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ABSTRACT

This article provides some insights into Radio Frequency Identification (RFID) technology and the Electronic Product Code (EPC) Network and investigates their impacts as enablers of Mobile Business (M-Business). "M-business is the application infrastructure required to maintain business relationship and sell information, services, and commodities by means of the mobile devices". 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 in a pilot project 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) they can improve the "shipping", the "receiving", the "put away" processes and allow "in transit visibility", iii) they offer opportunities for process optimization through the automation or cancellation of non value added processes, and through the emergence of new "smart processes", iv) they foster a higher level of information synchronization, visibility and sharing between supply chain members; and v) they enable supply chain members to leverage their existing IS investments. The paper helps to improve our understanding of the real potential of RFID and the EPC Network for mobile business processes.

Keywords

Retail industry, wireless technologies, RFID project implementation, mobile commerce, mobile business, process optimization, supply chain visibility.

INTRODUCTION

This article draws on the Radio Frequency Identification (RFID) technology and the Electronic Product Code (EPC) Network to investigate their real impacts on m-business with the aim of improving our understanding of how RFID technology and the EPC Network can be integrated into a specific supply chain.

Mobile Business

"M-business is the application infrastructure required to maintain business relationship and sell information, services, and commodities by means of the mobile devices" (Kalakota and Robinson, 2002, p. 8). As a subset of m-business, mobile commerce (m-commerce), considered as an evolution of e-commerce (Strader et al., 2004) is defined as "business transactions conducted while on the move". M-commerce is a recent phenomenon and analyst's predictions are impressive. Indeed, the worldwide m-commerce revenues were US$14 billions in 2002 (Upkar and Vetter, 2002), and are expected to reach US$554.37 billion in 2008 (Yang, 2005). This promise is driven by i) the expansion of e-commerce and ii) the rapid evolution in wireless technologies and the rapid diffusion of mobile terminals (i.e. Personal Digital Assistant (PDA), mobile phone, blackberry, etc.) (Strader et al., 2004). For example, more than 800 million mobile terminals were in use worldwide in

2002 (Barnes, 2002) and among this number, almost 237 million have been involved in m-commerce during the same period (Upkar and Vetter, 2002). Also, in 2004, wireless applications were identified as the second priority by worldwide companies in terms of intention for new technology adoption (eMarketer, 2004). In this context, m-business is expected to have an even greater impact on organizations (Scornavacca et al., 2005) and their supply chain management.

RFID as a Wireless Technology

Even through RFID technology seems to have emerged recently, the concept is not new. It has its origins in military aircraft identification applications during World War II (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 (i) recent key developments in technology (i.e. microprocessors, readers, antennas, middleware, enterprise information systems, etc.) and (ii) 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 through the increasing number of academic papers 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), supply chain management and warehousing (Srivastava, 2004; Lefebvre et al., 2005), information systems (Geng and Sirkka, 2005), and decision support systems (Ngai et al., 2005).

RFID technology is classified as a wireless automatic identification and data capture (AIDC) technology (Swartz, 2000) (see figure 1 for details). The AIDC technologies range from bar coding, optical recognition, biometric, card technology, touch or contact memory technology and RFID technology.

Wireless technologies represent an emerging area of growth being at the core of most m-commerce applications (Ngai and Gunasekaran, 2005). Even though the terms "mobile" and "wireless" are used interchangeably, they are two different things. Mobile is "the ability to be on the move" (Mallick, 2003), positioning mobile device as any terminal that can be used on the move (e.g. PDA, Mobile phone or laptops), while "Wireless" refers to the transmission of data over radio waves, positioning wireless devices as any terminal that use a wireless network to either send or receive data (Mallick, 2003). Wireless network can be divided into four main categories (i) Wireless Personal Area Network (WPAN) which can be used to connect PCs, PDAs, mobile phones and Blackberry to detect each other and interact; (ii) Wireless Local Area Network(WLAN) which includes standards such as IEEE 802.11 also called Wireless fidelity (Wi-Fi). WLANs provide easy Internet or Intranet access to PCs, PDAs and laptops equipped with a wireless network card; in a location such as building, hotel, warehouse, etc., (iii) the Wireless Metropolitan Area Network (WMAN) provide similar opportunities with a wider area coverage, such as city, and finally (iv) Wireless Wide Area Network (WWAN), is used by most cellular phone companies and Global Positioning System (GPS). In general, wireless network are used to access data, resources, vital information and communication tools of the enterprise, anytime, anywhere.

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).

While RFID infrastructure comes in a large variety of designs, the choice of the appropriate tags, readers, antennas, motion sensors, etc., depends on the objectives of each business application. This would also be the case for system integration allowing the configuration of automated business processes (see Kärkkäinen et al., 2003), such as the confirmation of a receiving at a specific location.

Based on recent market research (Research and Markets, 2005) RFID market is expected to expand from US$1.95 billion in 2005 to reach US$26.9 billion in 2015 as different RFID applications become mature.

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, 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).

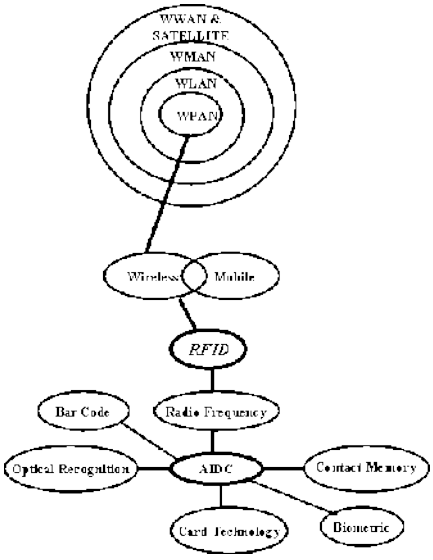

Figure 1. Positioning RFID in the Wireless and AIDC Landscape

In the retail context, supply chain management (SCM) is considered as an important activity where RFID technology and the EPC Network could have tremendous impacts. Indeed, the integration of wireless technologies to support business processes within a supply chain could have a significant impact on overall business operations (Kumar and Zahn, 2003), leading to competitive advantage in terms of cost reduction, supply chain responsiveness, and performance of supply chain functions (Eng, 2005) and, therefore impact the strategic management of all firms involved in the supply chain (Barnes, 2002).

The main thrust of this paper is therefore that RFID technology and the EPC Network could act as enablers of m-business.

THEORETICAL BACKGROUND

Current Context of the Retail Industry

A recent study by the U.S. Census Bureau estimated that the U.S. retail and food services sales for October 2005 were about $352 billion, an increase of almost 5.7 percent from October 2004 (Vargas, 2005). In fact, 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 a growing number of stock keeping units (SKUs) (Abernathy et al., 2000), the 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). Furthermore, manual capture of sales information increases transaction costs and can cause inventory inaccuracies (Fleisch and Tellkamp, 2005). 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).

In order to compete in this low margin sector, leading retailers around the world are moving toward the adoption of various information technologies (i.e. ERP, WMS, etc.), new customer-focused concepts to improve performance (e.g. VMI, CPFR, etc.) and finally AIDC to support their intra- and inter organizational business processes.

The last trend toward process optimization road map is driving major retailers and their supply chain members to explore RFID technology and the EPC Network potential.

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, as expected, major retailers such as Wal-Mart, Tesco or Metro AG are already achieving significant ROI. For example, a recent independent study conducted during 29 weeks shows that "Wal-Mart RFID-enabled stores" were 63% more effective in replenishing out-of-stocks than stores without RFID. Moreover, the researchers noticed 16% reduction in out-of-stocks, that products equipped with EPC tags were replenished three times faster than comparable items using standard bar code technology. Finally, manual orders placed by these stores were reduced by almost 10%, contributing to the overall inventory reduction (UsingRFID, 2005).

Among other potential applications of RFID technology and the EPC Network, these retailers are focusing on major area of costs savings such as (i) reducing out-of-stock through the supply chain (ii) improving tracking through warehousing and distribution centers and (iii) reducing inventory holding and carrying costs (Asif and Mandviwalla, 2005; Srivastava, 2004; Smith, 2005).

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). Since then the Metro Group had improve dramatically the read rate of RFID labels. In fact, according to Paxar (2005), this rate reached 100% at the pallet level.

With RFID the information needs to be shared in the whole supply chain in order for supply chain visibility. In fact, Wal-Mart and Target, which are competitors, are now cooperating in a pilot study to share EPC data with 13 manufacturers who supply them with consumer packaged goods (Trebilcock, 2005).

METHODOLOGY

Our study builds on previous work (Strassner and Schoch, 2004; Subirana et al., 2003) and focuses on a three-layer supply chain. 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.

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 11 consecutive steps (for a detailed version of the research design, see Lefebvre et al., 2005).

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 – 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).

The third and final phase of the research design validates the scenarios retained in the second phase, both in controlled conditions (proof of concept – step 10) and in a real-life setting (step 11).

Research Sites

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

Firm X's Profile

Firm X is one of the largest North-American publicly -owned Beverage Company, 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, confirming the ubiquitous presence of bar codes in the retail industry. Indeed, the use of bar code in the consumer packaged goods (CPG) industry has led to annual savings of almost $17 billion in 1997 (Kambil and Brooks, 2002). However, the bar code system often requires manual intervention and a line of sight is necessary in all cases. In addition to the bar code system, the firm uses various business applications (e.g. ERP, WMS, TMS). The TMS is linked to a GPS allowing "in transit visibility" of trailers at certain locations. 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.

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.

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.

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. The scenario-based design, as a concrete and flexible approach, was selected because it also promotes work-oriented communication among various stakeholders, allowing multiple views of a situation and "managing tradeoffs to reach usable and effective design outcomes" (Carroll, 1999, p. 1).

(ii) *On-site observations* in the four research sites 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) 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.

(iii) *Semi-structured interviews* in the four research sites with managers and operational personnel in order to obtain more detailed information and resolve a potential inaccuracy in the mapping of existing business processes (steps 5 and 6).

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 mapped with the *Aris Toolset*, procedures, ERP and middleware screens and a wide range of other technical or non-technical documents were also used when available.

RESULTS AND DISCUSSION

Within the scope of this paper, we will present and discuss 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 technologies (Subramaniam and Shaw, 2004).

Actual Business Processes

In Figure 2, 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 are mostly paper based and manual resources, thus involving 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).

Retained Business Processes and the Impact of Integrating RFID Technology and the EPC Network

Prior to discussing the proposed scenario it is important to consider that RFID tags have been installed by the focal firm suppliers on the products and pallets. Also, at the various locations in the supply chain, the readers are installed on the forklifts, allowing mobility of reading tags, receiving and transmitting information.

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, the following observations allowed us to analyze the impact and understand the resulting opportunities (figure 2).

RFID systems offer **standardized information** (i.e. SKU) which can be shared by all actors of the EPC Network, allowing the EPC tag to act as a mean for inter-organizational application implementation and integration. Thus, each actor of the supply chain can, at any time, anywhere, access this unique product information from the remote ONS via the local ONS.

RFID and the EPC Network can enable firms involved in the jointly agreed "electronic business model" to **leverage on existing IS investments** by providing them with accurate, standardized and real-time information, moving from a batch-based processing (ERP) to real-time based processing (ERP integrated with RFID and EPC network), allowing for real time decisions to support supply chain management.

Furthermore, "in transit visibility" of trailers would be enhanced, providing deeper level of information granularity by opening possibilities to track and trace trailers, its content (product location) and condition (temperature, position). The integration of the ERP, TMS, GPS, RFID and EPC network would fit the strategic direction of the company by fulfilling the mandatory requirements for high value products that need be "track and trace" at any location in the supply chain.

Process automation of manual activities like verification such as 1.3 in the "receiving" process, data entries such as 1.2 in the "receiving process", or 1.10 in the "shipping" process, thus providing more accurate information and very high level of granularity (pallet, box), also increasing processing speed.

Process cancellation of almost all the paper based activities such as 1.2 and 1.4 in the "receiving" process, 1.10 in the "shipping" processes, allowing operational improvements by removing potential mistakes caused by human error.

Process emerging also called "smart processes" triggered by automated events; for instance as soon as a truck leaves the shipping dock at the supplier facilities, an ASN is sent to the distribution center via the EPC network, also allowing "in transit visibility" through GPS tracking between supplier and DC.

Intra and Inter-organizational processes integration such as (i) the merging of receiving and put away during the receiving process, by automatically linking incoming product information to dedicated racks in the warehouse, thus reducing dramatically the need of staging areas (ii) the integration of processes such as the shipping from the supplier to the receiving

at the focal firm, linking incoming physical and digital (RFID tag) products to digital information received (ASN) through the EPC network from the supplier.

Information flow redefined with (i) **Synchronization** of product and information flow, merging of the physical market-place and the virtual market-space (with information attached to the product), (ii) **visibility** by gathering product information (place and condition) in the whole supply chain (intra and inter-organizational, and in-transit information), and (iii) **sharing** of information among all the supply chain players, using the same tags, but with different level of information accesses.

CONCLUSION

By presenting RFID technology and the EPC Network, this paper positioned these technologies as enablers of m-business. Although these emerging "electronic business models" may help retail companies to enhance product procurement, transportation, distribution, warehousing, etc, thus contributing to ensure product availability (by reducing out of stocks), and improving the supply chain's end-to-end visibility, their adoption and implementation may be challenging.

Indeed, at early phases of adoption, supply chain players will have to redefine their business strategy and revise their business relationship with their suppliers and clients, to jointly agree on various aspects of collaboration such as standards definition for technology infrastructure (e.g. tags, readers, middleware, software, etc), information requirements (e.g. information owners, information access, etc.) and for business applications. In brief, prior to any move toward m-business enabled by RFID-EPC network, they will have to "establish the ground rules for the collaborative relationship" similar to aspects collaborative planning, forecasting and replenishment processes (CPFR) (VICS, 2004, p. 7).

The next logical phase of the research design will be to validate the scenarios retained, in controlled conditions (proof of concept – step 10) and in a real-life setting (step 11). Finally, the specific setting (retail industry) of this study limits the generalization of the results, and it would be interesting to confirm them in other sectors.

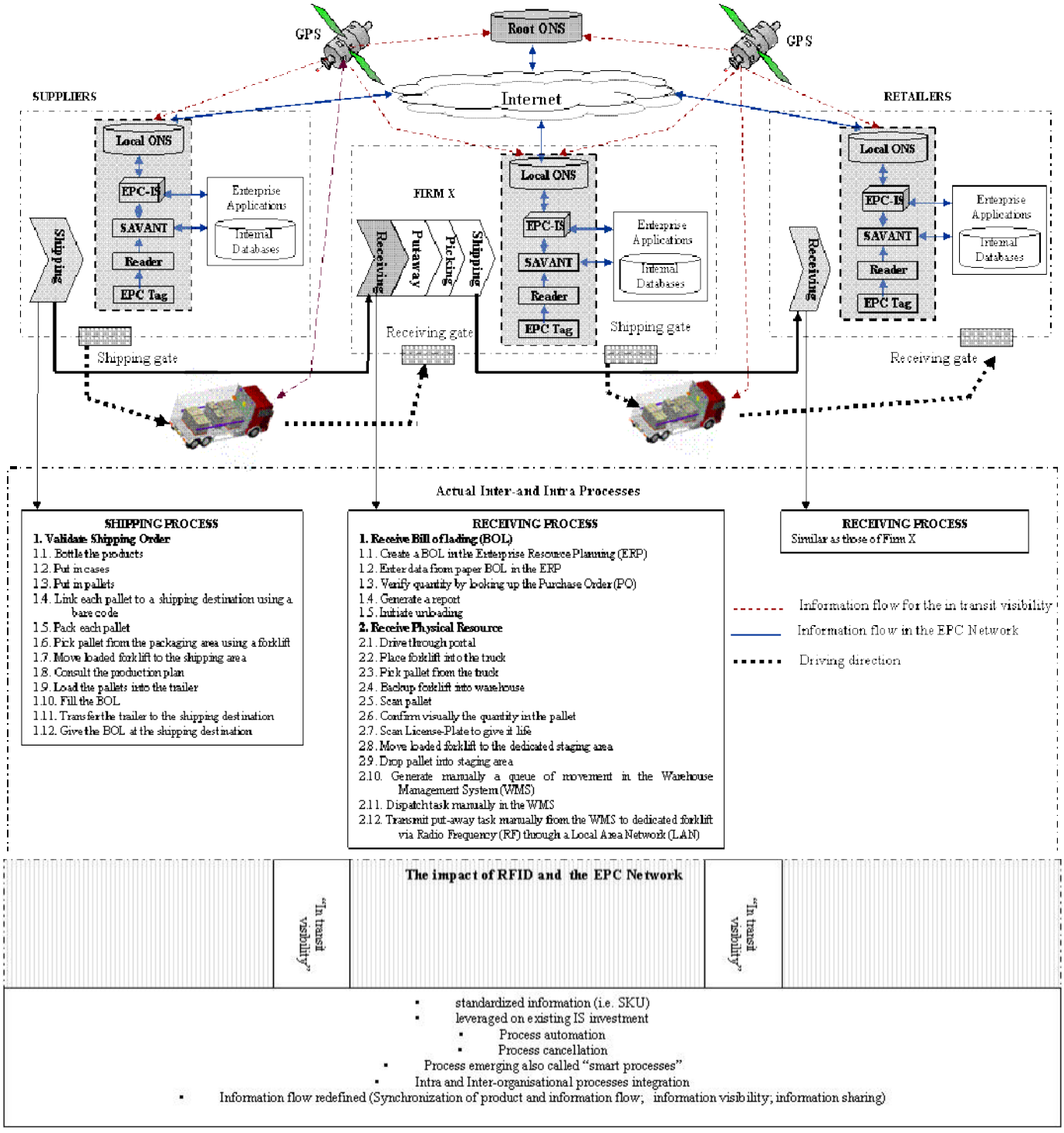

Figure 2. The Impact of RFID Technology and the EPC Network on the "Shipping" and "Receiving" Processes

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