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INTEGRATING RFID TECHNOLOGY AND EPC NETWORK INTO A B2B RETAIL SUPPLY CHAIN: A STEP TOWARD INTELLIGENT BUSINESS PROCESSES

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Abstract

This article introduces RFID technology and the EPC Network and investigates their potential for B-to-B eCommerce supply chain management. Based on empirical data gathered from four tightly interrelated firms from three layers of a supply chain, several scenarios integrating RFID and the EPC Network have been tested and evaluated. In the context of warehousing activities in one specific retail supply chain, the results indicate that i) the business process approach seems quite appropriate to capture the real potential of RFID and the EPC Network; ii) RFID technology and the EPC Network can improve the "shipping" and the "receiving" processes; iii) they can automatically trigger some business processes; iv) they foster a higher level of information sharing between supply chain members; and v) they promote the emergence of new business processes such as "process-to-process," "process-to-machine," and "machine-to-machine." The paper helps to improve our understanding of the real potential of RFID and the EPC Network for business processes.

Keywords: RFID, EPC Network, retail industry, warehouse management, supply chain management, intelligent processes, intelligent products.

1 Introduction

The main objective of this paper is to investigate the potential of the RFID (radio frequency identification) technology and the EPC (electronic product code) as enablers of intelligent B-to-B eCommerce supply chain management. More specifically, the aim is to improve our understanding of how RFID technology and the EPC Network can be integrated into a specific supply chain.

After first introducing the RFID technology and the EPC Network, the paper exposes the background of the study (section 2), elaborates the methodology (section 3). Findings and their implications are discussed in section 4.

1.1 RFID technology

RFID technology has been considered as "one of the most pervasive computing technologies in history" (Roberts, 2006 p. 56). But RFID concept is not new; it has its origins in military applications during World War II, when the British Air Force used RFID technology to distinguish allied aircraft from enemy aircraft with radar (Asif and Mandviwalla, 2005).

However, RFID technology has received a great deal of attention over the last few years, with a "boom" in early 2003 due to demands by Wal-Mart and the US Department of Defense (U.S. DOD) that major suppliers should adopt and implement the technology by the beginning of 2005 (Srivastava, 2004).

This interest in RFID is highlighted by many recent white papers published by technology providers (e.g. Intermec, Texas Instruments), consulting firms (e.g. BearingPoint; Accenture), infrastructure providers (e.g. HP; Sun Microsystems), enterprise software providers (e.g. SAP), and solution providers (e.g. IBM).

In the academic community as well, this emerging phenomena is reflected in various fields of research such as innovation management (Sheffi, 2004), project management (Bendavid and Bourgault, 2005), environmental management (Hilty, 2005), e-commerce (Smith, 2005; Bendavid et al., 2007), supply chain management and warehousing (Lefebvre et al., 2005; Srivastava, 2004), mobile business (Fosso Wamba et al., 2007) information systems (Geng and Sirkka, 2006), and decision support systems (Ngai et al., 2005). But, all too frequently, technology promises more substantial benefits than it can deliver, and information technologies are no exception (Coates, 1992). Are RFID technology and the EPC Network a new case of techno hype? Could RFID and the EPC Network be enablers of intelligent B-to-B eCommerce supply chain management? This paper aims to find some tentative answers to these questions with empirical evidence gathered from a field study of one supply chain in the retail industry where the most significant interest for RFID has arisen.

RFID technology is classified as a wireless automatic identification and data capture (AIDC) technology (Swartz, 2000). Basically, a RFID system is composed of three layers: (i) a tag containing a chip, which is attached to or embedded in a physical object to be identified; (ii) a reader and its antennas that allow tags to be interrogated and to respond without making contact (in contrast to bar codes, which require a line of sight and must be read one at a time); and (iii) a computer equipped with a middleware application that manages the RFID equipment, filters data and interacts with enterprise applications (Asif and Mandviwalla, 2005).

RFID tags come in a large variety of designs and have many different functional characteristics such as power source, carrier frequency, read range, data storage capacity, memory type, size, operational life, and cost. They may (i) either be read only or read/write capable and (ii) be active, passive or semi-passive depending on the way in which they drive operating power and transmit data to the reader. Active tags have a tiny embedded battery from which they draw power, allowing greater communication range, higher data transmission rates and larger data storage capacity than passive tags. Because they do not contain a power source, passive tags are less expensive than active tags (Asif and Mandviwalla, 2005). However, the choice of the appropriate tags depends on the objectives of each business application.

RFID readers may consist of a read or read/write module (Ngai et al., 2005); when requested, they can send the pre-configured location and the identification of an object to a computer, which can initiate business processes automatically (Kärkkäinen et al., 2003).

1.2 The EPC Network

The EPC Network is a standard for RFID infrastructure (Floerkemeier et al., 2003; Srivastava, 2004; EPCglobal, 2004). It is composed of five components: (i) the EPC code, which starts as a 64-bit to 128-bit identifier. Once it is incorporated into an RFID chip (also called an EPC tag) and attached to a physical object, product or item, it can provide information such as the manufacturer, the product category and size, the date when the product was made, the expiration date, the final destination, etc. (ii) The RFID reader identifies any EPC tag within its interrogating field, reads the EPC tag and forwards information to the SAVANT. (iii) The SAVANT is the middleware system located between readers and the application systems (AS). Based on configured business rules, it is responsible for data filtering and aggregation and interacts with the EPC Information Service (EPC-IS) and the local Object Name Service (ONS). (iv) The EPC-IS is the gateway between any requester of information and the firm's AS and internal databases. (v) The local ONS is an authoritative directory of information sources available in order to describe all EPC tags used in a supply chain (EPCglobal, 2004; Floerkemeier et al., 2003).

"This EPC Network is a method for using RFID technology in the global supply chain by using inexpensive

RFID tags and readers to pass EPC numbers, and then leveraging the Internet to access large amounts of associated information that can be shared among authorized users” (EPCglobal, 2004 p. 6). Moreover, products with an EPC tag have the ability to communicate with their environment and make or trigger basic decisions relevant to their management. Such products are also called “intelligent products” or “smart products” (Strassner and Schoch, 2004).

In the retail context, supply chain management (SCM) is seen as an important activity where RFID technology and the EPC Network could have tremendous impacts. The main thrust of this paper is therefore that RFID technology and the EPC Network are enablers of intelligent B-to-B eCommerce SCM.

2 Background

2.1 Current context of the retail industry

All The retail industry represents one of the largest industries worldwide. For example, in the United States, it is the second-largest industry in terms of both the number of establishments and the number of employees, with $3.8 trillion in sales annually and 11.7 percent of U.S. employment (Vargas, 2004).

In addition, this industry is facing similar trends to those affecting other sectors, for instance, the globalization of markets, aggressive competition, increasing cost pressures and the rise of customized demand with high product variants.

Nonetheless, the industry also faces specific challenges such as management of the short shelf-life of grocery goods, strict traceability requirements and the need for temperature control in the retail supply chain (Kärkkäinen, 2003). Retailers must also deal with a growing number of stock keeping units (SKUs). For instance, in a typical food store in the USA, the number of SKUs has risen from nearly 6,000 in the 1960s to almost 40,000 today. As a result, the number of daily sales transactions has exploded. Therefore, capturing sales information using manual, and therefore error-prone, methods has become almost obsolete (Abernathy et al., 2000).

Furthermore, manual capture of sales information increases transaction costs and can cause inventory inaccuracies (Fleisch and Tellkamp, 2005). Among the cases presented in the literature, the case of Procter & Gamble, which spends between $35 and $75 to process each customer invoice is a classic representation of these inefficiencies. Indeed, this kind of processing involves numerous human interventions at different levels such as order taking, data entry, processing of the order, invoicing and forwarding (Kärkkäinen, 2002).

With the intention of streamlining their supply chain processes and controlling costs, leading retailers around the world are relying more on the use of information technologies (e.g. Enterprise Resource Planning (ERP), Warehouse Management System (WMS), Transportation Management System (TMS) and Automatic Identification and Data Collection (AIDC)) to support intra- and inter organizational business processes, decision-making, workflow management and automatic information exchange with their supply chain partners. They also depend on new customer-focused concepts to improve performance (e.g. Vendor-Managed Inventory (VMI), Point of Sale (POS) and Collaborative Planning, Forecasting and Replenishment (CPFR)) (Sparks and Wagner, 2003). But the majority of the retailers place their hopes on emerging technologies such as RFID technology and the EPC Network to improve their supply chain management.

2.2 RFID and the EPC Network’s potential in the retail industry

The most significant interest in RFID and the EPC Network is in the retail industry. This so-called “intelligent network” has the ability to automatically link EPC code to product information stored in a database on the Internet or on a company’s local area network (LAN) (VeriSign, 2005) . Indeed, major retailers such as Wal-Mart, Tesco, Metro AG and 7-Eleven are very interested in the potential of RFID technology (Jones et al., 2005) and the EPC Network (Srivastava, 2004; EPCglobal, 2004). For instance, by adopting RFID technology, Wal-Mart stands to achieve annual savings of almost (i) $600 million in out-of-stock supply chain cost reductions; (ii) $300 million in improved tracking through warehousing and distribution centers; and (iii) $180 million in reduced inventory holding and carrying costs (Asif and Mandviwalla, 2005). Procter & Gamble has also estimated that it could save almost $400 million annually in inventory by deploying an RFID system (Srivastava, 2004; Smith, 2005).

Table 1. Broad processes in a distribution center and areas of opportunities provided by RFID and the EPC Network.

Broad processes	Description	Specific opportunities	Common opportunities
Receiving	Handling of products that arrive at the warehouse	- Automate the verification activities (Lefebvre et al., 2005; VeriSign, 2005) - Manage the flow of damaged goods (Keith et al., 2002)	- Simplify processes (Lefebvre et al., 2005; Keith et al., 2002) - Speed up processes (Keith et al., 2002)
Put-away	Moving and placing products in their specific storage location	- Lower costs of process by 20-30% (Capone et al., 2004) - Improve temporary storage (Lefebvre et al., 2005) - Reduce manual intervention (Lefebvre et al., 2005)	
Picking	Retrieving the products from their storage location to consolidate customer	- Lower cost of process by 30-50% (Capone et al., 2004)	
Shipping	Checking, packing and loading in the transportation unit	- Automate the verification activities (Lefebvre et al., 2005; VeriSign, 2005) -Reduce errors	

2.3 Real applications of RFID and EPC Network in the retail industry

In 2003, Metro Group opened its first "Extra Future Store," where RFID technology is used live for various applications throughout the supply chain (Collins, 2004).

In addition, the use of RFID technology and the EPC Network for product tracking in the retail supply chain can lead to a tremendous reduction in inventory levels and better collaboration among supply chain players. For example, Scottish Courage, a British beverage firm, is using RFID technology to track its 2 million keys at any point in the supply chain. As a result, the firm has eliminated shrinkage, reduced key cycle times, and improved delivery for outgoing and incoming stock (Srivastava, 2004). Marks and Spencer is also using RFID technology to track 3.5 million reusable trays, dollies and cages throughout its refrigerated food supply chain, leading to a substantial reduction (almost 80%) in the time taken to read a stack of multiple trays while increasing data accuracy and reliability. The overall result was a faster and more cost-effective SCM system (Jones et al., 2005).

Within distribution warehouses, many impacts and benefits are also expected from RFID and the EPC Network. A distribution warehouse, also called a distribution center, collects products from different suppliers and sometimes assembles them for delivery to a number of customer warehouses (Van Den Berg and Zijm, 1999). Four separate processes are usually identified in a distribution warehouse, namely receiving, put-away, picking and shipping (Van Den Berg and Zijm, 1999); all of which can benefit from RFID technology and the EPC Network (Table 1).

This paper focuses on a single "open-loop" supply chain initiative in the retail industry to explore issues related to the integration of RFID technology and the EPC Network between different partners.

3 Methodology

Our study builds on previous work (Strassner and Schoch, 2004; Subirana et al.; 2003) and focuses on a three-layer supply chain. The case study method seems appropriate to explore the complex issues related to the impacts of RFID technology and the EPC network.

3.1 Research design

Since the main objective of this case study is to improve our understanding of the potential of RFID technology and the EPC Network in the context of warehousing activities in one specific supply chain, the research design corresponds to an exploratory research initiative. Field research was conducted in 12 consecutive steps (Table 2, adapted from Lefebvre et al*;* 2005).

Table 2. Steps undertaken in the field study.

Detailed activities	
Phase 1: Opportunity Seeking	
Step 1	**Determination of the primary motivation to adopt RFID and the EPC Network:** Understanding the primary motivation to consider the use of RFID and the EPC Network technologies **(WHY?)**
Step 2	**Analysis of the Product Value Chain (PVC):** Understanding the activities specific to a given product **(WHAT?)**
Step 3	**Identification of the critical activities in the PVC:** Identification of critical PVC activities **(WHICH** activities to select and **WHY?)**
Step 4	**Mapping of the network of firms supporting the PVC;** Mapping the Supply Chain Network to understand the links within the network of firms supporting the product **(WHO and WITH WHOM?)**
Step 5	**Mapping of intra-organizational processes** for the identified opportunities as they are carried out now (“As is”) **(HOW within organization?)**
Step 6	**Mapping of inter-organizational processes** for the identified opportunities as they are carried out now (“As is”) **(HOW between organizations?)**
Phase 2: Scenario Building and Validation	
Step 7	**Evaluation of RFID and the EPC Network opportunities** in the PVC with respect to the product (level of granularity), to the firms involved in the network and to the specific activities in the PVC
Step 8	**Evaluation of potential RFID-EPC Network applications including scenario building** and process optimization (“As could be”) **(HOW within and between organizations?)**
Step 9	**Mapping of intra- and inter-organizational processes integrating RFID technology and the EPC Network**
Step 10	**Validating business and technological processes integrating RFID technology and the EPC Network with key respondents** Feasibility analysis and evaluation of the challenges including ERP and middleware integration and process automation
Phase 3: Scenario Demonstration and Analysis	
Step 11	**Proof of concept (POC) in laboratory simulating RFID-EPC Network physical environment and interface between supply chain players:** Feasibility demonstration and evaluation including ERP and middleware integration and process automation at all the supply chain members’ level **Proof of concept post-analysis and decision to go for the** beta test replicating POC scenarios in a real-life setting
Step 12	**Pilot** replicating POC scenarios in a real-life setting and evaluation of anticipated vs. realized benefits and impacts of RFID-EPC Network. **Appropriation by the different organizations involved and their staff members**

The first six steps correspond to an initial phase that could be broadly termed the “opportunity-seeking phase.” Step 1 represents the starting point, with a thorough assessment of the corporate motivations underlying the adoption of RFID technology and the EPC Network. Steps 2 and 3 allow a sharper focus on specific critical activities that will be targeted in the implementation of this technology. Steps 4, 5 and 6 reflect the current situation in terms of supply chain dynamics and existing intra- and interorganizational business processes.

The second phase – scenario building and validation – evaluates specific RFID and EPC Network opportunities (step 7) and assesses the potential of RFID and EPC Network applications (step 8). Step 8 represents a turning point where both business and technological concerns are evaluated. For business concerns, several questions need to be answered: How will firms in the network handle their respective activities? What would change in terms of activities, processes and organizational structure? Which products and product levels should be targeted? What information should be captured concerning the product and its accessibility on the network? Which application should be adopted? In parallel, other questions address the technological concerns: How will the existing IT infrastructure be impacted? What are the characteristics of the product to be tagged? How much information is required? Which application is to be used (i.e. read/write, distance, speed, security, etc.)? The answers to these questions allow one to map redesigned business processes integrating RFID technology and the EPC Network (step 9). Finally, in step 10, business and technological processes integrating RFID technology are validated with key respondents.

The third and final phase of the research design is used for the demonstration and analysis of scenarios retained in the second phase, both in controlled conditions (proof of concept – step 11) and in a real-life setting (step 12).

3.2 Research sites

Four firms participated in this field study, namely a focal firm we call Firm X, two first-tier suppliers and one retailer.

3.2.1 Firm X's profile

Firm X is one of the largest North-American-owned beverage companies, with almost 6,000 staff members and annual revenues of approximately $2.8 billion. The firm owns many large distribution centers. An overall volume of 15 million cases transit through the firm every year. Of these, 2.7 million cases pass through the docks of the distribution center where the field study was performed. Firm X relies on bar code systems to track the cases. In addition to bar code systems, the firm uses various business applications (e.g. ERP, WMS, TMS, B2B Web portal). The TMS is linked to a GPS (Global Positioning System). Firm X also has a LAN to optimize its intrabusiness processes and communications. The firm also uses an EDI server to communicate with some suppliers and retailers.

3.2.2 The two first-tier suppliers' profiles

These two first-tier suppliers are bottling plants that deliver their production to Firm X each day. They use a paper system, e-mail and fax to exchange business documents with Firm X. In both cases, employees in Firm X have to re-enter delivery documents sent by these suppliers into their business applications during the receiving process. This increases document processing errors and results in inaccurate data. These two first-tier suppliers use bar codes provided by Firm X to identify pallets, and do not have any means of tracking their products once they leave their facilities.

3.2.3 The retailer's profile

The retailer chosen for on-site observations is one of North America's biggest companies in its sector, with almost 30,000 employees and six distribution centers. In addition to e-mail, the firm uses files, databases, LAN, ERP and WMS to support its intra- and interorganizational business processes. One of the biggest challenges facing the relationship between this retailing firm and the focal Firm X is the recurrent discrepancy between the quantities sent by Firm X and those received at the retailer's dock. The elimination of this inventory discrepancy was one of the initial motivations of the focal Firm X and the retailing firm to look into the potential of the RFID technology.

In addition, the managers of all four firms involved in this field study had already been approached by some consulting companies and were aware of the other potential benefits to be derived from the implementation of RFID Systems (and EPC Network opportunities). Their initial motivations were focused on the reduction of inventory and warehousing costs within the supply chain. During the first focus group (which also included academic researchers and private and technological partners) (step 1), they clarified their initial strategic intent with the need to reduce lead times and to respond faster to changing market demands. In other words, their primary motivations dealt with issues related to a lean and agile supply chain.

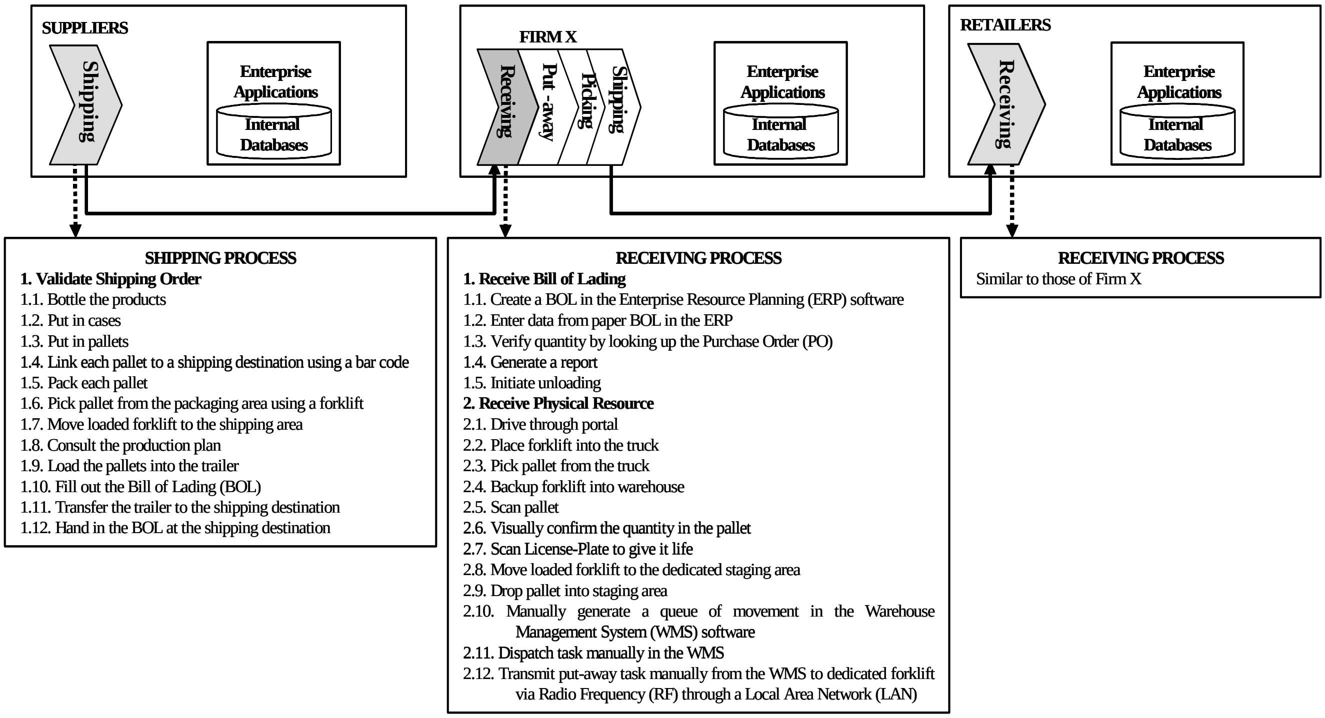

Figure 1. Actual Inter-and Intra Processes.

3.3 Data collection

Data collection for the case study was based on:
(i) *Focus groups* conducted in the university-based research center with nine functional managers and IT experts. The focus groups allowed to reach a consensus on strategic intent with respect to the use of RFID and the EPC Network in one product value chain (steps 1, 2 and 3) and, to evaluate different scenarios and select the "preferred" or "as could be" scenario (steps 7, 8 and 9). Each step of the methodology was evaluated and agreed upon with members of the focus groups.

(ii) *On-site observations* in the four research sites where performed in order to carry out the process mapping required for steps 5, 6 and 9. While some steps required more interactions (e.g. step 6 where the research center explained to partners its approach and methodology in order to identify RFID and EPC Network opportunities), others (e.g. step 7) where mostly partner "preferences." For example, the Director of the Logistics and Distribution division (Firm X) mentioned that tracking had to be done at the pallet and box level in order to maintain visibility of the boxes (from suppliers) while they are de-palletized and re-palletized for mix pallets (in Firm X), prior to being shipped to different customers

The researchers acted as observers, interviewers and facilitators (for focus groups). They also developed and presented the detailed scenarios that were developed from the empirical evidence gathered in the four research sites. Industrial reports and internal documents such as process documentation, procedures, ERP screens and a wide range of other technical or non-technical documents were also used when available.

4 Results and discussion

In this paper, we will present and discuss only the empirical results obtained from steps 5, 6 and 9 of the methodology using the suppliers' "shipping" process and Firm X's "receiving" process. These three steps build on the results obtained in the previous ones and represent the validated output of phases 1 and 2 of the field study, namely opportunity seeking and scenario building.

All three steps also correspond to the mapping of current business processes (actual situation) (steps 5, 6) and redesigned processes integrating RFID technology and the

EPC Network (steps 8, 9). The process view retained here provides (i) "a more dynamic description of how an organization acts" (Magal et al., 2001 p. 2), and (ii) a structured approach and a "strong emphasis on how the work is done" (Davenport, 1993 p. 5), which enables field participants to validate the research outputs. The process view is also increasingly used to evaluate the impact of information technology (Subramaniam, 2004).

4.1 Actual business processes

In Figure 1, processes are drilled down from the more general to the more detailed.

Based on the analysis of the actual inter- and intra-organizational processes in that figure, the following observations are made: (a) the overall "shipping" and "receiving" processes consist respectively of 12 and 17 second-level processes. (b) Most existing processes involve numerous interventions by the employees such as data input (e.g. 1.2. in the "receiving" process), pallet scans (e.g. 2.5. in the "receiving" process) or visual count of boxes in each pallet (e.g. 2.6. in the "receiving" process). (c) In addition, processes involved in "shipping" and "receiving" seem to fall into four categories, namely, (i) interaction of a machine with a product, or machine-to-product (e.g. 1.1. in the "shipping" process); interaction of a human with a product, or human-to-product (e.g. 1.4. in the "shipping" process); (iii) interaction of a human with a product via a machine, also called human-to-machine (e.g. 1.7. in the "shipping" process); and (iv) interaction of a human with another human, or human-to-human process (e.g. 1.12. in the "shipping" process).

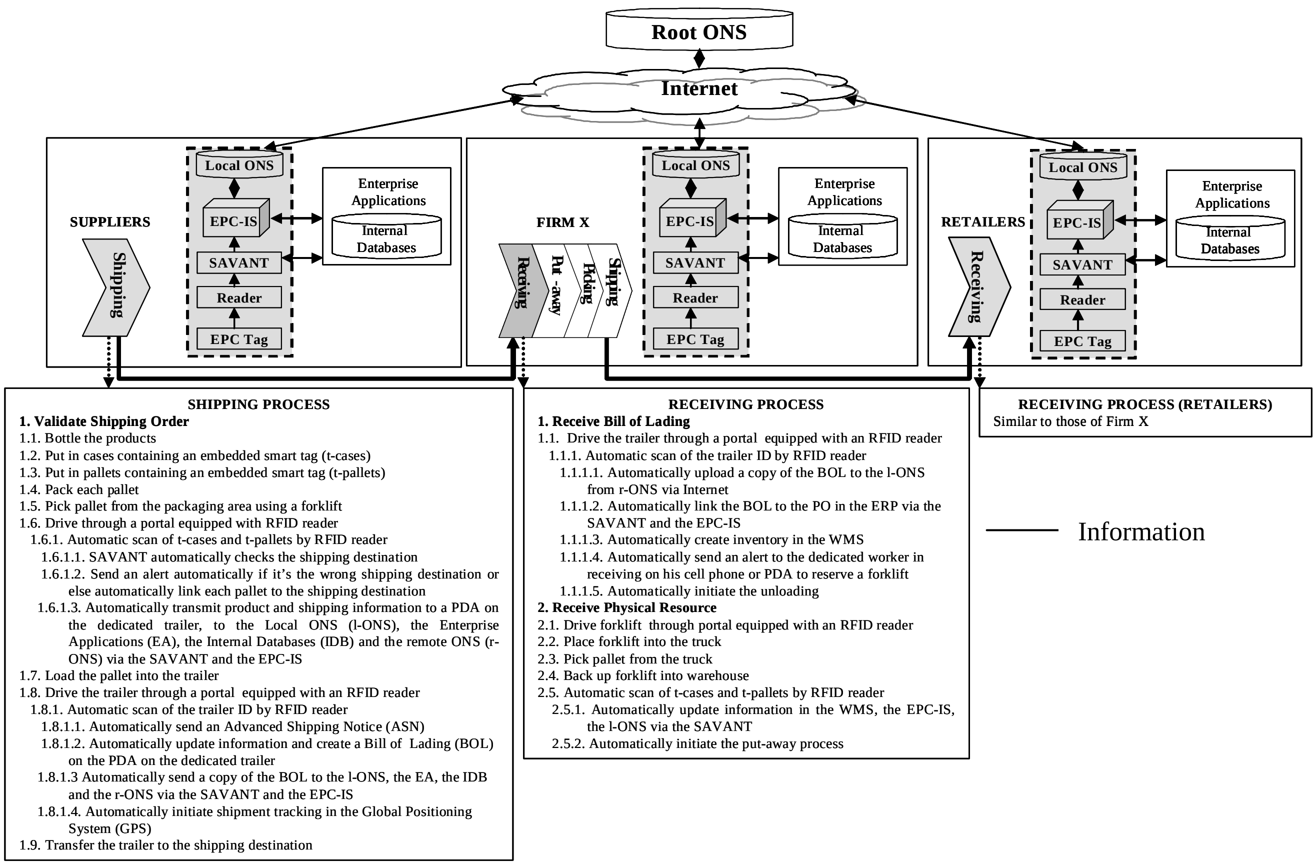

Figure 2. The impact of RFID and the EPC Network on the "shipping" and "receiving" processes.

4.2 Retained scenario integrating RFID and the EPC Network

The retained scenario (steps 8, 9), integrating the RFID technology and the EPC Network was thoroughly validated with the focus group. Based on this proposed scenario and the actual situation, a comparison was made and the following observations allowed us to analyze the impact and understand the resulting opportunities (Figure 2).

4.2.1 General observations

(i) RFID systems offer a standardized SKU which can be shared by all actors of the EPC Network. (ii) Each actor of the supply chain can, at any time, anywhere, access product information from the remote ONS via the local ONS. (iii)New categories of business processes are emerging.

4.2.2 Specific observations

a) The number of observed processes in "shipping" for the supplier changes from 12 second-level processes in the actual process to 9 second-level, 2 third-level and 7 fourth-level processes with RFID technology and the EPC Network For the "receiving" process in Firm X, the number of observed processes is also affected. Indeed, this number dropped from 17 second-level processes in the actual process to 6 second-level, 3 third-level and 5 fourth-level processes with RFID technology and the EPC.

b) All information-based processes (e.g. 1.1.1.1, 1.1.1.2, 1.1.1.3. in "receiving") are now automatically performed. In fact, the use of RFID technology and the EPC Network automates verification procedures during receiving and provides accurate information at a very high level of granularity (pallet, box); this information can then be shared among the whole supply chain. RFID and EPC can also eliminate almost all paper-based documents generated in the traditional receiving process.

c) In the "shipping" process, we can observe the disappearance of the human-to-human category (1.12.) and the appearance of new intelligent processes, namely, processes that are triggered by other processes (process-to-process) (e.g. 1.6.1.1., 1.6.1.2., 1.8.1.1., 1.8.1.2.) and processes which can trigger a machine action (process-to-machine) (e.g. 1.6.1.3, 1.8.1.3., 1.8.1.4.). In process 1.6.1.2., the "intelligent" management of outbound products makes it possible to avoid false shipments of products, and thus increase customer satisfaction and lower labor costs in the warehouse.

d) With regard to the "receiving" process in Firm X, the trigger for the whole process is the arrival of the truck. As soon as the truck passes the gate equipped with an RFID reader, it is read (machine-to-machine process 1.1.1.) and the information collected is distributed throughout the whole supply chain. At this point, it is possible to check whether inbound products have been ordered. If not, the dedicated employee at the receiving dock can refuse to let the arrival truck in, and thus avoid unnecessary unloading.

e) In addition, time-consuming activities such as data entry (e.g. 1.2. in the "receiving") and manual scanning (e.g. 2.5. and 2.7. in the "receiving") are now automatically performed using RFID readers, and thus avoid the possibility of human errors. Consequently, improving the quality and integrity of information in the supply chain.

f) Moreover, the use of RFID technology and the EPC Network enhances the information exchanged by different actors of the supply chain. Indeed, as soon as the truck leaves the shipping dock at the supplier's facilities, the truck, pallets and cases equipped with the EPCs are read by RFID readers, and an ASN is automatically transmitted to the remote ONS of the EPC Network via the local ONS and to Firm X. This increases visibility among all supply chain partners, making it possible to have the right product at the right time in the right place.

g) In addition, when the truck arrives at its destination, it is automatically scanned by the reader and all information about products is automatically downloaded from the remote ONS of the EPC Network to Firm X's local ONS and to the enterprise information systems. All these processes occur without any human intervention.

h) Furthermore, RFID technology and the EPC Network, coupled with a messaging technology such as e-mail, offer the possibility to send an alert to a dedicated employee to reserve a forklift during the "receiving" process (process-to-human) (1.1.1.4.) or whenever urgent deliveries arrive.

i) Finally, RFID technology and the EPC Network enable electronic integration of all firms involved in the supply chain. Indeed, any actor in the supply chain can, at any time, anywhere, obtain continuously updated product information from the remote ONS via the local ONS. In fact, product flows are totally synchronized with information flows. It is now possible to generate, automatically and in real time, all the information necessary for e-procurement, e-billing, e-forecasting, e-replenishment, from the local ONS and the EPS-IS and thereby enable intelligent management of B-to-B eCommerce processes.

5 Conclusion

By presenting RFID technology and the EPC Network by focusing on business processes, the paper departs from previous work. Results highlighted many SCM opportunities specially in terms of business process optimization, through reduction in employee information manipulation, and thus, contributing to cost savings. These may help retail companies to enhance product availability, which is a major concern and still represents almost US $31.3 billion in opportunities each year in terms of cost reduction regarding inventory shrinkage (Srivastava, 2004). Indeed, the EPC Network can provide the product EPC code at any point in the supply chain, in real time, thus improving the supply chain's end-to-end visibility.

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7 References

Abernathy, F.H., Dunlop, J.T., Hammond, J.H., and Weil, D. (2000). Retailing and supply chains in the information age. *Technology in Society*, Vol. 22, pp. 5–31.

Asif, A. and Mandviwalla, M. (2005). Integrating the supply chain with RFID: A technical and business analysis. *Communications of the Association for Information Systems*, Vol. 15, pp 393-427.

Bendavid, B. and Bourgault, M. (2005). Positioning project management for RFID implementation in a multi-firm, multi-project context. *In Proceedings of the International Association of Management of Technology (IAMOT'05)*, Austria, Vienna, May 2005.

Bendavid, Y., Lefebvre, É., Lefebvre, L.A. and Fosso Wamba, S. (2007) B-to-B E-commerce: assessing the impacts of RFID technology in a five layer supply chain. *In Proceedings of the 40th Annual Hawaii International Conference on System Sciences (HICSS'07)*, Big Island, Hawaii, January 2007: 143.

Capone, G., Costlow, D., Grenoble, W.L. and Novack, R. A. (2004).The RFID-enabled warehouse. Center for Supply-Chain Research, Penn State University.

Coates, V.T. (1992). The future of information technology. *The Annals of the American Academy*, Vol. 522, pp. 45-56.

Collins, J. (2004). Metro launches RFID test center. *RFIDJournal*: http://www.rfidjournal.com/

Davenport, T. H. (1993). Process innovation, reengineering through information technology. Ernst & Young, Center for Information Technology and Strategy, ed., Harvard Business School Press, 1993.

EPCglobal. (2004). The EPCglobal Network: http://www.epcglobalinc.org/home

Fleisch, E. and Tellkamp, C. (2005). Inventory inaccuracy and supply chain performance: A simulation study of a retail supply chain. *International Journal of Production Economics*, Vol. 95, No. 3, pp. 373-385.

Floerkemeier, C., Anarkat, D., Osinski, T. and Harrison, M. (2003). PML Core Specification 1.0. Auto-ID, Cambridge: http://www.autoidlabs.org/

Fosso Wamba, S., Lefebvre, L.A., Bendavid, Y. and Lefebvre, É. (2007). Exploring the impact of RFID technology and the EPC Network on mobile B2B eCommerce: A case study in the retail industry, *International Journal of Production Economics, Special Issue on RFID: Technology, Applications, and Impact on Business Operations*, to appear.

Geng, Y. and Sirkka, L.J. Trust and radio frequency identification (RFID) adoption within an alliance. (2006). *In Proceedings of the 38th Annual Hawaii International Conference on System Sciences (HICSS'05)*, Hawaii, Kauai, January 2006.

Hilty, L. M. (2005). Electronic waste – An emerging risk? *Environmental Impact Assessment Review*, Vol. 25, pp. 431-435.

Jones, P., Clarke-Hill, C., Hillier, D., and Comfort, D. (2005). The benefits, challenges and impacts of radio frequency identification technology (RFID) for retailers in the UK. *Marketing Intelligence & Planning*, Vol. 23, No. 4, pp. 395-402.

Kärkkäinen, M. (2002). RFID in the grocery supply chain – A remedy for logistics problems or mere hype?: http://www.ecr-academics.org/

Kärkkäinen, M. (2003). Increasing Efficiency in the Supply Chain for Short Shelf Life Goods using RFID Tagging. *International Journal of Retail &*

Distribution Management, Vol. 31, No. 10, pp. 529-536.

Kärkkäinen, M., Holmstrom , J., Framling, K., and Artto, K. (2003). Intelligent products - a step towards a more Effective Project Delivery Chain. *Computers in Industry*, Vol. 50, No. 2, pp. 141-151.

Keith, A., Tig, G., Gramling, K., Kindy, M., Moogimane, D., Schultz, M., and Woods, M. (2002). Focus on the supply chain: Applying Auto-ID within the distribution center. Auto-ID, Cambridge.

Lefebvre, L.A., Lefebvre, E., Bendavid, Y., Fosso Wamba, S. and Boeck, H. (2005).The potential of RFID in warehousing activities in a retail industry supply chain. *Journal of Chain and Network Science*, Vol. 5, No. 2, pp. 101-111.

Magal, S. R., Simha, R., Feng, M., and Essex, P. A. (2001). An exploratory study of Web-based electronic commerce applications. *Journal of Information Technology Theory and Application*, Vol. 3, pp. 139-149.

Ngai, E. W. T., Cheng, T. C. E., Au, S. and Lai, K.-H. (2005). Mobile commerce integrated with RFID technology in a container depot. *Decision Support Systems*, Vol. 43, No. 1, pp. 62-76.

Roberts, C.M. (2006). Radio frequency identification (RFID). *Computers & Security*, Vol. 25, No. 1. pp. 18-26.

Sheffi, Y. (2004). RFID and the innovation cycle. *International Journal of Logistics Management*, Vol. 15, No. 1, pp. 1-10.

Smith, A.D. (2005). Exploring radio frequency identification technology and its impact on business systems. *Information Management & Computer Security*, Vol. 13, No. 1, pp 16-28.

Sparks L., and Wagner, B. A. (2003). Retail exchanges: A research agenda. *Supply Chain Management*, Vol. 8, No. 1, 17-25.

Srivastava, B. (2004). Radio frequency ID technology: The next revolution in SCM. *Business Horizons*, Vol. 47, No. 6, pp. 60-68.

Strassner, M., Schoch, T. (2004). Today's Impact of Ubiquitous Computing on Business Processes. Institute of Information Management of University of St. Gallen.

Subirana, B., Eckes, C., Herman, G., Sarma, S. and Barrett, M. (2003). Measuring the impact of information technology on value and productivity using a process-based approach: The case for RFID technologies. MIT Sloan Working Paper, December, 2003.

Subramaniam, C., and Shaw, M. J. (2004). The effects of process characteristics on the value of B2B e-procurement. *Information Technology and Management*, Vol. 5, No. 1-2, pp. 161-180.

Swartz, J. (2000). Changing retail trends, new technologies, and the supply chain. *Technology in Society*, Vol. 22, pp. 123-132.

Van Den Berg, J.P. and Zijm W.H.M. (1999). Models for Warehouse Management: Classification and Examples. *International Journal of Production Economics*, Vol. 59, pp. 519-528.

Vargas, M. (2004). Retail industry profile: Overview of the retail sector, 2004. http://retailindustry.about.com/

VeriSign. (2005). The EPC Network gets real. RFIDJournal: http://www.rfidjournal.com/