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Abstract

Since the early 1990s, there has been a growing understanding that supply chain management should be built around information sharing and collaboration among supply chain partners. The emergence of RFID technology is expected to revolutionize many of the collaborative supply chain processes and to empower new collaboration scenarios, such as anti-counterfeiting, product recall and reverse logistics, collaborative in-store promotion management and total inventory management.

This paper proposes eight RFID-enabled supply chain collaboration services (e.g. dynamic pricing, smart recall, in-store promotion management, out-of-shelf response) in a networked retail business environment. The services are characterized, on a high-level, by the information shared between retailers and suppliers, the level of tagging (pallet/case/item level) and the location of the tag readers. Also, a scalable-distributed network architecture, building on the possibilities provided by web service orchestration and data stream management systems, is proposed to support these collaborative supply chain management processes. However, this paper introduces into a research-in-progress with the ultimate purpose to assess and categorize the RFID-enabled supply chain collaboration services according to four dimensions: the extent of collaboration required between retailers and suppliers, the RFID technology requirements, the transformation of existing (or the introduction of new) processes and the business performance impact of the RFID-enabled collaborative service. This research is partly funded by the European Commission (IST-2005, FP6) through the IST SMART research project with participating user companies being European grocery retailers and suppliers from the fast-moving consumer goods sector.

Keywords: Supply Chain Collaboration, Services, RFID

1 Supply Chain Collaboration In Retailing

Since the early 1990s, there has been a growing understanding that supply chain management should be built around the integration of trading partners (Barratt & Oliveira, 2001), the sharing of information and benefits (McLaren, 2004) and the collaboration of organizations (Patrakosol & Olson, 2006). Supply chain collaboration as understood today has begun to take form since the mid-1990s, when the forms of collaboration multiplied (Pramatari, 2006) and new forms of information sharing extended their focus to include not only a passive exchange of information between partners, but also a more proactive approach through common planning and synchronisation of activities and business processes (Skjoett-Larsen et al., 2003), taking advantage of innovative technologies. Anthony (2000) suggests that supply chain collaboration occurs when two or more companies share the responsibility of exchanging common planning, management, execution, and performance measurement information. Bowersox et al. (2000) state that firms collaborate in the sense of leveraging benefits to achieve common goals.

Supply chain collaboration in retailing and Fast Moving Consumer Goods industry (FMCG) has mainly been expressed in the form of practices such as Vendor Managed Inventory (VMI), Continuous Replenishment Program (CRP), and Collaborative Planning, Forecasting and Replenishment (CPFR). VMI is probably the first trust-based business link between suppliers and customers (Barratt & Oliveira, 2001), whereby the manufacturer (supplier) has the sole responsibility for managing the customer's inventory policy, including the replenishment process, based on the variation of stock level in the customer's main warehouse or distribution center (Blatherwick 1998, Cooke 1998, Frantz 1999). CRP moves one step ahead of VMI and handles the inventory policy not only with the variations of inventory levels at the customers' main stock-holding facility but also with sales forecasting, based on point-of-sales (POS) data from the retailer's stores (Andraski, 1994). Collaborative Planning, Forecasting and Replenishment (CPFR) can be seen as an evolution from VMI and CRP, addressing not only replenishment but also joint demand forecasting and promotions planning, focusing on promotions and special-line items (Holmström et al., 2002). CPFR is based on extended information sharing between retailer and supplier, including POS data, forecasts and promotion plans. Pramatari et al. (2002) further suggest a new form of CPFR, named Process of Collaborative Store Ordering (PCSO), addressing the daily store replenishment process. This process is supported by special IT infrastructure (a web collaborative platform) allowing: the daily online sharing of store-level information (e.g. POS data, store assortments, stock level in the store, promotion activities, out-of-shelf alerts, etc), the sales forecasting and order generation, the online collaboration of the trading partners, and finally the order exchange and order status tracking. Based on these short descriptions, VMI and CRP are more about efficient replenishment and supply, whereas CPFR puts more emphasis on the demand side.

There is a clear evolution path in the capabilities and sophistication of the Information Technology (IT) infrastructure supporting all these collaboration practices, in the amount of information exchanged between the trading partners and in the process(es) enabled by this information sharing supporting former versus later forms of collaboration. Compared to the traditional ordering process, VMI/CRP and CPFR highly increase the total volume of information transmitted between retailers and suppliers on a daily basis. The volume of information exchanged and the intensity of interaction are expected to further increase dramatically when the advanced data capture capabilities of Radio Frequency Identification (RFID) technology coupled with unique product identification and real-time information gathering are employed. The emergence of RFID is expected to revolutionize many of the supply chain processes, especially those involving collaborating partners (Prater et al., 2005). A recent industry report (GCI, 2005) refers to new supply chain collaboration scenarios that will be empowered through the use of RFID and information sharing between trading partners (supply chain collaboration services), such as anti-counterfeiting, product recall and reverse logistics, collaborative in-store promotion management and total inventory management. Figure 1 (Pramatari, 2006) below summarizes the evolving path of supply chain collaboration practices in retail and the underlying information technologies that have enabled this collaboration over time.

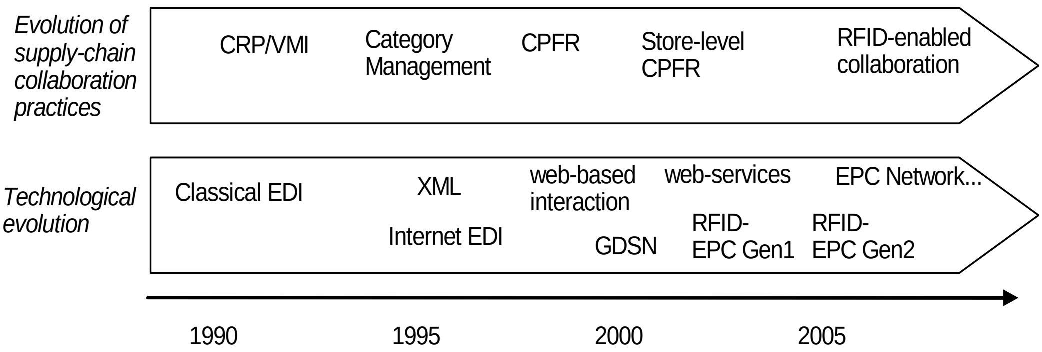

Figure 1: Evolution of supply chain collaboration practices and enabling technologies in retail industry

In this context, this paper proposes eight RFID-enabled supply chain collaboration services (e.g. dynamic pricing, smart recall, in-store promotion management, out-of-shelf response) in a networked retail business environment. The services are characterized, on a high-level, by the information shared between retailers and suppliers, the level of tagging (pallet/case/item level) and the location of the tag readers. Also, a scalable-distributed network architecture, building on the possibilities provided by web service orchestration and data stream management systems, is proposed to support these collaborative supply chain management processes. However, this paper presents the first findings of a research-in-progress with the ultimate purpose to assess and categorize the RFID-enabled supply chain collaboration scenarios according to four dimensions: the extent of collaboration required between retailers and suppliers, the RFID technology requirements, the transformation of existing (or the introduction of new) processes and the business performance impact of the RFID-enabled collaborative service. This research is partly funded by the European Commission (IST-2005, FP6) through the IST SMART research project with participating user companies being European grocery retailers and suppliers from the fast-moving consumer goods sector.

The paper begins with an overview of supply chain collaboration practices in retailing. The following section looks closely into the technology of RFID and the way it is employed in supply chain management. Section three describes the proposed architecture that supports RFID-enabled collaboration and decision-making. The eight RFID-enabled supply chain collaboration scenarios are described, in detail, in section four. The final section presents the conclusions along with suggestions for future research.

2 Adopting RFID in Supply Chain Management

Radio Frequency Identification (RFID) is a generic technology concept that refers to the use of radio waves to identify objects (Auto-ID Center, 2002). The core of RFID technology is the RFID transponder (tag) – a tiny computer chip with an antenna. Consumer good suppliers attach these tags to logistic units (palettes, cases, cartons and hanger-good shipments) and, in some cases, to individual items. Logistic units and individual items are identified by the Electronic Product Code (EPC). An RFID reader is used to identify the EPC stored on the RFID tag (Loebbecke, 2007). The antenna enables the microchip to transmit the object information to the reader, which transforms it to a format understandable by computers (Angelles, 2005). Finkenzeller (1999) provides a general overview of RFID technology while Sarma (2002) describes the specific technology for supply chain management.

Nowadays, many in the retail sector are already looking to the business case of RFID as the “next generation of barcode” through its capabilities to uniquely identify, track and trace consumer products along the entire supply chain requiring neither direct human contact nor line of sight, to store much more information and to enable a broad spectrum of supply chain applications ranging from upstream warehouse and distribution management down to retail-outlet operations, including efficient inventory management, shelf management, promotions management and innovative consumer services, as well as applications spanning the whole supply chain, such as product traceability (Ghisi & da Silva 2001, Kambil & Brooks 2002, Wong et al. 2002, Sarma et al. 2002, Penttilä et al. 2004, Loebbecke 2007). Although RFID technology is still emerging, RFID adoption is pushed by major retailers (RFID journal, 2003) which are already executing a number of pilot applications.

The benefits of RFID adoption in various application areas can be sought across the following axes (Pramatari, 2006):

- the automation of existing processes, leading to time/cost savings and more efficient operations;
- the enablement of new or transformed business processes and innovative consumer services, such as monitoring of product shelf availability or consumer self check-out;
- the improvement of different dimensions of information quality, such as integrity, accuracy, timeliness etc. (Ballou et al., 1998) and
- the formation of new types of information, leading to a more precise representation of the physical environment, e.g. a product’s exact position in the store, a specific product’s sales history etc.

For the full benefits to be ripped, the information needs to be shared among the supply chain partners in a complex network of relationships and decision making. The internal exploitation of RFID technology by a network leader-retailer looking solely at its own benefits is expected to have a negative impact on RFID market acceptance and adoption rates since suppliers will confront RFID as another unfortunate strategic necessity (Barua et al., 1997). Under this perspective, the proposed scalable-distributed architecture supports RFID-enabled collaborative supply chain processes and decision-making in a networked retail business environment, so that both retailers and suppliers can benefit from the employment of RFID.

3 A Scalable-Distributed Architecture for RFID-Enabled Supply Chain Collaboration in a Networked Business Environment

This section proposes a scalable-distributed architecture that can support new RFID-enabled supply chain collaboration services and decision-making in a networked business environment. The field case considers the grocery retail business sector, since it is characterized by an intense supply chain environment on one hand, handling thousands of products and supply chain relationships on a daily basis, and increased competition and consumer demands on the other.

This architecture employs the following technologies into an integrated network infrastructure:

- Data stream management systems (DSMS) supporting real time analytics and decision support based on queries of transient data streams regarding product movement across various stages of the supply chain.

Many applications involve data items that arrive on-line from multiple sources in a continuous, rapid and time-varying fashion. In these applications, it may not be possible to process queries within a database management system. For this reason, applications have recently been developed in which data is modelled not as persistent relations but rather as transient data streams. A good example of such an application would be one that constantly receives data of electronic product code observations across a chain. In data streams we usually have "continuous" queries rather than "one-time". The answer to a continuous query is produced over time, reflecting the stream data seen so far. Computing real-time analytics (potentially complex) on top of data streams is an essential component of modern organizations (Chatziantoniou et al., 2005).

Therefore, the ability to efficiently perform complex real time analysis on top of streams of RFID measurements is the reason data stream management systems are employed by this architecture. In addition, a relational database management system (DBMS) is used to support less information intensive scenarios and other elements of the application.

- Web service orchestration and/or choreography enabling secure and seamless information sharing and collaboration in a distributed environment (Muehlen et al., 2005).

A web service, as defined by the W3C Web Services Architecture Working Group, is a software application identified by a URI, whose interfaces and bindings are capable of being defined, described, and discovered as XML artifacts. A web service supports direct interactions with other software agents using XML-based messages exchanged via Internet-based protocols (W3C, 2002). In general, a web service is an application that provides a Web API, supporting application-to-application communication using XML and the Web.

Orchestration refers to an executable business process that may interact with both internal and external web services. Orchestration describes how web services can interact at the message level, including the business logic and execution order of the interactions. These interactions may span applications and/or organizations, and result in a long-lived, transactional process. With orchestration, the process is always controlled from the perspective of one of the business parties.

But choreography is more collaborative in nature, where each party involved in the process describes the part it plays in the interaction. Web Services choreography aims at the coordination of long-running interactions between distributed parties, which use web services to expose their externally accessible operations (Muehlen et al., 2005).

Figure 2 gives a high-level schematic representation of the proposed architecture. It is a distributed architecture, where the application layer runs on the system of each collaborating partner and web services implement the interface between the different partners' systems using SOAP (Ferris et al., 2003) requests and responses. The data layer is implemented by both a relational database system and a data stream management system providing the application layer with a continuous stream of unique product information. A central orchestration engine (Arkin, 2002) coordinates the exchange of messages between the partners' web services (W3C, 2002) following the logic of the specific collaborative process scenarios. A collaboration registry is also used, implemented by a Universal Description, Discovery and Integration (UDDI) directory enhanced with additional higher-level information regarding each collaborative relationship, to include and organize the necessary info of which partner collaborates with each other under which process scenario and with what security privileges.

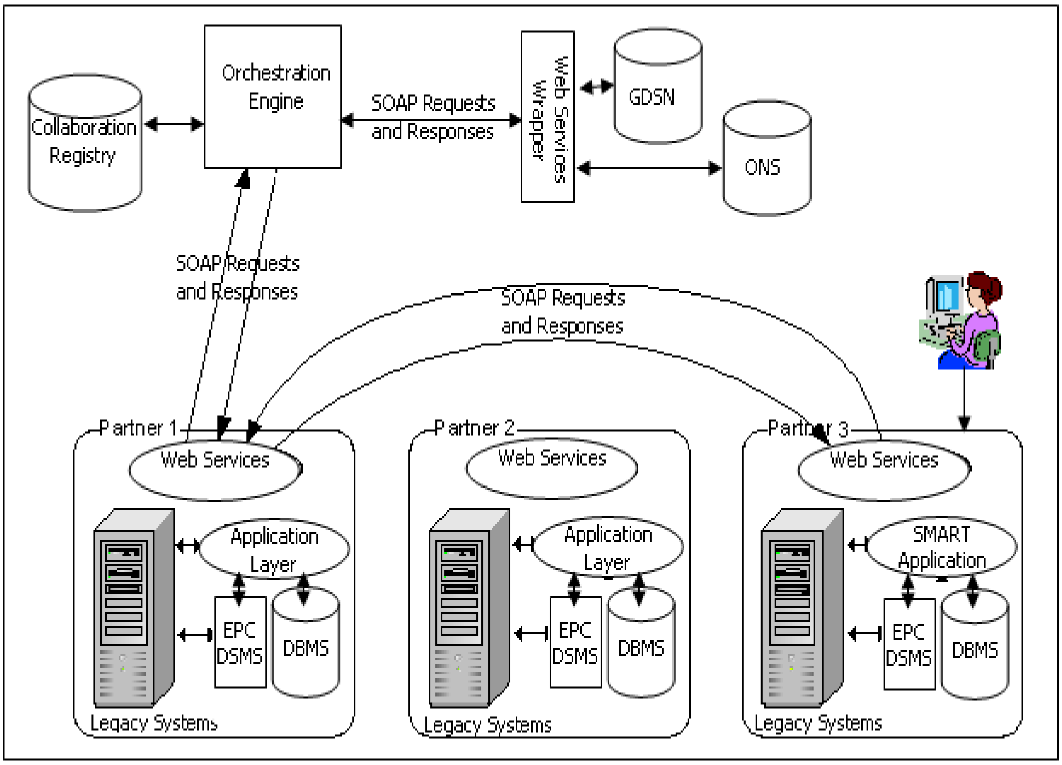

Figure 2: Schematic presentation of the scalable-distributed network architecture

Since, this architecture is developed to support collaborative processes and decision making in the grocery retailing sector, it is necessary to interlink it to the Global Data Synchronization Network (GDSN) and Object Name Service (ONS)/EPC Network infrastructures or similar infrastructures of the same purpose. The GDSN, established by GS1 (www.gs1.org) and GCI (www.gci.org) supports information sharing about product type –currently identified via a barcode– and is implemented through a collection of data pools and global registries. On the other hand, the EPC Network (www.epcglobalinc.com) supports information sharing about unique product instance –identified via an RFID tag, following the EPC standard (EPCglobal, 2004)– and is supported by the ONS infrastructure. The suggested architecture connects to either these two or similar directory services in order to get the master product information (e.g. product name, manufacturer, weight, etc.) associated with a specific product type identified via a barcode (GDSN), or additional information associated with a specific product instance (e.g. production date, distribution history, etc.) identified via an EPC (ONS/EPC Network).

Finally, the architecture enables different collaborative processes and decision-support scenarios. Each of these scenarios can be supported by separate components at the application layer. These components perform different functionality on each site, depending on what is the role of the collaborating partner, e.g. supplier, distribution centre, retail store.

4 RFID-Enabled Supply Chain Collaboration Services

The proposed system, categorized as a distributed Web-based decision support system according to Zhang et al. (2005), is employed in the course of the SMART research project, funded by the European Commission (IST-2005, FP6), with participating user companies being European grocery retailers and suppliers from the fast-moving consumer goods sector. Companies in the sector already have a more-than-ten-years collaboration history and some collaboration processes have become standard business practice across Europe, such as CRP/VMI employed in retail warehouse replenishment or Category Management dealing with the marketing aspects of managing product categories in the store (Pramatari, 2006).

The proposed architecture is a generic distributed architecture that can potentially support various supply chain collaboration and decision support scenarios, whether these are enabled by RFID technology or not. However, in the context of the SMART project, the research focuses on eight RFID-enabled collaboration services. Each RFID-enabled collaboration scenario, described in detail below, has its own value proposition and can be characterized, on a high-level, by the information shared between suppliers and retailers, the level of tagging (pallet/case/item level) and the location of the tag readers.

o Backroom Visibility

In this scenario, both retailer and suppliers have a clear picture of the products' stock level in the store, as well as of the products' sales and collaborate on order placement for store replenishment. The store personnel receive from the system real time information about the backroom inventory level of each product. If a product is out-of-shelf, but there is available stock in the backroom, the store personnel is informed to refill the shelf; otherwise, if there is no stock (out-of-stock), a new store order is placed and sent to the distribution center. The salesmen of direct-store-delivery suppliers have also direct access to this information through their PDAs

The system updates the backroom inventory records automatically and sends the information to the PDA of the suppliers' salesmen. The salesmen inform the store staff to refill the shelf, but if there is no backroom stock, they prepare an order based on the inventory information provided by the system. At the retailer's headquarters, they can monitor the orders that the suppliers' salesmen have placed. The salesmen leave the store satisfied, since they succeeded in moving their products to the shelves and they also took efficient ordering decisions to avoid out-of-stock & out-of-shelf. The tags are applied on case and item level. The tag readers are fixed on the backroom entrance and the backroom to sales floor entrance.

- Out-of-shelf Response

The last 50 yard problem of product shortages on the shelf is a crucial issue in retail operations, both for the supplier and the retailer. On one hand the retailer should be aware of the time to move items from the backroom to the shelf, and on the other hand the supplier should be able to monitor the level of out-of-shelf in the stores, in order to identify problems and take corrective actions about the service level of new products to the end customer.

The system monitors the stock in the backroom and on the shelves and when there are out-of-shelf cases it generates an out-of-shelf alert and sends specific instructions on the PDA of backroom personnel about which goods to move from the backroom to the shelf. The staff refills the shelf, following the orders from the PDA. In addition, the suppliers' product managers have access to a weekly detailed report about products' shelf availability and inventory levels. The tags are applied on case and item level. The tag readers are fixed on the shelves, the backroom entrance and the backroom to sales floor entrance.

This collaborative scenario enables the store personnel to better manage the shelf replenishment process, which is currently one of the major causes behind the out-of-shelf problem (Gruen et al., 2002). Sharing out-of-shelf alerts with the products' suppliers is also important, especially in direct-store-delivery where the suppliers are responsible for replenishing the store, in order to further monitor the problems as well as develop more accurate demand forecasts. While the previous scenario requires real-time information flows to support daily operations, this scenario is more about business intelligence and decision support.

- Remote Shelf management

Retailers and suppliers are provided with real time information about the actual shelf layout and have the opportunity to collaboratively manage the shelves allocation and appearance. RFID readers "scan" and "read" the shelves and provide their "digital image", including information about the size, specific products' position and layout, as well as information about the shelves' performance.

By using the system, the suppliers are now able to check if the products get the room they deserve on the shelf and are neatly positioned according to the store's planogram. If the suppliers notice that some of the products have fewer facings on the shelf, than what has been agreed with the retailer, or that some shelf space has been left empty, they informs the retailer, as well as the merchandiser to visit the store and take care of the shelf. Moreover, the suppliers monitor the shelves performance (shelves' sales) and can create a new planogram suggestion for the retailer. Both the retailer and the suppliers are satisfied, since they can better manage the limited, but so valuable, shelf space. The tags are applied on item level. The tag readers are fixed on the shelves. The process of shelf-management is already based on supplier-retailer collaboration to a great extent, but currently involves many manual and time-consuming steps that make it quite cumbersome. The adoption of RFID transforms the process with the automation of many steps, or even by making them unnecessary.

- Dynamic Pricing

Retailers and suppliers have the opportunity to identify products that are close to their expiration date, or are standing still on the shelves for a long time. For these reasons they can dynamically reduce the products' price, in order to boost consumer demand and reduce waste. This collaborative service (see Figure 3) is very useful for fresh products, such as dairy products, bread, meat, etc.
When consumers visit the store with their shopping list, they usually purchase products with the longest expiration date, since they cost the same. Thus, in order to avoid big on-hand stock of expired products, the system does periodic checks of on-hand stock to identify products approaching expiration date and then informs the suppliers. The suppliers, based on the system's recommendations, suggest to the retailer to decrease the price of these products. The retailer approves the suppliers' proposal for price change. In this case, the customers face a dilemma, if they should sacrifice the longest expiration date for a better price. But there are economic difficulties, so they usually choose the cheaper one. As a result, the customers leave the store happy that they managed to save money and both the retailer and the supplier are also satisfied because they managed to sell products that would otherwise be trashed. The tags are applied on case and item level. The tag readers are fixed on the shelves, on the backroom entrance, and on the backroom to the sales floor entrance.

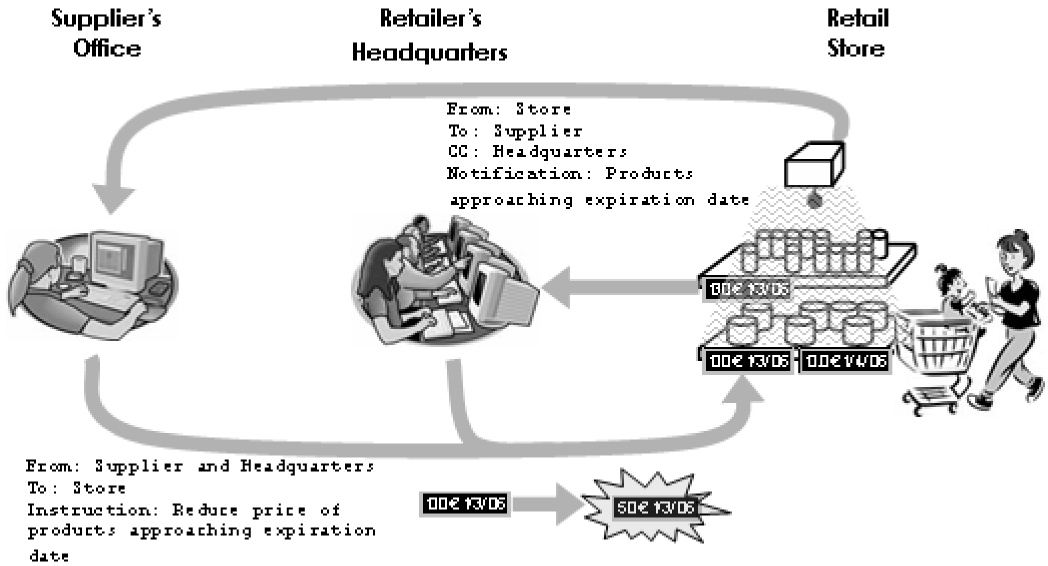

Figure 3: Dynamic pricing RFID-enabled collaborative service

o In-store Promotion management and Promotion evaluation

Customers get direct information about special offers and promotions relevant to the product they just picked up from the shelf. When the consumer picks up the product, the fixed tag reader scans it and the customer gets a promotion message on a special information screen or even its mobile phone.
The system distinguishes between shelf sales and promotion stands sales. The suppliers use the system to monitor the sales of products in every store and get assistance in the design of new in-store promotion events. The system even provides them with statistics, evaluation reports, recommendations and specific locations in the store to use, based on their performance and cost. The tags are applied on item level. The tag readers are fixed on the shelves, on the promotion stands and near the special information screens.

- Demand management

According to this scenario, retailers and suppliers are capable of monitoring the inventory and the sales of products in every store and relocate them, if needed, (e.g. in case of a special promotion event) in order to eliminate lost sales opportunities. Using the system, they receive, on real time, from every retail outlet the on-hand inventory level in the backroom, on the shelves, and even on the promotion stands. They also get sales data from the Point-Of-Sales system. For example, if the supplier runs a promotion campaign for product A and notices that product A is almost out-of-stock in store Y, where it has high sale rates, but in store X there is a lot of product inventory that is not sold then he issues an order "Move product A from store X to store Y". The tags are applied on case and item level. The tag readers are fixed on the backroom entrance, on the backroom entrance to the sales entrance, on the shelves and on the promotion stands.

- Traceability information

According to this scenario, the consumer at the end-point-of-sales (retail store) has a clear view of the products' history and origin. When the consumer reaches the shelf, he cannot be sure for the product's quality and safety. So, he picks up the product, the fixed tag reader scans it and, by special information screens, the customer gets details about production date and origin, expiration dates and other unique product's information that can ensure product authenticity and safety. The tags are applied on item level. The tag readers are fixed near the special information screens. The traceability information that belongs to the suppliers is shared with the retailers, in order to enable this collaboration service.

- Smart Recall

Retailers and suppliers have the capability to identify the location of products with specific characteristics and recall them fast and at minimum cost from the market, e.g. in case there is a risk with consumer safety.

When a crisis happens and the products of a specific production lot are found defective, the suppliers' quality managers issue an order "Recall the defective production lot from the market". The system identifies the products and provides with all the locations in the retailer's stores where the products of the specific production lot have been sent. The store personnel is informed to withdraw the products from the specific shelves, promotion stands and the backroom and prepare them to be sent back to the suppliers. As a result, the retailer has avoided the customers' dissatisfaction and for the suppliers it was not necessary to recall all the products of the kind. The tags are applied on case and item level. The tag readers are fixed on the backroom entrance and shelves, on the backroom to the sales floor entrance, on the shelves and on the promotion stands.

These innovative scenarios capitalize on RFID capabilities for automatic data capture and identification of unique product instances, in combination with other information that can be derived in association with RFID, such as the shelf location, the context of an in-store promotion event, etc. Some of the scenarios focus on the management of specific operations and processes (e.g. backroom visibility, dynamic pricing, smart recall), other focus more on supporting decision-making and building domain-knowledge (e.g. out-of-shelf response, remote shelf management), and other combine both aspects (e.g. promotion management, demand management, traceability information). Furthermore, collaboration between retailers and suppliers takes place either through joint involvement in a collaborative process (e.g. promotion management), through information sharing for decision-support purposes (e.g. out-of-shelf, promotion evaluation) or through information sharing in order to support the delivery of a service to the end customer (e.g. traceability information).

Table 1 summarizes the above RFID-enabled supply chain collaboration services. Each scenario is presented according to the information shared between the collaborating retailers and suppliers, the tag readers location, and the tagging level.

RFID-enabled Collaboration service	**Information shared**	**Tag Readers Location**	**Tagging Level**
Backroom visibility	Backroom on-hand stock Orders POS data	Backroom entrance Backroom to sales floor entrance	Case, Item
Out-of-shelf response	Backroom on-hand stock Shelves on-hand stock Out-of-shelf alerts	Backroom entrance Backroom to sales floor entrance Sales floor shelves	Case, Item
Remote shelf management	Number of products' facings Products' position Shelf layout Shelf sales	Sales floor shelves	Item
Dynamic Pricing	Products expiration date Backroom on-hand stock Shelves on-hand stock	Backroom entrance Backroom to sales floor entrance Sales floor shelves	Case, Item
In-store Promotion management and Promotion evaluation	Shelf sales Promotion stands sales POS data	Sales floor shelves Promotion stands near the special information screens	Item
Demand management	POS data Backroom on-hand stock Shelves on-hand stock Promotion stands on-hand stock	Backroom entrance Backroom to sales floor entrance Sales floor shelves Promotion stands	Case, Item
Traceability information	Product traceability information (production date and origin, expiration date, product history, etc.)	near the special information screens	Item
Smart Recall	Product information Product location information	Backroom entrance Backroom to sales floor entrance Backroom shelves Sales floor shelves Promotion stands	Case, Item

Table 1: Characteristics of the eight RFID-enabled Supply Chain Collaboration Services

However, the above table presents only the first findings of a research-in-progress with the ultimate purpose to assess and categorize the RFID-enabled supply chain collaboration scenarios according to the following four dimensions:

- the extent of collaboration required between retailers and suppliers,
- the RFID technology requirements,
- the transformation of existing (or the introduction of new) processes and

- the performance impact, the business case contribution of the RFID-enabled collaborative service.

The extent of collaboration between trading partners will be analyzed based on the collaboration index of Simatupang and Sridharan (2005), which defines three interrelated dimensions: information sharing, decision synchronization, and incentive alignment. Information sharing refers to the act of capturing and disseminating timely and relevant information for decision makers to plan and control supply chain operations; decision synchronisation refers to joint decision-making in planning and operational contexts; and incentive alignment refers to the degree to which chain members share costs, risks, and benefits.

The RFID technology requirements, the processes and the performance impact dimensions are based on the 5Ps of RFID proposed by Loebbecke and Palmer (2006) to analyse RFID implementations: the *Physics* of the tag, the reader and the data transfer; the *Processes* being changed and enhanced, the *Prices* for technical components and their installation, the *Privacy* aspects of capturing and retaining customer data and the *Performance* impact, the business case contribution, of RFID implementation (Loebbecke, 2007). Specifically, the RFID technology requirements refer to the level of tagging, the location of the tag readers and the cost of the implementation including the cost of necessary hardware and software infrastructure.

Tag costs constitute the bigger part of RFID deployment costs and, thus, the tagging level is the dominant variable when deciding on the adoption of alternative RFID-enabled processes (Alexander et al., 2002). On the other hand, the benefits of RFID are expected to increase significantly as adopters migrate from pallet, to case, to item-level tagging and tag readers are located in more areas. Moreover, time and labour savings, data accuracy, supply chain visibility, inventory management, products traceability, etc. are among areas in which improvements and enhancements of business performance are sought.

Using these four dimensions we will perform a detailed assessment for each of the supply chain collaboration scenarios, in order to understand the anticipated costs and benefits as well as predict the expected barriers of implementation and adoption, including process changes and collaboration incentives. This assessment follows both an operational and strategic perspective, as some of the scenarios focus on the management of specific operations and processes (e.g. backroom visibility, dynamic pricing, smart recall), other focus more on supporting decision-making and building domain-knowledge (e.g. out-of-shelf response, promotion evaluation), and others combine both aspects (e.g. promotion management, traceability information).

5 Conclusions and Future Research

Supply chain collaboration in retailing and Fast Moving Consumer Goods industry (FMCG) has mainly been expressed in the form of practices such as Vendor Managed Inventory (VMI), Continuous Replenishment Program (CRP), and Collaborative Planning, Forecasting and Replenishment (CPFR). The emergence of RFID is expected to revolutionize many of the collaborative supply chain processes and to empower new collaboration scenarios, such as anti-counterfeiting, product recall and reverse logistics, collaborative in-store promotion management and total inventory management.

This paper proposes eight RFID-enabled supply chain collaboration services (e.g. dynamic pricing, smart recall, in-store promotion management, out-of-shelf response) in a networked retail business environment. The services are characterized, on a high-level, by the information shared between retailers and suppliers, the level of tagging (pallet/case/item level) and the location of the tag readers. However, these RFID-enabled supply chain collaboration scenarios will be further assessed according to four dimensions (for details, see Section 4): the extent of collaboration required between retailers and suppliers; the RFID technology requirements the transformation of existing (or the introduction of new) processes and the business case contribution of the service.

Also, a scalable-distributed network architecture, building on the possibilities provided by web service orchestration and data stream management systems, is proposed to support these collaborative supply chain management processes. The proposed system, categorized as a distributed Web-based Decision Support System according to Zhang et al. (2005), is employed in the course of the SMART research project, funded by the European Commission (IST-2005, FP6), with participating user companies being European grocery retailers and suppliers from the fast-moving consumer goods sector.

Finally, to further extend this research, three of the proposed RFID-enabled collaborative services (out-of-shelf response, promotion management and traceability information) will be implemented and tested via field experiments, in order to evaluate in practice the benefits of RFID adoption from a business perspective. It is also important to evaluate the degree to which the proposed architecture adequately supports the corresponding scenarios and fulfils the requirements from various perspectives, which is a clear next direction of research in this area.

References

Alexander K., Birkhofer G., Gramling K., Kleinberger H., Leng S., Moogimane D. & Woods M., (2002): Focus on Retail: Applying Auto-ID to Improve Product Availability at the Retail Shelf, Auto-ID Center White Paper, www.autoidcenter.org.

Andraski, J.C., (1994): Foundations for successful continuous replenishment programs, International Journal of Logistics Management, Vol. 5, No. 1, pp. 1-8.

Angelles R., (2005): RFID Technologies: Supply Chain Applications and Implementation Issues, Information Systems Management, pp. 51-65.

Anthony, T., (2000): Supply chain collaboration: success in the new Internet economy. Achieving Supply Chain Excellence Through Technology, Montgomery Research Inc., pp. 241-44.

Arkin, A., (2002): Web Service Choreography Interface (wsci) 1.0.

Auto-ID Center (2002): Technology Guide, Auto-ID Center White Paper.

Ballou, D., Wang, R., Pazer, H., and Tayi, G., (1998): Modeling information manufacturing systems to determine information product quality, Management Science, Vol. 44, No. 4, pp. 462.

Barratt, M. and Oliveira, A., (2001): Exploring the experience of collaborative planning initiatives, International Journal of Physical Distribution and Logistics Management, Vol. 31, No. 4, pp. 266-289.

Barua, A., and Lee, B., (1997): An Economic Analysis of the Introduction of an Electronic Data Interchange System, Information Systems Research, Vol. 8, No. 4, pp. 398-422.

Blatherwick, A., (1998): Vendor-managed inventory: fashion fad or important supply chain strategy?, Supply Chain Management: An International Journal, Vol. 3, No. 1, pp. 10-11.

Bowersox, D.J., Closs, D.J. & Stank, T.P., (2000): Ten mega-trends that will revolutionize supply chain logistics, Journal of Business Logistics, Vol. 21, No. 2, pp. 1-16.

Chatziantoniou, D., and Johnson, T., (2005): Decision Support Queries on a TapeResident Data Warehouse, Information Systems Journal, Vol. 30, No. 2, pp 133-149.

Cooke, J.A., (1998): VMI: very mixed impact?, Logistics Management Distribution Report, Vol. 37, No. 12, 51.

EPCglobal (2004): The EPCglobal Network and The Global Data Synchronization Network (GDSN): Understanding the Information & the Information Networks.

Ferris, C., and Farrell, J., (2003): What are Web Services?, Communications of the ACM, Vol. 46, No. 6, pp. 31.

Finkenzeller K., (1999): "RFID Handbook: Fundamentals and Applications in Contact-less Smart cards and Identification,"John Wiley & Sons.

Frantz, M., (1999): CPFR pace picks up, Consumer Goods. Available at: www.consumergoods.com/archive/JanFeb99.

GCI (2005): EPC: A shared vision for transforming business processes, Global Commerce Initiative. Available online at: www.gci-net.org

Ghisi, F. and da Silva, A., (2001): The information technology on food supply chain management, In proceedings of the International Conference on Management of Engineering and Technology, Vol. 1, p. 169, Portland.

Gruen, T.W., Corsten, D.S. and Bharadwaj, S., (2002): Retail Out-of-Stocks: A Worldwide examination of Extent, Causes and Consumer Responses, The Food Institute Forum (CIES, FMI, GMA).

Hölmstrom, J., Framling, K., Kaipia, R. and Saranen, J., (2002): Collaborative planning forecasting and replenishment: new solutions needed for mass collaboration, Supply Chain Management: An International Journal, Vol. 7, No. 3, pp. 136-145.

Kambil A. and Brooks J.D., (2002): Auto-ID Across the Value Chain: From Dramatic Potential to Greater Efficiency and Profit, Auto-ID Center, White Paper.

Loebbecke, C., (2007): Piloting RFID Along the Supply Chain: A Case Analysis, Electronic Markets, Vol. 17, No. 1, pp. 29-37.

Loebbecke, C. & Palmer, J., (2006): A Real-World Pilot of RFID in the Fashion Industry: Kaufhof and Gerry Weber in Germany, Academy of Management Annual Meeting, (OCIS Division), Atlanta, GA, August.

Mclaren, T., Head, M. and M., Y. Y. (2002): Supply chain collaboration alternatives: Understanding the expected costs and benefits, Internet research: Electronic networking applications and policy, Vol. 4, pp. 348-364.

Muehlen, M., Nickerson, J.V. and Swenson, K.D., (2005): Developing web services choreography standards – the case of REST vs. SOAP, Decision Support Systems, Vol. 40, pp. 9-29.

Patrakosol, B. and Olson, D., (2007): How interfirm collaboration benefits it innovation, Information & Management, Vol. 44, No. 1, pp. 53-62.

Penttilä, K., Engels, D. and Kivikoski, M., (2004): Passive radio frequency identification in supply chain management, Int. J. Robotics Automation, Vol. 19, pp. 143-152.

Pramatari, K., (2006): Collaborative Supply Chain Practices and Evolving Technological Approaches, Supply chain management: an International Journal (Forthcoming).

Pramatari, K., Papakiriakopoulos, D., Poulymenakou, A. and Doukidis, G.I., (2002): New forms of CPFR, The ECR Journal-International Business Review, Vol. 2, No. 2, pp. 38-43.

Prater, E., Frazier, G.V. and Reyes, P.M., (2005): Future impacts of RFID on e-supply chains in grocery retailing, Supply chain management: An International Journal, Vol. 10, No. 2, pp. 134-142.

RFID Journal (2003): Wal-Mart draws line in the sand, http://www.rfidjournal.com/article/view/462/1/1/.

RFID Journal (2003): Wal-Mart expands RFID mandate, http://www.rfidjournal.com/article/articleview/539/1/1/.

RFID Journal (2003): Tesco Deploy Class 1 EPC Tags, http://www.rfidjournal.com/article/articleview/587/1/1/.

Sarma S., (2002): Towards the 5¢ tag, Auto-ID Center. White paper.

Sarma, S.,Weis, S. and Engels, D., (2002): Low cost RFID and the electronic product code, In the Workshop on Cryptographic Hardware and Embedded Systems, LNCS, pp. 6, Berlin.

Simatupang, T. and Sridharan, R., (2005): The collaboration index: A measure for supply chain collaboration, International Journal of Physical Distribution & Logistics Management,Vol. 35, No.1, pp. 44-62.

Skjoett-Larsen, T., Thernøe, C. and Andresen, C., (2003): Supply chain collaboration theoretical perspectives and empirical evidence, International Journal of Physical Distribution and Logistics Management, Vol 33, No. 6, pp. 531-549.

Wong, C., McFarlane, D., Zaharudin, A. and Agarval, V., (2002): The intelligent product driven supply chain, In Proceedings of the IEEE International Conference on Systems, Man and Cybernetics, Vol. 4. pp. 6.

W3C (2002): Web Services Architecture Requirements.

Zhang, S., and Goddard, S., (2005): A software architecture and framework for Web-based distributed Decision Support Systems, Decision Support Systems, Vol. 40.