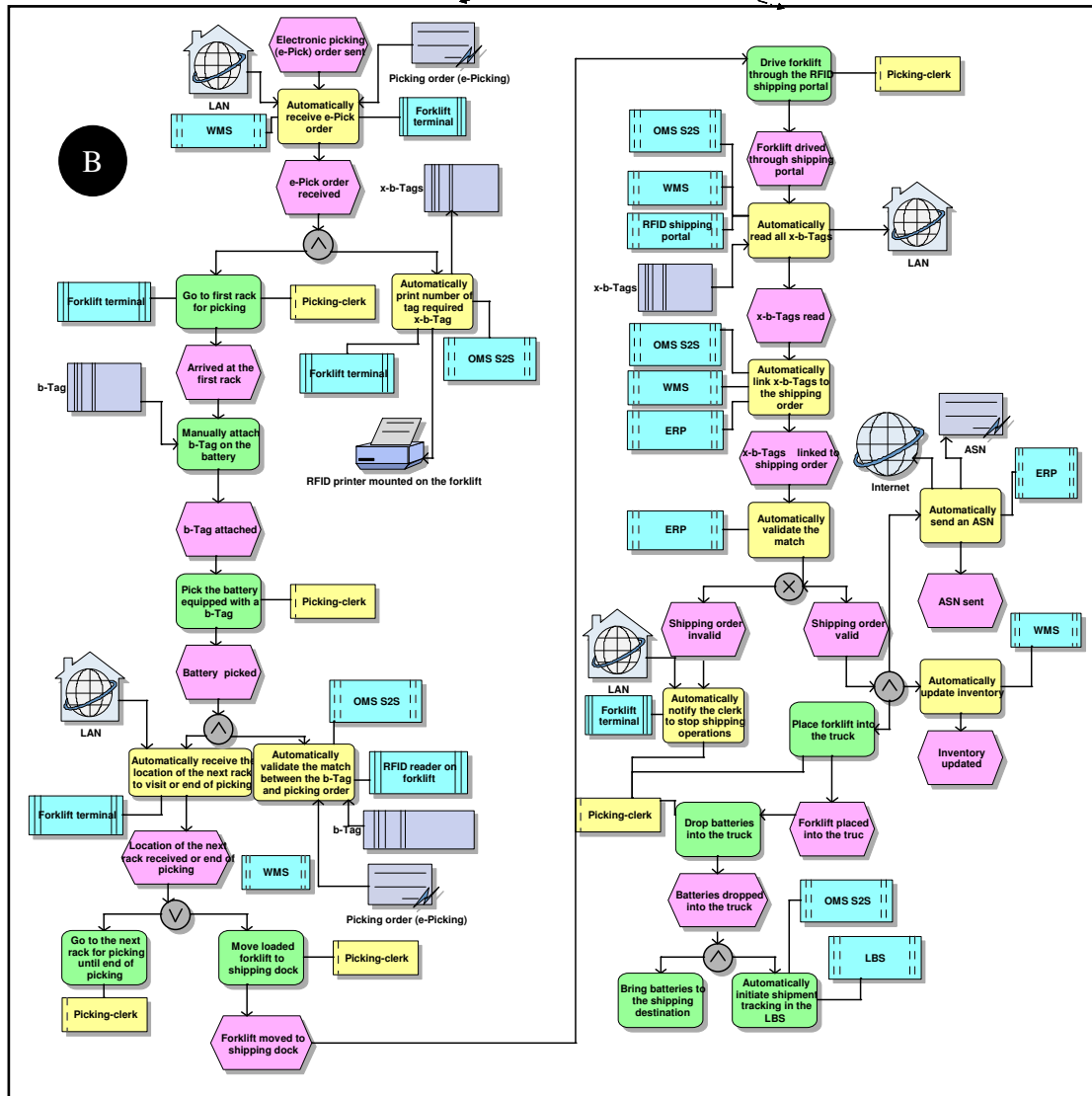
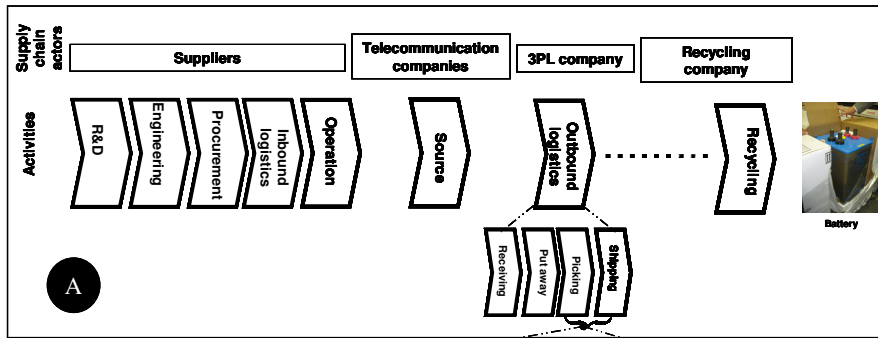


Figure 2: RFID-enabled picking and shipping processes



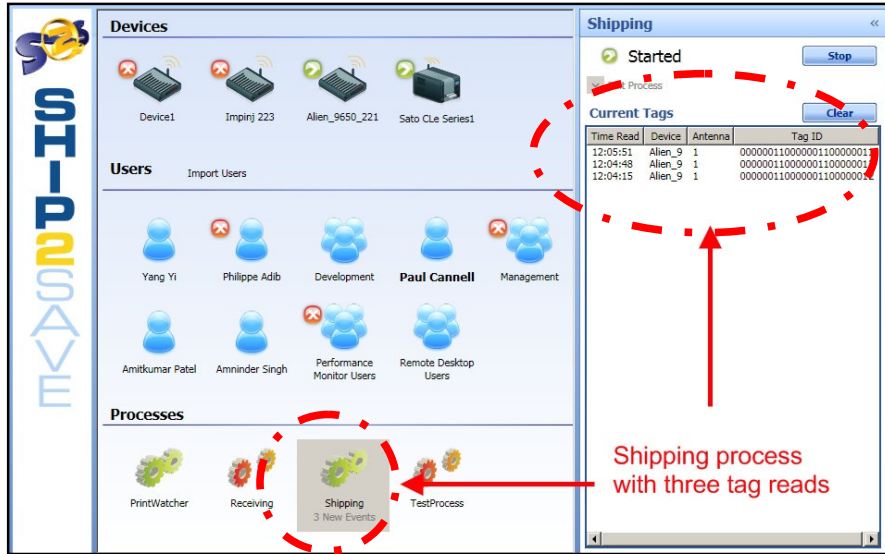


Figure 3: Automatically read all RFID tags on the batteries

## Discussion and conclusion

The results from this study confirm the initial findings from Bendavid et al., (2006), Fosso Wamba et al. (2006) and Lefebvre et al. (2006). The observations from this study can be summarized in the following figure (Figure 4).

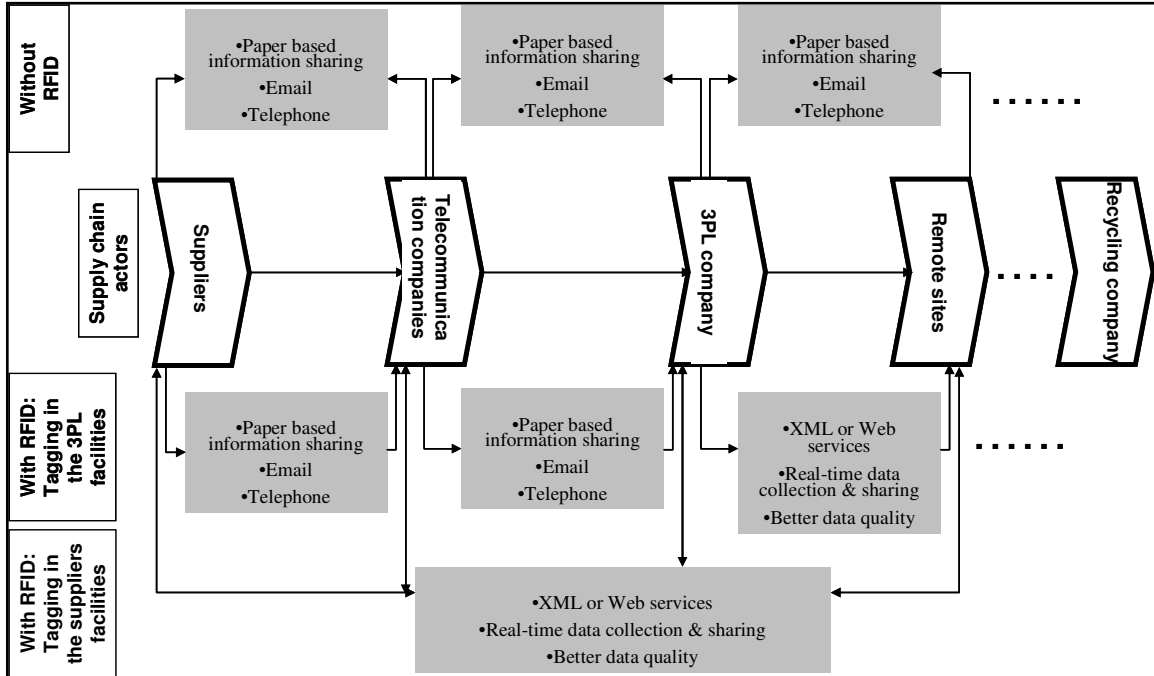


Figure 4: Impacts of RFID technology as function of the tagging strategies

First, RFID implementation can act as an enabler of business process redesign. Second, it reveals that the business value of RFID technology increase when the tagging process is conducted in the suppliers

facilities, and thus, allows real-time data collection and synchronization (within and between firms), better data quality, better information system integration (within and between firms) and real-time information sharing using collaborative technologies such as XML or Web services. Indeed, the full potential of RFID technology will only be achieved if all supply chain members are involved in its implementation. For example, in this project, because the suppliers are not yet part of the project, the 3PL firm needs to conduct the tagging process during the picking process. If this tagging process is done by the suppliers, they can use the technology to optimize their own activities and share the potential of the technology with the 3PL company and other suppliers' chain members. This strategy raises issues relating to costs and the performance management at the supply chain level. Indeed, if the tagging is done by suppliers, then how will the other supply chain members share the initial cost burden for the tagging infrastructure and the RFID tags? Also, how it is possible to choose the right RFID standard, design business rules in the various middleware units of the supply chain in order to achieve supply chain integration? On the other hand, firms planning to embark on RFID technology need to take into account the investment in complementary assets such as employees' further training. Moreover, performance indicators need to be identified at the firm and chain levels so as to help managers to monitor their new processes (Bendavid et al., 2007).

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