Published October 1, 2003. Distribution restricted to Sponsors until January 1, 2004.

AUTO-ID CENTRE

WHITE PAPER

Auto-ID Use Case: Improving Differential Item Pricing in a Retail Company – Impact on Existing Procedures and Information Systems

Humberto Morán, Yvonne Chow, Duncan McFarlane

AUTO-ID CENTRE INSTITUTE FOR MANUFACTURING, UNIVERSITY OF CAMBRIDGE, MILL LANE, CAMBRIDGE, CB2 1RX, UNITED KINGDOM

ABSTRACT

Determining the impact of Auto-ID implementations on existing procedures and related information systems is a difficult task, and requires deep analysis of both the current and Auto-ID-enhanced situation. Auto-ID offers many different implementation possibilities, all of them with their respective requirements, advantages and disadvantages, further complicating the impact analysis. This paper is an application of the "Use Case Approach for Determining the Impact of Auto-ID Implementations on Business Information Systems" (Morán et al, June 2003) aiming at analysing the use Auto-ID of to improve the current differential item pricing system of a leading retail company in the UK. We understand differential item pricing as the assignment of different prices to items of the same product line (SKU), consequence of individual characteristics or changes of status such as item aging or damaging. In this sense, two items of the same product with different "best before" date may be considered as different products for they target different markets and may be subject to different demands. This discrimination challenges operational practices as both share the same EAN – barcode, which makes impossible for information systems to differentiate them. Hence, the first step in the implementation of a differential pricing system is to enable item-level identification, which is an ideal application of automatic identification technologies. This industrial study (the third of four of this type developed in the UK by the University of Cambridge/Auto-ID Centre) involved numerous interviews with knowledgeable people in this company, and the thorough application of the aforementioned approach. It consisted of:

1. finding representative use cases for process improvement, in terms of current operational procedures, issues, and implementation possibilities;
2. contrasting their associated operational procedures with the proposed ones; and,
3. identifying the additional data and transactions required in their related information systems.

Based on the analysis of Auto-ID adoption and its impact on procedures and information systems, this work concludes that using this revolutionary technology to improve the company's differential pricing system barely affects existing operational procedures, but has a significant impact on installed information systems. In this sense, information systems must be changed to allow for a finer entity granularity in the stock database down to item-level; incorporate new functionality as to product reordering and price setting; deal with new and qualitatively and quantitatively expanded inter-system data flows; perform inter-organisational data exchanges with suppliers; and provide richer operational reports and new business performance indicators.

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Biographies

Humberto J. Morán
Senior Research Associate

With more than twelve years of IS experience, Humberto has occupied relevant positions in leading corporations such as Unisys, Lafarge, Oracle, and his own entrepreneurial venture. He has studied Computer Engineering; a Ph.D. in International Economics; and an MBA in the Judge Institute of Management, University of Cambridge. In the Auto-ID Centre, Humberto coordinates research on Auto-ID Use Cases, the impact of Auto-ID implementations on IS, and Auto-ID/IS integration possibilities.

Yvonne Chow
PhD Student

Yvone graduated from the Institute of Manufacturing at University of Cambridge in July 2003. She was based with the Auto-ID Center – Cambridge Labs for the duration of her Master's thesis, and this white paper draws heavily on that research.

Duncan McFarlane
Research Director Europe

Duncan McFarlane is a Senior Lecturer in Manufacturing Engineering in the Cambridge University Engineering Department. He has been involved in the design and operation of manufacturing and control systems for over fifteen years. He completed a Bachelor of Engineering degree at Melbourne University in 1984, a PhD in the control system design at Cambridge in 1988, and worked industrially with BHP Australia in engineering and research positions between 1980 and 1994. Dr McFarlane joined the Department of Engineering at Cambridge in 1995 where his work is focused in the areas of response and agility strategies for manufacturing businesses, distributed (holonic) factory automation and control, and integration of manufacturing information systems. He is particularly interested in the interface between production automation systems and manufacturing business processes.

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Contents

1. INTRODUCTION

This document covers the findings and results of an industrial application of the "Use Case Approach for Determining the Impact of Auto-ID Implementations on Business Information Systems" proposed by the Auto-ID Centre (Morán et al, June 2003) in order to determine the impact of Auto-ID implementations on existing procedures and information systems and show the most evident and relevant implementation possibilities. This study analysed the usage of Auto-ID to improve a differential item pricing system. That is, putting a different price on items of the same product (same SKU) because they have different characteristics such as expiration date or have been damaged or altered. Through the analysis of a business system currently being used by a large UK retailer, opportunities for improvement have been identified and examples of possible implementation solutions have been discussed. The industrial study involved holding interviews with knowledgeable people in the company, and the analysis of the findings using the aforementioned approach. The study followed these basic steps:

1. Finding representative use cases for process improvement – in terms of current operational procedures, issues, and implementation possibilities. This first step involved interviewing employees in charge of Auto-ID adoptions and business innovation in general, and employees performing daily operational procedures related to handling, storing and interchanging physical goods within the shop and with direct parties – third parties such as customers, suppliers and distribution centres. Some Auto-ID implementation possibilities were identified by considering different technologies and configurations.

2. Contrasting their associated operational procedures with the proposed ones. This step required the analysis of the information found in the previous one under each implementation possibility.

3. Identifying the additional data, transactions and functionality required by their related information systems. The supporting transactions and data currently performed or stored by the current information systems were identified by interviewing knowledgeable people in the IT department. The paper also proposes additional reports and business indicators result from an improved differential item pricing system.

1.1. Acknowledgements

We would like to express our deepest gratitude to the retail company's staff, who kindly and patiently cooperated in the multiple interviews and provided valuable support to the study.

1.2. Background

1.2.1. Business Information and Industrial Control Action Group

This research is part of the Auto-ID Centre's Business Information and Industrial Control Action Group activities. Combining theoretical research and industrial developments, this group aims at identifying the impact of Auto-ID on business information and industrial control systems while developing frameworks, models and methodologies to deal with this impact and provide sound integration alternatives. The Business Information and Industrial Control Action Group deals with business activities supported by commercial and bespoke information systems potentially suitable of improvement with Auto-ID, covering a broad area ranging from Auto-ID business strategy to Auto-ID use cases development and analysis of their impact on existing technology for business automation.

This research is also part of the Auto-ID Software Action Group, which aims at setting standards and legal frameworks for the software developments of Auto-ID. The Software Action Group recognises and proposes the development of specific Use Cases as a way of identifying technical requirements for the Savant and Auto-ID interfaces with business information systems.

1.2.2. Previous Works

This paper includes ideas from other previous papers: Timothy Milne and Amit Goyal's "Track and Trace Shipping and Verify Receiving Use Case" (Expected publish date:April 2003), Timothy Milne's "Sub Group and Use Case Focus Group Methodology" (November 2002), Duncan McFarlane's "Auto-ID Based Control – An Overview" (January 2002), and "The Intelligent Product Driven Supply Chain" (Brock et al, January 2002,), among others. Yoon Chang and Duncan McFarlane have also proposed specific methodologies to support the integration of Auto-ID and business information systems, and have provided a thorough classification for the last ones and an example use case – "Methodologies for integrating Auto-ID Data with existing Business Information Systems" (Chang, November 2002)

The research documented in this paper follows the steps and methodology suggested by the "Use Case Approach for Determining the Impact of Auto-ID Implementations on Business Information Systems" (Morán et al, June 2003), to be referred as "Use Case Approach". This approach has also served to support other similar studies, such as the one documented in "Auto-ID Use Case: improving inventory visibility in a retail company – impact on existing procedures and information systems" (Morán et al, September 2003); and "Auto-ID Use Case: improving handling and tracing of rework pieces in a leading manufacturing company – impact on existing procedures and information systems" (Morán et al, September 2003).

1.3. Use Case Characteristics

The retail industry in the UK generates over £200 billion of revenue per annum and year to year it shows signs of healthy growth. With power being passed from manufacturers to retailers, the opportunities of further industry growth are substantial. Nevertheless, competition is high and steadily rising. Technologies being adopted by large retailers are becoming increasingly sophisticated, complex and expensive to install, raising entry barriers and further intensifying competition.

In this context, one of the major challenges faced by retailers nowadays is to find the exact point in which perishables rotate perfectly and over-/under-stock does not happen. Of course, this perfect rotation and demand/consumption match rarely occurs, for demand, and sometimes even supply, is subject to significant uncertainty. In their attempt to prepare for the real demand, managers must decide whether to allow for extra-supply or for under-supply. That is, allowing for extra storage and waste costs, or for stock-outs, respectively. The latter is normally not an option for it hurts the brand, frustrates consumers, and makes them think twice before visiting the store again. Consumers tend to prefer places where "everything they need" can be found, rather than splitting their shopping errands among different stores in their search for their desired goods. Moreover, stock failures benefit competitors because many consumers will still buy the goods they need somewhere else. The former (extra-supply) is more an acceptable option, although some goods will unavoidably perish and will have to be disposed which, apart from the cost of lost goods, generates disposing costs and involves environmental issues. An alternative to disposal is to put aged, extra-products on sale to foster their demand. Although this practice may cannibalise sales of "regular" product items and reduced items are sold below cost, it is believed that the total cost of excess supply is reduced by doing so. The same rationale applies to hard-to-sell, damaged product items.

In an over-stocking scenario a product item becomes "special" and requests differentiation in both identification and price under the following two circumstances:

1. It is about to reach its expiration date, which would make it unsaleable.
2. It has become defective, though is still saleable as it still complies with minimum safety regulations and may be accepted by consumers willing to save some money.

The practice of putting "overstock" in sale requires discriminating them from the regular, non-on-sale items, which can be a difficult, costly and cumbersome task. It is there where Auto-ID can play a crucial role in identifying, locating and differentiating a product item suitable for differential pricing.

Following the classification proposed in the "Use Case Approach" white paper (Morán et al, June 2003), the Differential Pricing Use Case is classified as a **Process Improvement Use Case**, for it focuses on specific operational areas of the organisation and implies no significant changes in the current business model.

1.4. Document Structure

The Retail Differential Pricing Use Case is defined in terms of the current situation, the elements it touches, and the proposed changes. Described in section 2 of this paper, the former is specified in terms of:

1. Processes to improve: actors, procedure steps, product and information flows, activities, level of automatism, decision points, contingency plans and supporting assets.
2. IT infrastructure supporting the differential pricing system: systems and their main entities, transactions and interfaces.
3. Limitations of the current technology: requirements, complementary technologies, undesired externalities etc.
4. Opportunities and issues to solve or improve: what would be "nice to have", although is impossible nowadays.
5. Auto-ID capabilities allowing the improvements: tracking, tracing or inter-organisational.
6. Implementation decisions: how to use Auto-ID to improve the differential pricing system.
7. Potential benefits: qualitative benefits and valuation suggestions.

Described in section 3 of this paper, the latter can be specified in terms of:

1. Affected systems and their characteristics.
2. Auto-ID-enhanced operational procedures.
3. Impact of new procedures on existing information systems.

In this paper, the affected systems and some of their characteristics were explained in the Use Case definition section. This helps identifying their relationship and eases the reading. The "proposed changes" section provides more detail by specifying transactions and information flows.

2. USE CASE COMPONENTS

As explained in the "Use Case Approach" document, a Use Case is more than a simple description of the Auto-ID-enhanced procedures and advantages. It requires a thorough analysis and description of the current situation and a clear justification in terms of business benefits. That is, the Use Case must be framed within the business requirements themselves and under no circumstances should be justified for the sake of technology. In this section we list all the use case components, aiming at giving a clear picture of the current situation and the factors that bring opportunities for Auto-ID.

2.1. Processes to Improve

The current differential pricing system used by the company requires the identification, location and remarking of the involved items. It also asks for special treatment in the checkout process and techniques to ease their identification by customers. Most of these processes are done manually because automatic identification is not implemented, and requires frequent checking, moving and marking scores of products.

The current differential pricing system relies on or affects the following processes:

Product reorder: supermarkets must keep a constant flow of goods in order to stay in business. The product reorder process guarantees the upstream side of this flow by requesting replenishments from suppliers or distribution centres.

Item finding, remarking and moving: at least once a day, store employees scan and/or visually check perishables in order to find damaged product items or items about to expire. These goods are marked as reduced, usually by sticking a yellow label with the new price. In some larger supermarkets the re-pricing yellow labels incorporate another barcode to uniquely identify the item and ease checkout. These labels are normally stuck over the original barcode to prevent accidental scanning at checkout.

These yellow-marked goods are also normally moved to different shelves to allow for easy identification by customers: supermarkets usually have special shelves for reduced products so habitual customers known where to find these special offers. These shelves are clearly identified with labels such as "Reduced Price" or the like.

Checkout: in the case of non-bar-coded yellow labels, the checkout procedure must include special steps for reduced products. It normally implies removing the yellow label, scanning the original barcode, pressing a special key on the till to allow for price change and typing the price on the yellow label. In the case of bar-coded yellow labels, the checkout procedure remains the same (just to scan the barcode), but requires the cashier to check that the right barcode and product has been scanned.

Returns: return procedures are also affected by yellow-labelled product, particularly when the receipt is not available. This company has designed specific rules to negotiate and determine the refund amount in this case, which take into account the product offers by the time of purchasing, maximum and minimum price etc. To avoid losing money whilst providing best customer service, product returns should take into consideration reduced items when it comes to refund negotiation.

Details on all these current processes follow.

2.1.1. Product Reorder

The store or supermarket regularly sends replenishment orders to either the distribution centre or directly to suppliers. Product reorders are triggered automatically, and they may be scheduled to be made daily, every "n" days, or more than once a day. The order quantity depends on the current stock level, delivery time, expected product life, forecasted shrinkage, sales and safety stock. Normally an automated procedure, the reorder process bases its decisions on a combination of manual and automated data from may different sources: sales from the point of sales system; stock levels from the inventory management system; sales forecast from either the sales system, manual estimations or a combination; orders in transit from the order entry system; and historical statistical information from the order entry and sales systems such as delivery time and supplier's reliability, forecast variance, and product expected life. The product reorder procedure is affected by the differential pricing system as long as orders can specify minimum or desired product freshness.

The product reordering process involves three main information systems:

- **The ordering system (OS):** supports the process of ordering from suppliers, aiming at guaranteeing a constant supply of products at the lowest possible cost. It hosts the list of suppliers, products, hierarchy of substitute and related products, and historic and agreed delivery times. The most important system in the reorder process, the OS deals with placing orders based on the inventory level, average delivery time and other delivery and supplier characteristics. The OS is a supporting system, as opposed to a tracing system, and performs inter-organisational transactions by sending orders to suppliers. In the specific case of our company, the ordering system calculates up to two normal orders per day using the latest picture of the bookstock and expected sales. A "fill up" order, which is designed to replenish the shelves, is calculated so as to arrive late evening. The "fill up" order is designed to top up the stock of certain lines during the day.

- **The inventory management system (IMS):** keeps track of the stock levels by product type, store, deposit and shelf, aiming at optimising stock levels, avoiding stock failures, and reducing waste result of unsold perishables. Their master files include products, deposits, stores, shelves and backroom spaces. Their transactions come from the sales, deliveries, returns, transfers, waste and recount processes through the logistics and distribution, point of sales and ordering systems and manual recount procedures. In the reorder process, the IMS task is to store inventory counts and trigger replenishment orders to the ordering system. The IMS calculates inventory by subtracting what has been sold from what was previously ordered and received from suppliers. The IMS sends information on current stocks to the OS so the right order quantity can be calculated. The IMS system is a tracing and supporting system at the same time. It traces product stocks and their location, and supports location and ordering decisions as well. In the case of the studied company, the inventory management system maintains the store stock position using all available stock movements. Its stock position is maintained using sales drips – sent every 15 minutes, which are received throughout the day to keep track of store stock. Stores can also count at any time of day.

- **The sales system (SS):** support sales forecasts by store, region, season, time frame, product or product hierarchy – groups of substitute or related products. Their main files include product and product hierarchies, their sales history in money and volume, and regions and stores. Their transactions come from the sales procedure through the POS, which is explained below. In the reorder process, the SS registers sales per product and holds sales history to allow forecasting. The SS sends sales forecasts to the OS so the right order quantity can be calculated. The SS is essentially a tracing system as it registers sales for forecasting purposes mainly. In the case of our company, the sales forecast system forecasts the expected sales and product trading percentages that are used in the main order calculation system.

The product reorder process has the following characteristics:

Table 1: Product Reorder Characteristics

PRODUCT RE-ORDERS	
Actors	– Warehouse manager – Supplier or distribution centre
Procedure Steps	– Emission of the automatic report – Manual review and modification – Send order to the supplier or distribution centre
Product Flows	– N/A

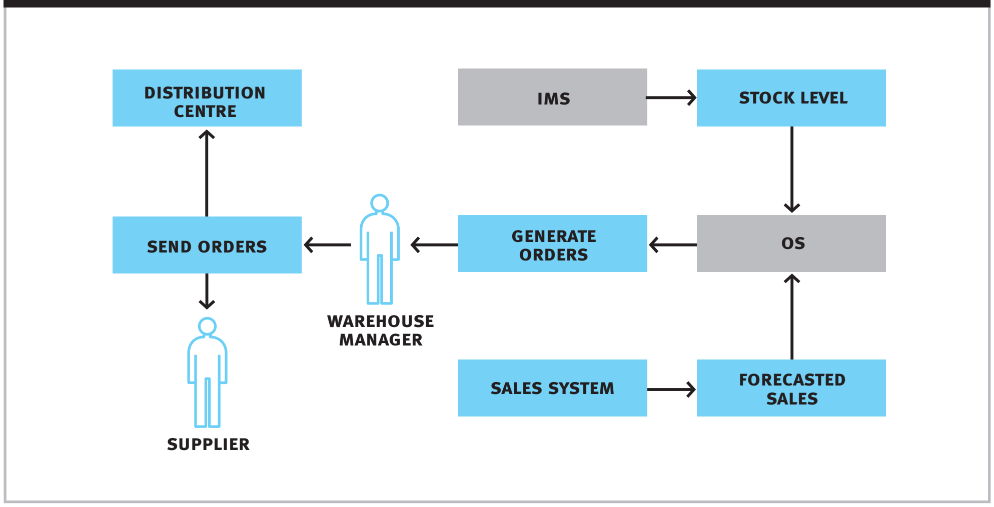
Continuation of Table 1

PRODUCT RE-ORDERS	
Information Flows	– Stock levels – Forecasted sales – Estimated delivery time – Related product characteristics – e.g. expected life – Orders
Level of Automatism	– High: orders are generated automatically, although a manual check and adjustment is performed
Decision Points	– Products and quantity to reorder
Contingency Plans	– None
Supporting Assets	– Information systems (IMS, OS, SS)

Use Case diagram for the product reorder procedure under the current situation (non-Auto-ID-enhanced):

Figure 1

USE CASE DIAGRAM FOR REORDER PROCEDURE



Main flow of events

M.1. Warehouse manager
- M.1.1. Emit reorders report from OS
- M.1.2. Review report
- M.1.3. Send reorders advices to distribution centre or suppliers

M.2. Supplier or distribution centre
- M.2.1. Pick and send the shipment
- M.2.2. If product items are not available, notify warehouse manager

M.3. Warehouse manager
- M.3.1. For unavailable products, find a substitute and reorder

2.1.2. Item Finding, Remarking and Moving

The finding of items in need for price reduction can be either an isolated activity or part of the shelf replenishment process – see “Inventory Visibility Use Case”. The former approach follows scheduled item verifications, in which shop employees daily or twice a day visually check shelves’ content to look for about-to-expire or defective goods. These employees also check perishables in the backroom in case of low-demand, as detected by the inventory management and sales systems. It is up to these employees to determine the destiny of defective or about-to-expire items, whether this is putting them on-sale or disposing them. If the decision is to put these items on-sale, shop employees generate a yellow sticker with the new price or a unique barcode on it. These yellow stickers display both the original and reduced price. Bar-coded yellow labels are generated ad-hoc using a PDA with a barcode scanner and small printer. The scanner helps identifying the original product, whereas the printer generates the corresponding price-reduced bar-coded yellow label. For this purpose, the PDA’s application has a list of perishable products and their predefined price reductions and associated barcode or barcodes, as some perishables can undergo more than one price reduction. Bar-coded yellow labels are normally put over the original barcode to avoid scanning errors, and it is usual to put more than one yellow label to properly identify the reduced item to consumers. The new price on non-bar-coded yellow stickers is written manually. They are normally used for loose products in which price depends not only on the item type but also on its weight; in this case, having a predefined barcode with an associated fixed price is impossible.

Currently, the information regarding these discounts or warehouse movements is not fed into the main information systems. The remarking system is manual, only partially supported by technology, PDAs in this case. There are not general rules as to how to calculate the reduced price, although every supermarket has its own preferences set by the shop manager. For instance, some use fixed percentages whereas others have pre-calculated reduction price tables per product and others prefer ad-hoc pricing depending on demand and size of overstock.

Once remarked reduced goods may be moved to a special shelf for easy identification and locating by customers. This normally happens in large supermarkets, whereas small ones tend to keep reduced items on their habitual shelves. If the re-pricing procedure was part of a replenishment activity, the same replenishment wagon is used to move these products. Otherwise, the employee must look for a wagon to move yellow-labelled goods.

The finding and remarking process involves the following information systems:

- **The inventory management system (introduced above):** the IMS supports the locating of product items likely to be reduced by providing location information on perishables and generating reports on stocks by expiration date. Although this system stores due date by product batches and may potentially alert on all perishables about to expire, the information it provides on current stock by shelf life is inaccurate for it does not receive sales per expiration batches and has to unrealistically assume perfect rotation in sales.

- **The point of sale system (POS):** support selling and return procedures. Among the master files it hosts are the product price list, tills, cashier, and special offers catalogues. The main transactions it supports are sales and returns, registering lists of goods, payments, loyalty cards and cash. These transactions come primarily from tills and most of their input data is bar-code generated. The POS reports every item sold at till point and keeps the inventory updated. The POS system is a tracing and supporting system: it supports real-time sales by providing the right price and performing payment transactions and related, and it traces all sales to allow future sales forecasts, product returns and keep inventory stocks updated.

The item finding, remarking and moving process has the following characteristics:

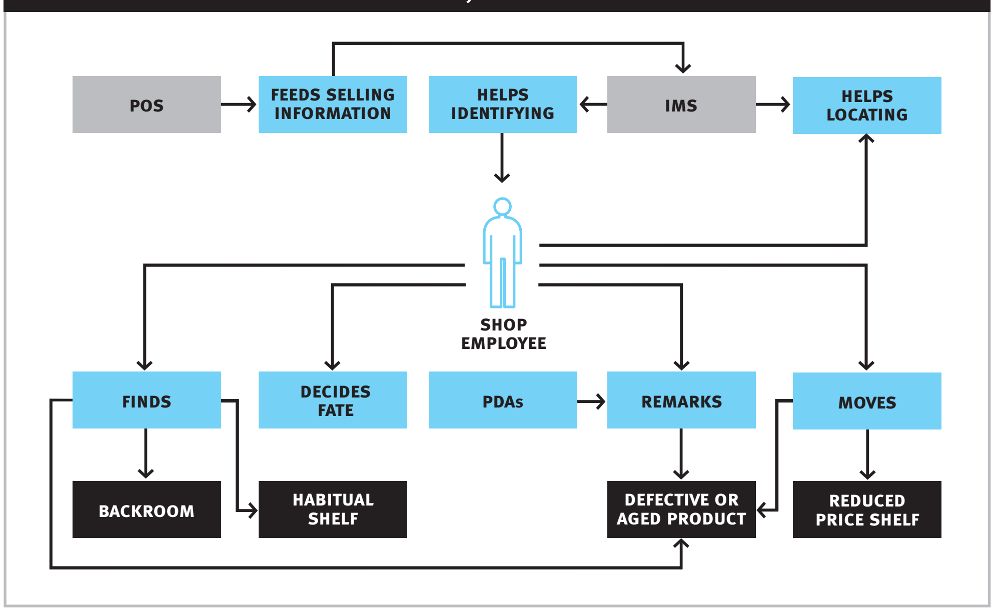
Table 2: Finding, remarking and moving process characteristics

FINDING, REMARKING AND MOVING PROCESS	
Actors Procedure	– Shop employee
Steps	– Generate report with possible expiring items – Generate report with location information – Check goods on shelves – In case of low sales, check goods in the backroom – Identify and remark products using yellow labels – If necessary, move products to the "reduced price" shelf
Product Flows	– From habitual shelves or backroom to the "reduced price" shelf
Information Flows	– From IMS to employee
Level of Automatism	– Low: although supported by automated reports and technology to print yellow labels, the finding and remarking process is a manual one
Decision Points	– Item destiny (reduce, dispose) – In extreme cases, the price itself
Contingency Plans	– Manual yellow labelling in case of technology failure
Supporting Assets	– Information systems (IMS) – PDAs – Wagons, trolleys

Use Case diagram for the item finding, remarking and moving procedure under the current situation (non-Auto-ID-enhanced):

Figure 2

USE CASE DIAGRAM FOR THE ITEM FINDING, REMARKING AND MOVING PROCEDURE



Main flow of events

M.1. IMS
M.1.1. As possible, keeps an inventory of perishables per batch, assuming perfect rotation and getting its information from the POS system
M.2. Shop employee – on replenishment or following scheduled verifications
M.2.1. Generates report with estimated perishables about to expire (from IMS)
M.2.2. Generates report with location information (from IMS)
M.2.3. Locates the items
M.2.4. Decides damaged or aged items' destiny
M.3. PDAs
M.3.1. Scans the items and print substitute barcodes in yellow labels
M.4. Shop employee
M.4.1. Remarks or disposes products
M.4.2. Moves products to "reduced price" shelves

2.1.3. Customer Checkout

In the case of bar-coded yellow labels, the checkout process remains the same, except that the cashier must take care of scanning the barcode on the yellow label instead of the original one. Nevertheless, this miss-scanning barely happens because yellow labels are normally put over the original barcode and cover it.

Cashiers must also check that the product description as shown by the till matches the acquired item. That is, that the yellow label has not been fraudulently or mistakenly changed.

In the case of non-bar-coded yellow labels (normally in products sold by weight), the normal procedure changes for the cashier scans the original barcode and presses a special key to allow for price change. Cashiers must then type the reduced price, remove the yellow label and keep it to avoid fraudulent reuse. In the case of more than one yellow label – multiple price reductions, cashiers must look for the one with the lower price and unstuck all them.

The checkout process is supported by the POS system (introduced above), which allows the scanning of barcodes on yellow labels and changes in prices. The latter are only allowed on authorised products, which are those products for which their master description file has a flag allowing for price changes at the point of sale. This selectivity prevents the cashier from mistakenly modifying the price of unauthorised products. The POS system also stores tables mapping prices of potentially reduced products and their respective barcodes.

The checkout process has the following characteristics:

Table 3: Checkout process characteristics

CHECKOUT PROCESS	
Actors	– Cashier

Procedure Steps	– For bar-coded yellow labels:
	  – Scan the barcode as usual
	  – Check that the product description matches the good
	– For non-bar-coded yellow labels:
	  – Scan the original barcode
	  – Press the "reduced price" key
	  – Find the yellow label with the lowest price
	  – Introduce the new price
	  – Unstuck the yellow label and store in the cashier

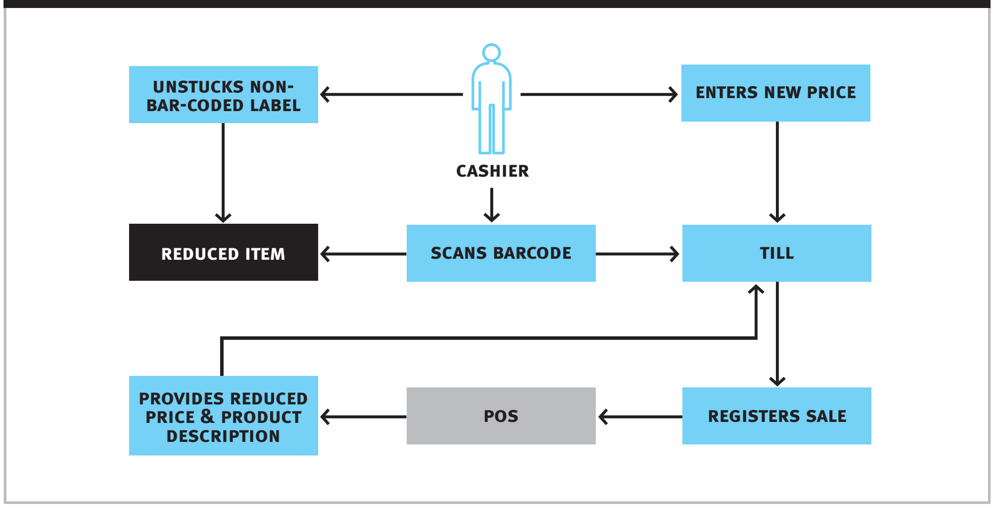
Continuation of Table 3

CHECKOUT PROCESS	
Product Flows	– Through the point of sale
Information Flows	– Sold items and prices from the till to the POS
Level of Automatism	– Medium: bar-coded yellow labels help the checkout scanning of reduced items, although non-bar-coded ones ask for manual dealing out
Decision Points	– N/A
Contingency Plans	– Manual price entry in case of unreadable or inexistent barcode
Supporting Assets	– Information systems (POS) – Till

Use Case diagram for the checkout procedure under the current situation (non-Auto-ID-enhanced):

Figure 3

USE CASE DIAGRAM FOR THE CHECKOUT PROCEDURE



Main flow of events

M.1. POS
- M.1.1. Keeps a table of reduced products with their barcodes and respective prices
- M.1.2. Keeps a table of products to which price changes are allowed

M.2. Cashier (bar-coded yellow labels)
- M.2.1. Scans the reduced-price barcode

M.2.2. Compares product description showed by the till with the product in transit
- M.2.3. If different, reject the sale of the product

M.3. Cashier (non-bar-coded yellow labels)
- M.3.1. Removes the yellow label and keeps it in the till
- M.3.2. Scans the original barcode
- M.3.3. Presses the "reduced price" key in the till
- M.3.4. Keys-in the new price

M.4. Till
- M.4.1. Looks for the product price and description in the POS system
- M.4.2. Sends the selling transaction to the POS system

2.1.4. Product Returns

Leading retailers accept product returns as a way of providing good customer service and gather information about market-rejected products in order to negotiate with suppliers and/or improve future product quality. Our company's policy is to accept and refund goods without making questions within 28 days after the sale, with or without receipt. This returning policy poses challenges to reduced product items when they are returned without receipt because the real selling price is not available. Therefore, the company has developed price negotiation rules that consider the highest, lowest, and regular product prices. Nevertheless, reduced items may still be refunded at higher prices than the real ones because the system does not register individual prices and item identification is not possible. However, it is believed that this does not happen very often.

The returning procedure is the first step of the reverse logistics procedure, covered in detail in the **"Auto-ID Use Case: improving inventory visibility in a retail company – impact on existing procedures and information systems"** (Morán et al, September 2003).

The returning procedure involves scanning the item's barcode when available or identifying the good by other means such as visual inspection when not. Then the customer service employee reviews the possible prices and agrees with the customer on the refund amount. The goods must also be checked for damages, and negotiate a lower price or deny the refund if the item is severely damaged or worn out.

As to bar-coded yellow labelled products, the simple scanning brings the real (reduced) price as long as the yellow label is available. Otherwise the scanning returns the normal price. This means that unscrupulous consumers always have the possibility of removing the yellow label and ask for a complete refund. Nevertheless, it is believed that these fraudulent refunds are not very frequent.

The returning process is supported by the following systems:

- **POS system (introduced above):** holds all possible prices for the returned product and eases the negotiation of the refund amount.
- **Customer service desk system (CDS):** registers returning information such as customer, return motive, date and product condition etc. Although the CDS system supports the returning process, it is essentially a tracing system as it registers the returning information in order to support other process steps such as supplier-level reverse logistics.

The return process has the following characteristics:

Table 4: Return process characteristics

RETURN PROCESS	
Actors	– Customer – Customer services employee – Warehouse employee
Procedure Steps	– Receive and examine the good – Find barcode or identify product – Negotiate refund amount – Refund – Register returning transaction – Store the good in the backroom or dispose it

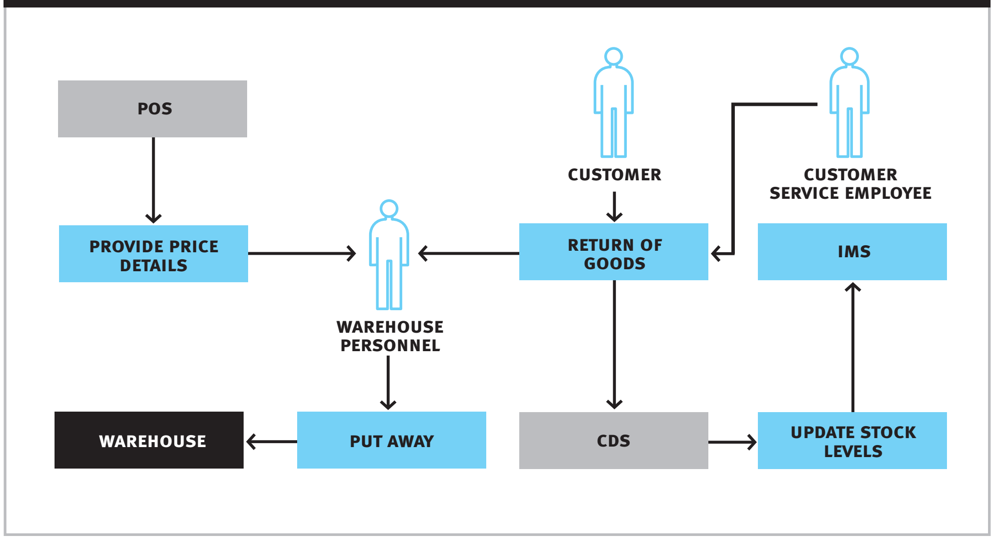
Continuation of Table 4

RETURN PROCESS	
Product Flows	– From the customer to the backroom
Information Flows	– From the POS system to the customer services employee – From the customer services employee to the CDS
Level of Automatism	– Medium: the POS support the amount negotiation, whereas the CDS traces the returning transactions
Decision Points	– Whether to receive the item or not – Amount to refund
Contingency Plans	– N/A
Supporting Assets	– Information systems (POS, CDS) – Till

Use Case diagram for the return procedure under the current situation (non-Auto-ID-enhanced):

Figure 4

USE CASE DIAGRAM FOR THE RETURN PROCEDURE



Main flow of events

M.1. POS
- M.1.1. Keeps a table of reduced products with their barcodes and respective prices
- M.1.2. Keeps maximum, minimum and offer prices for every product

M.2. Customer Services employee
- M.2.1. Receives and examines the good
- M.2.2. Finds the barcode and/or identifies the product
- M.2.3. Negotiates refund amount with the POS information
- M.2.4. Refunds
- M.2.5. Register the return transaction in the CDS system

M.3. Warehouse employee
- M.3.1. Stores or disposes the product item

2.2. Limitations of Current Technology/System

The current available technology limits the possibilities in the aforementioned processes. Some of these limitations are:

Items that have changed their status are difficult to identify: barcodes allow for product-level (as opposed to item-level) identification, which means that when a product item changes its status for any reason such as damaging or aging, it still has the same identification than other (good) items of its type. In fact, what is happening is that a defective or aging product item becomes a different product than the original one. It requests for different treatment, price, and even storage. As barcodes cannot change with the good status, this identification technology is ineffective to properly identify changing products.

Static existence and status checks are impossible to achieve: barcodes also require active action and intervention from employees, otherwise they remain meaningless. Whenever a product item remains static and not accessed – e.g. stored on the shelf, future processes concerning it must rely on historic information. That is, products are tracked only when they are involved in an ongoing and active process. This implicit marriage between item tracking and operational business processes has three consequences: first, processes relying on product existence or status may fail if the situation changes while the product items where static – e.g. damaged products. Second, additional processes or process steps such as stock verifications are required to ensure sound business operations. Finally, the whole process is more vulnerable to mistakes: any errors upstream the process chain affecting the product location, status or related information will be more difficult to identify and prevent, and is more likely to have a negative impact on the subsequent processes.

Locating items require manual intervention: barcodes must be scanned to properly identify the product, which is a manual process. Furthermore, identifying aging products require visual inspection for the expiration date is written in human-readable as opposed to machine-readable format. Although partially automated, most of the current remarking process itself requires human intervention to generate and stick the new labels, and to move the products to the “reduced price” shelves.

Changing prices is a slow process: as a consequence of the last point, price changes are slow and cumbersome, which means that only few price changes may be performed every day. Consequently, the flexibility to adapt to demand characteristics, (dynamic pricing) is considerably undermined.

Aspect of defective or aged goods is similar to that of normal ones: identification of aged or defective goods is important not only from the internal point of view. Consumers must also be able to locate and differentiate these items and clearly understand why they are reduced. The current technology asks for human intervention to change the item aspect, which consists on sticking one or more yellow labels with the word “reduced” and the former and current price on them.

An imperfect differential pricing system leads to imperfect rotation: whenever different items of the same product have the same price consumers will chose the better ones. It is well known that some shoppers thoroughly check the “best before” date when choosing a perishable, looking for the fresher goods. This necessarily breaks the rotation. Only a properly implemented differential pricing system would improve rotation as some customers would accept defective or aged goods for some savings.

The current system is prone to cannibalisation of regular items: reduced products that coexist with regular ones may cannibalise sales of the latter. Moreover, in case of extreme over-supply, cannibalisation may happen in cascade. That is, reduced products would cannibalise sales of future products, which would in turn have to be reduced to minimise waste and over-stocks, which would further cannibalise future sales, and so on so forth.

Information on reductions is not feed into information systems: one of the major limitations of the current differential pricing system is that, although PDAs are used to scan barcodes of reduced items and generate new ones, this data is not sent to the IMS or POS system. This limits the possibility of analysing turnover by product status, rotation quality, and detecting recurrent expiration patterns or cascade effects, as explained in section 3.3. This also limits the possibility of getting valuable information on consumer behaviour such as product demand curve, which quantifies the demand at different price levels.

Labels may accidentally unstick or be fraudulently changed: finally, an important problem with yellow labels is that they may become damaged, unstuck or, even worse, may be fraudulently swapped between goods. This creates a problem not only because of the cost and revenue loses result of improperly sold products, but also because information on stocks becomes distorted and inaccurate.

2.3. Opportunities and Issues to Solve or Improve

Reduction of manual intervention: the automation of item tracking and tracing procedures would definitely reduce the need for human work, intervention, and knowledge. Locating and identifying goods to reduce requires many employees and regular visits to shelves and the backroom. Similarly, the checkout process can be improved by simplifying the handling of reduced goods and their tags and prices. Involving humans in the aforementioned processes constitutes a problem for the following reasons: first, employees make mistakes; second, their availability is reduced to their working hours – holidays and resting hours rest productivity and availability to their experience and knowledge; third, humans generate other sort of requirements and related costs due to safety concerns, need of trust, etc. Finally, workforce is expensive and subject to many complex legal regulations.

Perfect rotation enabling: current information systems, reports and business analysis tools assume perfect rotation; that is, goods move in the same order within the supply chain and no overtaking takes place. However, it is clear that this is not the reality. An improved differential pricing system would help achieve perfect rotation as products with later “best before” or “expiration” date will be easily found and reduced to foster demand. Achieving perfect rotation is important as it directly impacts on product quality and level of waste, as explained below.

Improvement of the return process: item level identification at the return desk would allow for the fair refund of returned items without receipt, even if these items were bought at a reduced price.

Smoother and more frequent price reductions (dynamic pricing): as product finding, remarking and moving processes would be either simplified or avoided hence, the re-pricing itself would be speeded up, product items can undergo several (smoother) price reductions. This would allow dynamically adjusting prices to demand and stocks, maximising thus revenue and stock rotation, and minimising costs. Under the current system, the price changes drastically once or maybe twice when the product approaches its expiration date, giving no place to intermediate discounts. Intermediate discounts would allow fostering demand in case necesary.

Reduction of waste: imperfect rotation is always a source of waste because some goods reach their expiration date not due to the lack of customer demand, but for the mere reason that they are left behind in the replenishment process. Enabling perfect rotation by means of a reliable differential pricing system would notably reduce the level of waste. Reducing waste is important not only because of the cost reduction it involves, but also due to environmental concerns and regulations.

2.4. Auto-ID Capabilities Enhancing the Use Case

The main Auto-ID capabilities enhancing the Use Case are:

1. Tracking and identification capabilities to improve the finding, remarking, and checkout processes. The ability to know where a product item is stored and which product items need price reductions makes Auto-ID a remarkable technology to enhance the differential pricing system in order to reduce manual intervention, improve rotation quality, allow for dynamic pricing, reduce waste and allow for more accurate refunds in product returns.

2. Tracing capabilities to improve the return process. Having the possibility of tracing back a returned product notably enhances the returning procedure. The real origin of the product would be easily determined, and the returning process itself at the customer services desk would benefit from detailed selling, customer and product information such as paid price or date of acquisition.

3. Inter-organisational capabilities to improve the finding processes. One important piece of information enhancing these processes is the "best before" or "expiration" date. Auto-ID inter-organisational capabilities allow sharing this information between suppliers and retailers, which can be used to support decisions in the differential pricing process.

The following table summarises the relationship between current processes, opportunities and issues to solve, and the Auto-ID capabilities leveraging these opportunities:

Table 5: Opportunities of improvement, processes and Auto-ID capabilities leveraging them

	FINDING & REMARKING	CHECKOUT	RETURNS
Reduction of Manual Intervention	Tracking	Tracking	Tracing
Perfect rotation enabling	Tracking Inter-organisational		
Improvement of the Return Process		Tracking	Tracing
Dynamic Pricing	Tracking	Tracking	
Reduction of Waste	Tracking Inter-organisational		

2.5. Implementation

2.5.1. Implementation Pre-requirements

From a functional point of view, this paper assumes that some current policies and practices can be modified to suit a better differential pricing system by means of Auto-ID. Some of these possible modifications are:

Item moving: as long as they are properly identified; reduced items do not necessarily have to be moved to a different shelf. They could be kept in the habitual shelf, although may be moved beside (to a parallel track) for better identification by customers.

Item aspect: the methods to differentiate reduced items from normal ones can be changed. This is, yellow labels can be replaced by other visual or/and acoustic indications.

Availability of information: Suppliers are able to provide the required item-level information such as "best before" date, and make available via PML servers. Alternatively, the product reception process in the warehouse may include the scanning of this and other relevant information at item-level – see the receiving and put-away procedure in the **"Auto-ID Use Case: improving inventory visibility in a retail company– impact on existing procedures and information systems"** (Morán et al, September 2003).

Return policies: the refund negotiation rules may change result from better price information.

Some of the most important technical requirements are:

Queries: an interface is needed to allow queries to be made relating to product details (e.g. finding the price, location, name, supplier details of a product on the shelf). This interface must also be present on the handheld devices to provide full functionality.

Till and customer services desk reading configuration: for this configuration to work, readers in the checkout till and customer services desk must be properly configured to avoid double item checking or misreading.

Scan reliability: 100% scanning accuracy needs to be guaranteed. Accuracy is an important requirement as all perishables must be visible to detect any need for reduction.

2.5.2. Implementation Alternatives

There is more than one implementation possibility to the use Auto-ID to improve the differential item pricing system in retail. This application of the Auto-ID technology is complex in which the best results of differential pricing management seem to come not only from the bare application of Auto-ID, but also of complementary technologies such as digital price displays – either on shelves or goods, special packages etc. The reason for this is that it is not only important to internally identify goods asking for reduction, but also make these items clearly identifiable to consumers. Moreover, some complementary technologies such as colour-changing labels or the like make Auto-ID redundant as to differential pricing under certain implementation scenarios, for the same identification methods can be used by both customers and internal handling. The best combination of technologies is difficult to determine at first sight, particularly in the absence of thorough valuation techniques for both the benefits and costs. Nevertheless, we propose three implementation scenarios which are believed to cover the lower, medium and high cost possibilities.

In brief, the implementation alternatives depend on:

1. How items suitable for reduction are internally identified and located;
2. How their aspect and location is modified to allow easy identification by consumers;
3. How items and their price are identified in the POS to apply the reduction; and
4. How items are identified in the post-sale stage to allow for fair refund in case of return.

Auto-ID can address points 1, 3 and 4; or even 2 if special tags allowing for both automatic identification and price display are used.

The following table summarises the possibilities:

Table 6

IMPLEMENTATION POSSIBILITIES BY FUNCTION	
Internal Identification	– Manual, by visual inspection and/or barcode scanning (current) – Electronic tags on goods + – Mobile readers, or – Smart shelves in both the backroom and store
Aspect Modification	– Smart packaging[1] – Manual labelling (current yellow sticker) – Electronic price displays on goods – Electronic price displays and smart readers on shelves + electronic tags on goods – Smart tags with both identification and price display possibilities
POS Identification	– Tags on products + readers in POS – Smart packaging – Manual labelling (current) – Electronic price displays on goods
Return Identification	– Tags on products + readers in CS desks – Barcode (current) – Visual inspection (current)

[1] Smart packaging consists on electronic or chemical devices attached to the product package that alter the aspect of individual product items – e.g. changing colour or emitting a sound or light – when certain conditions are met – e.g. reaching the expiration date or being stored at a lower temperature than desired.

Some combinations make little or any sense. For example, once products are tagged with an Auto-ID chip, the same technology may be used for internal, POS and return identification, thus keeping some manual procedures is not necessary. Other combinations such as using smart packaging and manual product finding, checkout or return do not require automatic identification technologies and are thus out of the scope of this paper. Having reviewed the possibilities, this paper proposes the following implementation approaches:

a) Low cost scenario (pure Auto-ID).
   - Mobile readers connected to PDAs for product location and identification
   - Readers at POS and customer services desk

In this approach we propose using automatic identification technologies to support the location and identification of aging product items, and relying on manual intervention for re-pricing and aspect modification. Shop employees would use mobiles readers to scan shelves in search for products about to expire. Nevertheless, the search for defective products has to be done the same way it is done nowadays: by visual inspection. The aspect of the reduced goods would be modified manually for example, by using the same current yellow-labelling technique or similar. Similarly, reduced goods would still be moved manually to the corresponding shelf. Fixed readers at the POS and customer services desk would allow for quick and reliable item and price identification in the checkout and return procedures respectively.

This scenario addresses the challenge of identifying and locating products, although it still requires more or less the same amount of manual intervention for product re-pricing and re-locating. The main advantages are accuracy in the process, as almost no expiring product would be left behind, and efficiency in the use of workforce, as detailed visual inspection is not longer necessary to check due dates.

b) Medium cost scenario (Auto-ID plus price displays on shelves).
  – Smart shelves with fixed readers for product location and identification
  – Displays on shelves (connected to the network or with smart tags)
  – Reader at POS and customer services desk

In this approach we propose the use of automatic identification technologies combined with digital displays on shelves showing the price or prices of the different products on the shelf. There may be more than one price in the case of many product items with different expiration date but placed along the same shelf line. In this case the display may show the normal price and the reduced price or prices. That is, it would indicate whether there is "at least" one reduced item within the shelf's line. These displays can be connected to the shop network, or may alternatively consist of a smart (active) tag with a display, which would take the price information from the reader on the shelf. In this case, the reader first detects the aging products, transmits this information to the application, which finds in turn the price or prices in case of positive identification and sends them to the shelf's displaying tag via the same reader.

Alternatively, and to further reduce costs, this scenario may consider mobile readers connected to the PDAs instead of fixed readers on shelves. However, this approach is not believed to make a good solution as the price information would only be updated when a shop employee walks through the isle, and consequently a reduced price offer may be kept wrongly displayed well after a customer picked the last reduced item off the shelf.

Although the first version of this scenario (with smart shelves) is fully automatic as to price updating, some manual intervention may still be necessary to modify reduced items' aspect by yellow-labelling them, tidy up products on shelves or move reduced products somewhere else. The reason for this is that consumers may more likely be confused by seen the same product with different prices, or similar mixed up items with different expiration dates and prices.

c) High cost scenario (Auto-ID with smart tags showing the item price).
  – Mobile readers connected to PDAs for product location and identification
  – Smart tags on product items with logic to compute reducing conditions and a graphic display for price
  – Readers at POS and customer services desk

In this approach we propose the use of smart (active) tags which include a digital display for the individual item price. Readers are only needed at the POS and customer services desk to support the checkout and return procedures, although some mobile readers connected to PDA's would help location and identification in activities such as tidying up or replenishing shelves. Apart from the regular antenna and identification logic, these smart tags should include a battery and price display, and logic and memory to drive the latter. This would make the tag very expensive, which may make this scenario prohibitive. How tag prices evolve will determine the viability of this approach

Alternatively, smart shelves can be used instead of mobile readers to support the tidying-up procedures, although this solution would be even more expensive.

As with the previous scenario, consumers may be confused by similar mixed up product items with different prices and expiration dates, which may ask for manual intervention to keep shelves organised or move reduced items to another location.

2.6. Potential Benefits

In relation to the improvement opportunities, the main benefits that result from an improved differential pricing system are:

Productivity increase: a good differential pricing system assists in making the best possible use of the shelf as an asset, as expired or about-to-expire products are easily found and handled, saving thus shelf space. Productivity in the checkout and return processes is also improved for cumbersome tasks such as retiring the yellow label and typing the right amount for non-bar-coded offers are not longer necessary. The following improvement opportunities directly or indirectly help increasing productivity: **reduction of manual intervention** – as the location, checkout and return procedures would be more automatic; and **improvement of the return process** – same reason. The productivity increase result from all these improvement opportunities can be easily valued using cost/benefits analysis, so long the inputs are known. For example, the reduction in manual work required by visual item examination can be easily found by measuring current workforce requirements. Valuing this reduction in terms of money is straightforward because workforce cost is normally well known by retail companies.

Cost reduction: it comes from various improvement opportunities. **Reduction of waste** allows for saving not only the cost of disposed products but also that of disposing procedures; **reduction of manual intervention** which may be expensive; **Smoother and more frequent price reductions** which allows to dynamically adjust price to demand, reducing thus waste from expired perishables whilst maximising revenue; and **improvement of returns** which allows for fairer refunds as the original price would be easily identified and found. Valuing these benefits monetarily is a straightforward cost/benefit analysis in some cases such as reduction of manual intervention, but a more complex one in others where the inputs are not known such as cost reduction result from perfect rotation, for waste may result from both lack of customer demand and product left-behind. In the latter, some stochastic valuation techniques may be necessary.

Service improvement: these benefits are the result of improvement opportunities in **enabling perfect rotation.** Customers will find fresher products on the shelves and/or have the possibility to choose between paying more for a fresh item and saving some money for an aged one for immediate consumption. The organisation will also be able to provide a better product return service as more and more accurate information will be available at the customer service desk. Valuing the benefits of service improvement is trickier and sometimes impossible to do. Customers visit the supermarkets for a variety of reasons: proximity, attraction, habit, loyalty programs, cost, availability of products etc. The latter surely affects their decision, although it is almost impossible to find to what degree.

Information gathering: an Auto-ID enhanced differential pricing system generates valuable information on consumer preferences such as how much a consumer would be willing to pay for a product that must be consumed the same day. Similarly, selling the same product at different prices allows gathering information to build a demand curve, which could be used to improve marketing strategies.

Strategic value: finally, the Auto-ID infrastructure has strategic value as long as it can be used for other applications, either immediately or in the future. For example, readers in shelves could be used to gather valuable information on consumer behaviour for marketing purposes, and tags on products could be used to provide customers with detailed information about the product item. Strategic value can be estimated in terms of money by using complex financial formulae as real options or the like, but that is out of the reach of the current paper.

3. ASSESSING THE IMPLEMENTATION IMPACT

3.1. Identifying the Affected Systems and Related Data and Transactions

In this section we identify the impact of Auto-ID on the described procedures in a retail company and its related information systems. This impact is found by relating the decision points within these procedures with the information affecting decisions and their related transactions, as well as the information flows from the procedures to the supporting information systems. As a starting point to the analysis, table 7 summarises the current situation:

Table 7

PROCEDURE STEPS, SUPPORTING IS TRANSACTIONS AND GENERATED TRANSACTIONS

	Procedures	Finding, remarking and moving				Checkout	Returns		
Systems	Decisions/ activities	What products to reduce	Where to find products to reduce	Should the product be reduced or discarded?	What new price to assign?	What price to charge?	How to identify the product if barcode is not available?	How much to refund?	Reason to return
	Transactions								
IMS	List of products about to expire	List of products							
	Location		Shelf, row & line						
POS	Price per product and freshness				Reduced price				
	Price per barcode					Price			
	Range of prices per product							Max & min prices per product & date of purchasing	
	Product description						Product details		
CDS	Details on returning transaction								Motive
Manual	Visual inspection		Check all due dates	Product status		Price on label			
	Human decision				Reduced price		Product identification	Refund amount	

3.2. New Operational Procedures with Auto-ID

The new procedures resulting from the usage of Auto-ID to enhance differential item pricing significantly vary depending on the implementation scenario. For example, in scenario “A”, most of the current procedures remain the same. Scenario “B” is believed to bring the most changes to current operational procedures, as reduced products may not be moved anymore to special shelves but must be tidied up within their shelf.

Scenarios “B” and “C” ask for special tidying-up complementary procedures, which may or may not imply moving reduced goods to a special shelf. Information systems could alert needed tidying-ups should a smart shelf detects a high turnover and many reduced items mixed up with regular ones on it. In case of mobile readers in scenario “C”, Auto-ID could help locating reduced goods as shop employees walk through the isle, although would not be able to constantly provide the “degree” of entropy on shelves, defined as the proportion of mixed reduced-regular products plus turnover level.

As table 7 shows, many transactions and pieces of data flowing between operational procedures and information systems deal with item identification and specific details such as price and expiration date. The former is stored in the POS system, whereas the latter is hosted by the IMS. This poses important integration challenges for the Auto-ID infrastructure, for the reduced price results from joining the “due date” data and the table of possible prices per product in the POS.

The major changes in procedures are related to the finding and marking of items suitable to be reduced. In implementation approach “A”, Auto-ID helps finding them, although their remarking still requires manual intervention. In implementation scenarios “B” and “C”, there is no pressing need for item finding as prices change automatically once goods age beyond predefined thresholds. Nevertheless, identifying reduced items on shelves is still important to support the tidying up procedures in scenarios “B” and “C”.

The impact of Auto-ID on current procedures involves the inclusion of a new actor – Auto-ID infrastructure, which provides information about product location and identification. This new actor was included in the Use Case diagrams to properly reflect the impact, as shown below. The respective procedure steps also reflect the extra or modified steps.

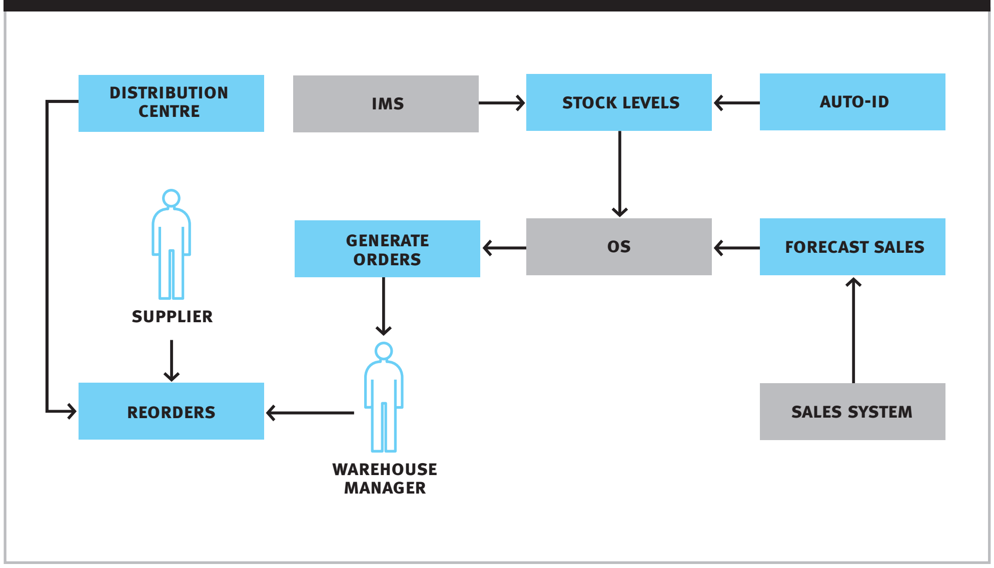
3.2.1. Reordering Process

Auto-ID will help gathering valuable information about physical existence by expiration date. The reordering process barely changes, except in the qualitative sense: better information on existence level will allow more accurate orders, and a better reordering formula will allow matching daily sales and “best before” dates – see section 3.3.1.

The following diagram shows how the new actor fits into the existing procedure.

Figure 5

USE CASE DIAGRAM FOR THEAUTO-ID-ENHANCED REORDERING PROCEDURE



Main flow of events

A.1. Auto-ID
- A.1.1. Provides accurate existence information

A.2. Warehouse manager
- A.2.1. Issues reorder report
- A.2.2. Checks reorder report
- A.2.3. Sends reorders advices to distribution centre or suppliers

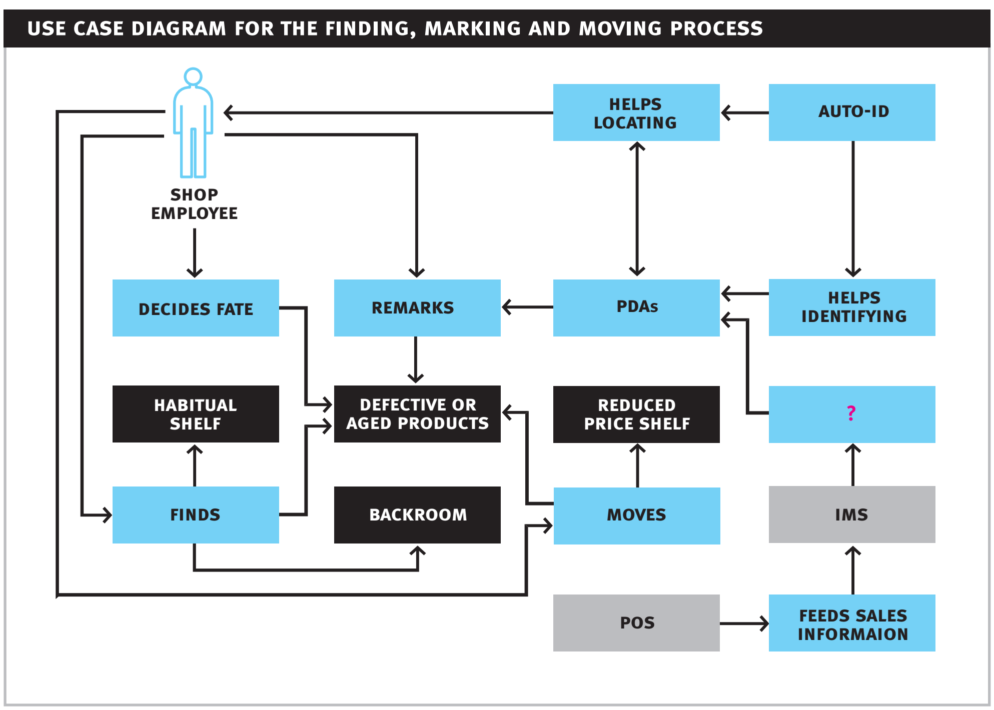
A.3. Supplier or distribution centre
- A.3.1. Picks and sends the shipment
- A.3.2. If product items are not available, notify warehouse manager

3.2.2. Finding, Remarking and Moving Process

Auto-ID allows for a more accurate and reliable product location. Since the IMS stores "due date" information per product item and batches, and EPCs™ of perishables obtained through the inter-organisational Auto-ID capabilities, and since the POS will register all sales by EPC™, the information in both systems can be combined to generate a detailed report of aged perishables per shelf. This report, together with the Auto-ID infrastructure, will allow operators to visit the shelves, find the products and remark them as reduced if necessary. In the case of implementation scenario "A", the actual finding will be made by means of mobile readers. In the case of scenario "B", smart shelves will provide detailed product location all the time, which may be included in the aforementioned report. Nevertheless, in the case of scenarios "B" and "C", the finding and remarking of the products is not longer necessary as displays on shelves or smart tags will change price automatically as programmed.

The following diagram shows how the new Auto-ID actor fits in the process in the case of implementation scenario "A":

Figure 6: Auto-ID-enhanced Use Case for the finding, remarking and moving procedure under scenario "A".



This Use Case diagram does not apply to implementation scenarios "B" and "C", for the finding, remarking and moving procedure is not longer necessary, see the new procedure: shelf tidying-up.

Main flow of events

M.1. IMS
  M.1.1. As possible, keeps an inventory of perishables at item-level, getting its information from the POS
M.2. Shop employee – on replenishment or following scheduled verifications
  M.2.1. Generates report with estimated perishables about to expire (from IMS)
  M.2.2. Generates report with location information (from IMS)
  M.2.3. Locates the items using the mobile readers
  M.2.4. Decides damaged or aged items' destiny
M.3. PDAs
  M.3.1. Scans the items and print substitute barcodes in yellow labels
M.4. Shop employee
  M.4.1. Remarks or disposes products
  M.4.2. Moves products to "reduced price" shelves

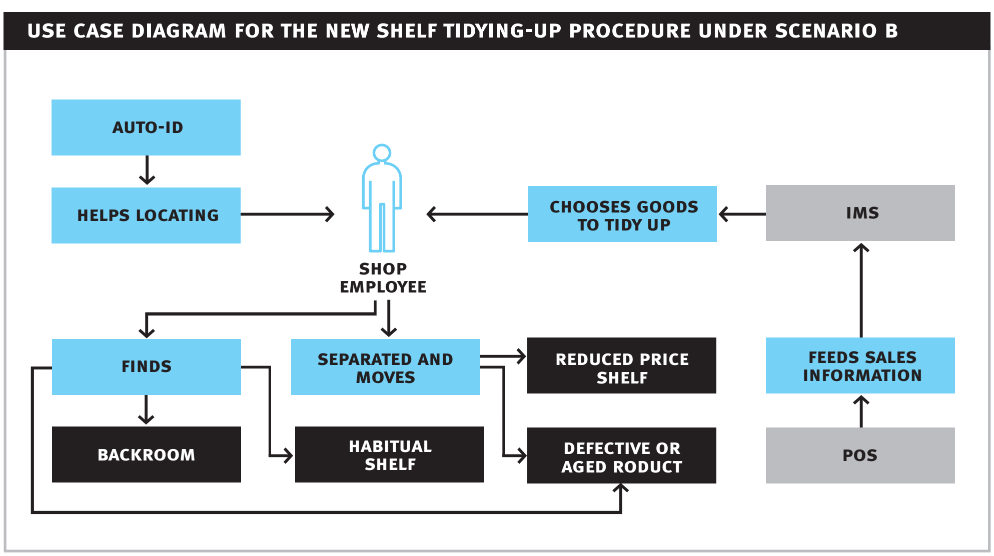
The main difference between this procedure and the current one (in 2.1.1) is that the information from IMS will be more accurate, as perfect rotation does not have to be assumed. The POS will provide more reliable rotation information on on-shelf existences as item-level turnover is gathered. This makes a quantitative difference because fewer products have to be reviewed in that case. The IMS would also "filter" out unneeded product verifications in case of high sale volumes or good rotation quality.

3.2.3. Shelf Tidying-up (New Process)

This new process is required for implementation scenarios "B" and "C", in which prices are automatically updated. Under scenario "B" or scenario "C" with smart shelves, the Auto-ID technology avoids unnecessary visits to shelves as prices change automatically and the system constantly monitors both turnover and mixing quality, alerting any required manual intervention. Under scenario "C" with mobile readers, a constant monitoring by employees is still needed. The IMS system will use this information to trigger a shelf tidying-up process, in which shop employees are instructed to review specific shelf areas to separate reduced product items from regular ones. Depending on the supermarket policies, this process may involve moving reduced goods to dedicated shelves for better identification by consumers.

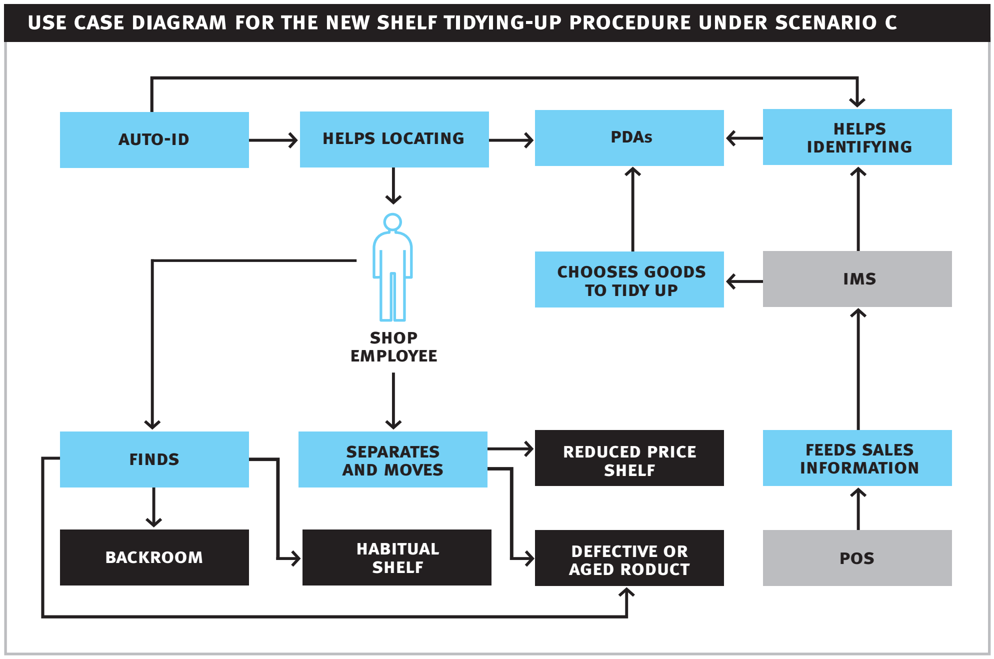
The following figure shows the Use Case diagram for this new process under scenario "B":

Figure 7: Auto-ID-enhanced Use Case diagram for the tidying-up process under scenario "B".



The following figure shows the Use Case diagram for this new process under scenario "C":

Figure 8: Auto-ID-enhanced Use Case diagram for the tidying-up process under scenario "C".



In these Use Case diagrams it is easy to see how Auto-ID simplifies the general process by providing location and identification information.

Main flow of events

A.1. IMS
- A.1.1. Consolidates information from the POS and Auto-ID systems (in case of smart shelves) to estimate level of tidiness per shelf and location

A.2. Auto-ID (mobile readers)
- A.2.1. Helps locating items asking for tidying-up

A.3. Shop employee
- A.3.1. Generates report with recommended product reviews and their locations
- A.3.2. Visits and tidies shelves

3.2.4. Checkout Process

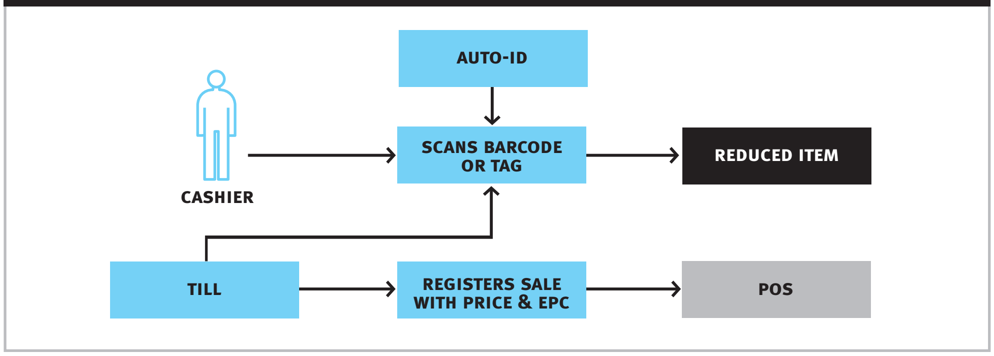
The checkout process can be simplified by the use of Auto-ID. Moreover, some Auto-ID Use Cases propose getting rid of cashiers and allow for a fully automatic checkout procedure. This is out of the scope of this study. Under our implementation scenarios we consider the co-existence of barcodes and Auto-ID tags and the intervention of human cashiers to scan both bar-coded and electronically tagged goods. The Auto-ID-enhanced checkout procedure will allow reducing product manipulation in retiring non-bar-coded yellow labels and typing the reduced price. It will also reduce the need for scanning as electronically tagged products will be automatically detected.

Nevertheless, the impact of Auto-ID on the checkout process, as long as human cashiers stay, merely constitutes a substitution of the barcode as an identification means. In other words, the impact is quite modest.

The following figure shows how the new Auto-ID actor fits into and simplifies the checkout process:

Figure 9

USE CASE DIAGRAM FOR THE AUTO-ID-ENHANCED CHECKOUT PROCESS



Main flow of events

A.1. POS
- A.1.1. Keeps a table with individual item prices – both regular and reduced

A.2. Cashier and Auto-ID
- A.2.1. Scan the electronic tag

A.3. Till
- A.3.1. Looks for the item price
- A.3.2. Sends the selling transaction to the POS system, including the EPC™

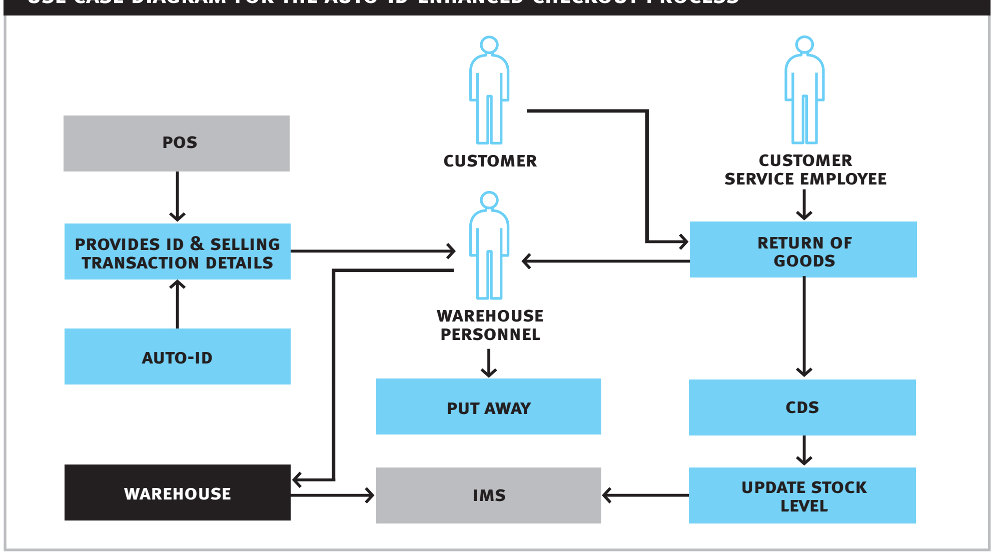
3.2.5. Return Process

The return process benefits from Auto-ID because more information will be available. This will allow better identifying the product and negotiating the refund price. Nevertheless, this requires the tag to be held active beyond the POS, which poses tremendous privacy issues which is the source of furious debate nowadays. This paper assumes that tags are not deactivated, although reality may be quite different result from regulations and public pressure.

The following diagram shows the role of the new Auto-ID actor in the return process:

Figure 10

USE CASE DIAGRAM FOR THE AUTO-ID-ENHANCED CHECKOUT PROCESS



Main flow of events

A.1. POS
  A.1.1. Keeps a register of all selling transaction at item level, including EPC™, for at least 28 days
A.2. Customer Services employee
  A.2.1. Receives and examines the good
  A.2.2. Scans the electronic tag
  A.2.3. Find the original price
  A.2.4. Refunds
  A.2.5. Register the return transaction in the CDS system
A.3. Warehouse employee
  A.3.1. Stores or disposes the product item

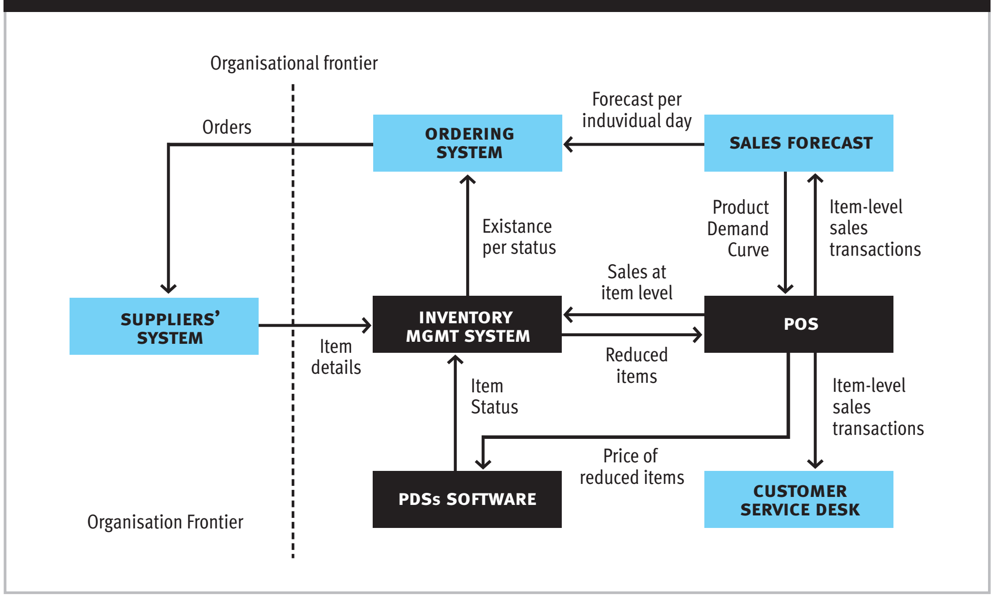
3.3. Impact of new Procedures on Existing Information Systems

Improving the current differential pricing system in our company by means of Auto-ID affects many systems and the data they share. Most of them require a finer granularity of their product entities, down to item-level. Some others such as the ordering system require new functionality and improved order computation algorithms (see below), as they will have more and more precise information to perform. Systems will also be able to generate more reports to analyse operations in the differential pricing system and improve its performance, such as the rotation quality report.

Perhaps the most important impact on current retail information systems as to differential pricing improvement is related to the qualitative and quantitative increment of intra-systems data flows. Systems will share information such as price and status at item-level as opposed to product level. In addition, sales forecast granularity must draw down to the "best before" minimum granularity – normally day-level. The following figure shows the new data flows between systems:

Figure 11

NEW DATA & DATA FLOWS CREATED BY AN AUTO-ID-ENHANCED DIFFERENTIAL PRICING SYSTEM



Blocks in black represent systems that have direct contact with Auto-ID. Blocks in blue represent systems which functionality is indirectly affected by Auto-ID.

The concrete proposal is to make the current differential pricing system more automatic, and feed the IMS with data on reduced items, either damaged or aged, as opposed to the current approach in which reductions are not fed back into information systems. Moreover, some systems will incorporate new functionality to make the most of item-level, Auto-ID generated information.

In the following sub-sections it is analysed the impact of Auto-ID on individual information systems.

3.3.1. Ordering System (OS)

The reorder system is affected by the granularity of ordering data. Instead of generating a list of required quantity per product, it will generate a list of required quantity per **day per** product. This assumes that suppliers are able to deliver products that will not expire before the required dates or divide their shipments to comply with the specified dates and quantities. As explained before, the reorder algorithm derives its basic inputs from the sales systems (sales forecasts) and inventory management system (stocks) etc. Consequently, these systems also need to modify their granularity to allow for forecast and existence report (respectively) per expiration granularity. That is, the main reordering formula must group item existences by product and expiration date instead of by product only.

Granularity aside, the system must to incorporate new functionality in terms of more complex ordering algorithms able to adjust frequency of orders, expected delivery time, minimum batch size, and average variability in order to optimise deliveries and maximise product aging window, and reduce cannibalisation. To illustrate, issuing more frequent and smaller orders would increment average product freshness and reduce store stocks, but increment delivery costs and reduce manoeuvrability in case of extreme demand variations. Conversely, less frequent and larger orders would affect product freshness and foster price reductions in case of low demand, requiring a drastic reduction of future order quantities to avoid cannibalisation in cascade.

Ideally, the ordering system should also work in combination with the sales and POS system in order to use consumer statistics to calculate and update optimum prices where regular and aged stock would be sold for a given forecasted demand during a day – demand curves, and to calculate daily reductions aiming at fostering sales to avoid overstock and hence, future further reductions. This achieves smoother reductions through dynamic pricing. By doing so, there will not be remaining stocks to cannibalise regular product sales once these products are replenished. Moreover, suppliers may be encouraged to provide fresher products or products better matching daily demands by negotiating different prices on longer-lasting batches, hence transferring the differential pricing system upstream the supply chain. Pushing the concept to extreme, the system could calculate statistics-based supply curves, and adjust the price to suppliers accordingly.

In a nutshell, the ordering system must not only match daily demand and stock levels with orders, but negotiate individual batch prices with suppliers depending on their “best before date”.

This new functionality poses a complex statistical scenario, which is not in the scope of this work. Our recommendation is to use non-linear regression models or Monte Carlo simulations to value all possible order size and frequency combinations aiming at minimising costs and cannibalisation under uncertain conditions – variable demand and supply. Furthermore, this simulation model should be an active part of the new ordering system, for input variables would change on-the-fly and new orders must reflect them immediately.

TRANSACTIONS

Orders (outgoing): in line with the explanation above, the product ordering transaction will include product, earlier allowed expiration date, and quantity.

Forecast per individual day (incoming): the sales forecast system will generate forecasts at day-level, so the ordering system can match them with stocks per "due date" day and order according.

Stocks per status (incoming): similarly to the point above, the inventory management system will report on stocks per "due date" to be combined with daily forecasts and generate day-level orders.

REPORTS

Freshness compliance: the reordering system will generate a report to analyse order compliance by suppliers. This report compares product requirements with shipments, not only in product quantity but also in quantity per required expiration date. This report may be used to force suppliers to keep a competitive level of product freshness by avoiding sending goods which may expire before being sold and thus, asking for reduction.

3.3.2. Sales System (SS)

In line with the reordering system's new granularity requirements, the sales system needs to be modified in its forecasting capabilities: more than storing aggregated information and generate sales forecast for the next "n" days, it must be capable of registering historic daily sales, analyse daily seasonal effects and generate forecasts at day level for both reduced and regular products. That is, the forecasting granularity must be brought down to product status and to days or freshness granularity if lower.

Furthermore, the sales system will need to incorporate new functionality to gather information on product demand curve. This will allow making dynamic and smoother price adjustments to match stock and demand aiming at selling all goods before they expire, as explained in 3.3.1.

STORAGE

Daily sales per product at item-level detail: the sales system will require historic daily sales information per product and expiration date. This information will be generated by the POS at customer checkout.

TRANSACTIONS

Sales forecast at daily level (outgoing): as explained in 3.3.1, the sales system will send sales forecast by product and day to the ordering system.

Item-level sales (incoming): these transactions will be generated by the POS system. The item-level, EPC-based sales transactions will incorporate individual prices and product status, so the sales forecast system can register sales per price, per day and even per time frame. The idea is to build a forecasting system as precise as possible which considers all variables such as price, time, product age etc.

Demand curve (outgoing): this transaction will consist on a table with the statistically estimated units to sell per price range; product status – age etc; seasonal moment – time frame, day of the week or month; and the statistical variability and distribution. It will allow the POS system to dynamically adjust the price of reduced items (or even regular ones) to avoid over- or under-stocks.

REPORTS

Demand curve: similarly to the transaction, the information gathered by the sales system on demand under different scenarios will be offered as a human-readable report.

3.3.3. Point of Sale System

As with the sales system, the POS will need a higher level of granularity in its price tables. Instead of product- or SKU-level prices, item-level prices are required. Furthermore, the POS system will incorporate data on the demand curve – generated by the sales system, so dynamic product pricing is possible. This new functionality will need joining data on current stock levels for regular and reduced items from the IMS, and sending EPC-related, calculated individual prices to either the Auto-ID infrastructure, so digital displays dynamically reflect them (implementation scenarios “B” and “C”); or to PDAs so yellow labels prices are correct (implementation scenario “A”). The POS system will also send stock movements at item-level to the IMS, so information on both regular and reduced item existences accurately reflects reality. The changes are summarised as follows:

STORAGE

Daily sales per product at item-level detail: The POS system will require historic daily sales information per product and expiration date. This information will be stored for at least 28 days to allow for easier product returns.

TRANSACTIONS

Demand curve from the sales system (incoming): see 3.3.2.

Item-level sales (outgoing): as defined in 3.3.2, this transaction would be automatically sent to the sales system, or to the CSD system upon request on product returns.

Item-level inventory movements (outgoing): the POS will also notify the IMS of all sales at item-level (using EPCs™), including the product status (regular, reduced). This transaction must be online, for the IMS is being used to feed the ordering system and report on other reduced items which price must be the same on both the shelf and till.

Price of reduced items (outgoing): under implementation scenarios “B” and “C”, the POS system will send updated prices to the Auto-ID infrastructure (Savant) or the digital displays attached to the network (scenario “B” without smart tags on shelves). This data transfer must be online to ensure that prices on displays on shelves or on products match prices on tills. Under implementation scenario “A”, this data will be sent to the PDAs software to allow for proper yellow labels printing. In this case, there will be a delay (either manual or system-generated) between a price change in the POS (tills) and its display on yellow labels. This implies that under scenario “A” prices can only be reduced; for it can be assumed that customers will not complaint about paying less than previously expected, but under no circumstance accept paying more than the amount showed on the shelf.

3.3.4. Inventory Management System (IMS)

The major changes in the IMS by incorporating Auto-ID are related to the storage and share of product item aging and identification information. One of the major impacts of Auto-ID on the IMS is that new entity granularity is required for product information: not only products and quantities should be stored, but also product items with their respective unique information such as “best before” or “expiration” date and particular location. The new detailed storage requirements are as follows:

STORAGE

Product items: this new entity will store information about every product item, “best before” date, location within the store or last location where tracked, and EPC™ code. Optionally, this entity may contain historic storage information such as refrigeration and handling conditions etc. In some cases this information can be held at batch level – e.g. “best before” date, so long the relationship with individual EPCs™ is also stored. Individual item characteristics will also include item status – regular, reduced, damaged; for other processes that depend on stock level such as product reorders require information on the real saleable stock.

The IMS will also need to include new reports and transactions, as follows:

TRANSACTIONS

Damaged products (incoming): the IMS will not only hold information on product stock levels, but also on item-level status. An individual product may be damaged but still saleable, or damaged and not saleable needing to be disposed. As we know, damaged, still-saleable products are good candidates for reductions, but they should not count as saleable stock as to calculate future replenishment orders. Shop floor employees will scan EPCs™ of damaged products using mobile PDAs, which will send a status change transaction to the IMS for the specific item.

Reduced items (outgoing): upon request by the POS system, the IMS will send the status of each item of a particular product line. This will allow the POS to dynamically update its item-price tables to reflect the right price at checkout. This transaction should be online, for reduced items' price must be the same on both the shelf and till.

REPORTS

Stocks by status: given that the status of items will be fairly updated to the IMS, it will generate an accurate report on item stocks by status (regular, aged, damaged, returned etc). This will allow analysing the quality of stock and even its value.

INTER-ORGANISATIONAL TRANSACTIONS

Product item characteristics: using Auto-ID, the inventory management system will receive detailed product item information such as "best before date" or storing conditions. This will replace some current procedures in which this information is manually scanned using barcodes – at the dock on product receipt, see "Auto-ID Use Case: improving inventory visibility in a retail company – impact on existing procedures and information systems" (Morán et al, September 2003). This information has to be be published by suppliers in their PML servers.

3.3.5. Customer Desk System

This system remains mainly unaffected, except for the fact that it will have to store the EPC™ of returned goods, as an alternative to the current unique barcode identification code for those items. The CDS will get the returning information from the POS instead of from the cashier – at least the original price; so long the product still has the electronic tag. This will improve the returning process and provide it with accuracy and reliability.

3.3.6. Business Intelligence Systems

NEW INDICATORS

Demand curve: business intelligence systems will combine historical information in the sales system with data affecting consumer demand such as macroeconomic variables, promotions and store-specific characteristics to obtain general, high-level product demand curves relating product price and demand quantity. This will allow optimal product pricing by season, and elasticity of demand to develop better competitive strategies.

Supply curve: similar to the above, but at the supply side.

Cannibalisation: by combining and comparing data on item-level sales, and stocks by status, and demand under different circumstances; the BI system will be able to estimate the level of cannibalisation between reduced and regular product items. This will allow finding optimal regular and reduced prices, delivery batch sizes etc; in order to maximise turnover, reduce costs and develop sounder marketing strategies.

Rotation quality: this new report will reflect the quality of sales rotation per product during a specific period. That is, only products strictly sold by "best before" date order, in which no overtaking took place, get 100%, whereas the rest get a lower percentage based on the "fresher products/existence on shelf" rate for every registered movement of goods. In this report, rotation quality will be displayed as a percentage: 100% means perfect rotation or FIFO; and 0% means a perfect LIFO.

Rotation quality is given by the following formula:

$$RQ = \frac{|P| - |POO|}{|P|} * 100$$

Where P = product items and POO = product items out of order, calculated as:

$$POO = \{p_i \forall p \in P \wedge i \therefore \exists p_j \therefore O(p_j) < O(p_i) \wedge i > j\}$$

Where $O(p)$ is a function that gives the desired order of item p – e.g. best before date.

Alternatively, this report may account for costs to compute a weighted average per product, and/or number of disposed or reduced products consequence of near expiration. That is, quality will not only be reflected as a percentage but also as a differential cost between perfect rotation and the others.

4. CONCLUSIONS

Improving the studied company's differential pricing system by means of Auto-ID has been a challenging endeavour, however with interesting rewards. It barely affects operational procedures and mostly simplifies them. Nevertheless, the impact on information systems is remarkable in both the depth of change and number of affected systems. Some of them would require new functionality such as alternative ordering formulae and algorithm for perishables; and some others require finer granularity in entities such as item-level data as opposed to product-level data. Intra-system data flows also increase dramatically and some change their granularity and even their nature – from batch to online updates.

The main changes can be summarised as:

1. **Improved entity granularity in stocks:** item-level data such as EPC™, price, "best before" date, status etc; is required in the IMS, POS, Sales and CSD systems.

2. **Further functionality:** the ordering, sales and POS systems require new functionality to deal with Auto-ID generated or improved information (alternative ordering formulae, demand curve management, dynamic pricing).

3. **A new operational procedure:** despite the fact that prices change automatically under implementation scenarios "B" and "C", operators will still have to regularly tidy-up goods on shelves. This new procedure would be triggered by the IMS based on turnover and degree of regular/reduced items combination.

4. **Expanded intra-system data flows:** these exchanges ask for both qualitative and quantitative expansions. First, some new data such as EPCs™, prices and status must be shared between systems not currently doing so – e.g. status sent from the IMS to the POS system. Second, some of these exchanges such as price changes must happen online. Finally, the granularity of some current transactions such as product sales must to be improved to provide item-level detail.

5. **Inter-organisational exchanges:** some inter-organisational data exchanges are needed to provide systems with the required item-level data. In particular, item- or batch-level expiration or "best before" dates will be required by the IMS.

6. **New performance indicators:** by incorporating information on regular and reduced sales per item, business intelligence systems will allow calculating new performance indicators such as cannibalisation level, rotation quality and demand curve. These could be used to develop better marketing and competitive strategies.

These modifications are not very difficult, but involve major changes on many systems. Most of them are essential, as the differential pricing system involves many systems and operational procedures. Nevertheless, some others such as the business intelligence reports are optional and may be implemented in later stages.

In this particular Use Case, the nature and depth of impact on current information systems do not allow for incremental adoptions. The implementation of an Auto-ID-enhanced system requires a big-bang approach. However, it is still clear to see that for some applications it is not necessary to perform a radical substitution of the installed information systems in order to incorporate Auto-ID, but just to add simple functionality extensions and a sound integration middleware.

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