Intelligent packaging from a distribution perspective

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Abstract

Methods and knowledge about traceability is developed in a joint research project between SCA Packaging, Philips and Lund University. This paper is based on a case study at van Eerd Group, a retail chain in Holland. Discrete event simulation is used as a method to analyse different scenarios, based on the existing case system. It is clear that intelligent packages play an important role not only for the customer but also for the retailer and the supply chain. In the study it is indicated that intelligent packages can be used to reorganize future supply chains towards more efficient and cost effective distribution systems. Because of the flexibility with the RFID technology temperature and handling information can be collected and analysed later. This additional information is important for providing good customer satisfaction and security.

Introduction

Supply chains are often beset with problems caused by the mismatch between material and information flow. The lack of timely and accurate information relating to order status, inventory levels or delivery times for example can introduce uncertainty and variability in a supply chain. One approach which is helping to alleviate such issues is the development being driven by the intelligent packages in establishing direct network connectivity between a physical product and its supporting information. With intelligent packages it is possible to develop standards and network infrastructure enabling tagged products to be connected to real time product information. Establishing such connectivity, and by coupling this information into existing business information systems, can immediately help to address inventory management issues such as stock outs, by reducing the amount of uncertainty around product and resource availability.

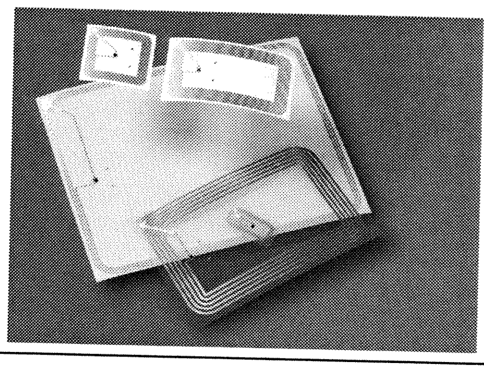

Figure 1. Examples of RFID tags

Extending this a step further, one of the keys to effective supply chain management is supply chain integration. A complete seamless integration of the supply chain enables real-time visibility of useful, digestible data in a collaborative manner, all across the supply chain. Approaches such as VMI, CRP, FRM, JIT, ECR, EDI, VAN or even CPFR are all methodologies for integrating aspects of the supply chain – enabling a company to work more closely with partners to identify improvements and address inefficiencies. By providing timely, accurate and complete item level data, RFID technologies can provide critical support for complete supply chain integration.

However, equally or perhaps more importantly, systems based on intelligent packages provide the basic infra-structure for reconsideration of, and possibly alterations to, the supply chain. This is based on the observation that a physical product connected to a network – which itself links different aspects of the supply chain – can potentially assess and influence its own functions. That is, through this network connection, a package (or a set of packages) can interact indirectly with those operations and handling resources that it comes in contact with. We refer in this document to such products being '**intelligent**' in a loose sense and in this paper we introduce the concept of an **intelligent package** and consider its potential impact on the entire supply chain – i.e. the life-cycle of the product.

Auto ID

Radio Frequency Identification (RFID) technology has shown potential as a means of increasing efficiency and effectiveness in supply chains (Kärkkäinen & Holmström 2002). Several companies have been able to improve their business processes e.g., improving efficiency in distribution centres, by using RFID technology (Falkmann 2000) (Frontline Solutions 2000). RFID technology uses radio-frequency waves to transfer data between a reader and a tag (transponders) that is attached to the movable item to be identified. This means that no physical line-of-sight or contact between the reader and the tagged item is required. There are several functionalities and types of tags. Tags can be read-only or read-and-write, which enables adding information to the tag. The information on the tags can range from static identification numbers to user-written data. Furthermore, memory capacity and the data transfer range also depend on the tag used. The readers can be at fixed points or mobile and be able to read and write information on many tags simultaneously, called "anti-collision". Unfortunately, the use of this technology has thus far been limited to tracking high value products or products in closed loop settings where the tags are continually reused. Studies of applying Auto-ID technology, such as RFID, in distribution centres on unit and product level have suggested that there is a great opportunity to improve both efficiency and costumer service (Alexander et al. 2002).

Once it has overcome various technical and economic obstacles, RFID will have the potential to one day be attached to ordinary consumer products and packages. Currently open standards and the price per tag restrain retail supply chains from applying them to consumer products, but the performance capabilities of RFID technology are being pushed forward, and price reductions are being worked on. By 2010, industry sources expect the prise per tag is to have fallen to less than 0.01 EURO (Harrop 2002). This means that RFID tags could be a substitute to the traditional barcodes.

The retail chain

The modelled distribution centre handles about 2 700 types of ambient fast-moving consumer goods and processes around 350 000 traded units per week, which are distributed to over 150 retail outlets. The distribution centre is made up of four sections, à 4000 square meters, were each section contains different product groups and is divided into zones. The material handling activities within sections are highly independent of one another. Orders received from retail outlets are divided into pick orders designed for every section or zone to enable efficient order picking. Furthermore, each section has its own allocated resources. This enabled us to concentrate on developing a model that describes one of the four sections in the distribution centre. The modelled section contains about 690 types of products, such as nuts, candy, chips, cans, tins, pet food, soup etc. The section consists of two zones that cover 4 aisles each. Though each zone runs a picking route where the pick locations are fixed and situated on the lowest rack level, whereas the other levels, 2-5, are used as buffer storage. In every section there are two reach trucks, and over 50 pick trucks are used all over the distribution centre. In every section there are two dedicated docking bays assigned for receiving goods, and six for deliveries to retail outlets. The three main activities in the retail distribution centre related to the material flow are receiving, picking and shipping.

Receiving Activities

The receiving activities are unloading, verification, labelling and transportation to buffer storage. The distribution centre automatically generates orders or indicates that an order should be generated when the stock level falls below a predefined point. Orders are in pallet quantity and are delivered according to a product-specific schedule. When the delivery truck carrying the ordered pallets arrives at the distribution centre it is directed towards a specific docking bay and is unloaded by the truck driver. The received pallets are verified for product type, quantity and due-by date by an incoming goods controller. The controller and the truck driver then sign the proof of delivery documents when all delivered pallets are verified and unloaded. One incoming goods controller is assigned to every section of the distribution centre. The pallets are then labelled and transported and put into the buffer storage by a reach truck using a manual method intended to place the pallet as close as possible to the pick location.

Picking Activities

The picking activity is one of the crucial activities in a distribution centre; therefore pick efficiency is one critical factor for success. When an order is received at the distribution centre, the ordered products are first allocated. Then at specific times orders are printed and manually split into pick orders for each zone or section to enable efficient order picking. When an order picker has obtained a pick order he/she collects empty roll containers and then begins to pick the order. The picking procedure consists of: travel to pick location, label, unit pick, and then stack the unit in the roll container. When stacking the units the picker has to make sure that the picking labels are properly placed on the traded unit so the contents of the roll containers can be checked. Furthermore, when stacking, the picker considers that the units should be stacked solidly and without causing damage. Time for the picking procedures is illustrated in Table 1, where the activities are performed in the simulation model with an exponential distribution. When a pick location is empty a reach truck driver is notified by a picker. The reach truck driver manually searches for the oldest pallet and replenishes the pick location. The picking trucks have the capacity to carry three roll containers, each of which, in the modelled section, has an average capacity of 35 units. When the roll containers are filled they are placed at the shipping dock assigned for that specific order.

	1 Unit		2 Units		3 Units		4 Units		5 Units	
	Without RFID	With RFID	Without RFID	With RFID	Without RFID	With RFID	Without RFID	With RFID	Without RFID	With RFID
Labelling	3	0	4	0	5	0	6	0	3	0
Unit pick	7	7	9	9	11	11	13	13	15	15
Stacking	4	2	5	3	6	4	7	5	8	6

Table 1. Time in seconds for the picking procedures relative to number of units picked.

Shipping Activities

The shipping activities involve the activities of verifying orders and loading delivery trucks. At the shipping docks an outgoing goods controller verifies the orders, making sure retail outlets get what they ordered. The controller organises the roll containers into the correct docking lane and order sequence depending on delivery route. Verifying an order is made through counting the amount of units and checking that the labelling corresponds with the product. The complexity of numerous product types, quantities and deliveries makes it almost impossible to check all shipments. Currently the distribution centre manually checks about 20% of the shipments to retail outlets. When a shipment is verified and organised, the delivery truck is loaded.

Retail Outlet

The modelled retail outlet usually orders about 9200 units per week from the distribution centre. The retail outlet does not have any backroom inventory, so orders are generated when the shelves are replenished. It is when the shelves are replenished that the outlet knows what products to order. The retailer orders up to a predefined order level and receives the order in accordance with a weekly delivery schedule. Orders are sent to the distribution centre within specific time frames, depending on the retail outlet. The retail outlet is open between 08:00 and 18:00 except on Sundays, when it is closed. The products modelled in the retail outlet are those that are handled in the modelled

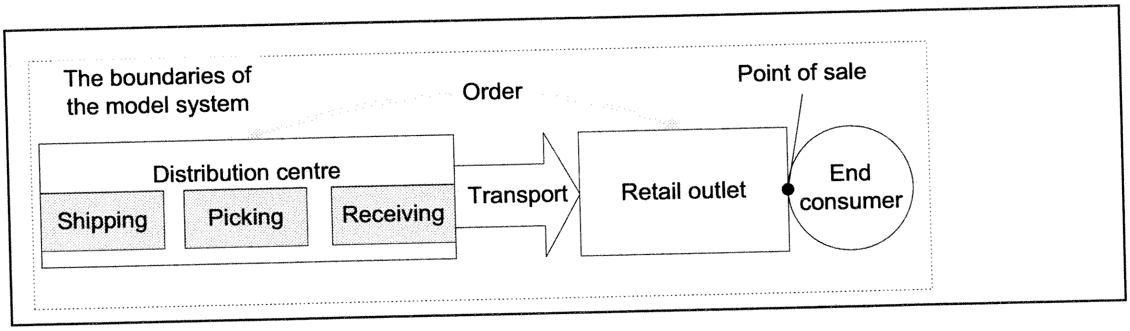

Figure 3. Boundaries of the model.

section of the distribution centre. In the model the daily demand of products is set to a constant distribution throughout each day. However, the demand is weekday-dependent and varies between 200-500 units per day. Furthermore, there are weekly variances in demand. These variances are between 2000-3000 units per week, with an average of 2700 units per week. To capture these variances in demand the model is provided with data from 4 different weeks in April, May and July. The inventory levels for all products at the outlet are set to have an availability of 96.5%, which reflect an ordinary situation of a retail outlet of this size and concept.

The Simulation Model

Simulation, according to Banks et al. (2001), is an "imitation of the operation of a real-world process or a system over time". Simulation is a description of how a model performs and behaves over time when different rules and policies are applied. A simulation model is developed to better understand relationships and operations over time as a function of policies and parameters (Banks 1998). By adjusting parameters and processes, different scenarios can be explored without disrupting the real system. This ability to evaluate scenarios makes simulation a useful technique for analysing how activities in a retail distribution centre respond when RFID tags are applied to all products and units.

The computer software, AutoMod™, which was used to develop the model, is a discrete event simulation tool. In discrete systems the variables in the model only change at discrete sets of points in time, whereas in continuous models variables continuously change over time. This means that the tool used handles both stochastic and dynamic behaviours. Furthermore the software visualises the model in three dimensions, making it easier to gain insight and understanding of the model.

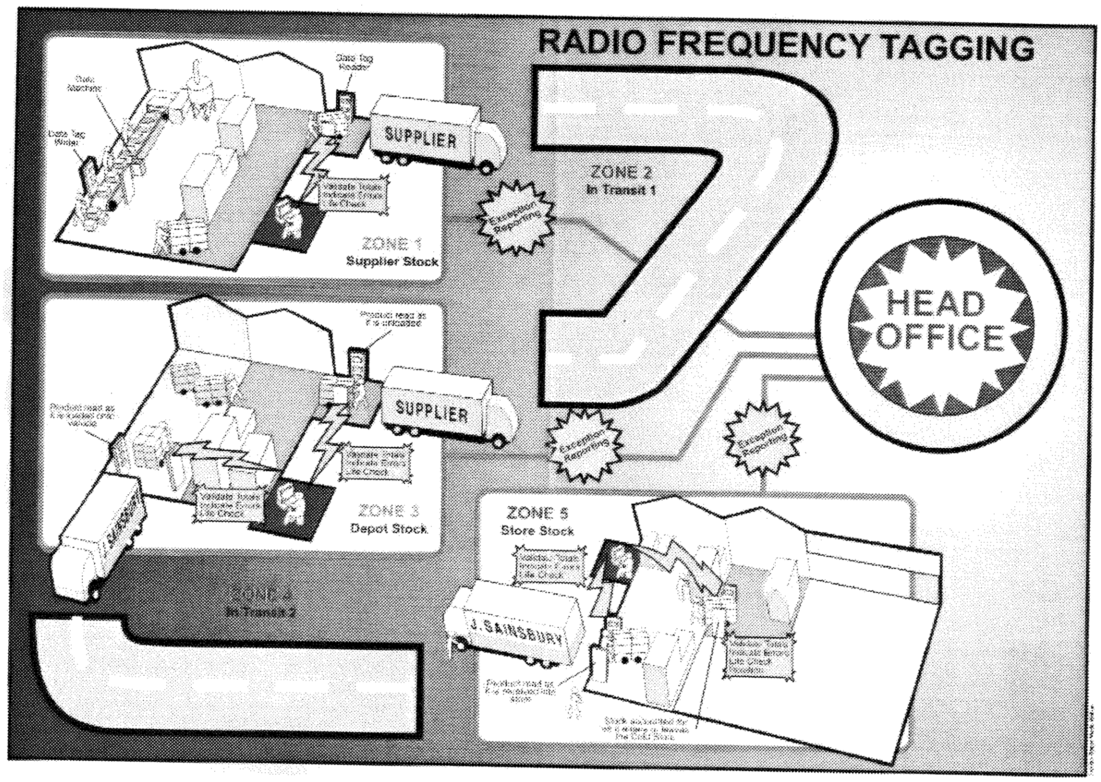

Figure 4. Future supply chain with tags.

The simulation model represents a retail distribution centre and a retail outlet. Consumers, product manufacturers and transportation activities are also, to some extent, embedded into the model since they affect the activities within the distribution centre. They were also included in the model in order to capture the dynamic behaviours of the retail supply chain. In order to model the material handling activities in the distribution centre, the information and material flow from all the retail outlets are of great importance. Since one retail outlet is modelled, the other retail outlets are embedded through providing the distribution centre with real order data, where order amount and point in time when pick orders are generated are taken into consideration. This enabled us to obtain a comprehensive representation of how the activities in the distribution centre perform and behave. Input data were collected from more than one month's on-site study of the retail chain, using interviews, archives and observations.

There are assumptions made in the simulation model that affect its performance when analysing how RFID technology affects material handling in a retail distribution centre. In the model, the performed activities are assumed to have total accuracy, with or without RFID. Furthermore the assumption was made that the distribution centre never ran out of units, thus causing incomplete orders and out-of-stock situations at both retail outlets and the distribution centre.

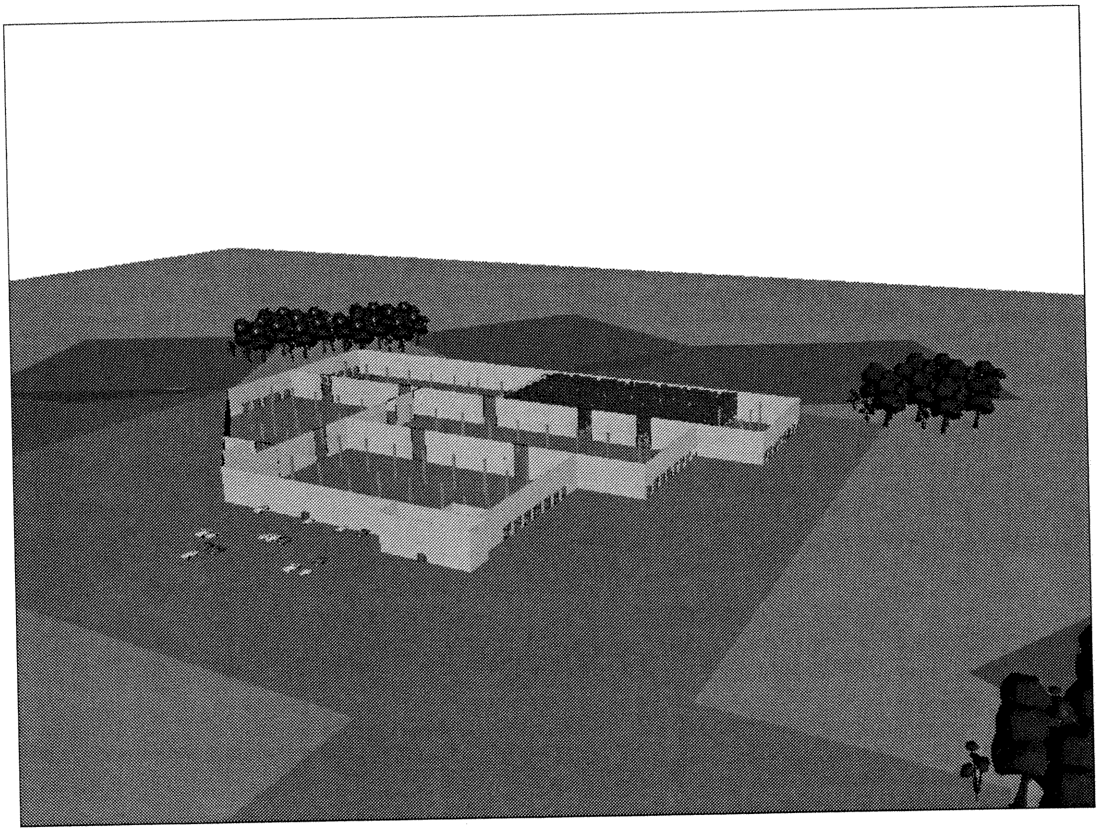

Figure 5. Animation of the simulation model.

Performing scenarios where RFID technology is applied on products and units in the retail supply chain are not only created by adjusting parameters such as handling time; RFID technology changes the processes within the retail supply chain. For example, an RFID system could make it possible to capture the behaviour and location of each individual product and unit through tagging in real time. For every product, the current stock levels and delivery status could then be distributed throughout the retail supply chain. This provides an opportunity to change the order process among actors within supply chains. Two scenarios were conducted with the model where the order process was altered.

Conclusion

The results from the simulation model indicate that an RFID system in which RFID tags are applied to products and units has a potential to increase the efficiency of the distribution centre. The speed of the distribution function was increased because the time to perform the activities was reduced, resulting in increased efficiency of resources. Labour generally represents the greatest cost in a distribution centre, and in the scenario performed approximately 20 fewer resources were needed in the distribution centre. Order picking represents the core activity of the distribution centre, and is the most labour intensive part of the distribution centre. The efficiency of the picking activity improved with RFID technology and resulted in saving approximately 12 picking resources. The simulation model also demonstrates how out-of-stock situations could be reduced by using the ability to capture the current inventory level of each individual product in the retail outlet through tagging. In the scenarios conducted to analyse the order process, the order was generated when it was about to be picked or when an out-of-stock situation was about to happen, all of which decreased out-of-stock situations.

The retail supply chain is a complex network of physical flows and information flows and involves several handling operations (order picking, unpacking of group packages, shelf handling, etc). Barcodes has been used until now but today's supply chains require better, more accurate and more flexible information. Intelligent packages will create new possibilities for combining supply chain requirements with customer requirements to offer a safe environment for products and customers. In future scenarios based on RFID technology it is also possible to reenginer the layout to create more efficient flow through the distribution system.

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