Position paper

Roadmap to Tracking Based Business and Intelligent Products

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Abstract

Item-centric tracking is an opportunity to increase visibility and control in different operations of a company. The economical feasibility of item-centric tracking is based on recent technological developments for monitoring the material flow on the item-level instead of the material type-level. It enables companies to track and trace assets over their lifecycle and manage supply chain operations across organizational boundaries. However, the challenge in practice is to find the right areas to start the development of business applications. In this viewpoint paper a means-ends framework for introducing item-centric tracking in business is proposed based on realized track and trace cases. Based on the framework a roadmap for introducing tracking in businesses operations is outlined. The proposed roadmap circumvents the most challenging business cases for introducing tracking and RFID-technology in the supply chain and focuses on asset management as a more accessible route for business.

Keywords

Track and Trace, RFID, Item-centric tracking, Supply Chain Management, Asset Management

1 Introduction

Item-centric supply chain management [1] and item-centric control and information management [2] is an approach that offers companies opportunities to better track and trace assets over their lifecycle and to manage their supply chain operations efficiently across organizational boundaries. However, business scenarios for improved material and asset information management across the life-cycle and over organizational boundaries

need to be further investigated in order to speed up the diffusion of the approach. Developing clear propositions is essential especially for diffusion of technology to small and medium sized enterprises.

This paper explores the business opportunities that result from shifting the focus of materials and asset management from ***location based*** control to ***item-centric*** materials and asset tracking [3]. The base principle [4] is to take the tracked item as the basic entity and treat the location as a property of the item. The result is that the item being tracked becomes the object of control instead of inventory and asset accounts in predefined locations. This way of shifting the locus of control to the product or item is a first step towards the intelligent product concept [5].

When in place, item-centric track and trace is a potential new means for companies to set up economically feasible concurrent enterprising solutions. The economical feasibility of item-centric tracking is based on recent technological developments in technologies for monitoring the material flow on the item-level instead of the material type-level. Tracking and automated identification are based on different types of bar codes and increasingly the use of Radio Frequency Identification (RFID) technology [6].

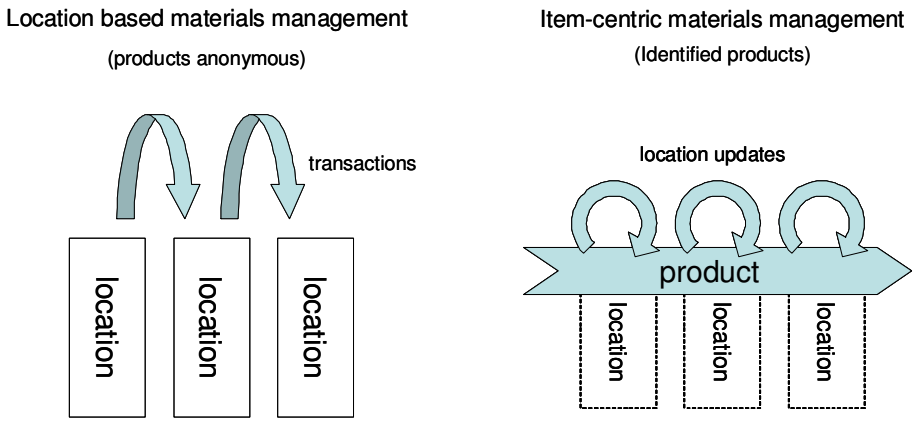

Figure 1: Tracking systems enable a change of control logic from location based to item-centric materials management [3]

To provide control over individual goods and assets it is necessary to develop technology that can maintain the identity of the item and that item properties, such as the location of the item, can be updated in the same way across locations (see figure 1). Item-centric supply chain management [3] focuses on the management of individual items instead of the material inventories at predefined locations**.** It is a proposed solution to the difficulty to develop value offerings over the life-cycle of items and across different enterprises in the

supply chain. Figure 1 illustrates the difference between a location based and item-centric approach to materials management.

There are many opportunities for businesses to benefit from item-centric control. The purpose of this paper is to identify state-of-the-art practices in item-centric supply chain management (SCM) and asset management (AM). Furthermore, we will analyse the identified applications and highlight the functional analogies between different types of applications. Based on the analysis we propose a roadmap for adopting item-centric control in different types of business applications.

2 Research Approach

The roadmap for introducing the item-centric control in business, i.e. of tracking based business, is based on a number of state-of-the-art examples that have been presented in professional and academic journals in 2005 and 2006. The state-of-the-art cases were found using the Proquest en EBSCO databases. The search terms used for the initial database queries were 'RFID' and 'tracking'. The cases from the past two years were then screened for further analysis and judged by two criteria:

1. The case must present a successful application of a *realized* automated identification based system, instead of hypothetical prospects of RFID and tracking which have been widely published in both academic and trade journals.
2. The description provides a presentation of the business case, the business environment, and technical details of the tracking and identification system that is sufficient to identify the type of solution and its rationale.

The structure of the paper is the following. First we develop a means-ends framework that identifies the factors that we use to analyze and differentiate state-of-the-art cases. This is followed by a more detailed analysis of selected cases that illustrate the main categories as described by the framework. In conclusion we present a roadmap for introducing tracking based business applications in a company.

3 Means-ends framework for tracking based business

The search identified altogether 20 different case descriptions that met the defined criteria of a *realized* automated identification based system and a presentation that is sufficient to identify the type of solution and its rationale, i.e. the means-ends proposition [7, pp. 211]

of the case. The identified state-of-the-art descriptions were each analyzed individually and the identification solution and its benefits documented.

The examples of automated identification and tracking based business were categorized based on the system functionality (i.e. the "means") and the type of goods and assets tracked (i.e. the "ends"). The categorization of functionality is based on the observation [6] that the basic functionality in tracking systems is the identification, and tracking itself an application based on identification. The more complex functionality in the analyzed applications allowed the sharing of the items' tracking information via web-portal or system-to-system integration depending on the value to the customer.

Asset management and supply chain management can be seen as different ends that can be achieved by the same means. Figure 2 illustrates how asset management and supply chain management applications from the item-centric perspective are long term and short term tracking applications respectively. Meeting the economic case for investment in tracking is easier for asset management applications than for supply chain applications because the benefits in asset management can accumulate over time.

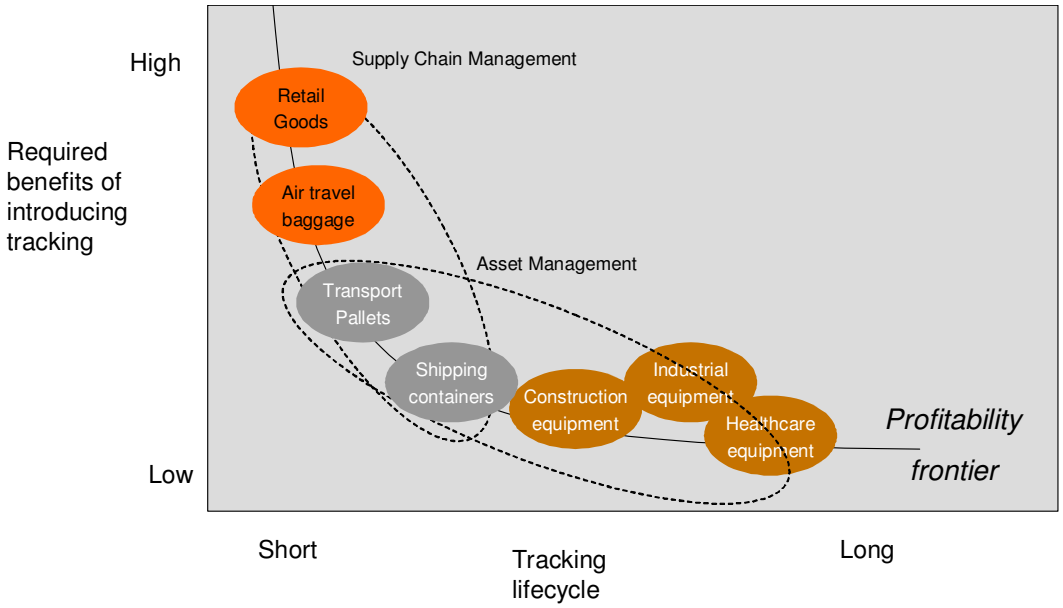

Figure 2: From an item-centric perspective asset management and supply chain management are different ends for the same means

The first step to tracking based business applications is the identification of the item. After implementing an identification system, the following step to enhance system functionality is to construct information management structures to support the gathering of data from the

points of identification. Tracking of goods is based on the centralizing of identification information of various tracking points in a single database. The database can be used to perform queries about the movement of items which serve as basis for analysis on the optimal material usages and routing. The construction of a tracking system requires therefore a change of view from location centric to item-centric materials management, which makes the item the object of optimization instead of the storage location.

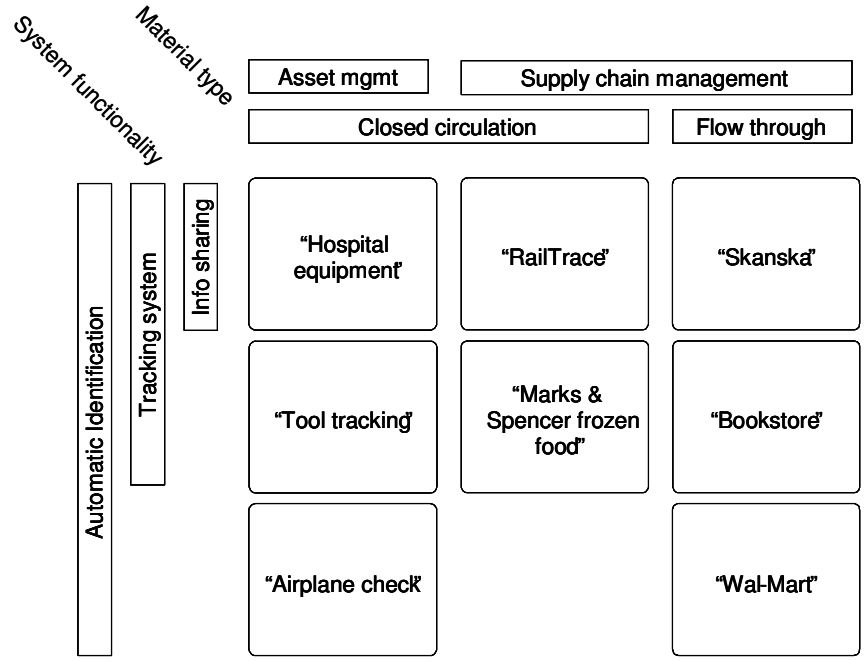

Figure 3: Means-ends framework for tracking based business and illustrative state-of-the-art examples

The closed circulation of goods in asset management systems is a major point that distinguishes it from supply chain management systems. In closed circulation the number of identified items in relation to the identification points can be kept much lower than in flow-through solutions. This directly affects the investment decisions, partly through the cost of identifier that is used, but also through the cost of creating and setting up the item to be tracked in the tracking system itself. Implementing supply chain management solutions using closed loop assets - such as roll cages and pallets – means that there is an overlap between asset management and supply chain management solutions.

Our proposed means-ends framework is summarized in figure 3. The framework identifies eight categories, based on the three divisions of system functionality and the distinctions

between asset management, asset based supply chain management, and flow through supply chain management. For each category an illustrative state-of-the-art example is presented and discussed in more detail below.

4 Examples illustrating the means-ends of tracking based business

This section briefly presents the examples of tracking based business in the means-ends categories introduced above.

4.1 Asset management

The first three illustrations deal with pure asset management. The tracked units in the examples are mobile equipment. The examples are presented in the order of increasing complexity by starting from automatic identification and ending with the information sharing example.

Airplane security check is a typical example of the application of automatic identification for asset management. The case of a British low-cost airline Flybe [8] illustrates the typical means and goals of this category. Flybe has tested and piloted the tagging of its safety equipment with RFID tags in order to speed up the safety checks before take-off. The use of handheld RFID reader to make an inventory count of required equipment in the plane before take-off has significantly reduced turn-around time at airports.

The example for the next category, tool tracking, illustrates the effects of introducing item tracking across sites in addition to item identification. Bowen Engineering [9] is a contractor specialized in large water and wastewater treatment plant projects that have implemented a tool tracking system. The tracking database has provided the management of Bowen Engineering visibility to the site and user of a specific tool, which has brought a new systematic approach to the company's asset management. The information on asset movements provided Bowen's management a possibility to plan the usage of the tools according to advance information on when the tools become free. Personal responsibility for the users of the tools has lowered their loss rate, and project-based charging has improved the tools' utilization as it is in the project managers' interest to return the tools as soon as they are not needed.

The effect of adding information sharing is illustrated by moving to the next category. In the example hospital equipment is used, tracked and maintained by a number of different parties. The Bon Secours [10] hospital chain in Virginia, U.S. provides users and

maintenance service providers visibility of its mobile assets' using the Internet. The maintenance information of the mobile equipment is integrated in the asset tracking database. With the system, service providers can issue maintenance notices in advance so that the equipment cannot be reserved for the time of scheduled maintenance. The users and service personnel also don't have to search for the right equipment as it is tracked and can be quickly found.

4.2 Flow through supply chain management

The benefits of tagging material that flows through a system are realized in supply chain management. Here, the examples illustrate how the basic challenge is that in these categories of tracking based systems the party that performs the task of tagging is usually not the one that receives the benefit.

An illustration of flow through identification is the U.S. based retail giant Wal-Mart. The company is one of the leading names in the adoption of RFID technology. By using its buying power over its suppliers it has mandated the suppliers to apply RFID tagging onto pallets and boxes at no extra cost to Wal-Mart so that Wal-Mart can speed up receiving of goods and reduce the incidence of stock-outs in the shop. A majority of Wal Mart's suppliers have answered to the mandates by adopting a 'slap & ship' practice to RFID tagging [11]. In 'slap & ship', the suppliers apply the RFID tagging to the units just before shipping or even by a third party before the delivery to Wal Mart.

The Dutch bookstore Selexyz [12] illustrates the benefits of upgrading the functionality from just identification to tracking of flow-through items. The experiences of Selexyz are based on a pilot project which featured automatic identification based tracking of books at one store. The tagging of the books with passive RFID tags was performed at the distribution centre before sending them to the pilot store. The solution gives the same benefits in improving handling at goods receipt as the Wal-Mart solution. However, by adding tracking the company has been able to develop a new service for its customers. If also the shelves are tagged it becomes possible to perform an inventory count operation using RFID that registers the shelf of each book. The customer can then use handheld terminals in the store to locate the exact place of the book she is looking for. In the case that a requested book is in the store the system will guide the customer to the right place. If the book has to be ordered, the system will ask for the customer's contact information and an announcement can be sent when the desired item arrives to the store.

The Skanska example [13] illustrates the addition of information sharing in a flow through supply chain. The central features of the pilot solution that Skanska, a construction engineering and construction company, has created is a four dimensional Building Information Model (BIM) of the construction project which unites the designers, planners, builders of the different stages of the project. The model of the building to be built is a 3D-model of the construction site which can be updated over the Internet to show the progress of the project in real time. The supply chain management module of BIM is based on RFID-tagging of the building's major precast reinforced concrete components, which are tracked from the suppliers' factory to the jobsite, where they are installed and approved by the jobsite supervisor. The status and location of the identified components are read at predefined stages of the delivery chain with RFID-readers embedded in mobile phones.

This solution gives the project participants a shared design artefact – consisting of the model of the building and the tagged components of the building in different stages of the supply chain. The solution improves and accelerates the information sharing in the enterprise and the supplier network.

4.3 Closed loop supply chain management

The third group in the means-ends framework are supply chain management applications that were introduced on an asset tracking platform. Such solutions are usually based on the tracking of transportation units which circulate inside the system and are re-used several times. This makes it easier to find an economically justifiable business case. However, as the tracked transportation unit is attached only temporary to the delivery contents, the link between them needs to be temporarily managed in a tracking database for the transportation units.

The benefits of item tracking in a closed loop supply chain are illustrated by the example of British retailer Marks & Spencer's [14]. The solution tracks frozen food on RFID tagged and recycled transport assets. Marks & Spencer's was able to introduce automatic identification for 3.5 million RFID-tagged reusable trays, pallets and cages. The acceleration of identification events along the supply chain enables a faster lead time for the frozen food from the distribution centres to the stores. However, because the tagged transport assets move in a closed loop the fixed costs of pallet tagging and tracking can be spread over time, and even reduced costs compared to the disposable bar codes which previously had to be applied again and again for each shipment.

To illustrate the purpose of info sharing through a web-portal on top of a closed loop supply chain tracking system the Finnish national railway operator VR's RailTrace service is our example. RailTrace is VR's tracking service for the tracking of VR's client shipments on the level of railway wagons. The system integrates data from VR's own identification systems and those of other European and Russian railroad operators as well as some other logistics service companies. The tracking information is managed in a centralized database by VR. A web-portal is the customer interface where users make queries based on the freight bill number. The result to the query is a delivery status and the location history of the desired wagon. The system can also send automatic notices to the customer if their deliveries are late from schedule.

5 Roadmap to tracking based business

The functional steps of *identification*, *tracking* and *info sharing services* are means that build on top of each other. On the other hand, the circulation of the item to be tracked has a significant impact on economic feasibility. The closed loop circulation in asset management systems allows for longer depreciation periods for the investment in identification than for applications in supply chain management. Therefore, for basic functionality asset management systems offer more profitable business cases for the initial investments in novel identification technologies, such as item tracking and RFID.

These two observations is the foundation for our hypothesis that the most attractive business propositions to start the development of item tracking applications are *location centric* applications for *asset management* such as tracking reusable containers. Later this asset management solution can be adapted and also serve as a platform for tracking the contents of reusable containers and transport units for supply chain management purposes. A much more challenging business case to formulate for a company is to immediately aim for *info-centric services* in *supply chain management* such as letting the customer follow the production of his customized product.

Figure 4 summarizes the proposal for introducing tracking based business in a company or other organization. This was validated in a working group chaired by GS1 in Finland and consisting of supply chain and logistics directors of leading players in the grocery supply chain in Finland. The working group found that the most feasible route to introduce item tracking and RFID identification starts with the tracking of assets such as reusable transport boxes and roll cages. Only once the network of readers and developed tracking

databases are in place does the flow-through end of the application spectrum become interesting.

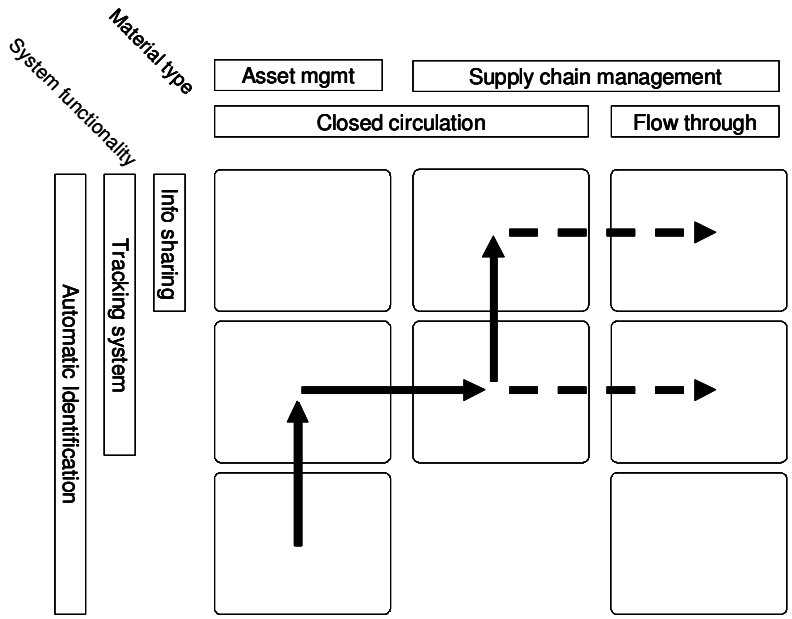

Figure 4: Roadmap for developing tracking based business

6 Coupling of tracking applications

To move from the individual tracking based business application towards intelligent products applications the individual tracking applications need to be linked and work together as a whole. A logistics asset that can receive control information from the tracking and tracing applications of the goods it transports would be a step towards simple intelligent interaction between two physical products.

Taking this next step requires that tracking applications can be easily and temporarily coupled. The simplest way of achieving such coupling is that one application queries another one for the information when needed as in the Bon Secours example. A more advanced coupling can be achieved by the "observer" or "publish/subscribe" functionality described e.g. by Främling et. al [15]. In the Bon Secours example the more advanced coupling would mean that different parties subscribe to specific events. A subscription could be defined for a specific piece of equipment or more generally for some type of equipment. For instance, subscribing to the event type "is-available" for a specific piece of equipment would result in a notification message to the subscriber as soon as the

equipment becomes available, rather than having to regularly query for the status of the equipment.

In many situations, the item to be tracked is not directly accessible because it is contained in some bigger entity such as a transportation unit. The coupling of item tracking and transportation units tracking then need to take place when a unit higher in a transportation hierarchy is being loaded. At that point, the items being loaded need to be identified together with the higher hierarchical unit. However, from that point on the coupling can be managed in the tracking database, which may automatically update the location and status of the individual shipments according to the tracking messages generated by the higher level transportation unit.

The software requirements for management of such hierarchical tracking data have already been proposed by Främling et.al [2]. In this solution proposal the coupling and decoupling of shipments and the higher level transportation units is done automatically when the individual shipments and transport units send tracking messages of their own to the tracking database.

In order to allow different applications to communicate (possibly over organisational borders) it would be essential that the used messages would be standardised. The EPC Information Services standard [16] is one of the first ones to address both the “observer” and “composite” functionality as standardised XML-based messages. These kinds of functionality may cover most of the needs in tracking and tracing but other kinds of functionality will most probably be needed when addressing the requirements of managing product lifecycles [17][18].

7 Conclusions

A company has to carefully consider exactly how it can benefit from increased item information gathering and sharing. The means-ends framework and roadmap proposal outlines how a company can proceed to develop state-of-the-art tracking systems suitable to their particular needs. The means-ends framework helps new adopters of identification and tracking technology to identify which functional features are needed, and in which order, for achieving desired goals in their own operations.

Associating data properties such as location, location history with individual items is a first step towards intelligent products. Tracking individuals alone does not justify the

designation “intelligent product”, but it is a key step towards augmenting products with functionality that allows reacting to changes in the environment and events. The importance of tracking is even seen in the role it plays in reacting to non-events, such as when a shipment’s location is not updated when and to what was planned. At this stage we can start speaking about “intelligence” of products.

For implementing more advanced means-ends propositions than the ones outlined in this paper data and functionality need to be organised in some agreed-upon way, as defined by standards or by more informal recommendations such as Design Patterns. This is an area of further research that can lead to innovative services that involve intelligent interaction between products, products and different organisations, and products and individuals.

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References

[1] Kärkkäinen M, Ala-Risku R, Främling K. The product centric approach: a solution to supply network information management problems?. Computers in Industry 2003; 52:147-159.

[2] Främling K, Ala-Risku T, Kärkkäinen M, Holmström J. Agent-based for Managing Composite Product Information. Computers in Industry 2007; 57:72-81.

[3] Rönkkö M, Kärkkäinen M, Holmström J. Benefits of an item-centric enterprise-data model in logistics services: A case study. Computers in Industry 2007; 58:814-822.

[4] Arthur WB. The structure of invention. Research Policy 2007; 36:274–287.

[5] Holmström J, Främling K, Tuomi K, Kärkkäinen M, Ala-Risku T. Intelligent product agents: The key to implementing collaboration process networks?. International Journal of Logistics Management 2002; 13:39-66.

[6] Kärkkäinen M, Holmström J. Wireless product identification: Enabler for handling efficiency, customisation, and information sharing. Supply Chain Management: An International Journal 2002; 7:242-251.

[7] Simon HA. The Sciences of the Artificial. 3rd ed. Cambridge, MA; MIT Press; 1996.

[8] Friedlos D. RFID accelerates safety checks. Computing 23 Nov 2006. Available at: http://www.vnunet.com/computing/news/2169324/rfid-accelerates-safety-checks; accessed on May 29th, 2008.

[9] ToolWatch. Case description: Boven Engineering. Available at: http://www.toolwatch.com/casestudies_bowen; accessed on May 29th, 2008.

[10] Health Data Management. Bon Secours to Use RFID Technology. Health Data Management 2004; 12:34.

[11] Chain Store Age. Research Confirms Wal-Mart's RFID Benefit. Chain Store Age 2005; 81:80.

[12] Trebilcock B. The book on item-level RFID tagging. Modern Materials Handling 2006; 61:43-45.

[13] Nikulainen P. Final Report: Jobsite Logistics (mobile RFID). TeliaSonera, Helsinki, 2005.

[14] Jones P, Clarke-Hill C, Hillier D, Comfort D. The benefits, challenges and impacts of radio frequency identification technology (RFID) for retailers in the UK. Marketing Intelligence & Planning 2005; 23:395-402.

[15] Främling K, Ala-Risku T, Kärkkäinen M, Holmström J. Design Patterns for Managing Product Lifecycle Information. Communications of the ACM 2007; 50:75-9.

[16] EPC Global. EPC Information Services (EPCIS) Version 1.0 Specification. Available at : http://www.epcglobalinc.org/standards/epcis/epcis_1_0-standard-20070412.pdf; accessed on May 29th, 2008.

[17] Anke J, Främling K. Distributed Decision Support in a PLM scenario. In: Proceedings of Product Data Technology Europe 14th Symposium, 26-28 September 2005, Amsterdam, Netherlands; 2005, p 129-137

[18] Corcelle C, Främling K, Rabe L, Anke J, Petrow J. Assessment of item-specific information management approaches in the area of heavy load vehicles. In: Proceedings of 4th International Conference on Product Lifecycle Management (PLM'07), 11-13 July 2007, Milano, Italy