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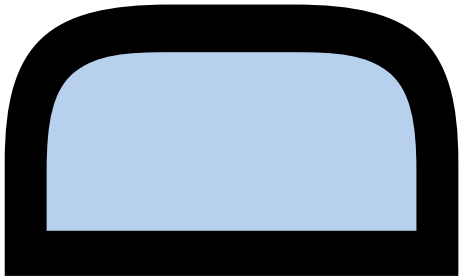

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From Pallet to Shelf: Improving Data Quality in Retail Supply Chains Using RFID

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The Lay Of The Land

High-Quality Data: A Prerequisite in Today's Retail Supply Chain

The retail industry ranks among the leaders when it comes to supply chain management and the use of inventory and demand data. Industry initiatives such as Efficient Consumer Response advocate close collaboration between manufacturers and retailers. Companies rely heavily on enabling technologies to support business processes: electronic data interchange (EDI) messages are used to transfer point-of-sale (POS) data, orders, and dispatch advices; bar codes allow companies to identify items, cases, and pallets in the supply chain and in the store; and global data synchronization initiatives are aimed at ensuring consistent product master data between trading partners. The grocery supply chain is driven to an ever-greater extent by information, and due to the increasing focus on inventory reduction and frequent, just-in-time deliveries, there is little margin for error. As a consequence, the importance of data quality is growing.

RFID and the Gap Between the Physical and the Virtual World

Despite the heavy use of data capturing (bar code) and data transmission technologies (EDI), data quality in the retail supply chain is still far from perfect. Some of the data quality problems are caused by a lack of integration between the physical and the virtual world. Recent developments in the areas of sensors, data transmission, and identification technologies reduce the cost of gathering data about the physical world and allow companies to narrow this gap.

Radio frequency identification (RFID) technology offers automatic product identification and can be regarded as a next step toward better integration of the real and the virtual world.

Companies in the retail industry can use RFID to improve different dimensions of data quality. Lower data capturing cost and higher data quality are major reason why leading retailers—including Wal-Mart and Target in the US, Tesco in the UK, and Metro in Germany—have announced a rollout of RFID systems at the case and pallet level within the next two to three years. These companies use low-cost, passive RFID tags that contain only a unique identifier. Passive RFID tags use the electromagnetic field of the reader for their energy supply.

The Research

In this article, we provide some examples on how companies can use RFID to improve different aspects of data quality. We then focus on product availability and examine how RFID can help improve inventory record accuracy and ensure that products that are in the store are also placed on the shelf when needed.

Our observations are based on research conducted within two research projects undertaken at the University of St. Gallen in Switzerland. The first was a collaborative project of five European universities that examined the logistics processes in the European retail industry. Data for the study was collected through in-depth interviews with 12 leading European grocery retailers. The interviewees were mainly directors or managers in charge of logistics and supply chain management, development, category management, or information technology. Additional interviews were conducted with more than 40 company representatives from different retail segments.

The second project is an ongoing research program that examines the business impact of ubiquitous computing technologies. The project is a joint initiative of ETH Zurich and the University of St. Gallen, in cooperation with several industrial partners. One main technology focus is RFID. The specific findings reported in this article come from four industry projects that involved four retailers and three manufacturers in total. The aim of these projects was to evaluate potential applications of RFID. Data gathering methods included interviews with representatives from different levels and departments within the companies, analysis of company documents and records, and on-site visits.

Data Quality and RFID in Retail Supply Chains

RFID Can Improve Data Accuracy, Timeliness, Objectivity, and Completeness

In the retail industry, RFID effectively "competes" with the bar code and to a lesser extent with manual data capturing methods. RFID has the advantage that the RFID tags can be read without human intervention and without line of sight, which allows for bulk readings. Conventional data capturing methods can be replaced by RFID. This reduces the variable cost of data acquisition. But RFID is more than just a substitute for the bar code: RFID enables new procedures that rely on more accurate, timely, and detailed data than before. Companies are likely to introduce RFID to increase data quality where the benefits of higher data quality exceed the cost.

Data quality is a multidimensional construct, and there is little agreement among researchers on its dimensions. Richard Wang and Diane Strong conceptualize data quality as "fitness for use" from a data consumer's perspective [7]. With RFID technology, certain dimensions of data quality can be improved in retail supply chains. These dimensions include data accuracy, timeliness, objectivity, and completeness. In this section, we want to illustrate this with examples from a number of projects.

With RFID, *data accuracy* can be improved over that achieved with bar codes, such as when objects that were previously not identified at a certain stage in the supply chain can now be identified. Say you have a mixed pallet made up of several picked cases. These pallets are prone to picking errors, which consist of missing, additional, or interchanged cases. Previously, picking errors often were not detected, but with RFID, retailers may now be able to identify each case when it is picked and put on a mixed pallet.

The retailers we worked with conducted random checks of picked pallets in order to measure picking errors. They were typically in the range of 0.25%-0.5% of picked cases—a serious issue for retailers due to the focus on frequent and just-intime deliveries. RFID can help solve the problem by recording any deviations between the physical content of the pallet and the electronic picking order.

Because objects can be identified at the very moment when they pass a reader, *timeliness of data* can be enhanced. One retailer that took part in a research project reported that in some instances, pallets in transit from the distribution center (DC) to a store are accidentally unloaded at a different store. Since store personnel count the number of pallets during the unloading process but do not uniquely identify the pallets, the errors are not detected until the truck has departed. This time delay can lead to excess inventory at one store and out-of-stock situations in as many as two stores. Identification of the pallets during the unloading process could eliminate these delivery errors.

Data objectivity refers to the extent to which data is unbiased and impartial. As RFID tags can be identified automatically without human intervention, the possibilities for manual intervention are limited. Data that is acquired via RFID is therefore more believable when there is a potential conflict between different parties. This can be important for manufacturers. In the case of delivery errors, some manufacturers claim that retailers tend to keep any additional products without informing the manufacturer but demand the return of any missing products. This asymmetric behavior can be eliminated with RFID, as automatic "proofs of delivery" can be generated.

Completeness of data measures whether the data available is sufficient for the task at hand. RFID can affect completeness of data in different ways. One example is the tracking of objects at a lower level of aggregation. Whereas previously companies were only tracking production lots (as the effort to keep track of every item was too high), companies now can trace individual products through the supply chain. At the moment, retailers still have a hard time figuring out which products from a certain lot have been delivered to which stores. They usually know when a certain pallet has been moved to the picking area. From the history of picking orders, they can then roughly derive which stores have received products from this pallet, but their ability to exactly trace products through the supply chain remains limited. As we said above, RFID has the potential to change all this—and not a moment too soon. As of January 2005, legislation in the European Union (EU) requires food manufacturers and retailers to have traceability systems in place for their products.

RFID: Not a Panacea for Retail Supply Chains

There are a number of consulting firms that advocate RFID as a potential remedy for supply chain issues in which RFID is in fact not critical for the application. One such claim is that RFID now offers manufacturers the opportunity to acquire data on end-customer demand. The consultants who make this claim ignore the fact that this information is often already available. Retailers gather this data via traditional bar code-based POS terminals. One well-known example is Wal-Mart's RetailLink system, which allows its

suppliers to access POS data. Making the data available to manufacturers is, to a large extent, a question of business policy. At the checkout, RFID could only help to further improve data accuracy by reducing scanning errors.

Another example is data synchronization. Promoters claim that RFID ensures that the right product data (e.g., on prices) is always available. Inaccurate product data is one of the main reasons for invoice inaccuracy. The retailers currently introducing RFID rely on RFID tags that contain only a unique identifier, which points to the relevant data in the information system. If the data itself is inaccurate, RFID does not provide any value. Based on the results of a survey, the Grocery Manufacturers of America (GMA) reports that trade allowances and pricing differences are the two most frequently mentioned causes of invoice inaccuracy [2]. Consequently, companies name EDI purchase orders, synchronization of price and promotion data, and EDI invoicing as the three most effective practices for improving invoice accuracy.

This does not imply, however, that RFID cannot improve the receiving process. It is undisputed that RFID can help to check delivery quantities. Quantity differences are the third most frequently cited cause of invoice inaccuracy.

RFID and Product Availability

Out-of-Stock: Still a Serious Issue in the Retail Industry

One specific area in which retailers expect to benefit from RFID is product availability. Out-of-stock (OOS) is still a serious issue: recent research shows that OOS levels have not decreased over the last three decades [3]. Most retailers report OOS levels of 5%-10%, resulting in a loss of up to 4% of turnover for a typical retailer. These results are rather surprising in view of the numerous initiatives on supply chain and category management that has been conducted in recent years.

Fully 72% of OOS incidents are a direct result of retail store practices (see Figure 1). The largest root cause (47% of OOS) is incorrect forecasting and ordering practices (i.e., retailers ordering too late or insufficient quantities). An increasing number of retailers rely on automatic store replenishment (ASR) systems in order to reduce the potential for human errors [1]. ASR systems, however, will perform better than manual ordering systems only if inventory accuracy is high.

The second largest root cause (25%) of OOS results from situations in which the product was actually in the store but not on the shelf.

One Swiss retailer found that out of 100 products delivered to the store, only 32 razor blades and 20 condoms were scanned regularly — the rest somehow disappeared.

RFID offers the potential to improve product availability by increasing inventory record accuracy and by improving replenishment processes from the backroom. In the following section, we describe how this can be achieved.

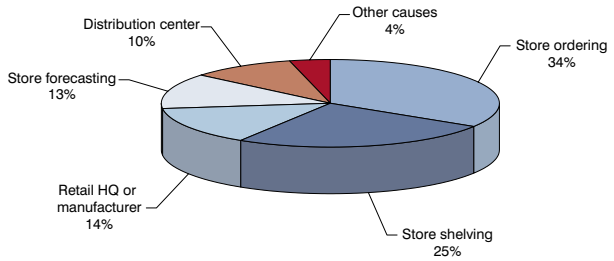

Figure 1: Causes out-of-stock [3]

Increasing Inventory Record Accuracy with RFID

Our research indicates that the main causes of inventory inaccuracy lie within the store. The majority of companies said that the current level of accuracy for deliveries from the distribution center to stores was acceptable. The product and data handling processes at the DC level seem to be reasonably under control, largely due to the use of bar codes. Some retailers have even stopped checking deliveries from their own DCs at the store gate, as, in their view, the cost exceeds the benefits.

One major cause of inventory inaccuracy in the store is shrinkage (employee theft, shoplifting, vendor fraud, administrative error, etc.); another cause is scanning errors at the checkout counter. The magnitude of these factors differs by product. One Swiss retailer manually checked inventory accuracy for two of the most critical goods, razor blades and condoms, over a period of three months. The company found that out of 100 products delivered to the store, only 32 razor blades and 20 condoms were scanned regularly—the rest somehow disappeared.

The Role of ASR Systems

ASR systems automate the ordering process. They help retailers to increase product availability and save labor in the store. However, with inaccurate inventory information (i.e., inventory records above or below physical inventory), ASR systems will order too few or too many products. This can lead to out-of-stock situations or excess inventory and can limit the benefits of ASR systems. Retailers that rely on automatic ordering systems therefore strive to keep inventory records as accurate as possible. To increase accuracy, organizations can adopt measures such as awareness building, incentives, and process improvements [4]. Another way is to conduct regular inventory cycle counts, though these are time-consuming and would reduce the initial labor savings. Due to a strong focus on cost, technological solutions such as RFID are interesting for retailers because they offer the possibility of achieving high levels of accuracy without additional labor cost.

Implementing Tags and Readers

Two important characteristics of RFID systems are the level at which RFID tags are attached and the supporting RFID reader infrastructure. In general, in order to be of use, RFID tags need to be attached at the level of the relevant handling unit. In retail supply chains, this usually means the pallet, case, or item level. Companies need to deploy RFID readers at any point in the supply chain where they want to identify objects.

RFID tags at the case level and readers at the receiving door in stores would allow the immediate detection of any remaining picking errors at the case level. (As described above, RFID tags at the case level can already prevent picking errors during the picking process.) However, the majority of inventory record inaccuracies seem to happen at the item level within the store. This means that individual products need to be equipped with RFID tags. In combination with RFID readers on shelves, retailers can conduct inventory counts in real time. This would ensure inventory accuracy at any point in time. Some companies are also conducting tests with mobile readers in order to conduct cycle counts.

While smart shelves and mobile readers would address only the symptom, other applications could reduce the causes of inaccurate inventory records: RFID-based checkout systems would help to eliminate scanning errors. Furthermore, the RFID tags can also act as an anti-theft device on every product. In combination with RFID gates at entrance and exit doors, this could reduce shrinkage rates.

Improving Replenishment Processes from the Store Backroom with RFID

Our research indicates that most retailers try to eliminate store backroom inventory. There are, however, some exceptions to this rule, which result from the need to efficiently use scarce shelf space. These exceptions can include certain fast-moving goods (e.g., beverages, toilet paper), promotional items, and bulky products such as TV sets or printers, of which only one or two are placed on the shop floor at the same time.

None of the retailers we talked to records the transfer of products from the store backroom onto the shop floor, as this would require manual bookings. This means that they rely on store personnel to monitor shelf availability. If an employee does not immediately recognize when a shelf needs to be replenished from the backroom, there is a risk that the retailer (and also the manufacturer) will lose revenue. The fact that fast movers and promotional items are among the products that are stored in the backroom accentuates the importance of this monitoring process.

With RFID at the case level and readers at the gate between backroom and shop floor, it becomes possible to separate shop floor and backroom inventory, assuming that the retailer moves cases and not single items. This provides a fairly accurate picture of the actual number of products available to the consumer: the inventory management system can derive an estimate of the number of products available on the shop floor by combining the data on the flow of products from the backroom with POS data. Based on this data, it can automatically generate alerts to replenish products from the backroom before an OOS situation occurs. There is no need for tagging products at the item level. However, given that inventory records can be inaccurate, item-level tagging in combination with smart shelves could further improve the process.

New Requirements on IT Systems

The introduction of RFID in the retail industry not only requires the deployment of RFID tags and readers, it also poses new challenges for a company's IT systems. The additional requirements depend on whether RFID is used to substitute for other data capturing methods or to gather additional data.

If RFID merely acts as a substitute for existing data capturing methods, changes to existing applications are likely to be limited. However, there is a need for middleware that filters and interprets read events. An RFID reader on a retail shelf, for example, will detect all products within its read range in each read cycle. The only relevant information that middleware should pass on to the inventory management system is the first detection of a product and its disappearance. Large enterprise software providers such as SAP [6] are currently developing such middleware products that can be integrated into their software suites.

If companies use RFID to gather new data in order to improve their processes, changes to business applications are required. For example, in order to improve the replenishment process, the inventory management systems must be able to keep track of backroom and shop floor inventory separately.

Conclusions

RFID: From Pallet and Case to Item Level

RFID is one means of improving data quality, but it is not the sole remedy for achieving total supply chain visibility. The potential performance impact of RFID depends on both the existing processes and the initial level of data quality. In order to realize RFID's full potential, itemlevel tagging is required.

In this article, we have specifically looked at RFID and product availability at the retail shelf. The examples show that RFID can help to address two of the main root causes for out-of-stock: store ordering and replenishment from the backroom. Furthermore, RFID data may also help to improve the forecasting process. Truth Software, for instance, is a startup company that aims to integrate the additional data gathered from RFID systems into forecasting models in order to reduce the out-of-stock problem [5].

At the moment, it is still too expensive to attach RFID tags to most retail products. The high RFID tag cost is one of the reasons why Wal-Mart and other retailers are initially focusing on RFID at the pallet and case level. (Other reasons include privacy, read rates of RFID tags and packaging, as well as the sharing of cost and benefits between retailers and manufacturers.) There are some products with special characteristics (e.g., products with high shrinkage rates such as razor blades) and some product categories (e.g., apparel) in which RFID at the item level is likely to be introduced first. With the declining cost of RFID tags, the number of products with RFID tags is likely to increase.

What Companies Can Do

Companies that want to explore the potential of RFID for increasing data quality can implement the following recommendations:

- Analyze existing processes and the impact of your current level of data quality.
- Assess potential changes to business processes based on RFID data for your company and your trading partners.
- Define the required level of data quality (e.g., tagging level, placement of readers) and new requirements for IT systems.
- Conduct pilot studies in order to ensure technological feasibility, redefine processes, and prepare a business case.

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