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From Automatic Identification And Data Capture (Aidc) To "Smart Business Process": Preparing For A Pilot Integrating Rfid

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Keywords

RFID projects, supply chain management, middleware configuration, smart business processes

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1 Introduction

RFID (Radio-Frequency Identification) technology is considered as "the next big thing" in management (Wyld, 2006 p. 154) since the technology enables 1) the optimization of multiple business processes through the improvement, the automation or even the elimination of existing processes (Fosso Wamba et al. 2007; Strassner and Schoch, 2004) and 2) the emergence of new processes called "intelligent processes" or "smart processes" which are automatically triggering actions or events. The latter point represents one of the most promising benefits from RFID applications and is the focus of this paper.

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Over the last four years, RFID technology has received a great deal of attention which was initially triggered by mandatory requirements from major organizations in the US (e.g. Wal-Mart and US Department of Defense) and in Europe (e.g. Metro AG and Tesco). Since then, the motivations for RFID adoption have moved from mandatory compliance to voluntary undertakings as companies are increasingly exploring the true potential of the technology, especially in the context of supply chains. As stated by Pisello (2006, p. 1), "the network effects of a synchronized supply chain will result in numerous benefits, including improved scan reliability, process automation and real-time information access".

Recent key developments in technology with respect to hardware (i.e. integrated circuits, readers, antennas, printers) and software (i.e. firmware, middleware) have permitted to overcome some technical limitations of RFID applications. However, if the ability to capture automatically data has improved substantially, the capacity to manage efficiently this data, and transform it into business intelligence is still limited. As the marketing director of a RFID solution provider involved in our project mentioned "Today, second generation tags are revolutionizing the way data is captured. Companies that initially performed pilots a couple years ago were faced with multiple technological limitations such as limited reading performance. Today, the main focus should be on one core component of RFID systems, that is the middleware". While most supply chain managers have now some knowledge of what RFID technology is about, they do not yet grasp the full implications of the business process redesign entailed by RFID implementation, and their understanding of the required configuration in the middleware to optimize supply chain operations is still limited.

The main objective of the paper is to propose an approach for configuring and validating business rules in a RFID middleware. Relying on empirical evidence gathered from a detailed field study. The proposed approach will facilitate the dialog and bridge the gap between technical professionals and managers involved in RFID projects. This would in turn allow to better capitalize on the potential of RFID technology and eventually lead to more successful RFID implementation.

2 Background and context

2.1 The middleware as a key component of the RFID system

RFID technology is classified as a wireless automatic identification and data capture (AIDC). A basic RFID system is composed of a tag containing a microprocessor, a reader and its antennas, and a computer equipped with a middleware program, in which business rules are configured (Asif and Mandviwalla, 2005). The tag generally attached to a product communicates through radio frequencies with the reader's antennas. The reader sends the location and unique identification of the product to a computer. Based on preconfigured rules, the middleware can adjust or initiate business processes automatically.

RFID middleware is considered as one essential intelligence- added component of any RFID system and could be linked with other firm information systems (see Figure 1). More precisely, the middleware consists of the operating system, the data repository, and the processing algorithms that convert multiple tag inputs into visible tracking or identification data. The middleware could provide the following: (i) multiple reader configuration, control and monitoring; (ii) access coordination to an environment with multiple applications; (iii) receiving events generated by a reader; (iv) data filtering, smoothing and aggregating; (v) data routing to enterprise applications such as a Warehouse Management System (WMS), Enterprise Resource Planning (ERP), Transport Management System (TMS) or a Manufacturing Execution System (MES) (Floerkemeier and Lampe, 2005; Nurminen, 2006).

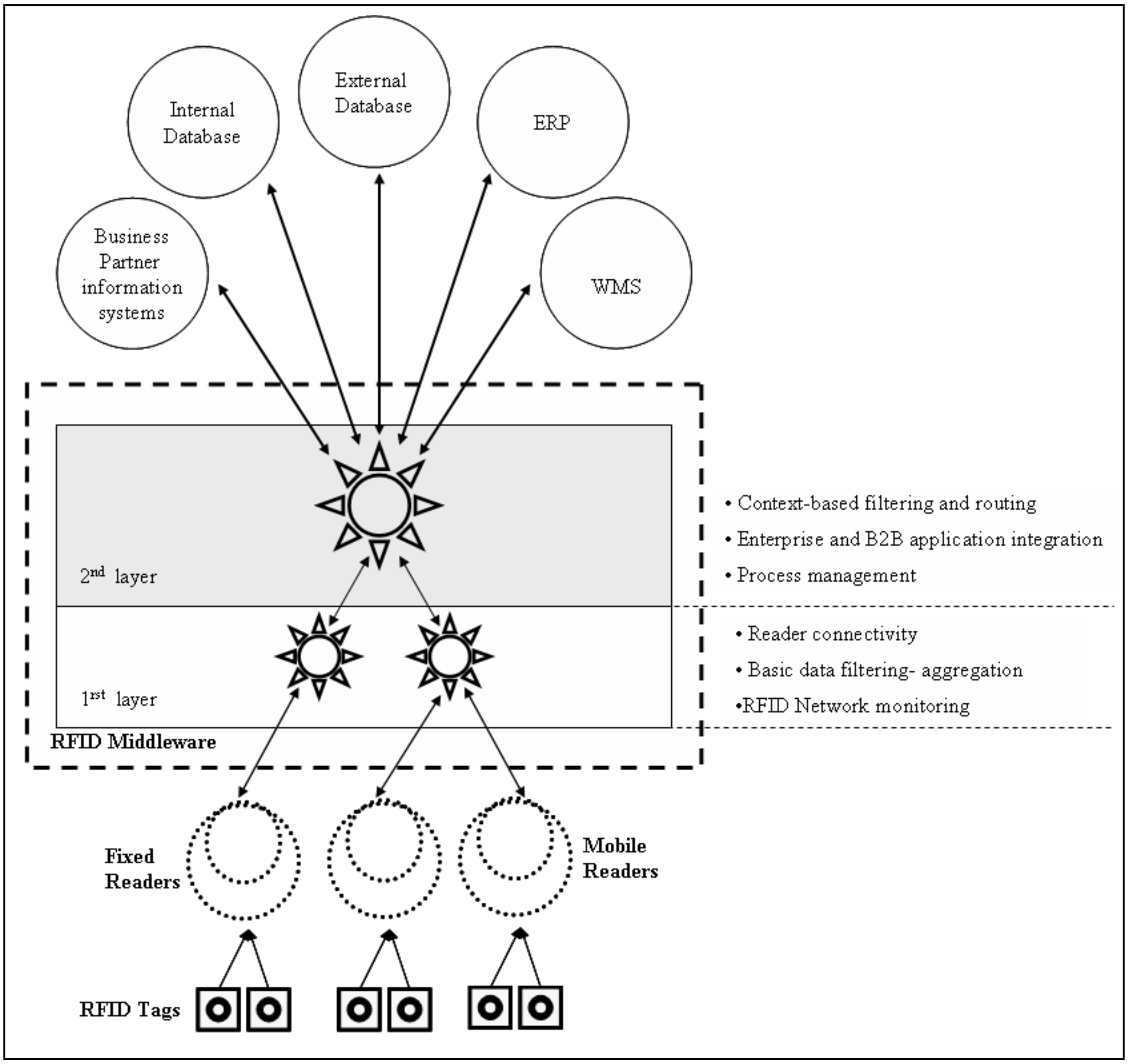

Figure 1: Positioning RFID middleware in an RFID system (www.forrester.com)

Driven by the rising number of RFID applications and by mandates from important players such as Wal-Mart, the US Department of Defense, Tesco, Target and Metro AG and from their own major suppliers, the market for RFID middleware has grown rapidly in recent years. O'Connor (2006) estimates that the global market for RFID middleware had expanded from 2004 to 2005 by almost 162%.Although the market for RFID middleware is estimated to reach for \$135 million in 2007 or roughly 3% of RFID systems revenues, it is projected to grow to almost \$1,557.5 million in 2011 (WinterGreen Research, 2005). The RFID middleware offering is characterized by the presence of numerous firms, ranging from (i) pure-play vendors such as GlobeRanger, and OATSystems, (ii) application vendors such as Manhattan Associates, RedPrairie, Oracle and SAP, (iii) integration specialists such as TIBCO Software and Ascential Software, to (iv) platform giants like Sun Microsystems, IBM, Oracle, and Microsoft (O'Connor, 2007).

Some of the major obstacles to widespread RFID adoption tend to disappear. First, the costs of an RFID middleware have decreased drastically, moving from about $125,000 per installed site a few years ago to $5,000 to $20,000 today (Nurminen, 2006). This downward trend positions RFID technology in a more affordable spectrum of potential investments and will eventually facilitate its adoption. Second, the current correct tags reading has reached 100% at the pallet level (Paxar, 2005) and is constantly improving at the item level. Third, chip technology has improved to a point where tags have become much more affordable. The concerns are now more focussed on middleware issues such as the capacity needs in order to manage large number of readers and the huge amount of data these readers generate (Floerkemeier and Lampe, 2005). In addition, the next trends in the RFID middleware will be more and more integrated with other technologies. For example, the integration with wireless technologies, such as Local Area Network (LAN), General Packet Radio Service (GPRS) and Global Positioning System (GPS) could enable real time tracking and tracing (LogicaCMG, 2004).

In all cases, "installing the software is only the start" (G X S, p. 11, 2005). Indeed, applications at the process level as well as the technical level need to be configured in the RFID middleware in order to trigger appropriate actions when specific events occur. Finally, the increasing concerns from supply chain members with the accuracy of inventory data and validity of RFID tagged items (O'Connor, 2004) can be effectively addressed by the RFID middleware which acts as a bridge between the "physical RFID world" and the "software RFID infrastructure".The middleware thus allows the automatic interpretation and the semantic transformation of observations generated from the automatic data collection on tagged items into business logic data prior to their integration into existing information systems (e.g. ERP, WMS) (Fusheng and Peiya, 2005).

Previous work on the role of the middleware in RFID applications within a supply chain context is still scarce but represents an emerging and fast growing area of research. Among the recent conceptual papers, Gunasekaran and Ngai (2005) suggest that RFID technology may facilitate the development of supply chain configurations by acting as an enabler of a build to order (BTO) strategy. In the same line of thought, Pramataris et al. (2005) suggest that RFID technology may constitute a link to more collaborative approaches such as CPFR (Collaborative Planning, Forecasting and Replenishment). Kelepouris et al. (2007) also suggests that RFID technology can act as an enabler of traceability in the food supply chain. While exploring the impacts of RFID technology in a retail supply chain, Lefebvre et al. (2005) also identify the emergence of "intelligent processes" to support RFID enabled Business-to-Business electronic commerce applications. Finally, Loebbecke and Palmer (2006) also examine the results of a joint RFID pilot project conducted between Kaufhof Department Stores, a leading European retailer and Gerry Weber, a fashion merchandise manufacturer. Results from the pilot study reveals that data derived from RFID technology about "products, processes, product movement, and even customer behaviour can be used for proprietary and distinctive capabilities to gain competitive advantage, if turned into understandable and usable "content"". The above mentioned work points to the overriding importance of middleware configuration and integration as a key aspect of RFID strategy.

2.2 Focus on business processes

IT (Information Technologies) and BPR (Business Process Reengineering) are strongly associated. BPR (Hammer and Champy, 1993) is considered as "a critical enabler of new operational and management processes" (Kohli and Hoadley, 2006 p. 41) and could be used for instance as a means to cut non-value-added activities and to improve competitiveness (Kohli and Hoadley, 2006). Yet, IT investments represent a major driver for changes in business processes, enhancing informational and coordination capabilities, and thus, leading to cost reductions and better customer services. IT and BPR could therefore be viewed as "complimentary factors and must be changed in a coordinated manner to improve performance" (Kohli and Hoadley, 2006 p. 42). In the particular case of EDI, Riggins and Mukhopadhyay (1994) showed that the alignment of business process and EDI adoption lead to better information sharing, and thus, higher firm performance.

In a supply chain context, Kohli and Sherer (2002) strongly suggest that in order to fully capture the benefits from IT investments, supply chain actors need to conduct major changes in their business processes by adopting a process approach. In fact, "when the process approach is used, other factors that affect the translation of IT assets to impacts are investigated more clearly" (Kohli and Sherer, 2002 p. 7). This process approach is also highlighted by many other authors (e.g. Mooney et al., 1996) when exploring that IT business value and its potential as an enabler of organizational processes and supply chain structure improvement. Finally, the business process approach has been promoted as an appropriate or even an ideal approach to study the impact of IT at a more detailed level by "investigating how IT use in one stage affects a downstream IT and other organisational effects" (Byrd and Davidson, 2003, p. 244).

More recently, some researchers such as Strassner and Schoch (2004), Subirana et al. (2003); Youngil et al., (2006); Lefebvre et al. (2005) and Bornhövd et al. (2004) show that automatic identification technologies such as RFID technology could have a strong impact on business processes. For instance, Lefebvre et al. (2005) used a process mapping methodology and found that RFID technology could be considered as a disruptive technology as it supports a new business model, entails major redesign of existing processes and fosters a higher level of electronic integration between supply chain members.

Our study builds on the business process approach and focuses on one supply chain in the retail industry.

3 Research design

As the main objective of this study is to improve our understanding of the role of the middleware as an intelligent interface supporting RFID applications, the research design clearly corresponds to an exploratory research initiative (Eisenhardt, 1989) and is grounded in real-life settings. The next sections briefly describe the industry and one of its supply chain, the research activities, the research sites and the data collection methods.

3.1 Choice of one supply chain in one industry

The current retail industry is highly globalized and facing fierce challenges: intense competition from powerful mega players (for instance, the ten largest American retailers' accounts for 65% of the US market share), increasingly sophisticated and customized demand from final consumers, and thin profit margins. Retailers have been relying on information technologies to lower their transaction costs, manage the explosion of the number of Stock Keeping Units (SKUs) within their stores, cope with high volume of daily transactions and automate manual processes (Fleisch and Tellkamp, 2005). Lately, they have turned to RFID technology and are considered as the lead users of this technology.

As a lead user, Wal-Mart is probably the most cited example in the retail industry: by adopting RFID, it would save annually almost $600 million and would in some cases cut by half its out-of-stock supply chain costs (Asif and Mandviwalla, 2005). RFID deployment at Wal-Mart is increasing at a rapid space. In fact, the number of Wal-Mart stores has increased from 100 stores in 2003 to 1000 stores in 2007 (Cecere and Suleski, 2007). Procter & Gamble represents another convincing example of rather successful deployment of RFID with estimated annual savings of almost $400 million for inventories (Srivastava, 2004) and reductions of out-of-stocks by half in some cases (Johnson, 2007). Yet, results are not as conclusive for all retailers RFID pilots since some have been delayed or even discontinued (Cecere and Suleski, 2007).

The retained supply chain under investigation in this paper (Figure 4.2) operates in the beverage retail industry.

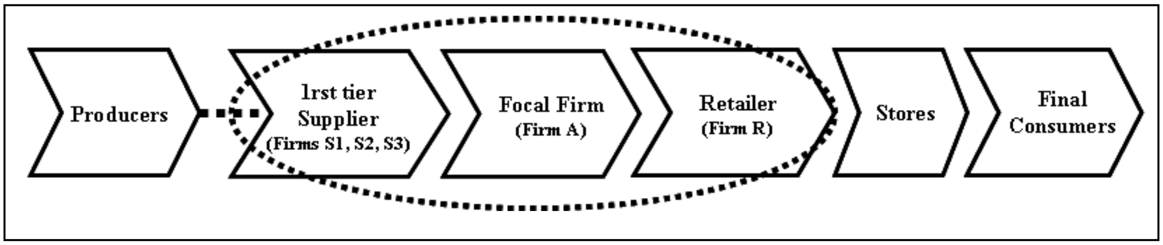

Figure 2: Focus of the field study in the selected retail supply chain

The focal firm, called here firm A, is considered as an important player with an overall annual volume of 15 million cases transiting through its Distribution Centers (DC), and with an average of 2.7 million cases passing through its docks and its business partners. The focus of the field study encompasses three layers as indicated in figure 2. Firm A indicated its primary motivations toward RFID technology were the reductions of warehousing costs (e.g. inventory) and the elimination of inventory discrepancies.

3.2 The field research and corresponding activities

The overall research project was conducted in four phases as indicated in Figure 3. Within the scope of this paper, results from phase 2 (i.e. scenario building and validation) and phase 3 (i.e. scenario demonstration) are presented. More specifically, results from steps 10, 11 and 12 which are directly linked to the middleware will be discussed in more detail. All data and information gathered in the previous steps served as an input to the subsequent steps. Although Figure 4.3 seems to indicate that research activities were conducted in a linear manner, a few iterations were actually necessary in order to reach a consensus among the participants.

Twenty four persons participated to steps 10, 11 and 12: seven key executives from the focal firm and its supply chain partners, namely three first-tier suppliers and one retailer, eight professionals and managers from technology firms (including the middleware developers) and nine members of the research teams. The role of the researchers ranged from full participants (when elaborating the technological scenario, for business rules configuration and testing in the middleware – i.e. step 10) and to full observers when activities 10, 11, or 12 were concerned.

Preliminary phase: vision and orientation	
Step a	**Choice of test bed based** on the partners accessibility openness, readiness, and, potential RFID applications
Step b	**Vision statement by** or with potential industrial and technological partners (focus groups).
Step c	**Identification of generic business applications and commitment** from strategic business partners to the research project.
⇓	
Phase 1: Opportunity seeking	
Step 1	Determination of the primary motivation towards RFID Understanding the primary motivation to consider the use of RFID 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 link between the network of firms supporting the product **(WHO and WITH WHOM?)**
Step 5	**Mapping of intra organisational processes for the identified opportunities as they are carried out now («As is»)**
Step 6	**Mapping of inter organisational processes for the identified opportunities as they are carried out now («As is»)**
⇓	
Phase 2: Scenario building and validation	
Step 7	**Evaluation of RFID 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 RFID potential applications including scenario building and process optimization («As could be»)**
Step 9	**Mapping and simulating of intra - and inter - organizational processes integrating RFID technology** Selecting specific process for the demonstration
⇓	
Phase 3: Scenario demonstration	
Step 10	**Proof of concept (POC) in laboratory** Configuring, testing and refining business rules in the middleware supporting selected processes

Step 11	**Demonstration of retained RFID enabled scenarios** using RFID infrastructure and evaluation of process redesign (e.g. automation, cancellation) at all the supply chain member's levels.
Step 12	**Demonstration of information system integration** (e.g. ERP and middleware)
Step 13	**Data analysis and decision to go** for the pilot replicating POC scenarios in real life setting
Phase 4: Real life implementation	
Step 14	**Pilot project in real life setting.**
Step 15	**Deployment of application and its appropriation by the different organizations involved and their staff**

Figure 3: Steps undertaken in the field study (Adapted from Lefebvre et al. (2005))

3.3 Research sites and data collection methods

The field study was carried on-site in the offices and distribution center of the five organizations involved as business partners in the chosen supply chain (see Figure 2) and in one university -based research laboratory. Both qualitative and quantitative data were collected. Figure 4 summarizes the different data collection methods and their use in the different research sites.

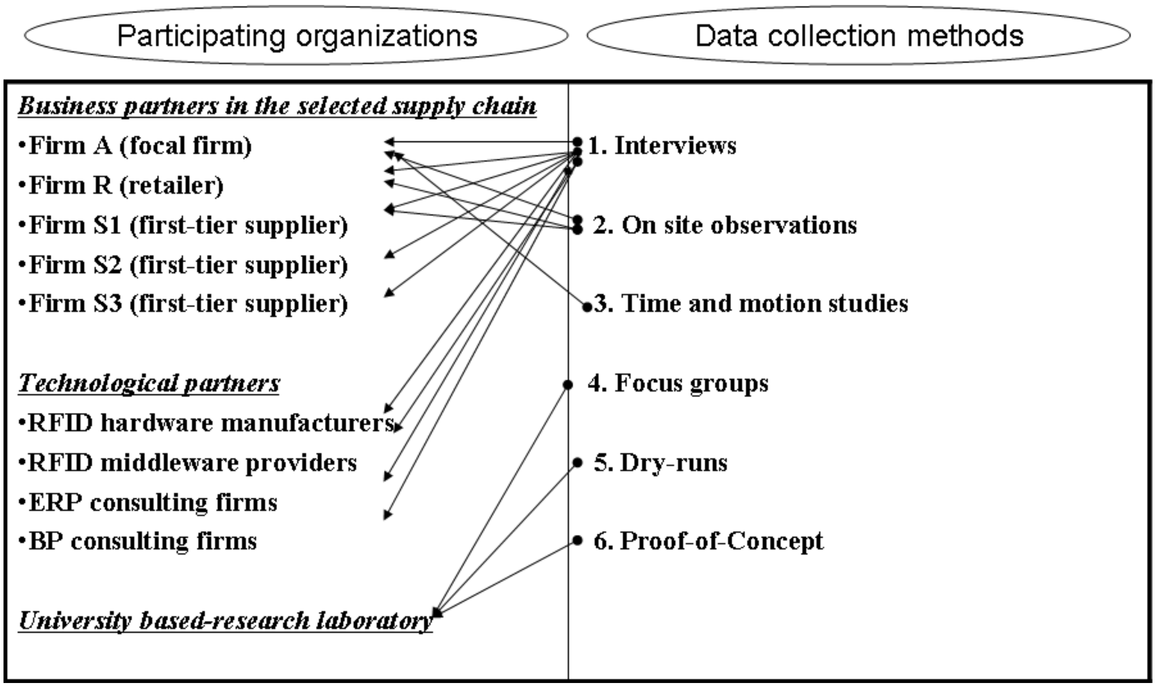

Figure 4: Research sites and corresponding data collection methods

4 Results and discussion

In this study, we have adopted a warehouse perspective in conformity with the choice of the managers of the focal firm A. This choice enables all participants to understand how the work is carried out within one type of a warehouse in order to fully grasp the impacts of implementing RFID technology. Four distinct warehousing activities are usually identified, namely the receiving, the put-away, the picking and the shipping (Van Den Berg and Zijm, 1999) that can benefit from RFID technology (Lefebvre et al., 2005).Within the scope of this paper, only the picking and shipping processes will be discussed. We will first describe the technological infrastructure (section 4.1) before presenting the underlying logic for the elaboration of the decision rules in the middleware (section 4.2). Finally, some examples of screen shots corresponding to these rules will be illustrated and discussed (section 4.3).

4.1 The technological infrastructure

Several RFID-enabled scenarios were tested in a university-based laboratory (Figure 5).

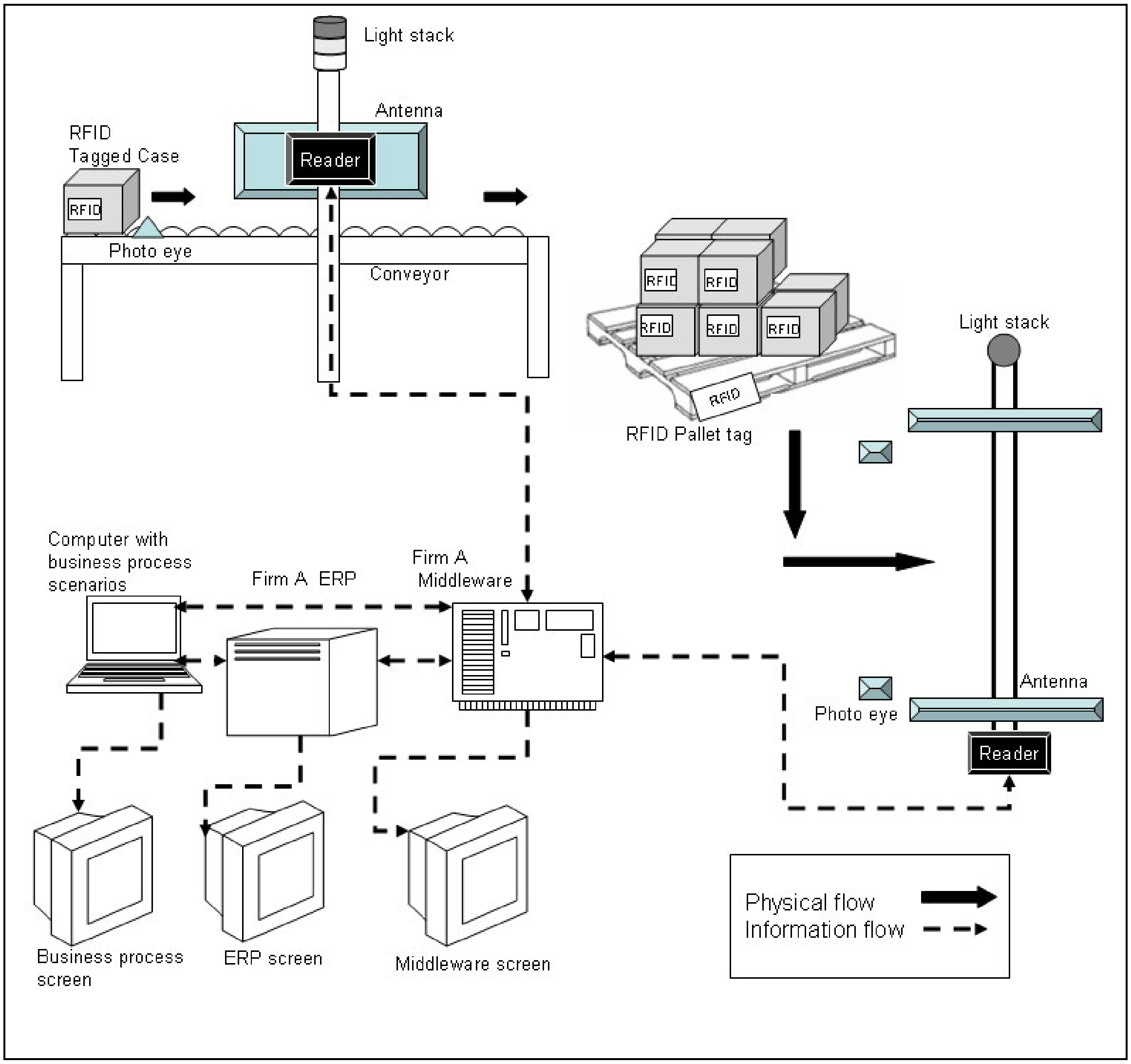

Figure 5: Technological infrastructure of the laboratory

The physical flow of products as depicted by the solid black arrows starts with a conveyor equipped with two antennas, one photo eye and one light stack (top left side of figure 5): this set-up simulates the picking process in the focal firm DC. The function of the photo eye is to automatically detect products equipped with an RFID tag and trigger the activation of the two fixed antennas thus allowing the antennas to be awaken and transmit radio waves when necessary. These two antennas are connected to a fixed reader that captures the information written on the tags and forwards it to the middleware. The stack light which is linked to the reader allows the confirmation of the status of the readings as the products pass on the conveyor belts. When the products reach the focal firm's shipping dock (right hand side of Figure 5) they go through another RFID equipped portal with two fixed antennas, two photos eyes and one light stack. Other technological options could be considered such as mounted RFID fork lifts or hand held RFID guns. Informational flows indicated in dotted arrows in Figure 5 link the readers to the firm 's middleware which then filters the information to the firm's ERP and-or other systems. The three screens display the different types of information available namely the RFID enabled business processes, corresponding ERP screens and the decision rules in the middleware.

4.2 The underlying logic for decision rules in the middleware

Figure 6 presents the decision rules that are or will be included in the middleware. The modelization used here corresponds to the EPC (Event-driven Process Chains) formalism which allows the logical representation of the activities within and between processes. An interesting aspect of the EPC formalism is that it highlights all the events that trigger the activities and the resulting sequence of events. Moreover, the modeling of a business process using EPC formalism uses three types of logical connectors (see bottom part of Figure 4.6) to indicate the workflow between activities and events, mainly the “^” (i.e. and), “v” (i.e. or) “XOR” (i.e. exclusive or).

In addition to the basic representation of a process using EPC formalism, it is possible to assign responsibilities of employees to a specific function, allocate a system which is used to perform the function (e.g. ERP, middleware), specify some business rules, assign them to logical connectors and quantify their probabilities of occurrence. The use Business Process Analysis (BPA) tools such as Aris Toolset was therefore required as it supports an extended view of eEPCs.

The overall picking process *The overall shipping process*

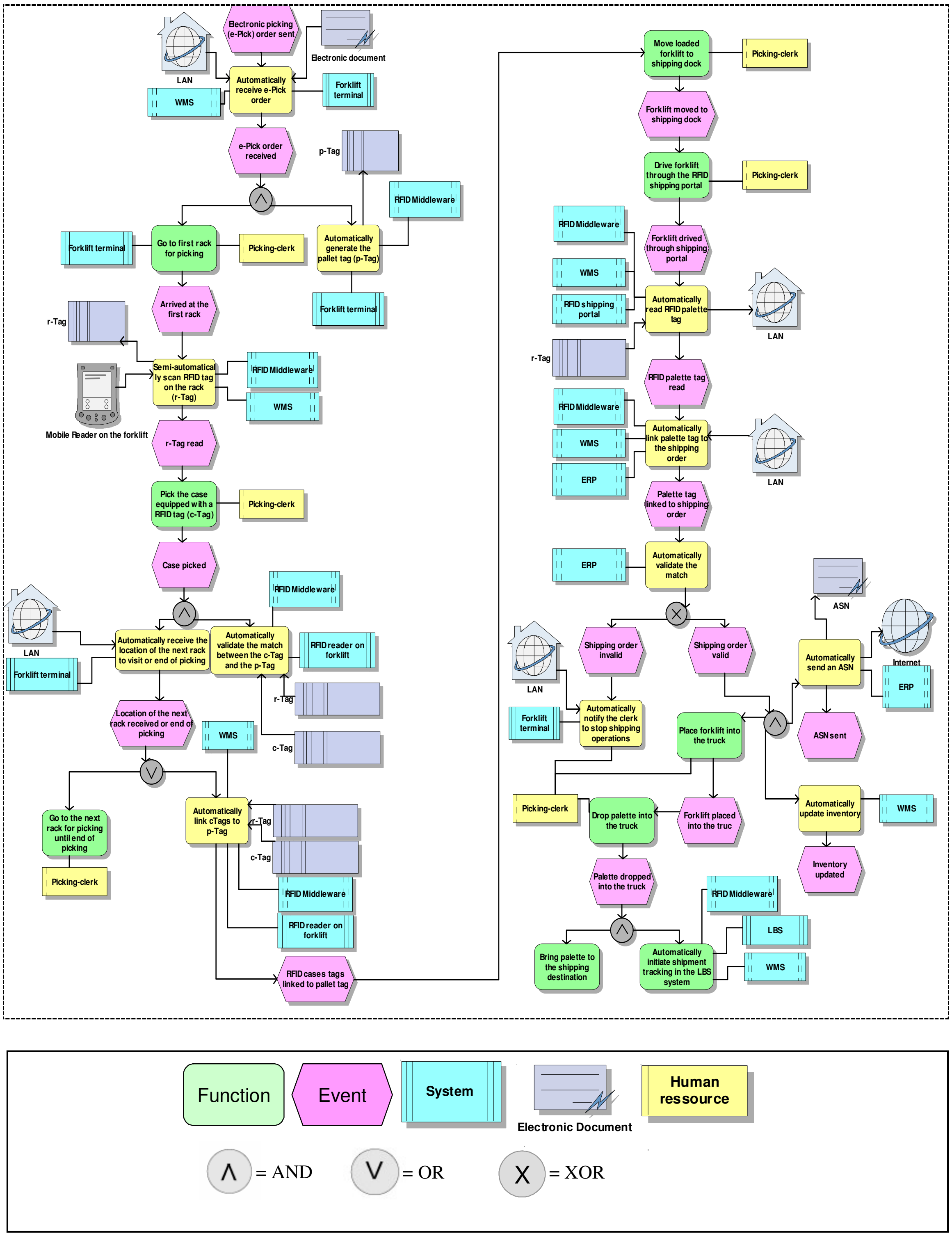

Figure 6: Decision rules for RFID-enabled picking and shipping processes

4.3 Examples of actions triggered automatically by the middleware

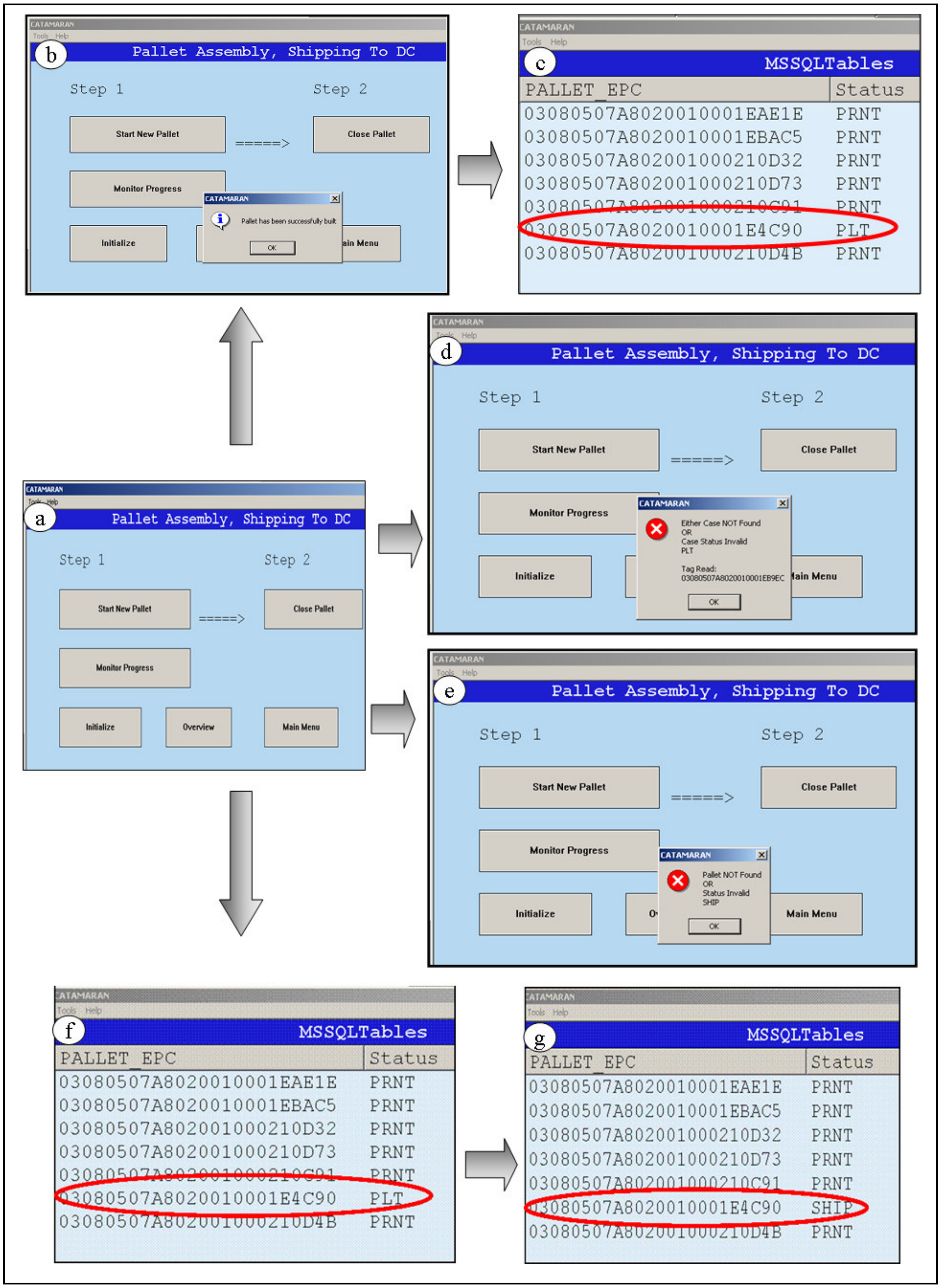

Figure 7: Business rules validation in the middleware and corresponding screen shots

For the scenario under investigation, the products are tagged at the case and pallet levels in order to ensure the product tracking when products are depalletized (upon receiving) and repalletized during the picking process. More precisely, it can be observed from Figure 7 that:

1. The picking process starts with the event ePick order which is received via an electronic document in the WMS and sent to a forklift clerk via a LAN. Upon reception of this order two functions are performed in parallel, namely (i) the automatic generation of a pallet tag (p-Tag) based on a number assigned by the middleware (screen shot (b), Figure 7) and (ii) the assignment of a picking order to a picking clerk (i.e. going to the first rack for picking). At this moment, the pallet status is automatically set to palletize (PLT) in order to specify its status and has all the information related to quantity of cases, types of products, customer ID (screen shot (c), Figure 7).

2. The connectors allow the modelization of the sequence of events as the picking clerk moves through the warehouse for the building of his pallet. At the assigned rack, the picking clerk scans the RFID tag (r-Tag) using a mobile RFID reader. As a case is picked, two activities are realized in parallel (i) the automatic reading and validation of the match between the case tag (c-Tag) and the pallet tag (p-Tag) in the middleware and (ii) the automatic location of the next rack to visit if the end of the picking process is not completed. If there is no match, an error message is automatically sent to the picking clerk (screen shot (d), Figure 7), resulting in improved picking accuracy and reducing very early in the process the probability of false shipment. Notice, that other configured rules such as horn alarm or indication by a stack light could be used. The conscious choice of mobile RFID reader for supporting the picking process addresses a key concern raised by the stakeholders who wanted to identify any problem at the rack level (and not at the shipping dock level) when using an RFID -enabled portal.

3. When the forklift drives through the shipping portal, the palette tag is automatically

read, and thus automatically linked to the shipping order. This in turn triggers automatically the validation of the shipping order by capitalizing on the information system integration (RFID middleware ERP WMS). If it is an invalid shipping order, based on a configured rule in the middleware, an automatic message is sent to the clerk to stop the shipping operation and thus avoid false outbound movement of goods (screen shot (e), Figure 7), thus reducing the probability of product discrepancies. In the case of valid shipping order, many other actions can be taken in parallel such as: (i) automatically send an Advance Shipping Notice (ASN) and update inventory; (ii) automatically initiate shipment tracking in the Location Based System (LBS); and (iii) automatically modify the status of the pallet from “PLT: palletized” to fit its new status (“shipped”), allowing real time tracking of the products. Because RFID tags have unique numbers, the same pallet cannot be shipped twice, since an error message such as "pallet not found" or "status invalid" will prevent such problem (screen shot (e), Figure 7).

Moreover, as the picking clerk takes the cases, the quantities are updated automatically (screens shots (h), (i) and (j), Figure 4.8). and when the pre-determined number of cases has been taken by the picking clerk depending on the initial circuit, the palette status moved from “PLT” to “closed pallet” meaning that the palette is ready to be shipped (screens shots (f) and (g), Figure 7).

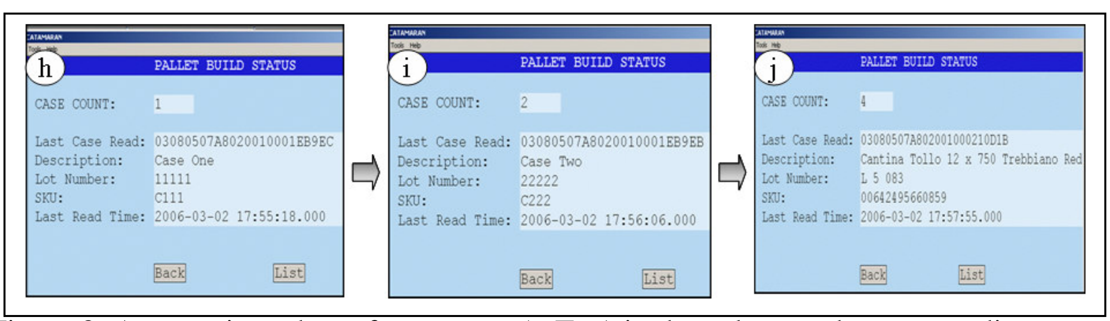

Figure 8: Automatic update of cases tags (c-Tag) in the palette and corresponding screen shots

The validation of the decision rules for the RFID-enabled picking and shipping processes as simulated in the above mentioned technological infrastructure (Figure 5) helped all participants to better understand the challenges and benefits of RFID systems and find a common ground for discussion.

5 Conclusion

In this paper, we examined the underlying logic behind the rules configured in a RFID middleware to support “smart business processes” in one retail supply chain. The validation of the retained scenarios integrating the RFID technology in the laboratory settings enable participants to validate the business rules configured in the middleware. Some implications emerge from the field research.

First, it reveals that the University based RFID laboratory can serve as a neutral environment to investigate the real impacts of RFID technology at the firm level and at the supply chain level), thus presenting a “win-win” situation where each player in the supply chain is willing to invest on the RFID infrastructure. This can reverse the current situation towards RFID adoption, where the supplier and manufacturers are required to absorb most of the RFID technology costs.

Second, the scenario validation which includes the configuration of business rules in the middleware came very late in the redesigning of the processes. In fact, prior to any configuration in the RFID middleware, firms need to conduct upfront homework in terms of identifying inefficient processes, ways to enhance them, redesign the new processes, validate them with key stakeholders (i.e. technology and business partners) and finally translate these processes in business rules to be configured. Moreover, this work has to be conducted at the firm level and also at the supply chain level, suggesting the importance of collaborating with their intra and inter organizational supply chain partner’s to agree on business rules. For instance, when considering intra organisational processes, all the key stakeholders agreed on a RFID-enabled scenario, later “translated” in a set of specific business rules that enabled the integration of selected processes (i.e. picking of an order and its shipping) that are conducted independently. In terms of inter organizational considerations, key stakeholders had to agree on issues such as the ways to organize the information flow between organization and how to ensure the integration of interrelated processes such as the shipping from the focal firm and the receiving at the retailer.

Third, flexibility is a key concern for the middleware configuration. As an example, the intelligence built in basic business rules could enable the same RFID portal to support multiple operational processes such as the "receiving" or the "shipping" of an order. In the laboratory settings, the use of ancillary devices such as photo eyes where used to indicate the presence and the direction of an object. By breaking the photo eye, a message is sent the reader as an indication to activate the antennas, read the tag number and send the information to the middleware as an indication to automatically perform a specific action attach to that rule. In real settings, the same logic could be replicated using similar ancillary devices such as motion captor. Moreover, in a warehouse environment other devices including screens and light stack can be used to facilitate the management "RFID transparent processes". A shipping clerk can validate its operation by looking at the visual confirmation sent through theses devices, which are in fact the results of processed information and transactions conducted in the middleware.

In terms of investment, the integration of flexibility in RFID infrastructure is the result of a laborious process that highlights the importance scenario building, validation (phase 2) and demonstration (phase 3). It is only by taking the time to assess each scenario and think of ways to include flexibility in the processes that firms can minimize their RFID infrastructure investment, by limiting the installation of costly readers and antennas. On the other hand, an alternative to the use of ancillary devices is the building of more intelligence in the middleware. For example when a tag is captured at a reading point in the warehouse, if it is not recognized, based on a basic rule (i.e. not created by the internal system) the transaction could automatically be considered as an incoming good and verification against an open ASN could be automatically realized to perform the "receiving" process. While building more intelligence in the middleware is a very interesting way to minimize the reliance on physical infrastructure, it is however very demanding in terms of defining, testing and validating the business rules. A cautious step by step approach such as the one undertaken should therefore be considered, starting with simple applications and building on the knowledge gathered from previous iteration to arrive to more complex applications.

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