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An Exploratory Study on Electronic Commerce for Reverse Logistics

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Abstract

In this paper we consider the role Electronic Commerce plays and can play for Reverse Logistics. After short introductions to electronic commerce and reverse logistics, we give an overview of existing internet sites for reverse logistics. These sites can be classified as electronic markets, supply of used parts and complete reverse logistic solutions. Finally we draw some lines to the future.

1. INTRODUCTION

Over the last few decades accelerating environmental concern which, in some countries, has already resulted in legislation, and financial interests in the reuse of products, parts or materials, have all contributed to reverse logistics recent popularity. In a broad sense, reverse logistics stands for all operations related to the reuse of products and materials. Reverse logistic activities include collection, disassembly and processing of used products, product parts, and/or materials, in order to ensure a new use or an environmentally friendly recovery. From a scientific point of view, reverse logistics brings new elements in collection/distribution management, production planning/remanufacturing, and inventory control. Besides, there are interesting relations with business economics, environmental management and information technology.

In this paper, we focus our attention on the relation between reverse logistics activities and information technology with the objective to examine and evaluate existing applications of E-commerce in this field. At large, E-commerce is defined as sharing business information, maintaining business relationships, operating business negotiations, settling and executing

agreements by means of telecommunication networks, often the Internet, in order to achieve business transactions [adapted from EITO99 and Zwass96]. In light of the reverse logistics context, E-commerce is examined in terms of technologies and emerging services, which are used to improve trading of used products and parts, including marketing, purchasing, sales and post sales. Also, we examine systems that can facilitate data collection for used products at the collection stage and IT applications to support remanufacturing and re-distribution activities. It is worth mentioning that although by definition E-commerce is inclusive for all electronic networks, the focus of our study will be on Internet-based E-commerce for two main reasons. First, the penetration of Internet-based E-commerce increases drastically, while a significant portion of EDI users intends to switch over to Internet-based applications [EITO99]. In addition, many of the actors involved in reverse logistics activities may not be able to have access to an EDI infrastructure.

Within this context, there are very few references of E-commerce for reverse logistics activities, except [Lee 1997] who presents a specific application for the electronic auctioning of used Japanese cars. Moreover, many researchers examined various aspects of electronic marketplaces [Bakos 1997, Beam 1999, Bichler 1999, Dutta 1998, Gebauer 1995, Klein 1997] in which used products are sold along with new ones, without explicitly considering the reverse logistics perspective. Thus, it is interesting to identify what kind of electronic markets are related to reverse logistic activities and how one can assess their risks and benefits. We are also interested to examine the relationship between E-commerce and the economic aspects of markets. For example, E-commerce potentials have been very carefully examined with respect to certain markets, which traditionally have not been functioning in a very efficient way through the traditional distribution channels [Wrigley 1997, Klein 1997]. Could, in fact, E-commerce create a homogeneous, electronic market for used products and parts open to all interested parties? And if so, what would be the critical factors for the successful implementation of such an electronic marketplace? In view of such developments and potentials, it is also interesting to examine how existing Web applications and other IT technology can promote other reverse logistics activities and identify what (if any) E-commerce promising, yet under-deployed potential exists. For example, could Web applications be used to decrease some of the uncertainty encountered in reverse logistic activities in some cases? Are there some others developments towards this direction and how do they compare?

In our study a series of relevant sites have been selected and examined based on specific criteria with the aim to identify how they function and how efficient they are. Based on this, an evaluation of the examined case studies is carried out and some directions for future

research and development have emerged. These are the main directions of this paper, which is structured as follows. In Section 2, we review reverse logistics activities and their relation to Information Technology. First, we identify important aspects that have not yet been addressed adequately from the Information Technology point of view. Then, we proceed to examine how Internet technologies can support some aspects of reverse logistics, focusing on those, which although not directly related to a business transaction, are still very important for an efficient operation of a reverse logistics network. In Section 3, we examine three main E-commerce models that facilitate business transactions for reverse logistics; we assess them and give a number of illustrative examples. An overall view, some directions for future research and development, as well as some speculations about future deployment of E-commerce with respect to reverse logistics are summarized in Section 4.

2. REVERSE LOGISTICS ACTIVITIES AND SUPPORTING IT SYSTEMS

The main objective of this section is to describe what the main reverse logistics activities are and how Information Technology supports and facilitates these activities. The description is mainly taken from several overviews on reverse logistics [Stock 1998, Fleischmann 1997, 1999 and Thierry 1997].

2.1 Description of Reverse Logistics and open issues

Figure 1 presents a graphical representation of the activities within a product recovery chain together with traditional supply chain activities. The recurrent reverse logistics activities include collection, inspection/separation, reuse, remanufacturing, recycling, re-distribution and disposal.
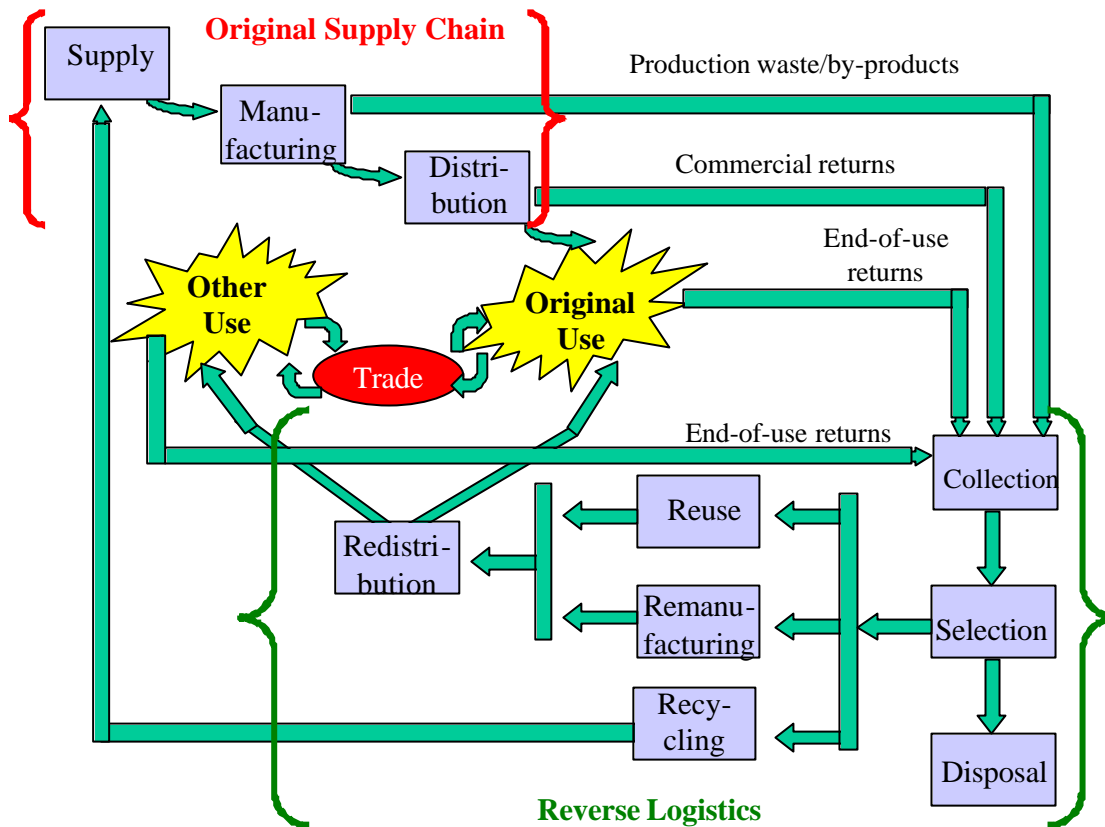
Figure 1 Product Flow in Supply and Recovery Chain

In Figure 1, the main concept is that products are brought to the market through some conventional supply chain. The majority of products is used in their original functionality; i.e. a company buys a state of the art computer for their virtual reality project. After a while, the product is not useful to the original user. In our example, the industry standards have evolved and that computer can no longer support them. Frequently, the product is traded in a marked down price once or several times. In our figure, this is denoted by the loop between original use and trade. It is worth to point out that through the repetitive changes of ownership, the product is still used in its original functionality. In our example, the computer might be bought for personal use or for entertainment, before it actually reaches the end-of-use return flow. The main idea for reverse logistics is to promote and support alternative uses for the product. In our example, the computer's keyboard could be directly re-used, its motherboard may be remanufactured in an electronic toy, whereas other parts (casing) could be recycled. Anyway, with new or old functionality the product (or parts of it) enters the market again where it may also go through several trading cycles. This concept is denoted by the closed loop between other use and trade in Figure 1. Certainly, at some future point in time, the product will reach again the end-of-use return in the reverse logistics network.

Supply, manufacturing, distribution and their cascading flows represent the traditional supply chain. From the reverse perspective, the flows for production waste and commercial returns are very important, because these two combined with the end-of-use return flow are all input flows in the recovery chain. Production waste includes the remains of raw materials / intermediates that is lost in the production, i.e. a part of steel sheet that is too small to be used in the manufacturing of a product, and the side products that come free during production. A commercial return would be any unsold product that a supplier has agreed to take back from the retail customer. Warranty returns of failed products were not explicitly mentioned in the picture, but should be added to the commercial return stream if the products can no longer be repaired. The same holds for all perishable products which can no longer be sold. An end-of-use return, as explained in our example, is either the turn-in of a product to the seller/OEM, because its use has been terminated and the seller is forced to take it back or the collection of the product by a waste collector.

The first stage in the reverse logistic process is collection, that is, all those activities that are necessary for reclaiming returned products, surplus or by-products and transporting them to a place, where they will be subjected to further examination and processing. Locating such products, purchasing, transporting them and storing them at a collection point, are all activities related to collection.

A major issue in collection is the encountered high uncertainty[1] regarding the locations from where used products need to be collected, their quantity and timing. These pose severe difficulties in planing and controlling collection processes. Furthermore, these uncertainty factors are detrimental to the integration of forward and reverse distribution networks, which is a very important issue if we consider that the additional transportation induced by return flows is a negative element in the overall ecological assessment of industrial reuse activities.

Another major issue for products entering the reverse logistic chain is that of their quality. This issue is central at the stage of selection, where a decision must be reached as to whether a product (or parts of it) will be reused, remanufactured, recycled or disposed. Physical inspection is necessary for determining further processing for most commercial products. The alternative of remote monitoring and control, that are currently available for certain products (like computing equipment and electronics) have not yet been employed to improve the reverse logistics operations.

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[1] Except for leased products.

Remanufacturing is a series of steps necessary to transform a part or product that has been used into one that is usable again. Some typical activities in remanufacturing include cleaning, disassembly, replacement and re-assembly. However, remanufacturing is so product dependent that it can barely be characterized by typical activities. For example, restoration for a piece of old furniture may require artistic skill, whereas remanufacturing of a piece of heavy equipment requires advanced industrial infrastructure.

For remanufacturing an unresolved issue is centered on decision making for dismantling or dis-assembling a product. In general, dismantling everything up front is a labor-intensive task, while on the other end, on-demand dismantling requires extensive storage capacity, has uncertain yields and variable throughput times. For many companies remanufacturing is a very sensitive issue. Re-processing is so product specific that if a third party is involved at this stage, in-depth information about a product can be easily gathered. In this respect this process is very similar to reverse engineering; thus, it is possible to provide grounds to product pirating, namely, to develop a new product based on the technical specifications derived from re-manufactured products.

Re-use refers to cases where returned products have such a good quality that they can be re-used almost immediately in the same or an alternative market. This happens for reusable bottles, containers and most leased or rented equipment. It may also happen for surplus goods, e.g. spare parts which are left over after discarding the original equipment.

Finally, re-distribution refers to the logistics activities required to introduce a product into a marketplace and transfer it to the customer. Obviously, this entails storage, sales and transportation. Moreover, efficient marketing of re-usable products requires protocols that support clear and concise communication between interested parties and mechanisms to facilitate matching of offers with requests.

2.2 Information Technology for Reverse Logistics

Based on Figure 1, one can observe that information flows between business partners are complementary to the actual product flow through supply and reverse networks. This observation could lead to the suggestion that information technology systems for reverse logistics can be prototyped based on the systems developed for the traditional supply chain. However, there is a fundamental difference between forward and reverse logistics, namely reverse logistics is in many situations an exception-driven process. In addition, data for the items entering the recovery chain are often of poor quality. Thus, a different overall

perspective is required for developing reverse logistics IT systems, as it was noted in [Rogers 1998]. However, it is important to see what the information dependencies between forward and reverse chains are and how IT systems can give support. Summarized, in order to handle reverse logistics efficiently, accurate and sufficient information is required in addition to information systems that satisfy specific reverse logistics requirements.

Therefore, we examine three interrelated issues in the following subsections. First, it is important to examine technologies that permit the collection of quality data regarding a product entering the reverse logistics network. Secondly, it is interesting to address the issue of interaction and information exchange between forward and reverse logistics systems. Finally, some emerging Web applications, although not directly applicable at present, but which can have great potentials for reverse logistics systems will be indicated as subject for future research.

2.2.1 Data Collection on Items Entering the Reverse Logistics Chain

In general it is important to know what product will be returned at which point in time at which place, in which condition and under what grounds. More specifically, for commercial returns one should know the as-perfect condition of a product or part and how the returned product measures to that. Also, for certain products that have high value and short life-cycle, it is very important to examine whether a product returned to the point of sale (POS) meets the allowed time frame requirements. Finally, an accurate explanation of the reason why this particular product enters the reverse logistics network can facilitate the selection/inspection phase.

Conventionally, product related information is recorded in paper-based catalogs, which present certain limitations: they are neither easily retrieved, frequently updated nor they can be searched in a speedy way. An alternative will be the Electronic Product Catalogues that can offer a multimedia representation of product information as well as retrieval, classification services and instructions for handling upon a return. Another alternative will be for that information to be embedded in the product. In fact, technologies like two-dimensional bar codes and radio frequency identification systems may be used to support this feature. Two-dimensional bar coding allows the user to embed much more information in a bar code than one-dimensional systems such as UPC. It supports the registration not only of a code but also a description and other textual data of significant capacity. Similar in concept, Radio Frequency Identification (RFID) uses small, very low powered radio transmitter that is installed in each product. This tag can have some memory capacity for data storage but it also

broadcasts a signal in 10M combinations, that is, it is practically unique. The battery is strong enough to send out a signal for years and the signal is strong enough to be picked up by receivers in a warehouse.

Information about end-of-use returns can be improved by keeping track of the installed base. Leasing forces the manufacturer to keep detailed information about the state of products. Hence following the product after its sale also gives marketing opportunities to influence the return of the products.

2.2.2   The Interactivity Issue between Forward and Reverse Logistics IT systems

The need for co-ordination among processes between forward and reverse logistics system also imposes a requirement for interactivity between the supporting IT systems. Business processes between trading partners in the forward supply chain have been supported by legacy EDI systems and Value-Added Networks (VAN) for electronic transactions and network configuration, respectively. This relationship, often described as business-to-business E-commerce and networking infrastructure, is also known as Extranet.

Electronic Data Interchange (EDI) allows trading partners to exchange information electronically in a very compact, concise and precise way and it provides different transaction sets for various types of business activities. The "180 transaction set" is, in principle, the transaction set that supports some aspects of reverse logistics. However, in practice, it is seldomly used. [Rogers 1998] contains a very detailed presentation on this topic. EDI applications are based on structured protocols, pre-established arrangements and bilateral information exchange; thus, a transaction supporting software is really necessary. Conventional EDI has been criticized for being expensive in terms of initial investment on infrastructure, software and training. Furthermore, because of its structure, this arrangement establishes and supports continuous relationships between known trading partners, thus creating a closed-club kind of electronic marketplace.

Addressing these technical impediments, the emerging standard XML/EDI provides the means for integrating EDI applications with the Web. Benefits resulting from this arrangement include lower costs, easier introduction of new trading partners and increasing commercial activity. From a reverse logistics viewpoint, there is the added benefit that XML/EDI can be the tool for interacting IT systems specifically designed for reverse logistics and legacy EDI systems that are still in use in the forward supply chain. Concluding, many

different types and platforms of systems may co-exist to serve different business needs, as shown in Figure 2.
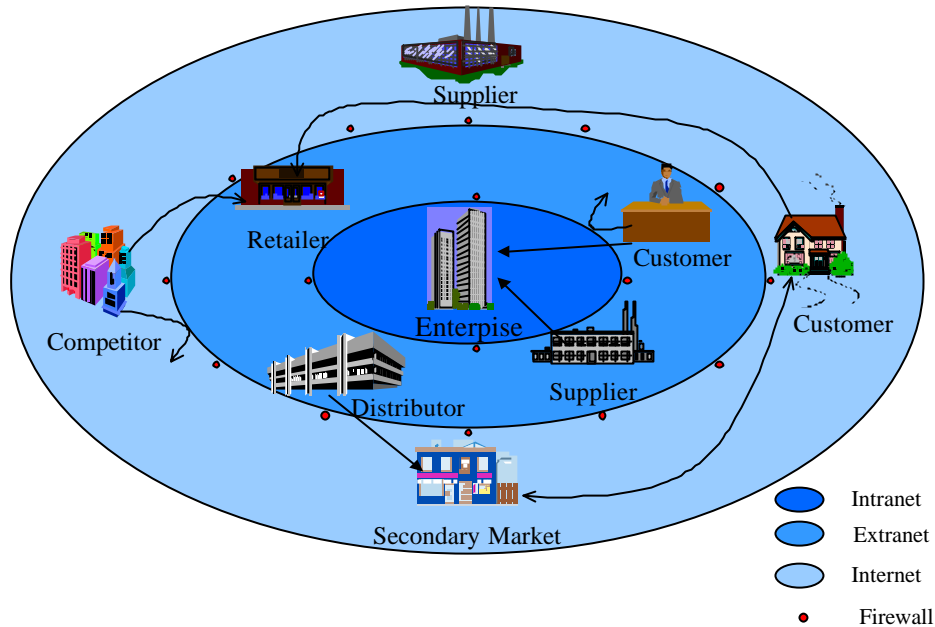

Figure 2 IT systems for forward and reverse logistics

Figure 2 presents three levels of networking infrastructure. Firewalls may be implemented to provide secure systems. Access originating from an organization outside the protected area can be denied if it violates security authorizations, whereas communication with trading partners (organizations that are located in the same ring) is supported through the networking structure.

2.2.3 Emerging IT Paradigms for Reverse Logistics

It is interesting to point out that some existing Internet applications, although not directly related to reverse logistics, have quite promising potentials for this area, as well. For example, several Internet-based applications support aspects of mass-customization in the sense that they provide interactivity to potential customers who are interested in purchasing products that are configured based on their own specifications (i.e. buying a computer from www.dell.com). From a reverse logistics point of view, it is interesting to note how easily accurate information can be collected from an E-commerce application regarding current

customers' needs on specialized, high-value products and their future influence on the reverse supply chain; albeit privacy protecting should also be ensured.

Moreover, there is a class of existing Internet-based applications (i.e. www.firefly.com) that capture data on their members' behavior to classify their clientele into groups of customers with similar preferences. Upon an event of interest (i.e. purchase of certain products by any member of a group), the relevant data may also be used to promote the same items to the rest of the group with an expected high degree of acceptance. From a reverse logistics perspective, such mechanisms enable interested parties to capture accurate information on different fragments of the market and identify possible trends or price changes.

3. E-COMMERCE AND REVERSE LOGISTICS

The general aspects of E-commerce for Reverse Logistics are summarised in Table 1, but not all of these are equally represented.

Table 1 E-commerce relation to Reverse Logistics

E-Commerce Applications	Reverse Logistics Tasks
• Marketing	Advertisement of available used products, parts or material.
	Notification of used products, parts or material, currently sought
• Purchasing	Search for suppliers/customers
	Making purchasing commitments
	Receive information of expected delivery
	Respond to request for sought used products, parts or materials
• Sales	Price setting (i.e. fixed, negotiations, auction)
	Order processing
	Tracking and tracing orders
	Customer invoicing, collection and payment
• Post Sales/ Service	Product tracking
	Customer support
	Customer / product monitoring

So far, we have identified three prominent e-commerce models for the support of reverse logistics activities. At present, the most popular model for E-commerce for reverse logistics is Electronic Marketplaces, which are used for both new and used products. Then, there are sites that use the Web to offer used parts or remanufactured equipment. Finally, there is also a Web based paradigm that incorporates collection, selection, reuse and redistribution. These E-commerce models are presented in Figure 3, which relates closely to Figure 1, but it concentrates on the reverse logistics part, for simplicity reasons.
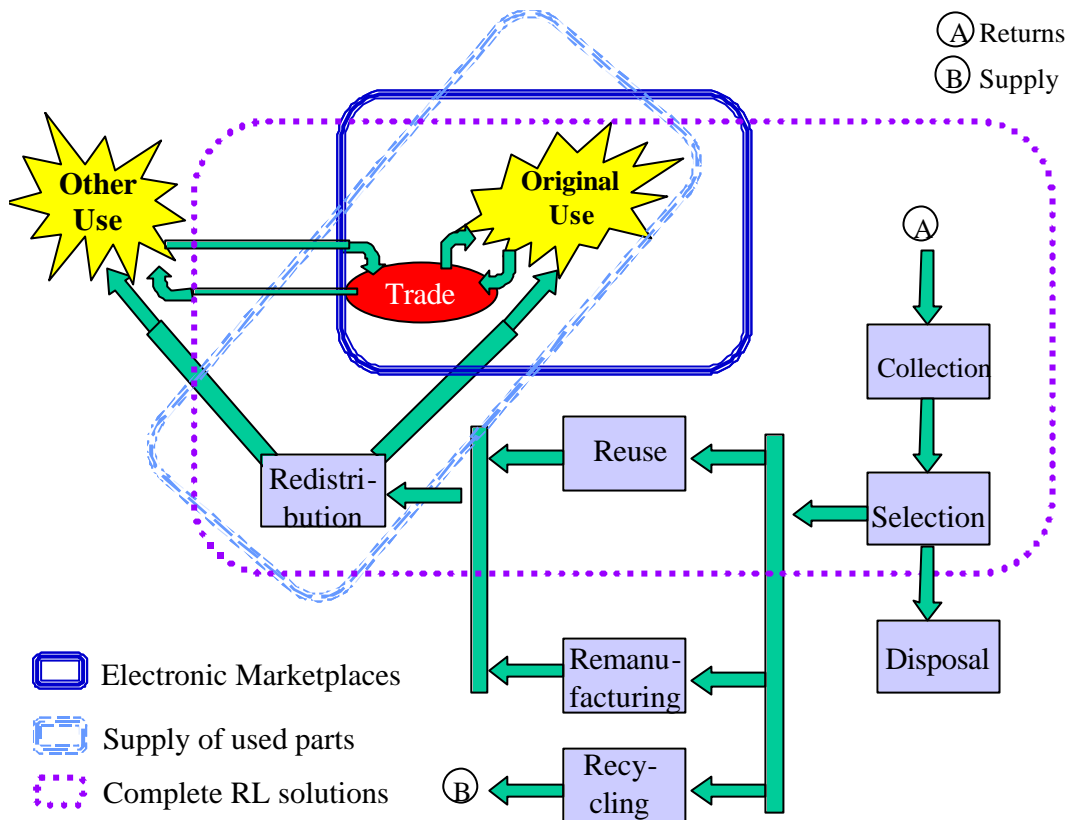
Figure 3 E-commerce models for reverse logistics

3.1 Electronic Marketplaces

A common feature of electronic marketplaces is the fact that they are product-centred. Various used products are for sale in these sites and potential customers have a chance to get relevant information on them, declare their interest and possibly buy them. The concept and the design of an electronic marketplace may vary greatly depending on a number of factors. We have examined sites based on geographical location of their servers, sectors represented in the site, access rights, price determining mechanisms, logistics aspects, and guarantees for customer satisfaction.

Geographical location of the WWW server and its target market varies but they have a high density over USA sites, as expected. Although US-based electronic marketplaces (like www.ebay.com and www.onsale.com) have significant visibility and coverage, they do not yet appear to be worldwide oriented; rather, they concentrate within the north American market due to their demographics or a managerial decision to simplify their logistics operations. In EU, electronic marketplaces may be even more localized (www.partikulier.nl)

having to overcome cultural, logistic, linguistic and monetary barriers between different member states of the EU. In view of these, www.qxl.com offers different content in its site for UK, France, Netherlands, Germany and Italy residents.

A wide variety of products that have entered the reverse logistics chain are traded, but some sectors like computer, electronics and hi-tech equipment are particularly popular. Nonetheless, some electronic marketplaces are vertically structured, that is, they are dedicated to a specific product like used cars (AUCNET) [Lee 1997] or used industrial equipment (www.bergerat-monnoyeur-tp.fr). Also, it is interesting to note that there are on-line marketplaces representing all three types of flows entering the reverse logistics chain, namely production waste (www.metalsite.com), commercial returns (www.qxl.com) and end-of-use products (www.ebay.com).

There are some trading communities open only to partners who have established relations through conventional interaction or where new members are introduced after some member's recommendation. However, for most electronic auctions, access is open to all buyers, whereas sellers have to register and pay fees. A price setting mechanism can be available online like in the cases of electronic auctions (www.onsale.com, www.qxl.com) or be subject to interpersonal communication through conventional means (www.particulier.nl, www.classifieds2000.com).

Logistics aspects of electronic marketplaces cover a great variety of services including inventory management, virtual warehousing, transportation, scheduling and routing, location identification, set up and operational specifications. To simplify the logistics operations of the electronic marketplace, subcontracting third parties to do some or all of the described logistic functions is a common tactic in many electronic marketplaces

To address customer satisfaction, a regulatory infrastructure or legislation may apply. For example, the AucNet system [Lee 1997] provides a standardized rating system for the quality of items featured in this marketplace. Thrusted Third Parties (TTP's) play important intermediate roles in case of conflicts between buyer and seller (e.g. if the goods delivered do not meet the specifications). Other policies for customer satisfaction include posting the seller's physical address, insurance coverage for damaged goods, guarantee of returns in case of unsatisfactory items etc.

3.2   E-commerce model for the supply of used or remanufactured parts or equipment

The main difference between sites for promotion of remanufactured parts or equipment and those for newly produced goods seems to lie in the fact that the first are customer driven whereas the latter are normally supplier driven. In the first case a potential customer provides details for the items in request and the supplier performs a search and provides the procurement details. Based on this orientation, two main characteristics emerge for this model. First, E-commerce for supply of used parts is region bounded, that is, suppliers usually serve a range of parts or equipment over a more or less defined geographical region; even Sears (www3.sears.com) covers only the US territory.

Identification of the part in request is a central issue to the success of this business process and it implies that both interesting parties manage to get in contact with each other and then use a common, unique and unambiguous framework to describe requested products or parts. Nowadays, search engines on the Web may be used to locate potential suppliers (www.find-a-part.com), while catalogues of spare parts offer a unique coding system. Identification of a part can be enhanced through oral communication or through the use of web-accessible search engines that are based on some prominent features of the part (brand, description, code etc). Anyway, the web sites for supply of remanufactured parts or equipment are mostly used for information dissemination and in this respective, they only address the marketing aspect of electronic commerce.

It is also interesting to note that demand driven dis-assembly may be possible, if a requested part is not directly available, but rather, it is included as a subassembly in a unit. Demand driven dis-assembly requires a sufficiently large inventory of used products to satisfy demand and this is often perceived as costly.

A special case of remanufacturing refers to preventive or reactive maintenance for heavy industrial equipment, which may operate in geographically remote places and under very stressful conditions. Remanufacturing industrial equipment is often a closed loop process, in the sense that, users give in a piece of their equipment and some time later they get it back re-manufactured. Severe time constraints and quality guarantees are important factors for remanufacturing.

Urgency is a determining factor, when somebody tries to purchase a part. In this respect, swift completion of the required process and logistics are very important factors for customer satisfaction in this trade. E-commerce thus plays an important role in stimulating re-use and remanufacturing of parts or products.

3.3   E-commerce for complete reverse logistics solutions

This model was rarely encountered in our study. We believe this is due to the fact that this model does not view E-commerce as a migration of existing practices and services over a new infrastructure, but rather as a new tool to restructure a business activity and offer new services. E-commerce complete solutions for reverse logistics run across the reverse logistics network in a particular industry/sector (i.e. pharmaceuticals for www.returnlogistics.com). Through this model, customers have two options. First, they can describe their returns, request a quote and upon agreement on the price, sell their products. Or, they may request a quote for an order they plan to place.

It is interesting to note that re-use of the returns (which is the current practice in this model) is less demanding than supporting remanufacturing, for example. An E-commerce model for complete reverse logistics solutions that could offer a combination of all reverse logistics activities could be a niche market by itself.

4.   CONCLUSIVE REMARKS

E-commerce for reverse logistics is an area of web applications that has been active and progressing aggressively, especially in the US, though it has not been explicitly recognised until now. It has given reverse logistics in general and especially remanufacturing of parts and re-use of surplus goods an important stimulus. However, existing E-commerce models are rather restricted and represent simply the migration of conventionally practices over the Web. Therefore, we expect further development in this area and we believe there are many interesting research issues in this respect.

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