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Impacts of RFID Deployment on Real Time Management of Retail Stores

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Abstract: The fast development of RFID and connective technologies is progressively changing the management of business units by introducing new challenges and appealing opportunities. In particular, promoters of connective technologies underline the abilities of these technologies to support decision making and, specifically, to increase supply chain performance. However, despite its huge potential, technology deployment does not ensure success unless it comes along with a reengineering process and appropriate integration efforts and tools. Keeping this in mind, this paper evaluates how different degrees of technology deployment impact the performance of retail stores and their relations with the rest of the supply chain.

1. INTRODUCTION

With the emergence of connective technologies such as RFID, wireless communication, internet, etc. and their increasing use in retail supply chains, retailers envision many potential benefits from the integration of these technologies inside the retail stores. However, since the product aggregation decreases from *pallet* to *case* and from *case* to *item* through the supply chain, retailers are facing the question of how the implementation of the connective technologies should occur in the stores (Harvey, 2003).

In addition, although the contribution of connective technologies to the evolution of the retail industry is well recognized, it involves important risks that are behind many retail failure stories (Kärkkäinen, 2004) (Hau *et al*, 2005). Investors are prone to gain from understanding the difference between adopting a connective technology as a mean to improve business processes and adopting it as a way to improve the retailer's business model. The former, which is more common, gives the wrong impression that just adopting such technologies will resolve all the retailer's existing problems and improve every facet of their business. The latter presents the adoption of connective technologies as an opportunity to review the old way of doing business and use such a technology as a tool, among others, to help improve the overall system. Instead of perceiving connective technologies as a magic formula, investors should assess reasonably the potential contributions of the technologies and focus on problems that can come up to the surface later.

In this paper we assess different configurations and levels of connective technology deployment in retail stores to provide a more elaborate and precise idea on the real advantages of connective technologies, as well as the potential gain from their adoption.

2. MAXIMIZING THE OUTCOME FROM CONNECTIVE TECHNOLOGIES IN RETAIL STORES

When adopting technologies, it is important to seek to maximize their benefits. The deployment of connective technologies, such as RFID, wireless communication and Internet, offers retailers a great opportunity to collect in near real time vast amounts of data concerning many business aspects and, in particular, about products and customers (Decker C. *et al*. 2003). Statistics and data mining tools can be used to extract from these data flows new information and knowledge to enhance management strategies, but we believe that the greatest contribution will result from the improvement of the real time store management and decision making. Indeed, faster reaction based on the analysis of the new data feeds may make the difference and justify the investment in such retail technologies. Connective technologies, in our opinion, have two major contributions: gaining more time for decision making and collecting more pertinent data. Making good use of these elements can bring numerous benefits to all stakeholders and change the face of the retail industry.

2.1 Collection of new kind of data and decision advantage

In the context of retail stores, connective technologies such as RFID are pushing the horizons of understanding customers and efficiently managing inventory, and are bringing logistics a step further by enabling live tracking of anything that carries a transmitter. For the first time, stores are able to trace and track their products individually in real time and consequently, monitor their detailed operations. Not only are they able to know which product entered or left the store, but they can also figure out exactly when it has

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been removed from the shelf, how many times it was touched and what was its path in the store.

In general, the tracking of products, customers, carts and employees is composed of two raw components: position and time. These two elements alone are not of great value unless they are tied to their context and their environment. In other words, an analytic effort is necessary in order to reach conclusions and produce high-level processed information from raw data. For example, knowing the position of a shelf and the current position of the products supposed to be displayed on it informs about its inventory level. Detecting a customer near a product in motion could mean that he is handling it. This last example shows that some conclusions could carry a certain degree of uncertainty. Fortunately, it is possible to increase the reliability of the results by different means such as artificial intelligence and integration of complementary technologies. For example, a smart cart equipped with a wireless computer may enable to get give clearer image on its content and on its operator. It is also possible to provide employees with mobile communication tools, in order to enable them to enter more pertinent information about their daily activities and to communicate with the central.

Since the most accurate information, on which the most precise forecasts are based, is that gathered at the point of sales (POS), the entire supply chain depends on stores to drive its overall operations and logistics. Future retail stores will be armed with powerful tools that will enable them to access new sets of pertinent, timely, finely-granulated and rich data that will give them more power through the supply chain.

2.2 *Time advantage*

In general, as shown in figure 1, an intervention process follows four main dependent steps: event, detection, decision and reaction[1]. Faster intervention after an event occurrence can be achieved by three means. First, detect events the earliest possible, an objective that could be achieved by adopting appropriate connective technologies such as RFID and accurate forecasts. Second, decrease the durations between detection and decision. Third, decrease the time between decision and reaction.

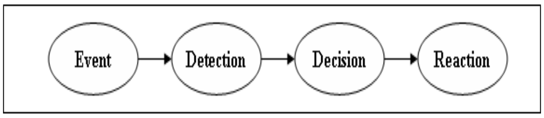

Figure 1: Reactive intervention process

[1] For the purpose of this paper, we simplified the decision process of Simon (1669)

2.2.1 *Decreasing the response time by using RFID*

The traditional comparison between RFID and barcode technology (Marsh 2003) is a good example to highlight the concept of detection time advantage. Whereas a barcode system enables the detection of a product removal from a shelf only when the customer pays at the checkout counter, item-level RFID implementation offers immediate detection at product handling. Therefore, RFID eliminates the detection delay occurred when using barcode technology, thus reducing the response time, as depicted in Figure 2.

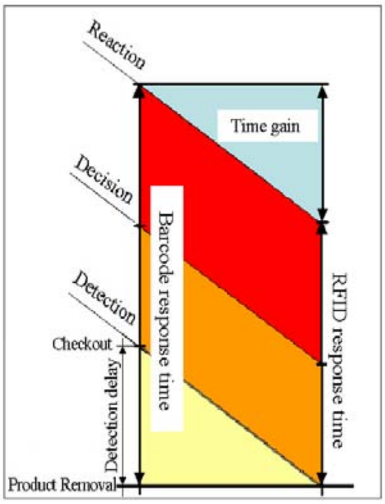

Figure 2: Response time of Barcode and RFID technologies

In fact, as shown by Figure 2, deploying RFID when the other factors remain unchanged, generates a potential for reducing reaction time by the time span between product removal and its scanning at a checkout station. This reveals that the real contribution of RFID, besides the new collected data, is the real time detection.

2.2.2 *Decreasing the response time by coupling decision support tools to RFID*

Whereas connective technologies such as RFID enable quasi real time detection, it has no effect on the duration between detection and reaction, unless it is combined with decision support tools that exploit this faster information access. While RFID removes the detection delay, the decision support tools contribute to improve the delay between detection and decision and reduce the time between decision and reaction, as expressed in Figure 3.

In fact, such tools can almost eliminate the lag between decision and detection since they can analyze the collected data and produce a decision in almost no time. This is what we call the decision advance. In addition, they can significantly decrease the reaction time by analyzing the available resources and affecting the tasks automatically in order to optimize the response time.

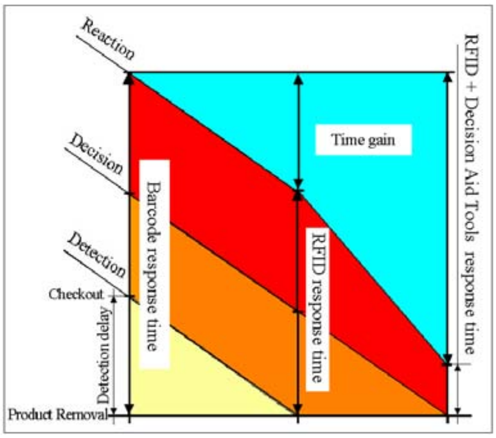

Figure 3 : Response Time when Combining RFID and Decision Support Tools.

2.3 *Successful combination of connective technologies and decision support tools*

To make the best use of connective technologies such as RFID, it is necessary to combine them with decision support tools. Connective technologies help getting pertinent information as early as possible. However, standing alone, those technologies do not assure optimal results. Gaining advantages from the collected data and the time advantage, in order to produce a decision advantage, depends on more than just adopting technologies (Hakimi *et al*, 2008). For example, assume a product is out of stock on a front-store shelf. Meanwhile a potential buyer known to often purchase this product is detected as having entered the store. If there are no tools to alert a store manager or associate about the situation, or automated procedures for requesting immediate replenishment from back store, or yet there is no available clerk to replenish the shelf, then having detected the situation leads to minimal value for the retailer.

Fast and efficient decision and reaction should be achieved in order to maximize the benefits of connective technologies. Tracking customers, products and employees generates huge amounts of data that are not possible to handle by the human brain, making mandatory to use of decision support tools. These information technology tools transform the raw data to filtered, well-ordered information useful for management purposes. By a simple glimpse to a computer screen, managers can have a clear global vision on what is happening in the whole store, what events need attention, where interventions are needed and where problematic situations occur. Multidisciplinary decision support tools may provide all kind of operational, financial, marketing and managerial information for managers who need to make fast decision and be alerted of any potential problems. Furthermore, some decisions can be automated, minimizing the need for human intervention (Hakimi *et al*, 2008).

To summarize, all we are saying here is that:

1. The faster you know about an event, the faster you can react;
2. The better information you have, the better decision you can make;
3. In order to choose the best reaction, both (1) and (2) are required simultaneously, so the faster you know about an event and the better information you have about it, the better[2] may be your reaction.

The understanding of statement (3) is necessary to follow the logic we used to evaluate the different scenarios discussed in the next section.

3. SCENARIOS OF CONNECTIVE TECHNOLOGIES INTEGRATION IN RETAIL STORES

In this section we show how the framework introduced in the previous section can help assessing the outcome of connective technologies deployment. Since there are many alternative levels of RFID technology integration maturity (Blossom, 2008), assessing the outcome of connective technologies is here done through a comparison study between four different scenarios, where the level of the deployment of connective technologies increases gradually. For each scenario we specify in table 1 the type of information or data that can be collected by the deployed technology, the impact on the detection time, and the potential benefit in terms of intelligence advantage. The raw collected data refers to the unprocessed data captured by the system. The detection time is the time when the information system received this data. The first level interpretation or the first level decision advantage refers to raw data processing which requires only simple computation of very limited number of variables. For example, to know the inventory level of a product on a shelf in scenario (3) whenever an item is removed, the system simply counts all the detected items.

It is important to mention that our discussion is exclusively concerned with real time management issues. Therefore the data that can be collected but not used to improve the real time reaction are omitted. That includes the information resulting from data mining processes, unless this information participates actively in the decision advantage in real time. It is also possible that in some cases the available technology nowadays does not enable some features, but we are addressing the question of what can we get from it, if it was possible.

Regarding the choice of scenarios, other pertinent scenarios could be added, but for the purpose of this study we found that the four chosen depict the essence of what we want to say. The scenarios here described highlight the best improvement between them and reflect what could be achieved in terms of benefits for customers, employees, suppliers and the store even if all those elements are not addressed explicitly in this paper.

[2] Note that we said "the better may be your reaction" and not "the faster and better may be your reaction" because the better reaction does not need to be faster in order to be better (as long as you have enough time to do it).

Scenario	Collected Data	Detection Time	First Level Interpretation (First Level Decision advantage)
(1)	• Reception data • Sales data	• Reception of products • Customers checkout	• The inventory in the store
(2)	• Data of (1) • The transition of product between the backroom and the shop floor	• Detection times of (1) • When the products leave the backroom	• The inventory in the backroom • The inventory in the shop floor • Shrinkage reduction
(3)	• Data of (2) • Products on shelves	• Detection times of (2) • When the products enter or exit the shelves readers detection area	• The first level interpretations of (2) • Shelves inventory • Identification of misplaced items • Instantaneous detection of items removal from shelves • More shrinkage reduction
(4)	• Instantaneous 3D position of products, carts, customers, and employees • The position of the shelves and checkout counters • Customers' data • Customers' requests • Employees' interactions with the system and with each others	• Whenever a product, a cart, a customer, or an employee changes position • When a customer issues a request for assistance • When an employee uses his communication devices	• The first level interpretations of (3) • Dynamic view of the store in real time • Color code vulgarisation of different store aspects • Exact position of misplaced items anywhere in the store • Shrinkage prevention • Determination of the carts' content • Shopping time of each customer • The time spent by a customer in each zone of the store • The path followed by a customer • The customer pickup order of products • Products manipulated vs. products sold • The status of an employee, etc.

Table 1: Comparison of four scenarios with different technological configurations

3.1 Comparison of four scenarios with different level of connective technology integration

First Scenario

Technological level

In this level we assume a barcode operated store. So the products, pallets and cases are equipped with barcode labels that enable their identification upon a direct scan. The scanning is done manually in two situations: during the receiving of products at the backroom entrance, and during the checkout.

Raw data collected

There are mainly two types of data collected in the case of barcode systems. First, the input data during the receiving of products at the backroom entrance and the output data at checkout counters in the shop floor. In this case, we can practically consider the store as a black box with an input and output of products flow[3].

In order to obtain more data, managers use visual counting of the products on the shelves and observations by the clerks. However, since these two sources[4] are not related to the connective technologies, they are not considered as criteria in our evaluation.

Detection time

The receiving event is detected when either the product or its case is first scanned and the sales event is detected when the product is scanned during the customers' checkout.

First level interpretation of the collected data

The collected data in this scenario only allows us to compute the remaining quantities of products in the whole store[5]. It is not even possible to know automatically what part of these quantities is in the backroom and what part is in the front store, except if there is a further scanning at each passage between front and back store. In addition, there is no way to detect any shrinkage that could occur inside the store between the input and output time. Therefore, important gaps may happen between the computed inventory and the real number of items in the store, forcing stores to show the expensive "close for inventory count" message on their doors.

Second Scenario

Technological level

In this scenario we assume that all individual products carry a unique identification code transmitter, which enables the item level identification. Also, wireless readers able to detect these transmitters are located at the entrance of the backroom, at the entrance of the shop floor, at the checkouts and at the store's exit. An example of this scenario is the RFID technology with passive tags and readers with a 3m detection range. The memory of the tag is only used to store the unique identifier of the item.

Raw data collected

The system detects what goes in and out of the backroom, what goes in and out of the shop floor, and what goes through the checkout counters. In addition, the system has static information about each item detected, such as its price, its time of production and its expiration date.

Detection time

Data are transmitted to the information system during the receiving of products, when the products leave the backroom

[3] There are also financial data in all the scenarios, but this issue will not be addressed in this article.

[4] We assume that the employees are not using any communication device.

5 In addition to what was received and what was sold.

for the shop floor, when the products go through the checkout counter and when the products leave the store.

First level interpretation of the collected data

In addition to the information already available in the first scenario, the second scenario allows tracking the inventory in the backroom, as well as the inventory in the shop floor. This can reduce stock-outs in the front store as long as the products are available in the backroom. However, it is still not possible to know the inventory level on each shelf when the same product is displayed on multiple shelves and in case of misplaced products. Also, inventory shrinkage can be reduced but not completely eliminated.

The item level tagging could not be used effectively inside the store, since even if the information system knows the state of an item; it does not know exactly where it is. For example, suppose that a given item approaches its expiration date which is known by the system. Then, even if the system issues an order to remove the item from the shop floor, the employees need to check the expiration date of all the items of the same product on the shop floor. If the item was misplaced, it could be a real challenge to find it.

Third Scenario

Technological level

In this scenario we add smart shelves to the setting described in the second scenario. Smart shelves are equipped with a reader that continuously scans the items located within them. This level of technology may be achieved by deploying RFID readers on shelves and passive tags on products.

Raw data collected

The system collects the same data as in the second scenario, in addition to the number of products on shelves.

Detection time

This scenario further allows detecting immediately when a product is placed or retired from a smart shelf.

First level interpretation of the collected data

In addition to the benefits stated for the second scenario, it is possible to know at any moment the number of items of each product type on the shelf. Therefore it is possible to insure that the products are always available on shelves, especially in the case that some products are displayed on more than one shelf in different locations in the store. The second benefit is that such a configuration helps locating misplaced products. Indeed, items may be on the right shelf, on the wrong shelf or in one of the (few) spots inside the front store which are not covered by the shelves readers nor by the checkout counter readers.

Also, in terms of time advantage, this scenario detects precisely the moment a product is removed from a shelf[6], which leads to a significant improvement in shelf inventory management as compared with the first two scenarios.

Finally, the shrinkage could be reduced dramatically since this configuration offers more tracking capabilities. At the moment the system knows when a product is not detected anymore, a message can be sent after to alert the store staff of the lost of the item.

Fourth Scenario

Technological level

This scenario assumes full detection coverage and enhanced communication tools. Customers carry traceable membership cards and employees carry electronic devices that enable them to communicate with the information system. The employees can send information about the tasks they are performing, such as its nature and its start and end times. They can also receive instructions from the system such as a request to start specific replenishment activities. Finally, we also assume that the exact 3D position of any transmitter inside the store is known at anytime. The products and the carts carry transmitters and the positions of shelves and checkout counters are known to the system. An example of this configuration is given by a RFID system with active tags, long range detection readers, and triangulation software to capture the 3D position of tags.

Raw data collected

In this level, the collected data is very rich and its amount may be very large. Basically, the system detects the instantaneous 3D position of each product, each customer, each cart and each employee. The system follows also the customers' requests for help signalled through their client card, and the employees' transmitted information. Moreover, the system can identify each customer through the membership information. It can also store the customer purchases and circulation path, generating or updating the customer shopping profile.

Detection time

The position of a moving transmitter is captured as soon as the product, the customer, the cart or the employee carrying that transmitter changes its position. Similarly, customers requesting for assistance or employee's interactions with the system or with another workmate through his communication device are instantaneously detected.

First level interpretation of the collected data

The configuration of this scenario provides precise dynamic insight on what is happening in the store. In fact, the system knows in real time everything that matters to produce a live image of the store. So, as showcased in the LiveRetail platform reported by Hakimi et al. (2008), one can generate a dynamic view of the store on a computer screen showing what's happening in the store in real time. A color code can be use to attract the manager's attention to specific points or elements. For example, shelves can be coloured according to their expected time before starvation: freezing blue if there is much too many products in the shelf, green if the shelf is

[6] In fact, in this case the detection is not exactly on the pick up of the product but rather when the product left the detection range of the shelf's reader. In this scenario we consider that the gap between these two events is not significant.

well filled with stock enough yet not too much, yellow if it is close to starvation, and red if the shelf is empty.

In addition, the inventory level of each product type on each shelf is known, so even if a product is placed on multiple shelves, we can prevent stock-outs on each of them. Moreover, the exact position of each item is known, so if the items placed in the front of a shelf are all sold and the remaining items are all hidden in the back, the system can generate a message requiring a refill of the shelf or the repositioning of the items. This can reduce lost sales.

There are many other direct benefits from the application of this technology deployment. Here are some of them:

- detection of misplaced items in the store;
- determination of the carts' content;
- shrinkage prevention;
- customer's shopping duration,
- time spend by a customer in each zone of the store (ex: in front of a shelf, in an aisle, in a section);
- path followed by a customer;
- customer product pickup order;
- products manipulated vs. products sold;
- status of an employee, etc.

Next Levels of Data Interpretation

The second level of data interpretation requires more analysis and business intelligence and would use the raw collected data and the first level interpretation information. Since the amount of resulting information at this level would be important and relevant to many business aspects, it is advisable to classify this information according to the store management relevant aspects. Examples are customers, employees, supply chain and supplier, and internal business, including operations management, merchandising, and product management. The classification of the information makes it easy to dedicate each set of information to the corresponding manager.

To give an example of the information of second level interpretation, let's consider the fourth scenario. The system detects a product in movement, and detects a customer close to it. The system can find a relationship between the product's and the customer's movement patterns. Then the system concludes that the customer is manipulating the product. In this example, the raw data is the position of the customer and the position of the product. The first level interpretation is the path of each one of them. The second level of interpretation is the linkage between both of them. This way of extracting information could be extended to more interpretation levels. Each level exploits the raw data and the available information form the previous levels. In this paper we mainly limited our discussion to the first level data interpretation.

CONCLUSION

Connective technologies such as RFID are introducing new challenges and appealing opportunities in almost every discipline that have already led to successfully applications, in particular concerning material flow and supply chain management. However, considerable less attention has been granted to the use of such technologies in the context of retail stores, the final link in the retail supply chain. To mitigate this drawback, we have analysed the potential impacts of connective technologies in retail stores through four different scenarios of technology deployment. For each scenario, we have analyzed the potential benefits. We have shown that even though the improvement achieved in terms of the collected data and the time advantage (detection time) have a linear relationship, the improvement in terms of intelligence advance increases exponentially.

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