Academic research on electronic commerce

Academic Research on Electronic Commerce

Proceedings of the second EDIspuut Workshop 1995 the Netherlands

Edited by:
Martijn Hoogeweegen Erasmus University Rotterdam
Bas Vermeer University of Technology Eindhoven

Academic Research on Electronic Commerce

'Bridging worlds'

Proceedings of the second EDIspuut Workshop 1995, The Netherlands

Published by Edispuut

Academic Research on Electronic Commerce

Martijn Hoogeweegen & Bas Vermeer (editors)

ISBN: 90-803344-1-3

Correspondence to:
Martijn Hoogeweegen, Erasmus University, Faculty of Business Administration, P.O. Box 1738, 3000 DR Rotterdam, The Netherlands

Table of contents

Preface

With the rise of the Internet and the Information Super Highway, the term Electronic Commerce has made its entrance. It is used as an umbrella term to cover a wide variety of electronic instruments and devices to be used in all phases of the business transaction cycle. This cycle encompasses the phases of searching, contracting, logistics and settlement. The last decade, the logistic phase has been given a lot of attention. An example is the 'hype' of Electronic Data Interchange (EDI). The exchange of standardised messages between computers of different organisations enables them to streamline and speed up the logistic phase. Earlier phases in the business transaction cycle, like searching and contracting need more informal ways of support and should be richer in the support of communication. Video conferencing and multi media applications make the richer support of communication possible.

Emerging research areas in the field of Electronic Commerce are for instance electronic markets and virtual corporations. This book illustrates the state of art in Ph.D. research on the various areas of electronic commerce. The majority of the papers deal with EDI, but the emerging aspects of Electronic Commerce, such as electronic markets, are covered as well.

This book contains the papers presented at the 2nd Edispuut Workshop, held in October 1995 at Nijenrode University. At this workshop members of the Edispuut presented their research findings and results. The Edispuut is a consortium of Ph.D. students of several major Dutch Universities. The research programs initiated by the Edispuut members stem from different disciplines: organisation theory, logistics, Information Technology (IT), systems development, sociology, information management, economics, business administration and computer science. With all members having Electronic Commerce as a common research interest, a multi-disciplinary consortium of researchers has been established.

The papers in this book illustrate the variety of research interests. Topics include:

- the impact of IT and EDI on markets and supply chains;
- business process redesign;
- electronic markets;
- virtual corporations.

The various topics are investigated in a wide variety of industries. For instance, case studies have been conducted in the agro and food industy, the building industry, the flower industry, and transportation sector. Some of these papers already have been published and/or presented at international conferences, which indicates the high quality of these papers.

We would like to thank our supervisors and our special guests at the workshop, Prof. Konsynski (Emory University) and Prof. King (University of California), for their presence and their useful comments on an earlier version of these proceedings.

Martijn Hoogeweegen
Bas Vermeer

Summer 1996

Information technology and the structure of markets

Hans van der Heijden* & René Wagenaar**

* Coopers & Lybrand N.V., Prins Bernardplein 200, 1097 JB Amsterdam, The Netherlands, Tel: 31 20 5687278, Fax: 31 20 5687395

** Free University Amsterdam and KPN Research, Leidschendam, The Netherlands, Tel: 31 70 3325365, Fax: 31 70 3326166, E-mail: R.W.Wagenaar@research.kpn.com

Abstract

The application of information technology (IT) in markets is a relatively new phenomenon of increasing relevance and interest. This paper is about the potential impact of IT on the structure of markets. The advantages of IT to enable shifts in market structure are discussed, as well as the preconditions and potential inhibitors for these advantages to become manifest. The advantages of IT in markets include the reduction of trading costs, and the improvement of market liquidity. Among the preconditions of IT in markets are the representability of product data and the reliability of the product representation. Potentially inhibiting the electronic market are, among other things, the presence of network externalities and participants that benefit from market inefficiency and market fragmentation in the current structure of the industry.

Shifts in market structures enabled by IT are proposed. These include both intermediation and re-intermediation in bargaining markets, as well as shifts towards more electronic auctions. The paper concludes that information technology is not only able to improve the current market structure, but has to potential to change the market structure as well. A second conclusion is that the abilities of information technology in many markets are limited, and so is the consequent impact of information technology on market structure

1. Introduction

The application of information technology (IT) in markets is a relatively new phenomenon of increasing relevance and interest (see e.g. Gurbaxani & Whang, 1991; Benjamin & Wigand, 1995). This paper is about the application of IT in markets, more specifically, about the potential impact of IT on the *structure* of markets. A market structure, or *market mechanism*, can be defined as the means through which buy and sell orders are converted into completed trades (Clemons & Weber, 1991).

In a typical trading process, at least three phases can be identified: the *pre-contractual* or *searching* phase, in which buyers and sellers search for potential trading partners, the *contractual* or *negotiating* phase, in which buyers and sellers negotiate and set up a contract, and the *post-contractual* or *settlement* phase, in which logistical and financial settlement takes place. The term commonly used for IT applications that support this trading process is "electronic markets". Sometimes the term explicitly refers to information systems (Bakos, 1991a), sometimes it is more loosely employed to denote market mechanisms being facilitated by IT applications (Malone et al., 1987). In this paper an *electronic market* is defined as an information system that links a number of buyers and sellers to support at least the pre-contractual and the contractual phase of the trading process (see Bakos, 1991a and Himberger et al., 1991 for similar definitions). By imposing the requirement that both pre-contractual and contractual phases should be supported, an electronic market can for example be distinguished from systems that solely support pre-contractual phases (e.g. product databases) and those that solely support post-contractual phases (e.g. many EDI applications).

This paper is structured as follows. First, the abilities of information technology in markets are presented. In this section the potential advantages of information technology in markets are discussed, as well as the preconditions and potentially inhibiting factors for these advantages to become manifest. In the following section different market structures are outlined, together with the rationale for each structure. Combining the abilities of IT with the theory on market structure, influences of information technology on market structure can be assessed. In the following sections, shifts from one market mechanism to another are subsequently discussed, as well as the applicability and implications of these shifts. The last and final section contains a number of conclusions.

2. Abilities of IT in markets

The potential of IT in markets becomes manifest to the extent that the advantages of information technology are put to use. Using IT in markets is subject to a number of preconditions however. Furthermore, the adoption of IT in markets is potentially inhibited by a number of factors. In order to outline the abilities of IT in markets, the advantages, preconditions, and potential inhibitors will subsequently be discussed.

Advantages

One of the major abilities of information technology in markets is that it can be used to improve the *efficiency* of the trading process. Efficiency advantages can be gained in all phases: the pre-contractual, the contractual, as well as the post-contractual phase. In the pre-contractual phase, the costs of searching a potential trading partner can be reduced (e.g. Bakos, 1991a, 1991b). In an electronic market, sellers can be categorised and selected in many different ways, for instance by product characteristics, by price, or by geographical distance to the buyer. Moreover, the accessibility of this data can be substantially increased by the use of information technology. In the future, information systems will be able to reduce searching costs even more through the use of intelligent agents. Intelligent agents can be conceptualised as software applications that use artificial intelligence (AI) techniques to select information in computer networks based on personal preferences of the user (Malone et al., 1987; Maes, 1994). An example of an intelligent agent application is "NewsAlert" (King & Jones, 1995). This application searches information on the Internet and, based upon the user's personal taste, composes a personal electronic newspaper (including comics). Applying these concepts to electronic markets, intelligent buying and selling agents can be envisioned that roam information networks, meet and exchange preferences, and backtrack to users if a potential trading partner is found. Current practice is certainly a long way from trading with this type of technology, but further AI research on this topic is likely to bring fruitful and interesting results.

Once a potential trading partner has been found through the electronic market, the decisions concerning the contractual and post-contractual settlement can be effectuated through information technology as well. IT applications in the contractual phase may include the support of contractual negotiation, or the formal matching of bids and offers. In advanced electronic markets, post-contractual settlement can be initiated by locating and contacting appropriate logistical and financial service providers. Clearly current logistical and financial service providers should be aware of these developments in markets migrating to an electronic one.

A second advantage of information technology, besides efficiency improvement of the trading process, is the ability to link more buyers and sellers to the system. Not only is an electronic market able to overcome geographical constraints, it is also able to operate in different time zones (see e.g. Freund, 1991). In other words, electronic markets create a virtual marketplace with less spacial and temporal barriers.

By increasing the number of participants, more *integration* of the market is achieved. The opposite of market integration is market *fragmentation*: the more fragmented a market is, the less buyers and sellers are aware of each other. A fragmented market has several disadvantages. One, almost inevitable, implication is the difference (*spread*) in prices for products: in fragmented markets a buyer is willing to accept a certain price because he is ignorant of competing prices from other sellers. In integrated markets all prices are accessible to all buyers and sellers, and consequently, prices quickly stabilise.

A second disadvantage of a fragmented market is the loss of *liquidity*, i.e. the ability to convert a product readily into cash, or to convert cash into a product without excessive delay (Clemons & Weber, 1991). The more ignorant a buyer is of sellers who are willing to trade, the less the buyer will be able to trade. Similarly, the more ignorant a seller is of buyers who are willing to trade, the less the seller will be able to trade. Through the ability of information technology to integrate markets, the opportunity arises to stabilise prices and increase market liquidity.

Preconditions

A number of preconditions hamper the use of information technology in markets. For instance, the product may not be *representable* by electronic means, or at least not in its entirety. While multi-media technology can help to represent the product (Lee et al., 1995), information technology is for example not able to convey fragrance, which can be an important, if not vital element in a purchasing decision. This is for instance the case in the markets for perfumes and (to a certain extent) for flowers. A key precondition is whether information technology is able to convey all data necessary to base a purchasing decision upon.

Another precondition is the *reliability* of the data made accessible by the electronic market. Since the electronic market replaces the product with a representation, the reliability of the representation is of critical importance. Few would make trading decisions on the basis of potentially unreliable product representations. This problem relates to a common problem in economics known as "adverse selection": the sellers are able to misrepresent their products and the buyers consequently select inappropriate trading partners (see e.g. Akerlof, 1970). There are a number of ways to cope with adverse selection: one is to introduce membership in an electronic market to protect market entry from unreliable trading partners. Another way is to introduce a quality coding system, and have an independent institution inspect and rate the products.

The preconditions of representability and reliability are generally more pressing in *differentiated* markets, as opposed to *commodity* markets. Commodity markets are markets where relatively homogeneous products are exchanged; as the products become more heterogeneous, the market becomes more differentiated. Examples of commodity markets include the markets for cotton, rice, wheat, corn, tea, coffee, sugar, cut flowers, etc. (see Lee & Lee, 1994). Examples of differentiated markets include the markets for books, garments, paintings, etc.

Commodity markets are more suitable for formalised and standardised (and thus automated) purchase procedures than differentiated markets. Commodity products commonly 1) have structured product descriptions (adding to their representability) and 2) are certified according to certain quality standards (adding to their reliability). Differentiated products often fail those requirements, at least partly, and consequently the adoption of information technology in many of those markets is less likely to be successful. For example, an electronic market initiative in the Dutch air cargo industry failed because, among other things, the market for air cargo was mistakenly treated as a commodity market by the developers of the system (see Christiaanse et al., 1995).

Inhibitors

The adoption of an electronic market in a traditional market, and consequently the degree to which the IT advantages of efficiency and integration can be used, is influenced by a number of factors. Among other things the adoption is influenced by the *externalities* involved in the use of the electronic market (Bakos, 1991a). Externalities imply that the value of a product is partly determined by the product being used by other consumers (Katz & Shapiro, 1985; 1986). A buyer may not be willing to use an electronic market if too few sellers are listed. Similarly, a seller may not be willing to use an electronic market if too few buyers are listed. These motivations create a "dead-lock" situation, where buyers and sellers wait upon each other to adopt the electronic market, and consequently the electronic market is not adopted at all. The presence of externalities is typical for many other technologies, including for example telephones and computer operating systems.

Network externalities are among the factors that market participants consider in their decision to adopt the electronic market. However, there are other motives for market participants in current market structures to reject such a system as well. For example, many parties benefit from inefficient and fragmented markets. Sellers benefit from fragmented markets because it allows them to increase prices to a level that exceeds the market clearing price. Various middlemen in markets benefit from inefficient markets, because they can offer their market expertise to buyers and sellers at a profit-making price. Clearly, the introduction of information technology in markets can be critically dependent on the cooperation of these parties as well. Whether they are willing to give up their advantages in inefficient and fragmented markets depends on the trade-off between the relative importance of the existing advantages and the advantages generated through electronic markets.

3. Market structures

The advantages of information technology, efficiency and integration, may have important impacts on the structure of markets. In order to examine these impacts, theory on the structure of securities markets will be applied. Garbade (1982) describes four different market structures in securities markets. These market structures are: direct search, brokers, dealers, and auctions. They will subsequently be discussed.

1. *Direct search*

   Direct search is what its name implies: buyers and sellers directly search for trading partners. A potential trading partner is found by negotiating bilaterally about prices and product characteristics. Logistical and financial settlement are negotiated and arranged as well. Examples of direct search in differentiated markets are the well-known flee markets.

The costs of a successful direct search for both buyers and sellers can be substantial, eventually to a level that direct search fails to be effective. At this level, brokered markets start to occur.

2. *Brokers*

   In return for a commission fee, brokers operate on behalf of buyers and sellers to search for and negotiate with a potential trading partner or to arrange logistical and financial settlement. Examples of brokers in differentiated markets are travel agencies and insurance agencies.

   For a number of reasons brokers are able to incur less costs in searching, negotiating, and/or settlement than buyers and sellers themselves can. One reason is that a broker develops market expertise, which allows him to quickly spot interesting trading partners. Buyers and sellers would have to make more costs to acquire the same expertise than the fee required by the broker. A second reason is that only a broker is willing to invest in resources with high fixed costs and low variable costs. This allows him to gain economies of scale in the search and settlement phases.

   There are markets where even the use of a broker does not reduce searching, negotiating, and settlement costs to an acceptable level. Under those conditions, dealers enter the market.

3. *Dealers*

   Dealers reduce searching, negotiating, and settlement costs for buyers and sellers by keeping a trade inventory: without having to search for trading partners first, dealers are continuously willing to trade. Dealers are profitable to the extent that they can buy products at a cheaper price than they are able to sell: the difference in prices is called *bid-ask spread.* Examples of dealers in differentiated markets are car dealers and drugs dealers.

   Dealers have a number of advantages over brokers in more sizeable markets. Dealers guarantee that a product can be bought or sold straightaway. Buyers and sellers using a broker in the same market cannot be guaranteed that the product will be sold or bought respectively in the first place. Furthermore, the searching time of a broker can be substantial, and in the time between the product being offered and the product being sold, buyers and sellers run a price risk.

   Dealers have some disadvantages as well though. One disadvantage is that an optimal price is not guaranteed. Dealers buy and sell at different prices, depending on their view on the market value of the products. For this reason, dealers are commonly used in addition to, rather than as a replacement for brokered or direct search market structures.

4. *Auctions*

Market structures such as direct search, brokers and dealers frequently co-exist to meet the various needs of buyers and sellers. These structures are, among other things, characterised by the fact that buyers, sellers, brokers, and dealers *bargain* about the prices and about logistical and financial settlement. In the fourth market structure, the auction mechanism, bargaining is no longer an option. In stead, buyers and sellers place bids and offers at a central place, and the auctioneer matches these bids and offers according to standardised, predefined rules. Examples of non-financial auctions are the well-known flower auctions and art auctions. In flower auctions, the most usual auction rule is to lower the price of a product until one buyer accepts the offer. In art auctions, the common auction rule is to increase the price of a product until only one buyer is willing to accept the offer.

Based on the differences between auctions and bargaining markets, at least two necessary preconditions can be identified for the successful introduction of an auction mechanism. First, it should be possible to locate a trading partner without having to negotiate. Thus, the market should be sufficiently liquid. Second, it should be possible to predefine and standardise the rules and procedures through which bids and offers are matched. This is usually less a problem for commodity markets since product descriptions are relatively simple.

In financial markets there are at least two types of auctions: *call* auctions (or batch auctions) and *continuous* auctions (see e.g. Amihud et al., 1985). In call auctions sellers and buyers place offers at the auctioneer until a certain point in time. At that time, when the call has been made, bids and offers are matched according to the predefined rules. An example is the set of predefined rules for the Globex financial trade system, depicted in Domowitz (1990). In a continuous auction there is no time lag: the auctioneer examines the bids and orders as soon as they are placed and as soon as a bid and offer match they are converted into a trade.

There are numerous advantages of an auction market over bargaining markets. There are cost advantages in the location of trading partners, price determination, and in clearing and settlement. The more costs need to be made for bargaining and negotiating, the more efficient an auction mechanism becomes. Auctions replace dedicated and costly negotiations with more efficient formalised and standardised procedures.

Summarising, a distinction can be made between *bargaining* market structures and *auction* market structures. Bargaining markets are characterised by searching and dedicated negotiating and settlement. Auction markets are characterised by formal and standardised procedures, which reduces both searching as well as negotiating and settlement costs.

One observation from this theory is that both trading costs and market liquidity determine to a large part the choice of the market structure. It is therefore likely that information technology, by being able to decrease trading costs and improve market liquidity has the potential to change the market structure.

Several shifts in market structure can be expected. An analysis of these shifts requires at least three types of shifts to be discussed. The first type is concerned with potential shifts *inside bargaining markets*. The second type deals with potential shifts *between bargaining markets and auction markets*: from bargaining markets to auction markets or vice versa. The third type deals with potential shifts *inside auction markets*.

In this paper the potential shifts inside auction markets are not discussed. In examining the role of information technology on the preferred type of auction mechanism, it is required to identify the determinants of auction structure in more detail. This theory is not trivial: besides call and continuous auctions there are at least twelve other types (see e.g. Davis & Holt, 1993; Reck, 1994). The influence of information technology on the type of auction mechanism is therefore suspended to further research.

The influence of IT on the first two types of shifts will be discussed subsequently.

4. IT in bargaining markets

According to theory on market structure, changes in bargaining market structures consist of direct search markets being transformed into brokered or dealer markets and vice versa. The shift to brokered or dealers markets is stimulated by the fact that brokers and dealers, among other things, are able to incur lower searching costs, negotiating costs, and/or settlement costs than buyers and sellers themselves do. The move towards brokers and dealers can be called *intermediation*, or *re-intermediation* (depending on the history of changes). Shifts to direct search on the other hand are, among other things, due to the fact that buyers and sellers are no longer willing to pay broker fees and dealer bid-ask spreads. Such a move, away from brokers and dealers and towards direct search markets, can be called *disintermediation*. Since information technology has the ability to reduce the trading costs of both brokers, dealers, buyers and sellers, influences on intermediation, re-intermediation, and disintermediation can be proposed. However, as other determinants play a role in the choice of market structure as well, *ceteris paribus* conditions do apply.

The critical issue is which participants in the market benefit most from using information technology to decrease trading costs. If buyers and sellers are able to decrease their trading costs, a shift away from broker and dealer markets towards direct search markets can be expected. On the hand, if brokers and dealers are able to reap more benefits from the abilities of information technology than buyers and sellers can, their position is strengthened in the marketplace and a shift towards more broker and dealer markets can be expected. Depending on whether either buyers and sellers or brokers and dealers benefit most from information technology, shifts towards intermediation or disintermediation are possible.

Examples of intermediation and disintermediation can be found in securities markets. Intermediation and disintermediation in those markets has become an important and relevant issue since the advent of screen-based trading systems (see e.g. Clemons & Weber, 1991; Weber, 1995). Screen-based trading systems are electronic securities markets accessible to large buyers and sellers in stock markets. These systems improve, amongst other things, trading efficiency in selecting trading partners, contracting, and subsequent settlement. In doing so, brokers and dealers are bypassed, and costs of broker commission fees and dealer bid-ask spreads are saved. These developments in securities markets support the disintermediation proposition: buyers and sellers are able to benefit from IT abilities and in doing so, attempt to bypass brokers and dealers.

In other markets disintermediation may not take place as prominently as in securities markets. First of all, the ceteris paribus conditions of the propositions make them vulnerable: other reasons for intermediation and disintermediation in a market may apply and be able to overshadow the influence of information technology. For instance, the market expertise of a broker concerning the value of products may be hardly subject to formalisation. Under those circumstances the advantages of information technology are of little use, and the market is likely to remain a brokered market. Other factors include legal constraints to disintermediation in some markets. In those markets, it is illegal not to use a certified broker or dealer.

Examples include the market transactions for which a notary is required, such as the real estate market.

Other reasons why intermediation and disintermediation can be limited in spite of the use of IT include the constraints that were identified previously. For commodity markets, one of the more important limitations is the presence of network externalities. The externalities of electronic markets may inhibit its adoption by a "critical mass" of buyers and sellers. This constraint is particularly appropriate in commodity markets with many, small to medium-sized buyers and sellers (see e.g. Narendran et al, 1995). Next to this constraint, in differentiated markets the preconditions of representability and reliability of the product also play a major role. In those differentiated markets where adoption of IT is limited because of these conditions, so is likely to be IT's influence on intermediation and disintermediation.

A final barrier to IT-enabled disintermediation is the presence of brokers and dealers in the market themselves. Few businesses will not attempt to anticipate on potential threats to their business operations, and neither will brokers and dealers. Instead, a broker can anticipate upon disintermediation for example by offering additional services such as logistical settlement.

5. The logic of electronic auctions?

A second type of shift in market structures is the shift from bargaining markets to auction markets and vice versa. According to market theory, auction mechanisms become the preferred mechanism if, amongst other things, the market is sufficiently liquid. Sufficient market liquidity guarantees the possibility of finding a trading partner without excessive delays due to searching and negotiating. A second necessary precondition is that trading procedures can be structured and standardised. This condition is more pressing in differentiated markets than in commodity markets.

A "logic of electronic auctions" (analogous to the "logic of electronic markets", Malone et al., 1989) can be formulated. Information technology, by being able to integrate the market, will make the presence of a potential trading partner more likely. Consequently, it will make an auction mechanism viable in bargaining markets that previously suffered from low liquidity. Thus, ceteris paribus, more *electronic auctions* (i.e. electronic markets that support the auction market mechanism) will appear.

The logic of electronic auctions should be applied with necessary caution however. As is the case with the propositions concerning intermediation and disintermediation, ceteris paribus conditions make them vulnerable, and use of information technology can be limited due to a variety of reasons. Specifically, the representability of the products to be exchanged is critical. For instance, the introduction of information technology at the Dutch flower auction initially failed because, among other things, the representation of the flowers was inappropriate (Van Heck & Groen, 1994). Next to that, it should be possible to structure and standardise the trading process. Furthermore, the success of electronic auctions depends, amongst other things, on the willingness of participants to conform themselves to these standardised allocation procedures. Participants may believe (and rightfully so) that they are more successful in bargaining markets than they would be in auction markets, because they can have more trading freedom in bargaining markets.

Set aside these reservations, information technology is clearly appropriate for the introduction of the auction mechanism. Through linking market participants from various, geographically dispersed locations, electronic markets create virtual centralised marketplaces. These virtually centralised marketplaces enable market participants to place bids and orders and have them matched as if they were operating in one, single market. Structured and standardised settlement procedures can be automated to a substantial extent, thereby reducing settlement costs as well. Furthermore, the role of the neutral auctioneer can be almost naturally imposed upon the market participants that manage the electronic auction.

An example supporting the logic of electronic auctions is the TELCOT system (Lindsey et al., 1990). This electronic market was developed to support trading in the U.S. cotton market. Originally, this industry was characterised by brokers and direct search. At present, the system features a call auction mechanism, where buyers of cotton blindly place bids on a particular offer during fifteen minutes. After fifteen minutes, the offer is allocated to the buyer that placed the highest bid. Many constraints to IT use in markets identified previously are either not applicable, or not substantial for this market. For instance, the electronic market was set up by an association of cotton growers serving at least 5000 members. This number gained enough critical mass to set up and use the system. Reliability of data was guaranteed through membership. Formalisation and standardisation of products was based upon governmental regulations.

Besides a shift towards electronic auctions, a shift away from auctions towards bargaining markets can be proposed. The latter shift occurs when auctions are no longer the preferred mechanism: for instance, because the liquidity of the market becomes insufficient, or because the formal procedures are no longer sufficient to trade effectively. It is however less likely that the use of information technology will induce this type of shift, for information technology is not likely to be employed to decrease market liquidity (although this may be an unwanted side effect because of network externalities). Furthermore, if formal procedures fail to represent a trading process adequately, it is less likely that information technology will be used at all.

Summarising, a logic of electronic auctions can be proposed under ceteris paribus conditions and with recognition of the various limitations of the use of IT in markets. These limitations are especially pressing in differentiated markets, reason why electronic auctions are more likely to arise in commodity markets.

6. Conclusions

In this paper the potential impact of information technology on market structure was examined. In order to do so, the advantages of information technology in markets were discussed, as well as the preconditions and inhibitors for these advantages to become manifest. Two advantages of IT use in markets were identified: the ability to improve trading efficiency (in pre-contractual, contractual, and post-contractual phases) as well as the ability to achieve more market integration.

Based on the advantages of information technology shifts within bargaining markets and shifts between bargaining markets and auction markets were discussed. Specifically, disintermediation was identified in case buyers and sellers benefited most from IT, and intermediation was identified in case brokers and dealers could benefit most from IT. Furthermore, a "logic of electronic auctions", i.e. a shift towards comparatively more auction markets as opposed to bargaining markets, was outlined.

A first conclusion of this paper is that the use of IT in markets is not only able to improve the current market structure, but has at least the potential to change the market structure as well. Market structure is determined, among other things, by market liquidity and trading costs.

Since information technology has the potential to increase both liquidity and decrease trading costs, shifts in market structure can be expected.

A second conclusion however, is that the abilities of information technology in many markets are limited, and so is the consequent impact of information technology on market structure. Preconditions of the use of IT in markets include the representability of the products and the reliability of product data. Inhibiting the adoption of electronic markets are the presence of network externalities and participants that benefit from market inefficiency and market fragmentation in the current structure of the industry.

Clearly, the feasibility of electronic markets is a relevant subject that needs further research. One direction for research in this area is the development of electronic market case studies in which the motivations to accept and reject these systems are pointed out. While the motivations to join an electronic market for current market participants are complex and full of contingencies, it is likely that the extent to which the advantages of IT can become manifest in the market is critical to electronic market acceptance. The degree of acceptance in turn, determines the extent to which markets will be restructured by information technology.

Acknowledgements

Material for this paper was prepared in close cooperation with two of our students, Taco Wiersma and Joost Hoeve. Both received their master degrees with theses in this area (Hoeve, 1995; Wiersma, 1995). Preliminary results of this work were presented at a seminar on electronic markets at Erasmus on June 28, 1995.

References

Akerlof, G.A., The market for "lemons": quality uncertainty and the market mechanism, *Quarterly Journal of Economics*, Vol. 84, 1970, reprinted in J.B. Barney & W.G. Ouchi (eds), *Organisational economics*, Jossey-Bass Publishers, San Francisco, 1990, pp. 27-71

Amihud, Y., T.S.Y. Ho, & R.A. Schwartz (eds), *Market making and the changing structure of the securities industry*, Lexington Books, Lexington, MA, 1985

Bakos, J.Y., A strategic analysis of electronic marketplaces, *MIS Quarterly*, September 1991a, pp. 295-310

Bakos, J.Y., Information links and electronic marketplaces: the role of inter-organisational information systems in vertical markets, *Journal of Management Information Systems*, Fall 1991b, Vol. 8, No. 2, pp. 31-52

Benjamin, R. & R. Wigand, Electronic markets and virtual value chains on the information superhighway, *Sloan Management Review*, Winter 1995, pp. 62-72

Christiaanse, E., R. O'Callaghan, J. Been & T. van Diepen, Electronic markets in the air cargo industry: institutional factors inhibiting successful implementation, in: G. Doudikis, R. Galliers, T. Jelassi, H. Krcmar & F. Land (eds), *Proceedings of the 3rd European Conference on Information Systems,* 1995, Athens, Greece, pp. 901-915

Clemons, E & B. Weber, Evaluating the prospects of alternative securities markets, in: J.I. DeGross et al., *Proceedings of the 12th International Conference on Information Systems*, New York, 1991, pp. 53-63

Davis, D.D. & C.A. Holt, *Experimental economics*, Princeton University Press, Princeton, NJ, 1993

Domowitz, I., Equally open and competitive: regulatory approval of automated trade execution in the futures markets, *Journal of Futures Markets*, Vol. 13, No. 1, 1990, pp. 93-113

Freund, W.C., Trading stock around the clock: the future growth of global electronic markets, *California Management Review*, Fall, 1991, pp. 87-102

Garbade, K., *Securities markets*, McGraw-Hill, NY, 1982

Gurbaxani, V. & S. Whang, The impacts of information systems on organisations and markets, *Communications of the ACM,* Vol. 34, No. 1, January 1991, pp. 59-73

Himberger, A., N. Krähenmann, T. Langenohl, D. Ritz, M. Schmid & S. Zbornik, *Elektronische Märkte: Grundlagen und Forschung*, Working paper IM2000/CCEM/14, Institut für Wirtschaftsinformatik, Hochschule St. Gallen, October 1991

Hoeve, J.A., *Nieuwe marktmechanismen door informatietechnologie: een toepassing in de sierteeltketen*, Master Thesis Rotterdam School of Management, August 1995 (in Dutch)

Katz, M.L. & C. Shapiro, Network externalities, competition and compatibility, *American Economic Review*, Vol. 75, Spring 1985, pp. 70-83

Katz, M.L. & C. Shapiro, Technology adoption in the presence of network externalities, *Journal of Political Economy*, Vol. 94, No. 4, 1986, pp. 822-841

King, D. & K. Jones, Competitive intelligence, software robots and the Internet: the NewsAlert prototype, in: J.F. Nunamaker & R.H. Sprague (eds), *Proceedings of the 28th Hawaii International Conference on System Sciences*, Maui, Hawaii, 1995, pp. 624-631

Lee, H.G. & R.M. Lee, *Intelligent electronic markets for commodity auction: integrated approach of economic theory and social choice theory*, Euridis Research Monograph RM-1994-01-01, Erasmus University, 1994

Lee, H.G., C. Wrigley & R.W. Wagenaar, Electronic marketplace with multimedia representation: SEA of flowers, in: *Proceedings of the Pan Pacific Conference on Information Systems*, Singapore, 1995

Lindsey, D., P.H. Cheney, G.M. Kasper & B. Ives, TELCOT: an application of information technology for competitive advantage in the cotton industry, *MIS Quarterly*, December 1990, pp. 347-357

Maes, P., Agents that reduce work and information overload, *Communications of the ACM*, Vol. 37, No. 7, July 1994, pp. 31-40

Malone, T.W. J. Yates & R.I. Benjamin, Electronic markets and electronic hierarchies, *Communications of the ACM*, Vol. 30, No. 6, June 1987, pp. 484-497

Malone, T.W., J. Yates & R.I. Benjamin, The logic of electronic markets, *Harvard Business Review*, May-June, 1989, pp. 166-170

Narendran, P., J. Strom & D. Whiteley, An analysis of electronic markets in the context of SMEs, in: G. Doudikis, R. Galliers, T. Jelassi, H. Krcmar & F. Land (eds), *Proceedings of the 3rd European Conference on Information Systems,* 1995, Athens, Greece, pp. 917-929

Reck, M., Types of electronic auctions, in: W. Schertler, B. Schmid, A.M. Tjoa & H. Werthner (eds), *Proceedings of the 1st international conference on information and communications technologies in tourism*, Austria, 1994, pp. 236-243

Van Heck, E. & T.P.R. Groen, Towards an electronic flower auction?, paper presented at the first international Conference on agri-chainmanagement, Wageningen, the Netherlands, 1994

Weber, B.W., Trade execution costs and disintermediated order crossing systems on the London Stock Exchange, in: J.F. Nunamaker & R.H. Sprague (eds), *Proceedings of the 28th Hawaii International Conference on System Sciences*, Maui, Hawaii, 1995, pp. 950-959

Wiersma, T.J., *Electronische markten: mogelijkheden en belangenanalyse*, Master Thesis Rotterdam School of Management, August 1995 (in Dutch)

A systematic approach to the analysis and (re)design of logistic networks -Telematics support for logistics[1]

Pieter W. van der Veer and Roger H.J. Demkes[2]

Telematics Research Centre, P.O. Box 217, 7500 AE Enschede, The Netherlands, tel: +31-53-894281, fax: +31-53-319271, E-mail: veer@trc.nl, demkes@trc.nl

Abstract

This paper describes the approach and first results of current research performed at the Telematics Research Centre (TRC) which focuses on a systematic approach to the analysis and (re)design of logistic networks. In this research, telematics is seen as a supporting technology enabling logistic network improvement.

The first part of the research aims at developing a reference model allowing the investigation of the application of telematics in logistics. This model uses a functional perspective: organisations carry out several functional processes. Insight in these processes and their interactions as well as in the possible telematics services and their interactions is necessary in order to successfully develop telematics applications for logistics.

In the second part, a method is developed for supporting the judgement of the technical, economic, and social aspects of the introduction of telematics, both quantitatively and qualitatively.

[1] This paper was previously published in: Bernus, P., L. Nemes and T.J. Williams (eds.), Architectures for enterprise integration - proceedings of the IFIP TC5 Working Conference 'Models and Methodologies for Enterprise Integration', Chapman and Hall, 1996.

[2] The authors would like to thank H. Bakker and P.H.W.M. Oude Luttighuis for reviewing this paper.

1. Introduction

The application of information technology, telecommunications, and telematics in logistics is expanding rapidly. A shift in market power from suppliers to consumers forces these suppliers to provide an increasing variety of products and services. To meet the more demanding needs and wants of customers in an increasing competition, organisations swing back to their core business and cooperate more closely with other organisations. The number of organisations involved in the process of providing customers with products and services, is growing. Not only the products and services themselves, but also the process of realisation is becoming more complex. The focus has shifted from one or several individual organisations towards chains and networks of many cooperating organisations. In these chains and networks, production, transport, and distribution are more and more considered equally important. Of course, improvements in efficiency can be brought about by optimising these processes individually. The real challenge however, is to increase efficiency and effectiveness by improving the functioning of entire chains and networks. Because coordination and therefore information is essential for this improvement, information technology, telecommunications, and telematics can and already do play an important role.

Research structure

The research consists of two parts. In the first part, described in Sections 2, 3, 4, and 5, insight is gained into logistic processes and their relations. A focus on processes instead of on organisations is necessary to optimise or (re)design these process structures without being 'blinded' by organisational limitations. Organisations execute and have interests in (parts of) these processes. Therefore we will describe organisations by functional networks, i.e. networks of interacting processes. Whenever we mention logistic networks in this paper, we refer to these functional networks.

Based on insight into logistic process structures, we can determine how a logistic network can be optimised using telematics applications. This insight is gained by developing a reference model. This model describes the generic logistic and telematics process structures and the way they interact. Specific situations can be described by applying these generic structures to specific situations, in other words, by instantiating the model.

Despite the fact that the application of telematics can contribute to the improvement of the related processes, telematics applications are not always successful. Many telematics projects cost more than they have yielded. Therefore, it is vital to have insight into the costs and benefits of telematics applications and the associated changes in the processes involved, from a technical, economic and social perspective.

In the second part of our research, described in Sections 6 and 7, attention is paid to the development of a method to enable organisations to decide whether or not to change their processes by investing in telematics. The method supports judgements of technical, economic, and social aspects, both quantitatively and qualitatively.

In Figure 1, the relation between the reference model and the method is shown. Using the model we can describe an actual situation and a new situation in which telematics is used. Based on these descriptions (instances of the model), the method can be used to determine whether a change from the actual to the new situation can be successful.

Our approach focuses upon logistic process structures, the interactions between those processes, and the feasibility of (re)designing those processes using telematics applications. In other words, our approach focuses on the application domain. Therefore, it can be used in addition to approaches which focus on the technical domain, like the Computer Integrated Manufacturing Open System Architecture (CIMOSA), see for example Williams et al. (1994), and Open Distributed Processing (ODP), see Van Sinderen et al. (1995).

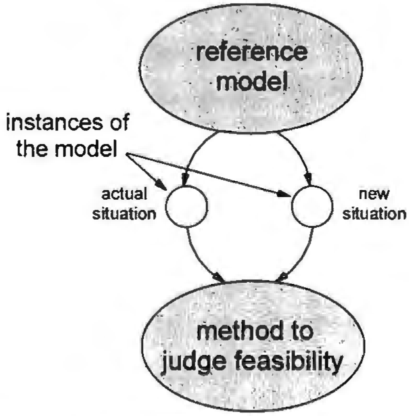

Figure 1: Research structure

Problem area

Telematics can be defined as the support of the interaction between people and/or processes while bridging distance and/or time, through the integrated application of information and telecommunication technology. Because of its distributed character, logistics is an important application area for telematics. See for example Lewis (1986) and Taylor (1991).

Broadly speaking, logistics in a commercial context comprises all processes aimed at planning, implementing, and controlling the total flow of goods starting at the gaining of raw materials up to the delivery of final products to their end customers. It does not only concern the short-term management of this flow of goods, but also encompasses decision making and management on a more strategic level. Besides the processes directly related to the flow of goods, supporting processes are also taken into account. For a more detailed description of logistics, see for example Ballou (1992), Bowersox et al. (1986), Van Goor et al. (1993), and Lambert and Stock (1993).

In literature, several logistic subsystems are distinguished, such as supply logistics, production logistics and distribution logistics (Pfohl, 1990). In our research, we do not focus on one or several specific subsystems, but we aim at all processes involved in the physical flow of goods through one or several organisations. This comprises physical, control, and support processes.

2. Objective and motivation for a reference model

To find out how telematics can be applied for improving logistic networks, it is necessary to have insight into the processes to be supported and their mutual relations. A model can provide this insight. Therefore, in the first part of the research, a reference model is developed, supporting a systematic approach to analyse and (re)design logistic networks and the role of telematics therein. A reference model expresses the general and overall problem domain. Specific situations, like current and future network situations, are obtained by instantiating this model.

Models for telematics and logistics

Within the field of logistics and telematics, a lot of models with different purposes are available, see e.g. Schuurman (1994). However, most of these models are aimed at specific organisations or specific parts of logistic chains or networks, but not at entire networks. There are for example many mathematical models which calculate specific values given a certain set of input data. Examples are models for determining the optimal location of a distribution centre or the most favourable route for a vehicle. Mathematical models in themselves however, are not sufficient for describing all relevant aspects of logistic processes and their relations. Not only the interdependence of quantitative factors, but also a view on process structures is important. Reference models can make these process structures transparent.

Within our problem domain, different reference models are available. For example, reference models exist for specific subsystems, such as production logistics (Biemans, 1989), or for specific telematics applications in specific logistic subsystems, such as fleet management systems in distribution logistics (Schrijver, 1993). Also, reference models for generally applicable telematics applications are available, such as EDI (Hofman, 1994). An integrated, systematic, and scientific approach of telematics applications within logistics however, is lacking at this moment. Van der Aalst (1992) developed a systematic approach for modelling logistic systems. Based on this approach, he suggests the development of a logistic library consisting of generic components which can be used to model logistic systems. Although this library is not described in detail and does not consider telematics applications either, these ideas can be used in the development of our reference model.

3. A reference model for telematics and logistics

Our approach is based on the viewpoint that telematics technology is supporting the application domain processes. Therefore, the successful development of telematics applications requires insight into this application domain. Hence, our model consists of two submodels: a logistic and a telematics submodel. In the following, we will introduce the basic concepts, i.e. building blocks, used in both submodels: process, interaction, entity, service, and organisation.

Process

An important observation is that, both in telematics and in logistics, processes occur which determine the behaviour of telematics and logistic systems. A *process* can be looked upon as a black-box with a particular input and a particular output. The behaviour of a process consists of the interactions with other processes and the time-and-value dependencies between these interactions.

Van der Aalst (1992) identifies three elementary types of processes: physical, information, and control processes. Physical processes have at least one point of physical interaction. Examples of physical processes are production and transport. Information processes do not have physical interaction points. Their interactions consist of the exchange of information. Order processing is an example of an information process. Physical and information processes are controlled by control processes, like production planning. A control process can also control other control processes. Notice that telematics processes are either information or control processes.

In this paper, we start with a classification of physical processes. We will refer to them as *primary processes*, because they are the main processes in logistics. Information and control processes will be related to these primary processes. Therefore, we will not differentiate between them. They are referred to as *secondary processes*. Note that the terms 'primary' and 'secondary' are not relative to organisations. A secondary process in our perspective can easily be the most important, in other words the primary, process of an organisation.

Interaction

Two processes are related when they are engaged in *interaction*. In interactions, entities are exchanged between those processes. Interactions define the relation between two processes, but allow us to abstract from the implementation and the form of exchange. An interaction takes place at an *interaction point*, which may or may not have a fixed geographical location.

Entity

An object exchanged in interaction will be referred to as *entity*. Every process can exchange one or more entities. Entities can be physical objects, like raw materials and products. These objects are part of the flow of goods. However, there are also physical entities which cannot be included in this flow, such as means of production and transport. Therefore, we will refer to the first kind of entities as *goods* and to the second as *resources*. Resources are used by processes to perform their operations. Management of these resources is important, because their capacity is often limited.

Besides these physical entities, *information* can be recognised. Information can be exchanged horizontally, i.e. between information processes, or vertically, i.e. as control information, between control and controlled processes.

Service

Our classification of primary processes results in a layered structure. Every layer represents a class of processes and offers a *service* to the layer above. The top layer offers the final service to the end customer. This principle, also referred to as horizontal stratification (Liefting et al., 1994), is also used in the Open Systems Interconnection (OSI) reference model. This model, developed by the International Organisation for Standardisation (ISO), is aimed at structuring open distributed systems.

The ISO-OSI reference model has eight layers (layers 0, ..., 7). Every layer has its own functionality, see among others ISO (1984) and Tanenbaum (1981). Every layer uses the service provided by the underlying layer. Layer N offers a supporting service to layer N+1, using the service of layer N-1. ISO refers to this as *N service*.

This service concept is the strength of the reference model. Layer N is only concerned with the service provided by layer N-1. How this service is provided by layer N-1, is of no interest to layer N. Irrelevant aspects can therefore be discarded. By using this service perspective, the user is relieved from technical and implementation problems. Also, it is easier to identify services independent of whether or not they are already provided by existing protocols and products.

Organisation

In our reference model, another important concept is *organisation*. An organisation in our model carries out a cluster of processes and can therefore be described in terms of these processes.

In the method for the a priori judgement of technical, economic and social aspects of telematics applications in logistics, organisations play a crucial role.

Using these generic concepts, we have developed a first version of a reference model for telematics and logistics. This version has been developed largely as part of the 'Raamwerkstudie Telematica-Infrastructuur Verkeer en Vervoer'. This project, which has been carried out by the Dutch Ministry of Economic Affairs, the Ministry of Transportation, seven consultancy organisations and two research institutes, was aimed at analysing the possibilities of telematics services in traffic and transport and has resulted in strategy and policy recommendations for both government and industry. The model served as a framework used for describing the desired functionalities and services for a telematics infrastructure (Liefting et al., 1994).

4. The logistic submodel

Based on the principle of horizontal stratification, we will divide the primary processes in logistics into four layers, see Section 4.1. Because the layered structure is based on a classification of the primary processes, these processes are always bounded to one layer. Although secondary processes can be part of several layers, we will describe them layer by layer in Section 4.2. Section 4.3 shortly describes the role of organisations within these layers and Section 4.4 refers to similar layered logistic structures found in literature.

4.1 Logistic services

The world of logistics can be looked upon as a complex system consisting of a large variety of related processes. We used the primary processes to classify these processes into four clusters, each representing one layer in our logistic submodel. We start with distinguishing the USE processes from the logistic service. Then we will decompose this logistic service into COLLECT/SEPARATE processes and a transport service. Finally, this transport service will be decomposed into MOVE processes and a traffic service. Because the traffic service is not part of the world of logistics, we will end our decomposition at this service.

USE processes and the logistic service

At the highest level, we distinguish the *USE processes* and the underlying *logistic service*. The USE processes are all social and economic processes which make use of the movement of persons and goods. These processes, such as production and assembly, change the form of these goods. They require supply of components, transport of final products, and transport of employees. But the same processes might also be observed in health care or in the social sector. These processes have in common that they generate the demand for the movement of goods and persons: they send and receive shipments. Therefore the USE processes can be divided into sending and receiving processes. A sending process can send both persons and goods, for example an air traveller with his luggage. In our research, we will only consider production-oriented processes and the movement of goods.

The logistic service provides in the *end-to-end transport of shipments*. The interaction between the USE processes and the logistic service therefore consists of the exchange of shipments on the interaction points, which have a fixed geographical location. The realisation of the logistic service is not relevant for the USE processes, as long as quality-of-service agreements like delivery time and delivery reliability are met.

The USE processes, the logistic service, and their interaction points are depicted in Figure 2.

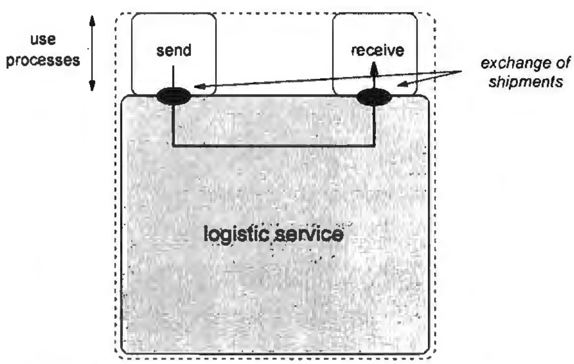

Figure 2: USE processes and the logistic service

COLLECT/SEPARATE processes and the transport service

We decompose the logistic service into *COLLECT/SEPARATE processes* and an underlying *transport service*. Besides collecting and separating goods, these processes also include packing and unpacking, storing, and transferring goods. They include all processes needed to prepare shipments for transport. The transport service provides in the *end-to-end transport of loads*. We consider a load as a collected or separated shipment which is offered for transportation to the underlying transport service. So, to use the transport service, exchange of loads at the interaction points is necessary. These interaction points have a fixed geographical location. We can for example think of loading and unloading facilities at distribution centres.

The COLLECT/SEPARATE processes, the underlying transport service, and their interaction points are depicted in Figure 3.

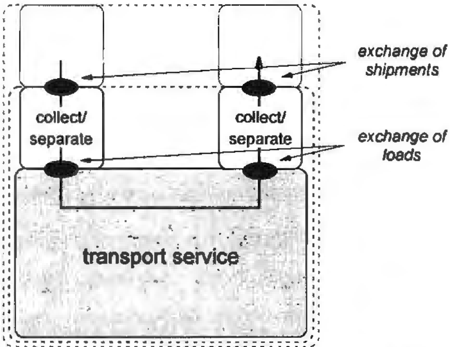

Figure 3: COLLECT/SEPARATE processes and the transport service

In many cases, COLLECT/SEPARATE processes are executed stepwise. Therefore, we can make a further horizontal stratification of this layer into a number of sublayers. See Figure 4. Between those sublayers *collection units* are exchanged, such as boxes, pallets and containers. A collection unit of the highest level is called a *shipment* and a collection unit of the lowest level is called a *load*. Each of the sublayers provides a transport service for collection units of a certain level using the underlying transport service: the transport of collection units of a lower level. A specific sublayer can for example provide in the end-to-end transport of pallets by consolidating these pallets into a container and using the underlying end-to-end transport service for containers. In practice the number of sublayers will differ. This number has a minimum of one, but has no maximum.

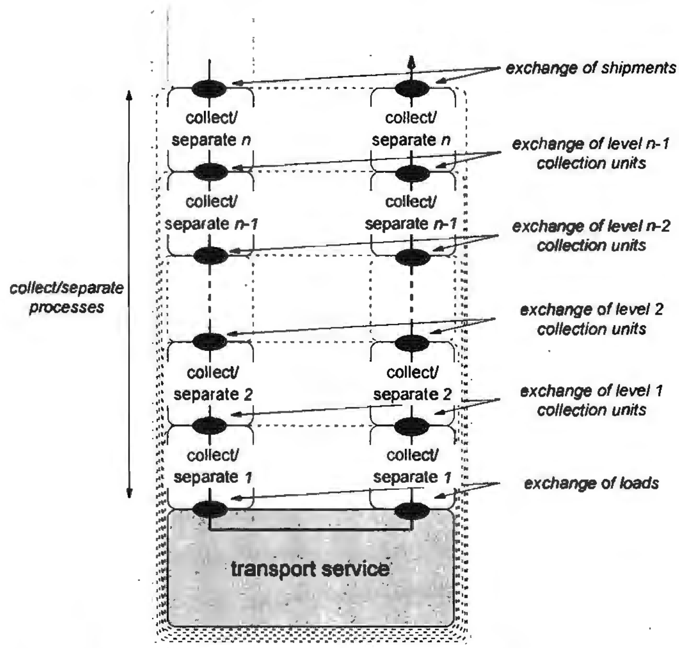

Figure 4: Decomposition of COLLECT/SEPARATE processes into sublayers

The term *COLLECT/SEPARATE processes* suggests that collection always takes place at the sending side and separation at the receiving side. However, this is not true. Several types of collection and separation can be distinguished, which can occur in different combinations. Each sublayer can only be related to one type. An example of a specific type of collecting/separating is the separation of an air traveller from his luggage preceding the flight. At the same occasion, this traveller joins other passengers during this flight.

MOVE processes and the traffic service

The transport service takes care of transport, in other words, the physical movement of offered loads. These processes change the location of goods. For this purpose, different means of transport can be used. We decompose the transport service into *MOVE processes* and an underlying *traffic service*. Moving the offered loads using means of transport is only possible by making use of the traffic service, which provides the *carrying of means of transport*.

The interaction between these MOVE processes and the underlying traffic service is different from the earlier mentioned interactions. In contrast with the exchange of shipments and loads, the movement of means of transport does not take place at one physical location. The geographical location of this interaction point is continuously changing because of the movement of the means of transport. See Figure 5. The MOVE processes are depicted as one block, because there is no functional difference between MOVE processes at the sending side and MOVE processes at the receiving side.

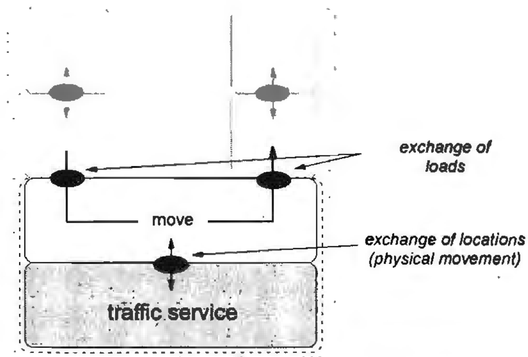

Figure 5: MOVE processes and the traffic service

The MOVE processes require means of transport for operation. Examples of means of transport are planes, trains and automobiles. Besides individual means of transport, also fleets of means of transport can be distinguished. This difference however, does not occur in the primary processes, but in the control, i.e. secondary, processes. In other words, a fleet of means of transport is only a fleet because it is controlled integrally, not because it is one physical object. Secondary processes are described in Section 4.2.

Traffic service

The traffic service provides a traffic infrastructure which *carries* the means of transport of the MOVE processes above. In maintaining a high-quality traffic service, traffic control (a secondary process) plays an important role. We will make a further distinction between primary and secondary processes in Section 4.2. Because the traffic service is necessary to perform logistic processes, we added this service to our model. However, because the traffic service is of minor importance to logistic chain and network control, we will not further decompose the primary processes within this service.

The traffic service is shown in Figure 6. Because the interaction of this service with the MOVE processes above does not have one physical location, this service is depicted as one block.

The traffic processes provide traffic infrastructures to carry means of transport. Examples of these infrastructures are the air, rail, road and water infrastructures. We will refer to them as *modes of transport*.

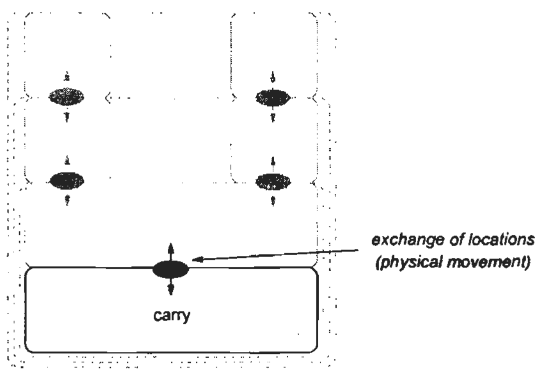

Figure 6: Traffic service

Modes of transport can only support specific means of transport. However, this is not a one-to-one relation. For example, the road infrastructure can be used by bicycles, cars, trucks, buses, etc. This is an example of a one-to-many relation. Other examples are means of transport which can use several modes of transport, like amphibious vehicles. This is an example of a many-to-one relation.

The four layers

To refer to (parts of) this described model easily, we distinguish the layers USE, COLLECT/SEPARATE, MOVE and CARRY. The relation between those layers and the described model is shown in Figure 7. In this paper, we will make use of this simplified representation of the reference model.

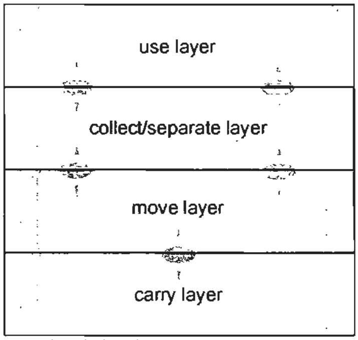

Figure 7: The logistic submodel

4.2 Primary and secondary processes

Primary processes are those processes which are directly involved in changing or moving goods at the different layers. These primary processes are controlled and supported by *secondary processes*. A secondary process supports and therefore interacts, directly or indirectly, with one or more primary processes.

Secondary processes can be related to primary processes on the sending side, on the receiving side or can be related to distributed primary processes. Secondary processes which are bounded to either the sending or the receiving side, we call *local secondary processes*. The other processes, which are not bounded to one side, we will refer to as *non-local secondary processes*. Local secondary processes can be further divided by using the number of resources these processes relate to. An example of a local secondary process which relates to one resource, which we call a *single-resource local secondary process*, is controlling a vehicle. Controlling a fleet of vehicles is an example of what we will refer to as a *multi-resource local secondary process*, i.e. a local secondary process which is related to more than one resource in the primary process.

In this section we will distinguish primary and secondary processes in each layer. Also, a distinction is made between local and non-local secondary processes. In the figures in this section, 'P' indicates a primary process, 's' indicates a local secondary process and 'S' indicates a non-local secondary process.

USE layer

We can divide this layer into primary processes, local and non-local secondary processes. The primary processes are concerned with changing the form of goods. They all have in common that movement of these goods is necessary in order to provide end users with the desired products.

Figure 8 shows the different types of processes which can be recognised in this layer.

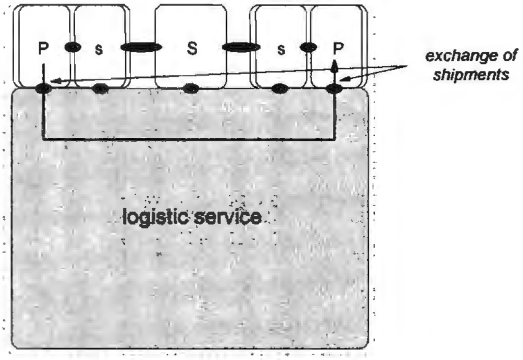

Figure 8: Primary and secondary processes in the USE layer

An example of a local secondary process is the operational control of a primary process like production or assembly. Examples of non-local secondary processes are production planning, process information exchange and order processing.

COLLECT/SEPARATE layer

The processes in this layer can be divided into a number of sublayers. In every sublayer, COLLECT/SEPARATE processes take place. On the interaction points between these sublayers, shipments packed in collection units are exchanged.

Figure 9 shows the different types of processes which can be recognised in these layers.

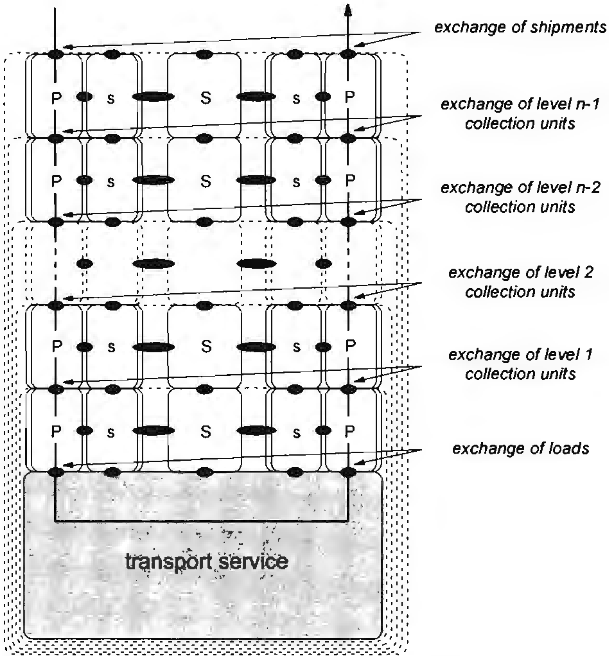

Figure 9: Primary and secondary processes in the COLLECT/SEPARATE layer

An example of a local secondary process is the operational control of primary processes like packing/unpacking and sorting goods. Examples of non-local secondary processes are collection and separation control, tracking and tracing goods and invoicing.

The information exchange concerning shipments between sublayers takes place in terms of the exchanged collection units. A logistic service provider communicates with the shipper in terms of shipments (articles, boxes, etc.), but the transport service provider in terms of loads (containers, trailers, etc.).

MOVE layer

The primary processes in the MOVE layer concern the physical movement of means of transport on the traffic infrastructure. In contrast with the USE and COLLECT/SEPARATE layer, we cannot distinguish a sending and a receiving side in this layer. This means that no non-local secondary processes can be identified. However, we can identify local secondary processes, depicted in Figure 10.

For individual means of transport we can for example distinguish the following (single-resource) local secondary processes: operational control of a single means of transport and route planning. An example of a (multi-resource) local secondary process for fleets is fleet management.

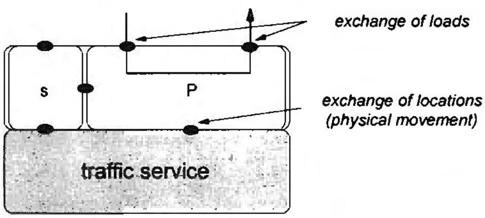

Figure 10: Primary and secondary processes in the MOVE layer

CARRY layer

Also in the CARRY layer, only a distinction between primary processes and local secondary processes can be made, see Figure 11.

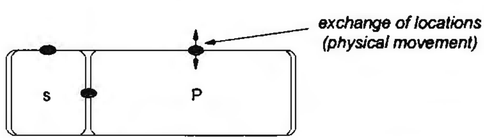

Figure 11: Primary and secondary processes in the CARRY layer

The primary process of this layer is carrying means of transport. Local secondary processes are for example traffic control, road pricing and incident management.

4.3 Processes and organisations

Our layered submodel provides a functional view on logistics. It tells us *what* happens in terms of 'behaviour'. In our submodel these terms are USE, COLLECT/SEPARATE, MOVE and CARRY. The model so far does not tell us *who* carries out these processes.

An *organisation* in our model carries out a cluster of processes in a logistic chain or network. Examples of organisations are Philips, Nedlloyd, and Frans Maas. Every organisation plays a certain *role* in a chain or network. This role relates an organisation to one or more processes in our model. Examples of roles are 'Philips as a production service provider', 'Nedlloyd as a logistic service provider', and 'Frans Maas as a transport service provider'.

Notice that organisations can play different roles in different chains and networks and that these roles can change in course of time. Therefore, these roles can differ in each instantiated model. For example, Philips can decide to distribute and transport some of its products itself. In other words, for these products Philips plays the role of production service provider, logistic service provider, and transport service provider at the same time.

The mapping of actors and processes has various reasons, such as economic, historical, or political reasons. These reasons form the basis of the *interests* of organisations, which largely explain their behaviour.

4.4 Similar models

Layered views of logistics are not new. The TRAIL research institute of the Delft University of Technology uses a similar four-layer reference model for describing the scope of their research program (Evers et al., 1994). Another model, consisting of three layers, is mentioned in an OECD report (OECD, 1992).

These models do not use the concepts of the ISO-OSI reference model. The model described by Linnartz (1991) does. His model consists of five layers: a social, interaction, transport, infrastructural and physical layer. In contrast with our model, which is based on a classification of primary processes, Linnartz structured his model using the classification of processes used in the ISO-OSI reference model.

For our model, the distinction made by Linnartz between the two upper layers is not relevant. Our *USE layer* resembles the social and interaction layer of Linnartz. In our *COLLECT/SEPARATE layer*, the focus is on the movement of goods and people from origin to destination. The movement of goods and people by vehicles, vessels, planes, and trains however, we place in the *MOVE layer*. Both layers can be compared to what Linnartz describes as the transport layer. We include loading and unloading activities in the *COLLECT/SEPARATE layer*. Routing of individual vehicles, trains, vessels and planes is included in the *MOVE layer*. Routing of flows of these means of transport is an infrastructure control process. Therefore, we include this process in the *CARRY layer*, together with all other processes related to the physical infrastructure. This layer corresponds to a part of the infrastructural layer and the physical layer as recognised by Linnartz.

5. The telematics submodel

Having described the logistic submodel, we will now focus on the description of the telematics submodel.

The ISO-OSI reference model, used for describing open distributed systems, consists of eight layers. To gain insight into existing and future telematics applications, it is not necessary to study all these layers in detail. Besides the interconnection aspects focused upon by OSI, there is a growing need for interoperability. ODP aspects must be taken into account as well (Schürmann, 1995).

We distinguish between three layers: a network layer, a generic application layer and a specific application layer for logistics. These layers and their relations are depicted in Figure 12. The network layer and the generic application layer emphasise interconnection aspects, while the interoperability aspects are more important in the specific logistic application layer. The network layer is described in Section 5.1, the generic application layer in Section 5.2, and the specific application layer for logistics in Section 5.3.

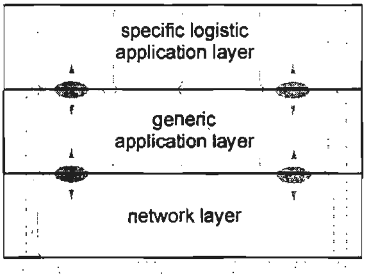

Figure 12: The telematics submodel

5.1 Network layer

The network layer provides an end-to-end data transport service, using the physical telecommunication infrastructure. This layer corresponds to the layers 0, ..., 4 of the ISO-OSI reference model. The network services can be distinguished using several dimensions:

- *type of connection*: fixed versus mobile;
- *type of communication (1)*: simplex versus duplex;
- *type of communication (2)*: point-point versus point-multipoint (multicast and broadcast);
- *type of signal*: analogue versus digital;
- *switching technique*: packet switched versus circuit switched;
- *bandwidth*: narrowband versus broadband;
- *geographical range*: local, national, or international.

These seven dimensions determine the type of service provided by the network layer. Theoretically, this allows for $2^6 \cdot 3 = 192$ possible kinds of services. In practice however, not all of these combinations are provided. The dimensions can be used to classify existing telecommunication services, like fixed or mobile telephone services, and satellite and beacon systems. It is also possible to identify new services for which no, or hardly any existing products or services are available.

5.2 Generic application layer

The generic application layer takes care of the distributed storage and processing of and access to data, as well as the exchange of data. For bridging the physical distance, the described network services are used. Examples of generic application services are the following.

- *Directory services* are necessary to store and retrieve electronic addresses. Without these services it is not possible to send any message.
- *Distributed database services* allow for the distributed storage of data in such a way the user perceives one logical consistent database.
- *EDI services* provide a communication service for the exchange of structured data. The sender is committed to use the structure of the specific message. Structured messages can be read and implemented by automated systems of the receiver. Therefore the messages can be processed without human interference.
- *Distributed processing services* support the distributed processing of data.
- *File transfer services* take care of the transparent exchange of data files between users.

- *Isochronous/synchronous services* offer a isochronous/synchronous data exchange for various types of data. An example of the use of such a service is video-conferencing, with which video, audio and text are offered synchronously.
- *Message handling services* (E-mail) concerns the transmission of short electronic messages. The sender is not bound to a specific message structure.
- *ODA services* concern the transparent exchange of documents which are structured according to a standardised syntax.
- *Identification/authentication services* take care of the identification of persons and processes and the authentication of messages. This application service uses other application services, like transaction services.
- *Positioning services* offer the possibility to determine the geographical location of an object. Both satellites and beacons can be used.
- *Public page services* provide the possibility to retrieve information from public pages.
- *Transaction services* allow distributed transactions to take place. An example of such a transaction is making a travel reservation.

5.3 Specific logistic application layer

For developing telematics applications for logistics, it is necessary to describe the matching between the described submodels. In other words, it is necessary to determine in which way the exchange, storage, and processing of data in logistics can be supported by telematics applications. After analysing the information flows within and between logistic processes, the functional specifications for the supporting telematics applications can be defined. Using these specifications, applications can be implemented using existing or new components.

Within the logistic submodel, a structure of processes is described, in which complex interactions take place. These interactions encompass both the exchange of goods and the exchange of information. In order to determine the possibilities of the application of telematics, a thorough analysis of these interactions is necessary.

So far, this has not been included in our reference model. The services provided by the telematics applications, i.e. the exchange and processing of information, correspond to one or more interaction points within the logistic submodel. Both interaction points between, as well as within the logistic layers, are concerned. This is depicted in Figure 13.

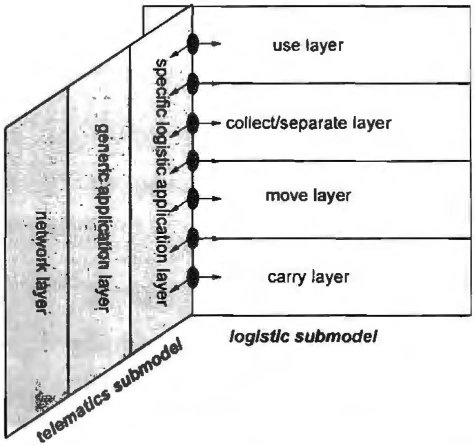

Figure 13: Reference model for logistics and telematics

We will give two examples of some specific logistic applications and the way they support the processes in logistics: fleet management and navigation.

Fleet management

One of the important functions within fleet management is the communication between a driver and a planner, for example using on-board terminals in the truck. This application can be implemented by several telematics applications.

Suppose a planner has typed a message in his computer for a specific truck driver and wants to send it. First, this computer has to determine the physical address of the communication equipment of the truck, using *directory services*. Then the message can be send using *message handling services*. Besides these generic application services, a network service is used for transporting the data to the truck. In this case a *mobile point-to-point data transmission service* is needed. This service can be implemented using for example GSM or Inmarsat-C.

Navigation

The driver in the previous example can use navigation equipment to find his way to loading and unloading addresses. These applications provide the driver with information on the cheapest or fastest way to a certain destination. In its simplest form, an electronic navigation system can consist of a database with route information, mostly stored on CD-ROMs, and a computer for retrieving, processing and presenting route information to the driver. The database provides a *(distributed) database service* to the on-board computer. This computer provides a *navigation service* to the end user, the truck driver. To provide the driver with up-to-date information, the database needs to be updated regularly. In this example, this is possible by replacing the CD-ROMs.

More complex electronic navigation systems can determine the location of the vehicle themselves and can also take into account incidents on the chosen route. A *positioning service* is for example provided by GPS. Traffic information can for example be obtained by RDS, a *network service.*

6. Objective of and motivation for a method to judge feasibility

The reference model can be used for describing and designing logistic networks. Another important use of the model is the determination or evaluation of the impact of telematics in a network. To do so, we need a method which enables us to analyse and compare specific situations represented by instances of the reference model. By taking two instances it is possible to compare the benefits of telematics in a new situation with its initial situation.

The method which we are developing, is aimed at enabling organisations to decide whether or not to change their processes by investing in telematics. Therefore, the method provides decision support. It must be able to compare instances of the reference model on both financial and non-financial consequences. In addition, the method takes both quantitative and qualitative factors into account.

In practice, organisations frequently have little notion of the impact of the use of a telematics application for their organisation and the entire logistic network. Often they also lack a quantitative basis to justify an investment in a telematics application (Dos Santos, 1991). Existing methods either focus on one aspect of the investment problem (mostly the financial or technical aspect) or on a part of the logistic network.

Cost-benefit analyses are difficult to perform and take only financial aspects of the application into account. Initial investment in the application can mostly be quantified, but an assessment of the expected benefits and the development of the costs in the following stages of telematics-use is difficult (Oirsouw et al., 1993). Besides, most cost-benefit analysis methods neglect many other (qualitative) factors, which influence the success of a telematics application. This leads to decisions for telematics applications on the basis of expected, but highly uncertain benefits (Mahmood and Mann, 1993).

Such decision behaviour is imaginable, given the complexity of the problem. Although their applicability is limited, existing methods are quite useful and work well. Yet, decisions taken on the basis of these methods may lead to unexpected results and sub-optimisation (Reekers and Smithson, 1994). Our method is based on a broader foundation and comprises eventually (parts) of other analysis methods.

7. A method for the a priori assessment of feasibility aspects

For the development of the method we use a stepwise approach. This approach is represented in Figure 14.

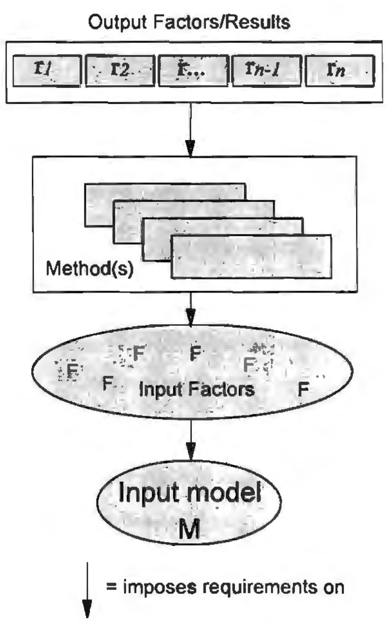

Figure 14: Approach for the design of the method

We started with determining what kind of outcome is desirable and what form it should take. The result of the method is a set of output factors representing properties of the situation expressed by an instance of the described model. At this moment, we distinguish the following classes of output factors: financial, commercial, technical, operational, organisational, socio-economical, and environmental classes (partly based on Verweij et al., 1994).

Eventually, the user of the method should judge the situation represented by the instance, considering the results of the method and his or her own interest (a shipper's evaluation of the results may differ from that of a policy maker or a carrier). For example, the use of tracking and tracing services may lead to a positive effect on the financial and technical classes for a cluster of functions within the network. The organisation which executes this cluster (a carrier) will judge positively on the telematics use, whereas the other organisations in the network do not directly benefit and hence may give a negative judgement.

The output factors determine the input factors as well as their relation with the input factors. This dependence is expressed in various analysis methods. Because of the diversity of the classes of output factors (the financial class is quite different from the environmental class), we cannot make use of a single analysis method. The diversity makes it necessary to develop a combination of existing analysis methods and newly developed methods. There must be a balance between economic, social, and technical methods and between methods which can analyse quantitative and qualitative factors.

Besides the methods combining quantitative and qualitative analysis for investment decisions in CIM and Flexible Manufacturing Systems, we might use analysis methods like *Activity-Based Costing, Multi-Criteria Analysis and Function-Point Analysis.* We have started with the study of Activity-Based Costing (ABC) (Cooper, 1988). Parts of this product costing technique are useful, because ABC traces costs to products according to the activities performed on them. The use of activities in ABC can be mapped to the reference model because the reference model constructs logistic networks on the basis of processes (*activities* is synonymous to *processes*). Moreover, the functions which ABC can perform, i.e. cost management, process control, and responsibility reporting, are separated from each other, as opposed to traditional cost accounting systems. This makes it easier to use the parts of ABC we need.

The next step is to search for other analysis methods which can be combined within the overall method. These determine in what form the instances need to be extracted from the reference model.

Parallel to the study of analysis methods, we have already started with a search for input factors. The current set of input factors is composed via literature search, interviews with experts and based on case material (Verweij et al, 1994; Magal et al., 1988; Oirsouw et al., 1993; Schuurman, 1994; Teeuw et al., 1994). This set of factors is broader than the sets found in literature and comprises all kinds of factors, varying from hardware costs to the complexity of the environment. However, the set is not complete and must be structured (for instance to minimise mutual dependencies between input factors). It is possible that the output factors in the different classes depend on the same input factors. Such dependencies are determined by the method used in each case. The method is not the same for every class. For example, the input factor 'total amount of travelled miles' will be reflected in the financial class of output factors and in the environmental class of output factors.

The input factors form the linking pin between the reference model and the method. The reference model must enable the extraction of the input factors from its instances.

Figure 15 shows a possible use of the method. By using two instances of the reference model, it is possible to compare a current situation (m_1) in the application domain and a subsequent situation (m_n) in which telematics is introduced. The decision in m_1 to invest in a certain telematics application will eventually lead to the actual use of that telematics application in m_n. If there is no single-step transition of m_1 to m_n, there can be a migration path from m_1 to m_n.

Judgements of the results of the telematics application will therefore not only depend on the comparison of m_1 and m_n, but also on the migration path. The migration path consists of instances and transitions which relate the instances to each other. The instances on the migration path are obtained from the reference model. They represent a situation of a logistic network, whereas the transition represents a change of the situation. This implies that the output factors are not only based upon the results of a comparison of m_1 and m_n, but also on the transition between the instances.

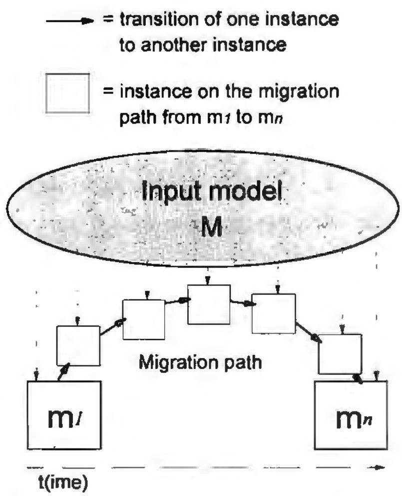

Figure 15: A migration path from the initial instance (m_1) to the new instance (m_n).

We can segment the input factors according to whether they should be attributed to the migration path or to the new instance.

The method has the following advantages.

- It is integrated with the reference model, which provides a fundamental and structured manner to analyse and improve logistic networks.
- It integrates both quantitative and qualitative factors.
- It supports its users to analyse a new situation in advance as well as to evaluate the situation afterwards.

8. State of the research and further work

In the previous sections, we have given an overview of the research performed at TRC considering the analysis and (re)design of logistic networks. We introduced a reference model by which we can describe an entire logistic network in a systematic manner. This first step of our modelling activities resulted in a classification of logistic and telematics services. This classification provides a structured view on logistics, which turned out to be very useful to describe logistic activities in several projects.

However, to be able to describe logistic networks in more detail, we need to decompose these layers into different generic process descriptions, i.e. building blocks, which can be used to construct specific chain or network situations. These generic building blocks can then be used to describe almost any logistic situation based on which a thorough analysis of the application of telematics can be obtained.

Future work related to the model, therefore concerns the following.

- A further decomposition of secondary processes into control and information processes, including descriptions of their interactions and behaviour, is necessary.
- The classification of processes must be further decomposed into process descriptions which can be used as generic building blocks for constructing instantiated models.
- The model needs to be validated using case-material.

Future work for the method comprises the following steps.

- The classes with output factors must be fine-tuned and defined more clearly.
- The set of input factors must be completed and structured, dependent on the output factors and the analysis methods.
- The analysis method needs to be completed and validated with case material.

The surplus value of the research lies in the combined use of the reference model and the method. Although the described model and method are only a first step to a systematic approach to the analysis and (re)design of logistic networks, the results are encouraging.

References

Aalst, W.M.P. van der (1992) *Timed Coloured Petri Nets and their Application to Logistics.* Dissertation, Eindhoven University of Technology, Eindhoven, The Netherlands.

Ballou, R.H. (1992) *Business Logistics Management.* Third Edition. Prentice Hall, Englewood Cliffs, USA.

Biemans, F.P.M. (1989) *A Reference Model for Manufacturing Planning and Control.* Dissertation, University of Twente, Enschede, The Netherlands.

Bowersox, D.J., D.J. Closs and O.K. Helferich (1986) *Logistical Management - A Systems Integration of Physical Distribution, Manufacturing Support and Materials Procurement.* Third edition. Macmillan Publishing Company, New York.

Cooper, R. (1988-1989) The Rise of Activity-Based Costing - Part One: What is an Activity-Based Cost System. *Journal of Cost Management*, Summer 1988: 45-54.

Dos Santos, B.L. (1991) Justifying Investments in New Information Technologies. *Journal of Management Information Systems*, 7(4): 71-90.

Evers, J.J.M., P.H.L. Bovy, J.L. de Kroes, et al. (1994) *Transport, infrastructuur en logistiek: een proeve van een integrerend onderzoeksprogramma.* TRAIL studies No. 94-1. TRAIL Onderzoekschool, Delft, The Netherlands. (In Dutch)

Goor, A.R. van, A.H.L.M. Kruijtzer and G.W. Esmeijer (1993) *Goederenstroombesturing, voorraadbeheer en materials handling.* Second edition. Stenfert Kroese, Leiden, The Netherlands. (In Dutch)

Hofman, W.J. (1994) *A Conceptual Model of a Business Transaction Management System.* Dissertation, Eindhoven University of Technology. Tutein Nolthenius/Bakkenist, Spits en Co, 's-Hertogenbosch, The Netherlands.

ISO (1984) *Information Processing Systems — Open Systems Interconnection — Basic Reference Model.* International Standard ISO/DIS 7498. Geneva, Switzerland.

Lambert, D.M. and J.R. Stock (1993) *Strategic Logistics Management.* Third edition. Irwin, Homewood, USA.

Lewis, L. (ed.) (1986) *Information Technology in Physical Distribution.* Technical Press, Aldershot, UK.

Liefting, J.R., P.W. van der Veer, P.H.W.M. Oude Luttighuis, et al. (1994) *Basismodel TIVV – Subgroep Generieke Basisfuncties, Rapportage fase 2.* Raamwerkstudie Telematica-Infrastructuur Verkeer & Vervoer, Subgroep Generieke Basisfuncties, Den Haag, The Netherlands. (In Dutch)

Linnartz, J.P.M.G. (1991) Verkeer met snelheidsbegrenzers of met lichtsnelheid? *Informatie en Informatiebeleid.* 9(3): 25-35. (In Dutch)

Magal, S.R., H.H. Carr and H.J. Watson (1988) Critical Success Factors for Information Center Managers. *MIS Quarterly*, September 1988: 413-424.

Mahmood, M.A. and G.J. Mann (1993) Measuring the Organizational Impact of Information Technology Investment - An Exploratory Study. *Journal of Management Information Systems*, 10(1): 97-122.

OECD (1992) *Road Transport Research – Advanced Logistics and Road Freight Transport.* Organisation for Economic Co-operation and Development, Paris, France.

Oirsouw, R. van, J. Spaanderman and H. de Vries (1993) *Informatie Economie – Investeringsstrategie voor de informatievoorziening.* Academic Service, Schoonhoven, The Netherlands. (In Dutch)

Pfohl, H.-Ch. (1990) *Logistik-systeme – Betriebwirtschafliche Grundlagen.* Fourth edition. Springer-Verlag, Berlin, Germany. (In German)

Reekers, N. and S. Smithson (1994) The distribution of the benefits and drawbacks of EDI use in the European automotive industry, in: *Proceedings of the Fifth World Congress of EDI users* (ed. R. Till), Brighton, UK.

Schrijver, P.R. (1993) *Supporting Fleet Management by Mobile Communications.* Dissertation, Delft University of Technology, Delft, The Netherlands.

Schürmann, G. (1995) The evolution from open systems interconnection (OSI) to open distributed processing (ODP). *Computer Standards & Interfaces*, 17(1):107-113.

Schuurman, W.P.J.A.M. (1994) *Management of Distribution Logistics.* Report No. TRC-RS/94012, Telematics Research Centre, Enschede, The Netherlands.

Sinderen, M. van, L. Ferreira Pires, C.A. Vissers, et al. (1995), A design model for open distributed processing systems. *Computer Networks and ISDN Systems*, 27(8): 1263-1285.

Tanenbaum, A.S. (1981) *Computer Networks.* Prentice/Hall, Englewood Cliffs, USA.

Taylor, K. (1991) *Computer Systems in Logistics and Distribution.* Kogan Page, London, UK.

Teeuw, W.B., J.R. Liefting and R.H.J. Demkes (1994) *Product Data Interchange – Towards successful introduction of PDI in practice.* Report No. IRS/94015, Telematics Research Centre, Enschede, The Netherlands.

Verweij, K., R. ter Brugge, and F. Ballhaus (1994) General evaluation framework to assess the impacts of ATT-applications in freight transport, in: *Towards an Intelligent Transport System – Proceedings of the first world congress on applications of transport telematics and intelligent vehicle-highway systems*, 3: 1452-1459, ERTICO, Paris, France.

Williams, T.J., P. Bernus, J. Brosvic, et al. (1994) Architectures for integrating manufacturing activities and enterprises. *Computers in Industry*, 24(2-3): 111-139.

Supply chain data management: towards tracking and tracing in the agro and food industry

Monique Jansen

Eindhoven University of Technology, Graduate School of Industrial Engineering and Management Science, P.O. Box 513, PAV D10, 5600 MB Eindhoven, The Netherlands, Tel: +3140 472952, Fax: +3140 451275, E-mail: m.h.jansen@bdk.tue.nl

Abstract

There is an urgent need for safe, wholesome food which hasn't been harmful for the animals and is environmentally benign. Government and consumers require guarantees with respect to quality and production and they should be able to choose a product on the basis of reliable and full data. Therefore, the history of a product should be traceable, and in case of exception handling, products should be recalled from the market. However, today's Enterprise Information Systems can not handle the necessary inter-enterprise communication because of the dynamic behavior of the business environment.

The main problem caused by such dynamic behavior is how to generate all relevant product data at any time, which requires that the data should be stored somewhere and that it could be coupled to a specific product. Therefore, tomorrow's Enterprise Information Systems distinguish product independent data, connected to an article code, and product dependent data, connected to an individual product or a batch of products.

The data can be stored either at one or more parties in the supply chain, or at a third party "above" the supply chain or at the product itself. If it is stored centrally, one should be aware of the strategic impact this data could cause. Once the location is chosen, the level of aggregation has to be considered; first the level of product aggregation and secondly the level of data registration.

There are several view-points whether to collect data or not and they should be balanced depending on the specific situation each enterprise has to face. Since it is very expensive to collect data that describes the product history, the reasons to do so very much depend on the strategic aims of the enterprise in the supply chain.

1. Introduction

The public, government and consumers require more and more of agricultural products. There is an urgent need of safe, wholesome food, which hasn't been harmful for the animals and is environmentally benign. Consumers and government like to know the way in which products are produced and composed. They need guarantees with respect to the quality and the production process and they should be able to choose on the basis of reliable and complete data. Therefore, producers should have a `face', should be communicative with respect to their products and services, and should make their products traceable.

To fulfil these requirements, product history data such as production processes and production means are necessary (Evens & Rose; Jansen 1994). These data can be derived from the phases a product has passed through: product design, selection of raw materials, production, distribution, use and waste (or recycling) (Zürn 1994). In the product life cycle in the meat chain, one refers to these phases as: breeding, increasing, fattening, slaughtering, retailing and consuming.

Usually, at least one supplier is involved in each phase of the product life cycle of a product and these suppliers have to communicate to deliver the products to their customers. However, each supplier can frequently be substituted by others (Brown et al. 1995), which creates a problem in the communication between these enterprises. In the above mentioned example, quite a few fatteners deliver to a slaughter and each of them can decide to deliver to another slaughter. At the moment, Enterprise Information Systems, which can be used to store product data like quality data and environmental issues, are designed for internal use and have to be adapted to communicate with other parties in the supply chain. However, today's Enterprise Information Systems cannot handle the dynamic behavior caused by frequent substitutions in the supply chain.

The main problem of such dynamic behavior is how to generate all the relevant product data at any time, which requires that the data should be stored somewhere and that it could be coupled to a specific product. In this paper, we first consider the goods flow and its data flows and examine the aims for local data storage (internal flows) and the aims for data storage in the supply chain (external flows). The second step to be taken is the coupling of the goods flow with its matching data flows; the matching can be made on several levels, which is illustrated by the application of the EAN code system. The remaining steps are to consider the location of data storage and the appropriate level of aggregation, both with respect to product aggregation and data aggregation.

2. Goods flows and data flows

When considering goods flows, we distinguish company internal flows and external inter-company flows. In this section we first go into detail for internal, local registration and secondly, we consider goods flows in supply chains.

2.1 Internal flows

The production of goods carries with it the generation of data. This data is registered mainly because of business economic reasons: business valuation, budgeting and invoicing. Furthermore, this data is used by subordinates who have to justify the management of goods and the control of the goods flow. Last but not least, the data are used by the enterprise itself to justify the production means and methods with respect to quality, logistics and effects on environment and common health. Related to the latter, for several enterprises it is important to be able to recall products from the market by tracking the product during its life (forward in time) or to trace the history of products (backwards in time).

Apart from business economic reasons, enterprises use their (historic) data for product development and user- and service documentation. This kind of data is used in decision support systems, and for simulation and knowledge management.

The data should be registered as soon as a certain phase has been finished: by change of ownership or value, or by transition of management, control, or uncertainty. We distinguish (1) state independent data, in which case we are collecting data on the level of product types, and (2) state dependent data, in which case we are collecting data on the level of specific products (individual or in batches).

2.2 Flows in supply chains

In general, several enterprises are involved in the product life cycle and therefore in registration of the goods flow. To fulfil the demand of a buyer at the end of the supply chain, two data flows are necessary: (a) down-stream flow: product properties, which include production means and methods, product specification and transaction information; (b) up-stream flow: consumer demands, which include actual demand and historical market data.

The exchange of the above mentioned data requires a lot of communication between enterprises which usually are spread all over the country or even all over the world. The use of electronic data interchange (EDI) eliminates many of the drawbacks of geographic borders, the volume of data and the synchronization between buyer and supplier. Therefore, supply chain information systems that are based on EDI are a means to communicate trade orders, market data and production data with (1) the direct buyer, with respect to strategic alliances, (2) the final consumer, as a guarantee for trade-marks, hall-marks and certificates, (3) government, for regulation and policy and (4) public community.

Other applications of supply chain information systems include the coupling of product and product data (a) for production control, (b) for tracing (exception handling) and (c) for tracking of products that are considered valuable or risky: parcel-post for which a third party is responsible, waste which is harmful or regulated, or opium which is risky when it is used in the wrong quantity.

In this paper, we consider data flows in supply chains and we especially focus on the data storage in behalf of tracking and tracing.

3. Object identification in supply chains

3.1 Definitions

The coupling of a product with its data requires unique identification of the product concerned. Especially for agricultural products this is not trivial, as will be shown in this section. We distinguish product types, product batches and individual products.

A *product type* is the definition of a group of products, which can be referred to by its article code. A product type is described by state independent data, like the bill-of-material, its dispensing, and packing, and can typically be found in a catalogue. The main characteristic of a product type is that it doesn't exist physically but only as an abstract description of physical products. An example of a product type is boeuf Bourgignon; when you order this plate, the cook will serve the kind of beef you expect, but you cannot distinguish it from the one that is served to your neighbor.

A *batch* is a group of physical products, that have some properties in common, apart from the state independent properties. We have for example a batch of meat that is supplied by one farmer and processed by one slaughterer at a certain day. The main characteristic of a batch are (1) that there is a certain point in time before which the batch didn't exist and after which it does exist; (2) that there is a certain point in time after which the batch doesn't exist anymore; and (3) between these two points in time, the physical products undergo the same actions. The batch can be identified by a batch code attached to an article code, and has to be described by state independent data (attached to the product code) and state dependent data (attached to the batch code).

An *individual product* is a batch with size one. In general, this implies that there is a property which distinguishes two products. In a slaughter, for example, cows will be supplied by several farmers and therefore in several qualities. However, at the moment, the slaughterer only has one article code for beef and the batch code is not related to the farmer. If one of the farmers supplies cows that turn out to have a disease and therefore the beef cannot be used, the slaughterer has to recall all the beef of that production day.

The coupling of goods with its matching data can be interrupted by disturbances in the supply chain. The location where this interruption appears is called an *information decoupling point*. At an information decoupling point, the available (up stream) data is gathered, aggregated and attached to the product or batch; after the decoupling point, only new (down stream) information is attached, gathered at the locations that have added value to this product or batch. It can be considered as the Markov property of a product or batch with respect to a specific aspect and it implies that there are decoupling points for production control, but also for quality data, environmental issues, etc.

3.2 Identification of product types

All enterprises use their own enterprise information system, with their own internal article codes. When goods are supplied, the store-keeper immediately translates the external delivered codes into internal product codes. Communicating product codes therefore causes a lot of misunderstanding, especially when these codes often change due to engineering changes. To handle this problem, a system is needed which can be used by any enterprise to translate their internal product code into a universal product code. The internal code can still be used within the enterprise, only the universal code will be exchanged.

The European Article Numbering (EAN) organization has built such a coding system, which is compatible with the Universal Product Code (UPC) that is used in the USA and which enables the store-keeper to couple the goods flow and the data flow automatically. The EAN code system distinguishes the following units: articles (consumer units and packages), trade and order units, supplementary information, locations, shipment units and deposit tickets.

The EAN article codes are decentrally attached to the product types, at the source. The code is constructed as follows:

	System code	**Connection nr.**	**Article nr.**	**Control nr.**
Location	13 12	11 10 9 8 7	6 5 4 3 2	1
Example code	8 7	5 2 3 2 7	6 1 8 1 0	6

The system code identifies the EAN code distributor; the connection number identifies the enterprise that is responsible for the product, usually the manufacturer or the owner of a hall-mark. The article reference number is decentralized attached by the owner of the connection number.

Using the same article codes enables the enterprise to exchange data automatically; this is referred to as Electronic Data Interchange (EDI). Apart from the benefits of EDI that are mentioned in section 2.2, there are some other effects that have a great impact. First, planning and prognosis data can be retrieved for suppliers and customers to improve their internal production and logistics. Secondly, shorter delivery times can be achieved by preliminary ordering and level supply control, which gives the supplier a clear insight into the market. In addition, electronic parcel tickets enable the customer to do the control of goods delivery automatically, price lists can be delivered electronically and invoices are no longer necessary

3.3 Identification of batches

A problem with the EAN-13 article code, however, is that the article code is attached to a product type and thus all products of that product type are considered to be equal. In reality, however, all products of a product type are not equal, *e.g.* food products which are perishable. The expiration date is a key factor for delivery to optimize the stock value. Other examples of data that can not be modeled by EAN-13 are batch numbers, serial numbers, forward codes and weight indications.

To solve these problems, the concept of an Application Identifier (AI) is added, using the EAN-128. code as an extension of the article code. The AI standard defines data blocks, each block starting with an identifier of 2-4 characters for the meaning, format and length of the field. A number of common identifiers are predefined and new identifiers can be asked for. Note that EAN-128 is usually applied to trade units, whereas EAN-13 is applied both to trade units and consumer units..

The benefits of EAN-128 for the manufacturer are in internal logistics: product registration and pallet structure (which articles, quantities, batches and tenability). The main benefits for distribution are sorting, routing, tracking and tracing.

3.4 Bottle-necks

The EAN coding system is very useful if it is necessary to distinguish specific products or batches of products. The unique coding of products or batches, however, is not applicable in all cases, because it is either not possible or too expensive. The coupling of goods and data can be interrupted by disturbances in the supply chain at so called information decoupling points. In the meat chain for example, pigs are supplied in the slaughter with unique numbers which make them uniquely identifiable. After the pigs are slaughtered the (numbered) head is removed and the carcass can no longer be distinguished from the others. This situation is not.

desired but can hardly be avoided, however, since other business applications require this way of aggregation.

Except for disturbances, identification of products can also be difficult due to the product itself. At a certain point in time (parallel case), it is not always beneficial to distinguish products because the customer doesn't want or isn't able to distinguish them. In the slaughter case again, this appears when the farmer supplies numbered cows. Before they are processed, they can be distinguished, but afterwards, when all beef of the day is in the box marked "beef" and all filet in the box marked "filet", no one will ever know which beef and filet belonged to cow number 12345. If only for this application, the cows could be supplied without numbers, thus saving the costs of registration.

It is not always possible to recognize a product at a different place or time in the supply chain, due to changes in name, number or composition. For example, computers are sold with a unique serial number, that is translated into an internal code to be used within the company. After some time one decides to change the configuration. Although it will be internally registered, the supplier won't know and if the translation is lost, he even cannot know these changes.

Furthermore, coding may be undesirable, mostly because uniquely identifying products requires a high level of detail that leads to costs. Especially products with low value and risk that are produced in large quantities are not suitable for unique identification; decreasing the level of detail probably yields a better cost/profit balance.

4. Location of data registration in supply chains

Once we have determined which data should be stored, we have to consider where it can be stored. The location for storing product data depends on the applications that will use that data later on. One way of data storage can be applicable for one goal but too expensive or even impossible for another. Therefore, an overview of the alternatives is given.

4.1 Central registration

Central data storage implies that all parties in the chain have one location in common to store their data, either in the chain or at a third party.

When the data is stored in the chain, it is possible to store the data (1) at the first party, usually the manufacturer, which enables tracking, (2) at the final party, usually the consumer, which enables tracing, or (3) at any information decoupling point. For all cases, it follows that identification of the goods and coupling with product data is not trivial.

An example of data storage at the final party is the production of slaughter chicken for the German market. In Germany, it is required that the chicken slaughterer be able to know which increaser supplied which chicken to which fattener and which breeder supplied it in the beginning. One advantage of the application of the first example can be shown by a case of tainted baby food. In this case, the manufacturer has been able to trace a quantity of tainted baby food back to a subcontractor of one of his meat suppliers. However, he was not able to recall the complete batch since he didn't know which buyers were using it and he had to recall the products of the full production day.

Secondly, the data can be stored at a third party, either a chain manager or an independent organization. The concept of a chain manager works only when the chain manager is a powerful party. In many cases, however, the power is divided into a number of small parties and in such a case the data should be stored at an overall or inspecting organization. In the Dutch processing of cows, for example, this role is played by the national cattle syndicate which stores all data on cows in the national herd-book.

The main benefit of the central concept is that tracking and tracing are easily implemented. Nevertheless, in the opinion of many chain parties the concept is not satisfying because the central storage of data empowers one party to use the collected data strategically, thus wielding power on the chain.

4.2 Distributed registration

In the case of decentralized data storage, the product data is stored at the location it has been produced, thus avoiding the above mentioned disadvantage. However, to be able to follow goods in the supply chain, products still have to be identified. If the data is registered at several locations, this is frustrated by the use of different concepts, but nevertheless it is still possible if a central control on data management is admitted, which can be used as a basis for tracking and tracing. A variant of the decentralized concept is to store data only at decoupling points, implying central data storage in parts of the chain.

Decentral data storage has one main drawback, however: it usually ends up with many different, non compatible systems, which is the price to be paid for avoiding shifts of power in the supply chain. However, using this option also enables parties in the chain to implement systems independently so that they can be part of internal production systems.

4.3 Attached to a product

Different from data storage at one or more parties is data storage on the product itself, for example in a covering document or in a covering or even attached chip. The coupling between a product and its data is easily done; tracing is possible by retrieving the enterprises that have added information. Tracking is not possible, unless additional databases in the chain are set up, as is the case for communication of order data.

5. Other issues

5.1 Aggregation of products

Aggregation of products in batches is possible if they can be considered to be identical. In this context, identical means that there is no distinction of products relative to a certain criterion. This is usually not the casein food industry, since two products are never exactly the same. Example: for the production of slaughter-chicken, chickens are considered to be identical if they have their genetic material in common and are kept and fed under the same circumstances. On the other hand, in the production of beef, cows are considered to be different, because they differ significantly in genetic material and weight. In both cases, the criterion is that the animals are considered to be equal or not, depending on their quality, shape and composition (in the opinion of the buyer).

5.2 Aggregation of registration data

If the quality of a product should be determined, it can be done either by measuring of the end product, or by describing its history. Measuring of the end-product is sometimes easy and should be preferred. However, this way of quality determination often is very complex and thus expensive and sometimes quality is determined by attributes that cannot even be measured on the end product, like production methods that are not harmful for the animals.

When a product is produced by only one enterprise, a quality assurance system can be used during the production. When a product is produced by a number of enterprises, as is the case for the above mentioned kinds of meat, the quality registrations have to be coupled, either directly or indirectly. These registrations are usually part of an assurance system that can be certified by a standardization organization like ISO. A certificate is a means to aggregate product data and production data. ISO has certificates for quality assurance (ISO 9000), quality assurance systems (ISO 9002), environmental quality (ISO 14000), etc. Once an organization has a certificate, it is known which production rules are used (as is the case for ISO certificates), and sometimes it is known that these production rules meet (standard) requirements (as is not the case for ISO certificates, but it is, for example, for the quality mark McDonald's attaches to its hamburgers).

Certificates can be used to aggregate the information that is collected within the enterprise and should be communicated to parties in the supply chain. Several levels of data interchange can be distinguished, using the above mentioned certificates. On the first level, the only requirement is that the supplier is certified and this is communicated by a simple yes or no. On the second level, the supplier has to be certified as well. The communication, however, is extended by the criterion on which the certificate is based. For example, the buyer requires that the supplier has an ISO 9000-certificate that includes environmentally benign production methods. On the third level, the supplier also has to supply the data that is collected to meet the requirements of the certificate. For example, it is specified that the production should be environmentally benign, implying that the caused water pollution is less than x.

Apart from these three levels, the product quality can be guaranteed by the following extensions. First, the product history can be communicated if the path of the supplier and the supplier's suppliers is registered, either directly or indirectly. Secondly, the quality control that is recorded by means of the certificate is not only applied to the supplier, but can be specified to particular shipments, batches or even individual products.

6. Conclusion

To meet the requirements of tomorrow's dynamic behavior of the business environment, Enterprise Information Systems distinguish product independent data, connected to a product type or product code, and product dependent data, connected to a batch of products. The way this data should be registered depends on the desired communication in the supply chain and the political relations.

There are several view-points whether or not to collect data and they should be balanced depending on the specific situation each enterprise has to face. Since it is very expensive to collect data that describes the product history, the reasons to do so very much depend on the strategic aims of the enterprise in the supply chain. This implies that the following, dependent, issues should be balanced:

- aims and scope of the enterprise, often related to the general enterprise strategy
- aims for the supply chain: supplementary investments are necessary, because external automation is a prerequisite for effective and efficient communication
- level of aggregation of product types, batches and individual products
- level of aggregation of registration for the above mentioned level of products
- location of registration, with respect to the goals and the political impact

References

Browne, J., P.J. Sackett and J.C. Wortmann, *Future Manufacturing Systems - Towards the Extended Enterprise*, Journal of Computers in Industry, 26/ 1.

Davenport, T.H. and J.E. Short, *The new industrial engineering: Information technology and Business Process Redesign*, Sloan Management Review, Summer 1990.

EAN Nederland, *EAN128-barcodes en de AI-standaard*, (in dutch) brochure EAN Nederland, Amsterdam 1994.

Evens, S. and P. Rose, *Environmentally Conscious Design Using a Global Knowledge Network*, The CIM Institute, Cranfield University.

Hegge, H.J.M., *Intelligent Product Family Descriptions for Business Applications*, dissertation TUE 1995.

Hovenkam, L., *Geen produkt buiten de deur zonder Euro-keur* (Products should have Euro hall-mark; in Dutch), Financial Economic Magazine, July 27, 1991.

Jansen, M.H., *Environmentally benign products in the Extended Enterprise*, Proceedings International Symposium on Environmental Information Management and Electronic Data Interchange, Taiwan, December 1994.

UAC transcom, *EAN the hidden unity, the key to logistical renewal* (in dutch: *EAN de verborgen eenheid, de sleutel tot logistiek vernieuwing)*, brochure Stichting UAC, Amsterdam, 1992.

Veen, E.A., *Modelling Product Structures by Generic Bills-of-material*, dissertation TUE 1991.

Willig, J.T., *Environmental Total Quality Management*, McGraw-Hill, New York 1994.

Wortmann, J.C., *Reasons for registration of the goods flow* (in dutch: *Waarom registreert men de goederenstroom?* Syllabus college "Registratieve informatiesystemen" NADOlogistiek 1994.

Zürn, J. and J. Diener, *Ecological Assessment of Products and Processes Challenge and Opportunity*, International Seminar on Life Cycle Engineering, Germany, October 1994.

Business Process Redesign in Financially oriented organisations

Roland Toppen

Robeco Groep, Coolsingel 120, 3011 AG Rotterdam, Tel: (31) (0) 10-2242438; Fax: (31) (0) 10-2242121

1. Introduction

In todays business, change has become an aspect with increasing value and it can generate new opportunities. Change can be initiated internally or externally. Internally generated changes are often consequences of the use of information systems and automating various processes and procedures. The reason can be seen as proactive (Johnson & Scholes 1988) to gain competitive advantage. External changes faced by organisations are the consequences of developments in other organisations and often need a response. The reactions of organisations to external changes can therefore be seen as reactive (in terms of Johnson & Scholes 1988). In both situations it is important to carefully review the internal processes and external environment of the organisation in order to deal with these changes in the best possible way. The evaluation and reconstruction of the internal processes is commonly referred to as Business Process Redesign (BPR) (see for a definition by Hammer & Champy (1993) later on in this paper). BPR has been the subject of many articles and the results of the reconstructions have often been spectacular. The results are more efficient and more effective processes, often leading to new situation which itself enable new developments and changes that were not possible or identified as options in the old situation. Bright (1968) was one of the first authors who has highlighted this aspect and the importance of business process redesign:

> *"The most important application of a new technology is not always that which was visualized at first, and as corollary, technological innovations frequently gain their first foothold for purposes that were originally not thought of or are deemed to be quite secondary".*

It is not easy to anticipate the impact and possibilities of these changes for a specific organisation or department. When you ask managers what future developments are likely to influence their organisation or the competition, they will probably come up with answers like applying product differentiation, using Electronic Data Interchange (EDI) and process automation using information systems. Research and pilot projects, often accompanied with simulations, enable organisations to preview the advantages and possibilities of these developments. In this paper we will focus on the advantages and possibilities of the above mentioned business process redesign and the use of information systems by financially oriented organisations. Within this sector we can identify banking organisations, mutual fund companies, insurance companies, but also corporate treasury departments, each having different strategies, goals and intentions. The intention of this paper is to analyze the possibilities for this category of organisations, and in particular those organisations involved in securities transactions (stocks, bonds and derivatives for example) and payments related to these transactions, from a theoretical perspective as well as from a practical perspective. Therefore the remaining of this paper consists of a theoretical part, followed by a part in which various practical alternatives will be dealt with. The final part consists of an evaluation and conclusion based on the advantages and disadvantages of the various alternatives.

2. Information systems & Business Process Redesign

The developments related to the use of information systems have been successfully implemented in mainly production and logistically oriented organisations. Organisations in the financial sector have been familiar with the use of information systems for a few decades, but they mainly focused on using it as a source of information supporting processes rather than using information systems within processes. During the last few years, production oriented organisations have not only incorporated information systems within their processes internally but extended the use of information systems to inter organisational processes by integrating information systems over the boundaries of organisations (these systems are often referred to as Inter Organisational Information Systems (IOS)). One of the theoretical framework commonly used to analyze the opportunities of the development of an IOS is the value chain approach by M.E. Porter.

The value chain is often used for analyzing the internal processes of organisations, while the value system is often used for analyzing the processes over the boundaries of organisations. The value systems approach analyses the way organisations exchange information and how the value chains of these organisations are connected to each other. Regarding value chains and value systems, it is very important to distinct between information exchange between departments and between organisations. The exchange between organisations not only has to deal with differences regarding processes and organisational goals but also has to deal with cultural differences.

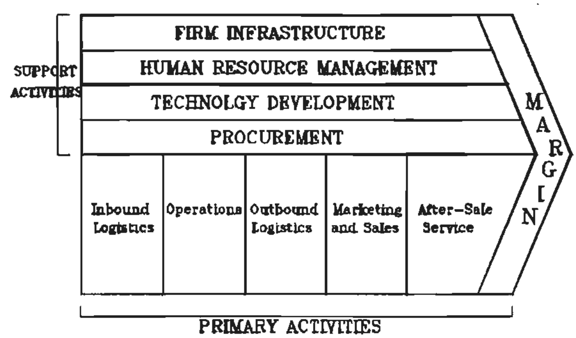

Figure 1: The value chain

In developing intra (within organisational boundaries) and inter (between 2 or more different organisations) organisational information systems various levels can be identified within and between different organisations. This is often caused by different strategies and priorities in certain areas of the organisation. For instance banking organisations tend to focus on developing information systems tuned to the processes related to handling payments and generating customer statements reporting debits and credits and current standings. Mutual fund organisations tend to focus on information systems tuned to the processes related to handling securities transactions (stocks, bonds and treasuries) and although payments are involved their primary focus is on transaction confirmations and instructions to custodians in order to move securities (in the next paragraph an overview of the processes will be given). In this paper the lifecycle of a securities transaction can be defined as the value chain of organisations involved in investment management.

In order to gain insight in the different levels of the use of information systems in various departments and organisations the 5 level framework of Venkatraman can be used.

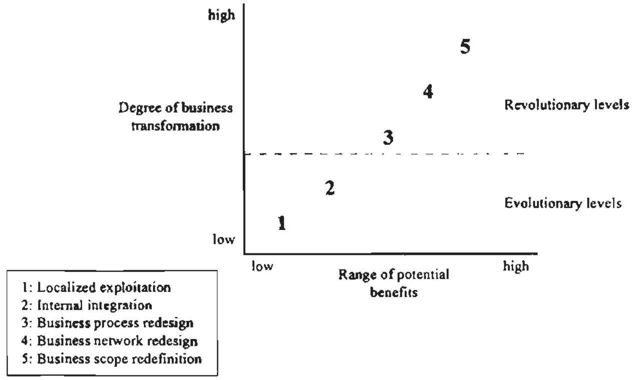

Figure 2: Levels of IT induced reconfiguration by N. Venkatraman

The first level, localised exploitation, identifies organisations using information systems within departmental boundaries. The information systems are especially designed or tuned to the needs of the specific department (or sometimes even parts of a department). The second level, internal integration, identifies organisations trying to integrate the information systems to the entire internal business process. This not only means integrating the information systems in a technical way but also integrating the organisational business process interdependence. The third level, business process redesign, identifies organisations who are not only trying to integrate information systems between departments and 'automate the existing', but are trying to evaluate the existing processes and preview the future processes supported by information system. This interaction is important because the mistake of '*by automating being able to perform those processes more effectively, which would not be necessary at all, when you would have used information systems efficiently*' has been made to often. The fourth level, business network redesign, identifies organisations which are not only taking their internal processes into account but are involving processes within other organisations in order to tune the information system to the organisational boundary crossing processes. The fifth level, business scope redefinition, identifies organisations which are evaluating the use of the existing situation in order to prosper new situations where parallel value chains (value systems) might be integrated in the value system. Venkatraman sees the first two levels as evolutionary and the latter three as revolutionary. The difference is that the first two levels take the existing situation and the latter three levels take the desired situation as a point of view. This framework can present an overview of the current situation of the environment of the organisation. However, as we concluded before it is important to remember that different departments and organisations have different strategies and/or goals and using a framework on an organisational level might be to abstract. In his model Venkatraman depicts the range of potential benefits to the degree of business transformation. Regarding the revolutionary levels it is very important to realise that fundamental knowledge, not only of the internal business processes but also of the business processes of other organisations, is required in order to be successful at the higher levels.

When considering to incorporate the use of information systems in redesigning business processes it is very important to focus the business strategy to the information strategy. Venkatraman & Henderson 1992 have tried to picture the relationship between these two strategies in the following diagram.

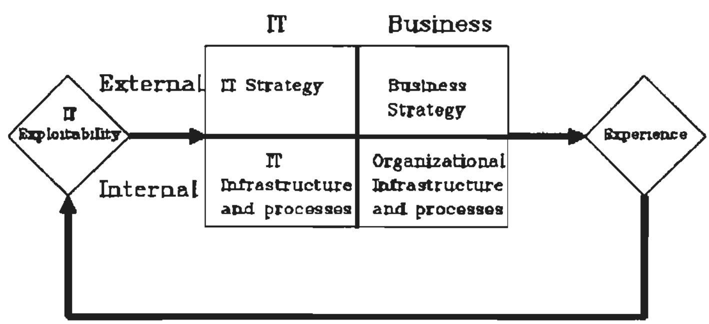

Figure 3: Conceptual model of IT exploitability (adapted from Henderson & Venkatraman (1992))

In order to establish a link between business strategy and information strategy, it is important to decide on one of three options:

- *Internal focus* - meaning managers first want to develop their internal information systems and redesign the internal processes before focusing externally.
- *External focus* - meaning managers first want to develop a link (using information technology) between their organisation and other organisations and then focus on integrating the external information exchange with their internal information systems and processes.
- *Internal & External focus* - meaning managers want to simultaneously develop their internal information systems and establish an integrated link with other organisations.

While the first two options will mainly consist of incremental changes (Quinn 1980 page 51), the last option will consist of major changes from the old situation to a new situation. Especially in the last option it becomes evident that it is necessary to have a clear picture about what the organisation wants for the future. The internal structure of business processes must be suitable for achieving the maximum from externally focused information systems integration. In all three options it is important to combine information technology developments with redesigning existing processes.

The term Business Process Redesign has been defined by M. Hammer & J. Champy (1993 page 32) in their definition of 're-engineering'.

> *"The **fundamental** rethinking and **radical** redesign of business **processes** to achieve **dramatic** improvements in critical, contemporary measures of performance, such as cost, quality, service and speed"... It is doing more with less.*

We therefore conclude that it is very important for organisations in general and, because it is rather new to them, for organisations in the financial sector in particular, to realise to what extend information systems can support processes and what future processes should look like.

3. The financial sector: Payments & Securities

In the previous paragraph theoretical points of view have been discussed regarding business process transformation using information systems. In this paragraph we will focus on the developments in the financial sector and in particular on developments related to processes around payments and securities transactions.

In the first part of this paper a distinction has been made between banking organisations, mutual fund companies and treasury departments. We will use this distinction in order to discuss and evaluate the use of information systems in the area of payments and securities transactions in these three kinds of organisations. In order to do this we will first describe the general process and the opportunities to use information systems related to this general process. Next, we will discuss the motives and market forces and the various strategic options available to these types of organisations.

In the figure below, the lifecycle of a securities transaction is depicted. This lifecycle applies to the various kinds of securities (stocks, bonds, derivatives etc). This lifecycle will be used to put the motives and market forces into perspective and this lifecycle can be seen as a value chain of a mutual fund organisation and banking organisations involved in the securities business.

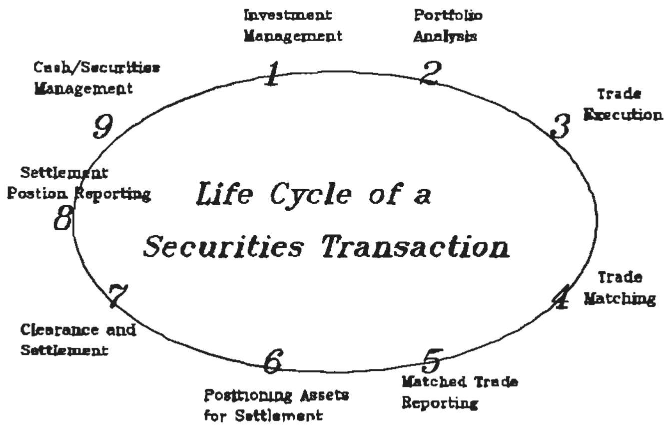

Figure 4: Securities life cycle, adapted from JP Morgan/Euroclear 1994

The process around securities transactions from an investment management institutions point of view consists of nine steps (see figure above). The securities life cycle starts with the front office fund manager's decision to either buy or sell a specific security based on his opinions about the current portfolio and his expectations and analysis (step 2). The order to buy or sell is given to a broker which executes the order at the exchange where the security is listed (or buys it directly from another organisation - over the counter). The fourth step is to match the confirmation of the trade information with the order to check the correct execution of the deal and to initiate the correct settlement of the transaction. When the transaction information is matched the fund manager gets a matched trade report in order to be able to update his portfolio (this report is also used as management information to the back office). In order to be able to settle the securities transaction it may be necessary to move the securities to a central place (securities might be held at different locations or can be lend out). When the securities transaction settles delivery versus payment (avoiding unnecessary risk) the payment will not be done unless the securities are exchanged at the same time (clearance and settlement). It is also possible to separate the payment from the delivery, but this means taking the risk of non payment or non delivery. A global custodian might take care of the clearance and settlement of the transaction but it needs to be instructed to take care of the settlement (step 7). When the settlement has been successful the back office will receive a notification (statement of holdings (securities) and will be debited or credited to the bank account mentioned in the instruction). The last step in the lifecycle consists of handling the various corporate actions (dividends, coupons, splits, mergers, rights issues etc) and is responsible for keeping the existing portfolio up to date to enable the fund manager to analyze his current portfolio and initiate new investment decisions.

It becomes clear that in the above mentioned cycle there are several exchanges of information (both internal and external). The fund manager needs to have access to information about his current portfolio, the various securities markets and potential investment possibilities (information about companies and economic situations). The buy or sell order is given to the broker (external exchange), which confirms the execution of the trade. Settlement instructions are sent to the custodian in order to be able to settle the trade and the custodian confirms the clearing and settlement of the trade. There are different ways for organisations to handle the required information exchanges. A few years ago, most of the information exchange would be done by sending a manually generated telex or facsimile to the other organisation, which would be rekeyed by the other organisation.

Managers in financial organisations have initiated changes in the above mentioned process by using information systems to automate the manual processes in order to support the process (less errors and a more efficient and effective process). Besides the internal motives of managers to make the life cycle more efficient there have also been market forces which forced the organisations to speed up the consecutive phases in the life cycle. The reasons behind the external forces are reducing the risk of non payment or non delivery. The Group of 30 recommendations (see report of Morgan Guaranty Trust Company, 1993), for instance recommended transactions to be settled at T+3 rolling settlement (recommendation number 7), meaning the whole life cycle should be dealt with within 3 days and the recommendation to use ETC (recommendation number 2). In some countries settlement periods have to be reduced from T+15 (or more) to T+3 (or even to T+1 as a final goal). In the UK for instance a change has been implemented by June 1994 to reduce the settlement period from T+10 to T+5 and are currently preparing to reduce the period even further to T+3 in 1995. In the Netherlands the period takes 7 days, while in the United States is proceeding towards 3 days as from june first 1995 (decision by Securities and Exchange Commission (SEC) and ISMA). For example Germany is already using T+2 and in HongKong T+1 is already implemented. When T+1 (or even same day rolling settlement) becomes the standard settlement period, organisations must be able to finish the process within 1 day. This can only be done using information systems for the exchange of information because manual processes take to long, especially when you consider time differences. On the one hand there are internal motives to redesign the process to become more efficient and on the other hand there are external forces who force the organisation to change the process. In the remaining of this paper we will discuss various options for the different kinds of organisations involved in the securities markets.

4. Business Process redesign

Organisations have to respond to the external forces and internal strategic motives, but there are several different ways for organisations in which they can respond. In the figures below we show 6 different situations, which we will describe before we evaluate the different situations.

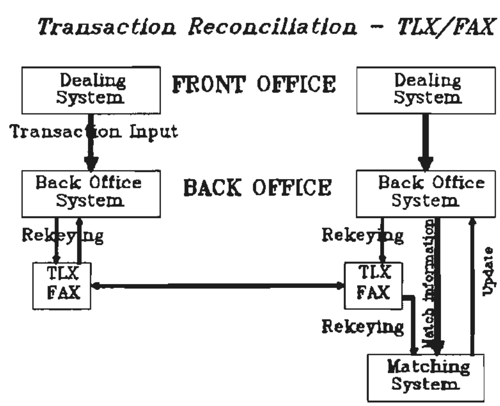

Figure 5: Transaction reconciliation using TLX/FAX

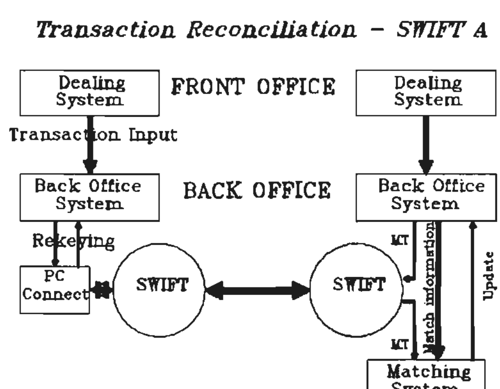

Figure 6: Transaction reconciliation using SWIFT - A

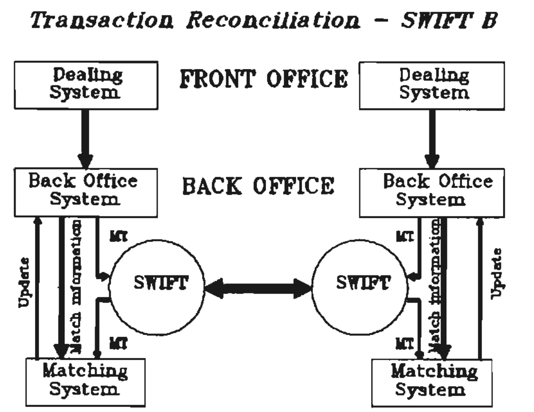

Figure 7: Transaction reconciliation using SWIFT - B

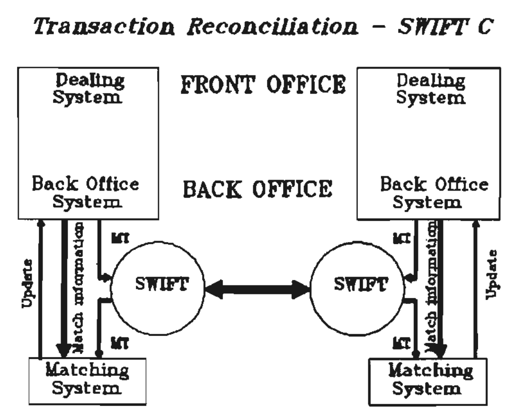

Figure 8: Transaction reconciliation using SWIFT - C

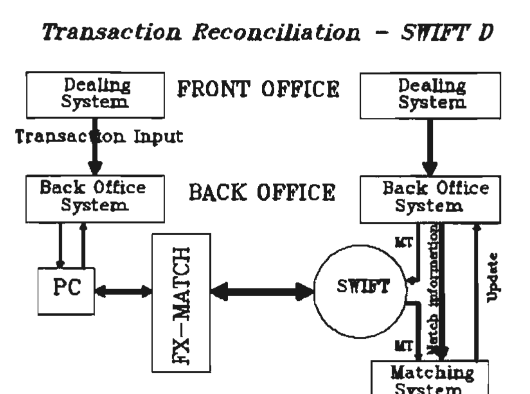

Figure 9: Transaction reconciliation using SWIFT - D

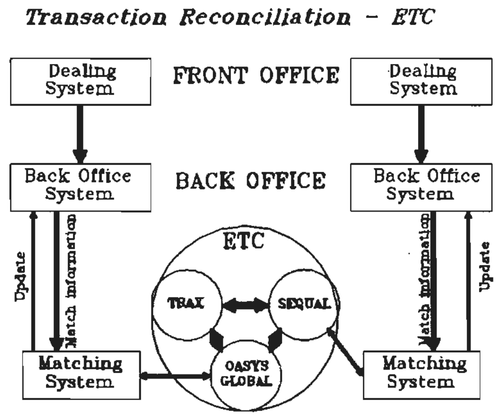

Figure 10: Transaction reconciliation using ETC

In all the above figures the exchange of information between two organisations is highlighted. The difference between the figures is concentrated on the left side of the figure. In figure 5 a situation is depicted where most of the required activities are manual. In the previous paragraph we focused on the securities life cycle and therefore we do not get into information systems supporting the investment decisions but take the dealing system for granted (the dealing system might therefore be a process supported by an automated system or a manual process). When a transaction is initiated it will be manually entered into a back office administration system. This back office administration system, for instance, takes care of generating reports related to the portfolio(s). The transaction confirmations have to be sent by a manually generated telex or facsimile (telex has a different legal status) so both organisations agree on the transaction information. Most of the time it is the broker who sends a confirmation and the ordering institution affirms or rejects the confirmation. On the right side in figure 5 an organisation is depicted with a matching system to keep track of matched and unmatched transactions. The back office system of this organisation takes care of putting the transaction information into the matching system, where it waits for the confirmation by the other party. When the transaction information appears to be correct the matching system returns an updated status back to the back office system. This process consists mostly of manual input and rekeying of information and therefore not only takes a lot of time but also leads to errors due to the rekeying of information.

In figures 6 to 9 the same situation is depicted, but now both organisations use SWIFT (Society for Worldwide Interbank Financial Telecommunications) to exchange information concerning the confirmation of transactions. Although SWIFT was originally focused on international payments between banking organisations and handling cheques payments, there are several different ways to use SWIFT in the security life cycle process. In figure 6, the left organisation uses SWIFT by manually entering the necessary information in the required SWIFT standard message format (PC Connect is one of the applications supporting organisations to enter messages in the required format) and then sends the transaction confirmation message to the other organisation. SWIFT has developed message types to cover the confirmation of treasury transactions (MT (message type) 3 series) and is currently working on a message type to be used for the confirmation of stocks and bonds transactions (MT511 and MT512). The situation in figure 6 shows an internal process in the left organisation which is still mainly manually based. The organisation only uses the telecommunications network to send the message and this is the same as replacing SWIFT with the telex and facsimile. The main disadvantage of this situation is that both organisations have to be attached to the SWIFT network. Because of the fact SWIFT is initiated by banking organisations from all over the world, non-banking organisations were not allowed to become a member of the SWIFT organisation. Some two years ago, SWIFT opened up this restriction by allowing a few other types of financial institutions (mutual funds organisations, exchanges, brokers etc) to become a participant and be able to use the SWIFT network. Although SWIFT is currently deciding to open up to corporates as well, corporate treasury departments are still not allowed to become participant and make use of the SWIFT network.

In figure 7 the left organisation has connected the back office information system to the SWIFT network by generating standard SWIFT messages and sending them on to the SWIFT network. They make use of a matching system which waits for the affirmation or rejection of the confirmation before updating the back office system with the corresponding status. When the confirmation is rejected a new confirmation can be send from the back office system eliminating the manual rekeying between the back office system and the SWIFT network.

In figure 8 the integration is further extended internally by integrating the front office system (dealing system) and the back office system, eliminating the rekeying of transaction information into the back office system. In order to benefit from the external integration of incorporating the SWIFT network to the back office system, the manual input of transaction information into this back office system becomes the bottleneck. By integrating front and back office and eliminating manual rekeying as much as possible organisations are prepared to meet the T+3 settlement period. When the previous integration is extended to sending settlement instructions using the

SWIFT network the whole lifecycle process can be automated using information systems. Because of the fact SWIFT opened up to securities oriented organisations they also committed themselves to the development of message standard related to the securities sector and this means developing standard settlement instructions. When organisations fully integrate the life cycle process (value chain) the following situation might be achieved. A transaction order is entered into the dealing front office system, which is to be checked through the system for risk exposures and whether the entered information is complete. The back office system generated a SWIFT transaction confirmation message which is sent to the counterparty awaiting an affirmation or rejection. This affirmation of rejection is matched and the status is updated in the back office system, which generates either a new transaction confirmation message or a settlement instruction to the custodian, based on the available information in the back office system. The custodian takes care of the clearing and settlement and reports the result (clearing and settlement with or without problems back to the back office system using SWIFT messages). The back office updates the portfolio to enable the front office to initiate new transactions based on the up to date portfolio. The same can be done for the corporate actions. The custodian (who keeps the securities) informs the investment institution about corporate actions using SWIFT and the back office system responds using SWIFT messages and send clearing and settlement instructions if needed, also using SWIFT. Based on the corporate actions, the back office systems updates the portfolio.

The situation in figure 8 is only possible when both organisations are attached to the SWIFT network and this is not yet applicable for corporate treasury departments. However, there are banking organisations (for example FX MATCH; subsidiary of CITICORP) who supply applications to these corporate treasury departments in order to enable them to receive transaction confirmations electronically. The applications use the SWIFT network and translate the SWIFT messages into readable screens on which the transaction information is shown. All treasury departments need to do is to affirm or reject the information and the application returns a SWIFT confirmation message. This data in the PC application can be integrated to the back office system of these treasury departments by using an interface between the application and the back office system (see figure 9). The problem is that this application can only be used for matching treasury transactions (foreign exchange (forex) deals) and is not yet applicable to stocks and bonds for instance. In the near future this application will be extended to currency options, but there are no plans for extensions in the direction of stocks and bonds.

In figure 10 another possibility is shown. Because of the fact SWIFT could only be used by banking organisations until a few years ago, the Industry User Group (IUG) consisting of several brokers has taken the initiative to start working on a transaction confirmation information system, specifically intended for the confirmation of securities transactions excluding treasury transactions (forex deals). There are currently three vendors which are licensed by the IUG to operationalise an ETC (Electronic Trade Confirmation) system. These vendors are the London based Thomson Financial Services with OASYS GLOBAL, The London Stock Exchange (LSE) with SEQUAL and ISMA (International Securities Market Association) with TRAX. At first they operated as competitors but since the IUG (Industry User Group) proposed an intervendor link in order to achieve critical mass, the three vendors started working together to connect to each others systems, establishing the intervendor link (fully operational by this autumn). The intervendor link should achieve the critical mass because of the fact that OASYS GLOBAL and SEQUAL are mainly used by brokers (by the end of 1994 together about 170 brokers and 60 institutions) and TRAX by about 270 institutions involved in bond markets (of which 230 are member of the Eurobond community). The disadvantage about ETC is that ETC mainly focuses on stock and bond transactions and does not include treasury transactions. The intervendor link combines the specialisation of OASYS GLOBAL on the stock market and of TRAX in the bond market, which has been one of the problems why the three vendors were not able to achieve the critical mass individually. Sequal has also agreed on linking Sequal to the Depository Trust Company (DTC) which operates a system that takes care of confirmation and settlements in the United States (London Stock Exchange 1994). When an organisation wants to trade US equities or bonds it has to use DTC. One of the big advantages of ETC is avoiding trade failures caused by information errors. Even in mature markets of HongKong, Tokyo and Singapore trade failure rates are running at between 25-30% compared to the 5-10% now being achieved in London and New York because of ETC.

Although the purpose of the systems is to confirm transactions electronically, many organisations are using the systems for transaction reporting only. Another aspect which is very important is to consider what organisations want to achieve in the future, because transaction confirmation is one of the first steps in the lifecycle. When an integrated approach involves settlement instructions as well, organisations must realise OASYS GLOBAL cannot establish a link with SWIFT because Thomson Financial Services, being a commercial vendor, cannot become a participant to SWIFT, while the other two vendors are allowed to become SWIFT participant.

SWIFT offers the most integrated exchange of information between organisations in the financial sector. However, SWIFT can only be used by organisations which are allowed to become member or participant and therefor corporate treasury departments will have to use either specific applications (FX-MATCH) or keep using telex/facsimile for confirmation purposes. ETC is not tuned to their needs because the corporate treasury departments do not make use of stocks and bonds transactions very much.

5. Evaluation & Conclusions

Based on the above case situations it has become obvious that organisations need to have a clear picture about what they want to achieve internally and which specific market forces they are confronted with, in order to maintain or strengthen their competitive position. As organisations have different opportunities in exchanging information with other organisations it is important to tune the internal motives to the external market forces. It is important to avoid using an information system for external exchange of information which can not be integrated into existing or new internal information systems. Therefore organisations need to analyze their own internal processes and redesign these processes in order to be able to choose the most applicable information system for external exchange of information.

Organisations in the financial sector still have a long way to go before a complete integration of internal and external exchange of information is implemented. In this paper three strategies were identified. Based on the securities life cycle, which can be seen as the value chain of organisations involved in investment management, we have indicated several situations to be achieved. Because every organisation is different, it is not possible to identify one of these strategies to be the best. We have tried to indicate that it is important for organisations to review their internal processes, their internal and external exchanges of information and developments in organisations with whom they exchange information in order to take the best decisions regarding business and information strategy. The situations depicted in figures 8-10 are based on the straight through processing concept and depending on the characteristics of both organisations, these situations are more efficient and effective than the figures 5-7. If an organisation develops a flexible internal system it might even be able to integrate the three options depending on the necessity and coverage of the different systems. One should realise that not every organisation with which transactions are carried out is able to use the same system your organisation has chosen.

Business Process Redesign is necessary when organisations want to exploit the possibilities offered by using information systems. In this paper, a distinction has been made between three different strategies to be used by organisations in order to integrate business processes and information systems. The framework of Venkatraman shows five levels of redesigning organisational processes based on using information technology.

When managers want to achieve major changes (one or more levels at once) they ought to apply the combined internal & external focus. When they want to achieve minor changes (incremental changes) they ought to primarily use the internal or the external focus, depending on the current status of the organisation and it's environment. When organisations focus on one of the revolutionary levels it requires BPR in order to be successful. In order to gain the necessary insight in the possibilities, organisations have to have some experience in applying Information Technology in business processes. They can gain this insight by applying theoretical models or by translating the situations and experiences of other organisations to their own organisations.

In this paper we have tried to integrate both methods by discussing theoretical models and by showing various situations to be achieved by organisations in the financial sector.

References

Bright, J.R.,"*Some Management lessons from Technological Innovations Research*", National Conference on Management of Technological Innovation, Bradford University, 1968.

CrossMar (subsidiary of Citicorp),"*FX-Match- Foreign Exchange Confirmation Matching Service*", june 1994.

Hammer, M.,"*Reengineering Work: Don't Automate, Obliterate*", Harvard Business Review, july/august 1990, page 104-112.

Hammer, M. & J. Champy,"*Reengineering the corporation - a manifesto for business revolution*", Nicholas Brealey Publishing, London, 1993.

Henderson, J.C. & N. Venkatraman,"*Strategic Alignment - A model for Organizational Transformation through Information Technology*" in T. Kochan & M. Useem (ed),"*Transforming Organizations*", Oxford University Press, 1992.

Johnson, G. & K. Scholes,"*Exploring Corporate Strategy*", Prentice Hall International, 1988.

JP Morgan & Euroclear,"*Global Custody Guide*", 1994.

London Stock Exchange, S. Young,"*Link between Sequal and DTC ID Services*", Official publication, august 30, 1994.

Morgan Guaranty Trust Company of New York, Brussels office,"*Cross-Border Clearance, Settlement and Custody: Beyond the G30 Recommendations*", june 1993

Peters, T.J.,"*Liberation Management - Necessary Disorganization for the Nanosecond Nineties*", Fawcett Columbine, New York, 1992.

Porter, M.E.,"*Competitive Strategy: techniques for analyzing industries and competitors*", The Free Press, New York, 1980.

Porter, M.E.,"*From competitive advantage to corporate strategy*", Harvard Business Review, vol. 65, nr. 3, may/june 1987.

Porter, M.E. & V.E. Millar,"*How information gives you Competitive Advantage*", Harvard Business Review, vol. 63, nr.4, july/august 1985, page 149-160.

Quinn, J.B.,"*Strategies for change: Logical Incrementalism*", Irwin, Homewood, 1980.

Quinn, J.B.."*Managing Innovation: Controlled Chaos*", Harvard Business Review, may/june 1985, page 73-84.

Suomi, R.,"*Inter-Organizational Information Systems as Company Resources*", Information and Management, nr. 15, 1988, page 105-112.

Thomson Financial Services,"ETC - Electronic Trade Confirmation", several brochures, 1992.

Venkatraman, N.,"*IT-enabled business transformation: from automation to business scope redefinition*", Sloan Management Review, winter 1994.

Factors determining the failure of global systems in the air cargo community

Ellen Christiaanse

Nijenrode University, Straatweg 25, 3621 BG Breukelen, Tel: 31-3462-91545, Fax: 31-3462-65453, Email: echristiaanse@Nijenrode.nl

Abstract

Air cargo parties are getting increasingly aware of the importance of Information Technology and they are more and more understanding the value Information Technology could provide for the total value chain performance. However, whereas in other sectors Information Technology scores big successes, there are no real signs of IT successes in the air cargo community. This paper describes the failure of global systems in the aircargo community. It draws on extensive fieldwork in the air cargo community in Europe, in addition to a review of relevant trade and academic literature. The paper provides interesting data on the IT-related dynamics in this industry. After the most important business dynamiics in this network are outlined, the paper describes a set of determinants that might account for the failing of systems in the global aircargo market. It concludes with suggestions for further research.

1. Introduction

Just like in other sectors, there is a growing attention for Information Technology in the air cargo community. Air cargo parties are getting increasingly aware of the importance of Information Technology and they are more and more understanding the value Information Technology could provide for the total value chain performance. In recent years many industries have undergone dramatic changes as a result of IT. However, whereas in other sectors Information Technology scores big successes, there are no real signs of IT successes in the air cargo community. Although a large number of attempts have been made to automate air cargo processes, it has turned out that there is really no system that truly fits the air cargo process structure and the demands of air cargo parties. King (1995) observed in this regard:

> ***"Computers are everywhere in the air cargo community but there are no comprehensive systems that tie the business across company lines."***

In the situation as it exists the air cargo community seems to be trapped in her own information technology infrastructure. The web of networks, systems, computers, programs and procedures has oppressed heavily on investment capacity without reflecting really positive results. The present information technology does not seem to fit properly to the structure of the air cargo process and the wishes of the market, resulting into a sector with 'useless' technology and a cry for distress for new systems properly fitted to the whole community. An important question to be raised is:

> ***Which factors are responsible for the fact that existing Information Technology initiatives in the air cargo community can not be considered successful ?***

Therefore, the objective of this research study is to describe the situation in the air cargo community in such a manner that from this the underlying causes for Information Technology systems 'failures' can be extracted. By providing insight in the existing information systems, the evolving dynamics in the air cargo community and the demands of different air cargo parties towards these systems we want to come up with a set of determinants of the failure of IT initiatives in the global aircargo industry. The paper will explore the determinants of such failures from a theoretical perspective as well as from insights from exploratory fieldwork that was conducted in the European Aircargo community. Some examples of failures and the possible reasons thereof will be provided and placed in a future research perspective. The paper will conclude with suggestions for further research in this area.

2. The aircargo business community

Vervaat (1994) defined the air cargo market as follows:

> ***"The relationships of buyers and sellers as a whole, directed towards achieving exchanges of money and services concerning air transport of goods from a region of departure to a region of destination".***

Based on weight air cargo only accounts for 1 per cent of total general cargo transport. However based on the market value of goods the share amounts approximately 25 per cent. Of the total $200 billion in world scheduled airline operating revenues (Air Transport World Airline Report, 1993), the air cargo industry represents a relatively small share at around $30 billion (Mc Arthy, 1991 estimate).

Already in 1975 IATA concluded that 78% of total travel time air cargo is at the airport "waiting" for transport and there are no signs that there has been much improvement since (Been and Van Diepen 1995). According to IATA this inefficiency was caused mainly by the lack of communication and integration of administrative processes. It was expected that pre-defined document standards would reduce data-entry and re-keying of information and coupling cargo systems and accounting systems will speed up billing processes and reporting procedures.

The air cargo community is a very complex community. In spite of this complexity there has been shortage of research with respect to this mode of transport as compared with other modes of transport like civil aviation. In particular passenger air transportation has been one of the most prominent examples of the use of IT for strategic advantage and electronic integration (Copeland and McKenney 1988, Christiaanse 1994b). The passenger reservation systems have provided airlines with considerable competitive advantages, because airlines gained considerable influence and control over their distribution channels. It is in fact very surprising that these (community) systems have in fact been mostly failures not only in Europe but in the US and Asia as well (King et al 1994, 1995). In the aircargo business there have been numerous examples of initiatives to replicate the success of reservation systems and the implications such systems had on airline performance and marketing practices. However none of these systems have been able to replicate the success of CRSs in the US in the 1980s (King and Forster 1994; King 1995; King and Forster 1995a and 1995b).

We will address the fact that it might not be the technology that is wrong and that it is not the fact that the aircargo community is short on talent to produce such systems but argue that the issue is the *nature of the business* instead the nature of the technology or available talent, as also indicated by King (1995) and Ritz (1995). To gain more insight into the nature of business in this setting we will discuss the most important dynamics in this business network.

3. Dynamics between the parties in this business network

Below the parties in this business network will first be described. This will be followed by an outlining of the key characteristics of the air cargo market..

3.1 The Parties in this Network

Airlines:

Two important types can be distinguished: scheduled airlines and charter airlines. Scheduled airlines are airlines performing flights based on a fixed schedule. Traditionally they take care of the airport-to-airport transport of cargo, with the help of combination planes and/or full-freighters. They traditionally sell space through forwarders, who take care of all activities before and after shipment. Next to this, scheduled airlines have been selling space to brokers and consolidators for many years now. Charter airlines perform flights from airport-to-airport on ad hoc basis, with the help of convertible freight planes. Charter airlines sell space to forwarders, but also to other airlines facing possible shortages. In practice, many air carriers can be considered a combination of these types of airlines.

The Shippers/Consignees:

Shippers and consignees together form the parties demanding the air cargo services. The difference between shippers and consignees is that whereas shippers are the ones sending the shipments, consignees are the ones receiving the shipments.

The Forwarders:

A traditional air cargo party is formed by the forwarders. Examples of large forwarders are the Dutch company Jan de Rijk and Swiss company Jacky Maeder. It is not wholly appropriate to think of forwarders as the travel agents of the air cargo community, although there are some similarities between both parties. Like travel agents, forwarders need to have perfect knowledge of prices, routes and carriers. However, the activities of the forwarders are usually more differentiated. They provide many functions on behalf of their shipper clients (Shaw 1985). The most important activity in terms of its contribution to the forwarder's profitability is that of consolidation. This activity has become so attractive to carry out, that new kinds of parties have emerged the air cargo market, fully concentrating on this activity. These parties are called brokers and consolidators.

The Brokers/Consolidators:

Brokers and consolidators buy large amounts of space from airlines and resell this bought space in smaller sizes to shippers and smaller forwarders. Brokers usually buy at an ad hoc basis, while consolidators publish a kind of schedule, in which bought space is mentioned. Another difference between brokers and consolidators is that consolidators offer additional services to shippers.

The Integrators:

The integrators form a relatively new party in the air cargo markets. An integrator can be considered a combination of an air carrier and a forwarder, having all necessary equipment (for example airplanes, trucks, etc.) at his disposal, for door -to-door services. The integrator business started in the United States, but nowadays there is also an increasing number of integrators operating in the European air cargo market. DHL and Federal Express are examples of very successful integrators.

The Logistic Service Suppliers:

Another relatively new party in the air cargo markets is formed by logistic service suppliers. These are hired by shippers to take care of the logistics management of their flows of distribution. Their primary task is to calculate the optimal logistical product route for their clients. By means of an efficient planning and control of their transport and warehousing shippers expect to achieve a decrease in total logistic costs. When using air cargo transport, logistic service suppliers buy space either through forwarders or directly from carriers.

The Customs Authority:

One party that plays an important part in air cargo transport, although not really part of the air cargo community, is the customs authority. "Customs activity is part of the distribution system and how it functions will effect the effectiveness of the system as a whole" (Smith 1974). Whereas the parties mentioned are focused on providing services to shippers, the customs authority has its primary tasks to examine, to tax and to control the movement of cargo. Therefore, customs regulations and procedures inevitably act as a restraint on the international air cargo distribution system. The air cargo industry tries to minimize the impact of customs by pressing for simplified procedures.

3.2 Key Characteristics of the Aircargo market

Market Intransparencies:

The air cargo market is characterized by a high degree of intransparency and information-asymmetries. Transparency concerns the familiarity of prices, production, sales and other market characteristics for market parties. Knowledge of this data decreases the uncertainty and the range of expectations. "In the traditional air cargo community, data transparency would transform power relations by changing information asymmetries" (Forster and King 1994). "Access to or control over information flows and power are two sides of the same coin. Most participants are well aware of it, and those who are not suffer the consequences" (Huigen 1993). For example, carriers are increasingly trying to displace forwarders by providing door-to-door services. Insight in the prices charged by forwarders would be very useful in this attempt. This information can help carriers in their presentation to the market and probably more important in setting the prices for this kind of services.

Multi-modular Transportation Strategies:

Above the most important players in the air cargo community were introduced depicted. However, nowadays differences between air cargo parties are not so clear anymore. This is mainly caused by the fact that air cargo parties are more and more expanding their services. Integration (both horizontal as well as vertical) is becoming increasingly important. Integration can be achieved in two ways. The first way is to cooperate with other parties from the same mode of transport or from other transportation modes. In the air cargo community many cooperations have been closed. For example KLM has closed a joint venture with forwarder

Frans Maas. The second way of integration is by performing activities that lie outside the scope of the traditional functions of a certain party. This process is familiar under the name 'ALIAS' - effect. In the air cargo community an enormous 'ALIAS'-effect has been taken place since the first air cargo transport activities, because new parties have entered the market and because parties have started to perform activities that lie in the scope of other parties' traditional operations. Airlines for example, have developed new markets by means of road feeder services (road transport from and to airports, airlines do not fly to) and more and more parties have started to offer logistical services. Global strategic initiatives like multi- modular transportation and value-added logistics need to be supported by IT and require insight in to the effects of these new technologies.

The above makes clear that the main strategy in the aircargo community is one of integration of services and strategies. Both vertical and horizontal integration characterizes this market, resulting in parties meeting eachother in the market place. Figure 1 below depicts the situation.

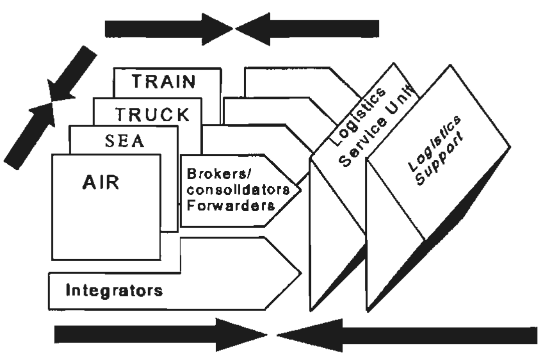

Figure 1: Dynamics in the air cargo distribution chain (Adapted from B.Grin 1994)

The Gap between Supply and Demands of Logistic Support:

Our fieldwork pointed out (Been and van Diepen 1995) that globally there is a clear gap between the demands for logistic services and the logistic support that is provided at the moment. Research by the Dutch Ministry of Transportation confirmed this (Telematics in Aircargo 1995) for the Dutch situation. The information asymmetries in the market are a clear disadvantage to those without access to the necessary information, however all parties require more information then currently is available: Shippers demand tracking and tracing information, road-transporters require optimal route information, carriers want more specific booking information, pre-arrival information and transportation documentation and customs want information on importation requests. Several initiatives in the global aircargo market have recognized this gap and have in various ways, attempted to provide these additional services. The next section will present three examples of global information systems and discuss their objectives and their achievements.

4. Global IT initiatives in this network

Based on the description of the strategies of the various parties and the above discussed characteristics, in particular the gap, we will discuss some of the attempts to computerize the aircargo community. We do not focus on the efforts of individual firms to computerize their own internal operations but will concentrate on those projects established to create global systems that can be used to co-ordinate air cargo operations across organizational and national boundaries. We will discuss: 1) cargo community systems and present Traxon as a case in point. 2) A logistic service supply initiative (Encompass) and 3) An Electronic Market initiative by a third party (Reuters) and show how each of these pre-trade and trade systems is trying to address the demands of the aircargo market, and address the gap between supply and demand of logistic support.

Cargo Community Systems:

Cargo Community Systems (CCS) are air cargo information- and communication-systems meant to integrate the administrative systems of the in air cargo involved parties. CCSs are considered trade systems as opposed by pre-trade systems such as electronic market (EM) initiatives[3]. Trade systems are used for the arrangement of a transaction. Trade systems have become common property in the air cargo industry while pre-trade systems are a very new phenomenon. CCSs serve as a clearing house of information. Two basic coordinating features of every CCS are a message switching system and an international database of supply and

[3] The most important difference between a CCS and an EM is that a CCS is a *trade* system and an EM is a *pre-trade* system. Pre-trade systems offer pre-trade information and enable buyers and sellers to expand their view of the market and to anticipate possible changes. Pre-trade systems support the processes that can bring together buyers and sellers.

booking information. In the rhetoric of the system designers, this system will span countries and organizations while remaining neutral and unbiased towards any of the many interest groups (King and Forster 1994). However, the reality of CCSs is quite different from the vision. Forwarders look suspiciously upon CCSs as attempts by powerful alliances to either lock them in or to bypass them entirely by placing terminals in the offices of their shippers. A large number of CCSs has been introduced all over the world. But none of these systems has generated the number of subscribers required to create network externalities in the larger community, or the number of transactions needed to achieve economies of scale in processing (Foster and King 1994). Why are these systems not successful? King and Forster (1994) note:

> ***" The difficult part has been getting companies to join the systems on a permanent basis. To succeed, a CCS requires all relevant parties to enter their supply and booking information into the system and make it available for other to use. This creates two problems: First , it is expensive and second , information asymmetries play a role"*** **(King and Forster 1995, p.23)**

Traxon as an example[4]:

In April 1990, Air France, Cathay Pacific, Japan Airlines and Lufthansa set up a joint venture to build a Global Logistic System (GLS) which was to be owned and operated by an independent company. Lufthansa is the world's largest scheduled cargo carrier, second only to Federal Express, the market leader among the integrators. It is commonly estimate that the four airlines jointly invested approximately $500 million in the set -up of the Cargo distribution system and the GLS company owning it (Mecham and Proctor 1990). The system was called Traxon. The heart of Traxon Europe is formed by a message switch that is owned and operated by the GLS Europe company, headquartered in Frankfurt, Germany. By the end of March 1994, thirteen carriers were accessible to participating forwarders. At the same time approximately 210 freight forwarders were connected to Traxon.

In short, the purpose of Traxon is to improve the quality of service and the circumstances of transport by improving communication between carriers and forwarders in air cargo. According to the initiators of Traxon, in this way carriers and forwarders will be able to compete with integrators more accurately. To achieve this goal they need to have the airline office, at the point of destination, retrieve information from forwarders on the final delivery of

[4] This material is coming from a case study reported by Ritz (1995) and is used with permission from the author.

the cargo. In the development stage of the system two other important goals were defined, namely the creation of central databases and achieving door-to-door functionality, but in 1992 these two goals were abandoned. One of the ways that door-to-door functionality could be achieved is by making the traditional airway bill an "electronic airway bill". Due to problems implementing an exclusively *electronic* airway bill this was abandoned. However as our conclusions will outline, an important aspect of the traditional aircargo chain was that cargo *fysically* needed to be accompanied by the airway bill, something that however can be questioned and might be one of the reasons that aircargo is waiting a significant amount of total travel time at airports.

Table 1: Chronological Project history of Traxon (Adapted from Ritz 1995)

1983	Drawing up of a conception for a freight data exchange system by Lufthansa
1984	Decision to implement the proposed system
1987	Specification of a conception for a multi airline switch (MOSAIK)
1988	Issue of a request for proposals for hard and software suppliers
1989	MOSAIK operational with Lufthansa being the only airline connected
1990	Signing of a memorandum of understanding between Air France Cathay pacific, Japan Airliners and Lufthansa regarding the setup of a Global Logistics system (GLS)
April 1990	Foundation of the GLS project group Europe company as the first of currently three distribution centers worldwide.
January 1992	Commercial Start -up of Traxon
1995	Traxon links 15 member airlines with 1370 forwarders around the world (Airline Business April 1995)

In Hong Kong, Traxon Asia has invested in TCN (Transportation Community Network), a company that will handle surface shipment information, not only for forwarders, shippers and consignees but also for financial institutions (Airline Business, April 1995).

Evaluation:

In general forwarders are reluctant to adopt systems that might lock them in, and therefore the system is not as successful as was expected. Ritz (1995) concludes "After almost two and a half years of commercial operation, Traxon is a large network in terms of access connections and messages transmitted. However, despite the size of the network, the average coverage of its target market remains relatively low. Most forwarders are currently making rather low usage of the system despite the fact that the majority of them is host-to-host connected. The volume of message traffic remains lower than previously forecasted. In particular the number of airway bills transmitted is still substantially below expectations" (Ritz 1995. pp 239).

Logistic service systems: Encompass

An important example of a logistic service system is *Encompass*, which is an initiative of American Airlines, Seaworld and the Dutch PTT and was developed as an answer to the 'failure' of the traditional CCSs in the United States and Europe. This initiative is aimed at providing logistic support for the full distribution chain (sea, road and air cargo transport). In fact, Encompass has tried to create a system similar to the in-house systems of the integrators. Like almost all IT initiatives in the air cargo world, this information method is based on the principles of EDI. This worldwide system was not meant to replace the cargo reservation systems, but to enhance these systems. Encompass has been developed to solve the problems of the diversity in modes of communication existing among forwarders, shippers, carriers and so on and to make it possible for international trading partners to communicate electronically through a single, neutral interface, regardless of the type of computer systems the companies use internally or where they are located. It is meant to "become the new mode of correspondence, replacing telephones and facsimiles, and provide, along with a paperless system, the ability to perform shipment planning, bookings and inventory management and the use of a multimodal path finder" (Air Cargo World, July 1992).

Evaluation:

The system is not as successful as was expected. From the moment that Encompass became operational to serve air cargo processes, carriers have been playing a waiting game and therefore not enough carriers are connected. In addition, forwarders try to hold up Encompass, because the system is not in their interests. As a result, "instead of a door-to -door logistical control system it appears that it will be more an aircargo Official Airlines Guide (OAG)" (Forster and King 1994 p 8).

The Reuters Electronic Market Initiative[5]:

In 1992 Reuters, the world-wide press agency and supplier of business information services, started developing an electronic information system on behalf of parties in the spot-markets for air cargo space. The so-called Reuters-initiative is an international initiative with terminals in Amsterdam, London, Paris and Frankfurt. It is primarily meant to be placed between the forwarders and the carriers. The fact that prices are now completely set in the market and not regulated by IATA any longer provides a good opportunity to develop an information system for the spot-market for air cargo space.

The content of the information system consists of a scrolling news page consisting of general and specific air cargo news, a summary of all available business information, such as oil prices and exchange rates, and most important, a summary of indicative price quotes input by sellers showing demand.

The Reuters-initiative is focused on creating a symmetric transparency in the air cargo market. In the situation before the Reuters-initiative the markets for air cargo can be called extremely non-transparent. There are a great number of different market parties, each with his own exploitation problem. Uncertainty about their own situation of capacity compared with the market situation and fear for mutual price underbidding cause mysteriousness and in-transparency between airlines. On the other hand there is much more transparency for buyers in the markets for air cargo. For them there are replaceable alternatives. They have knowledge of prices and price differences by shopping. This higher transparency for buyers then for sellers causes a heavy price-competition, because sellers react (too) slow to changes in market conditions. Higher transparency causes a decrease in uncertainty and because of this a more efficient tuning between demand and supply. The creation of a symmetric transparency causes the possibility for the sellers to react to changing circumstances more quickly. In micro-economical terms this means the sellers are capable of being more price-elastic because of a better view on the market (Vervaat, 1994).

Evaluation:

The information system has run on trial at the airport Schiphol from august 1993 to January 1994. In the system there was no trade. It was completely filled with *pre-trade* information. The

[5] This section is based on an earlier paper describing the failure of this electronic market initiative and was published in the Proceedings of the European Conference of Information Systems in Athens May 1995.

information system has not been given much support. In the financial world the reactions where very positive, but in the branch of industry itself parties were very opposed to the Reuters-initiative. The following objections were provided during field interviews: The *forwarders* had serious doubts related to a fear for the elimination of the forwarder and a fear for decreasing margins due to increasing transparency of the market. In addition the negative attitude in general towards electronic business has played an important role. The reaction of the *carriers* has not been positive either. They are of opinion that the initiators of the Reuters-EMP have overlooked a few important facts (Grin, 1994). For instance, air carriers claim the demand and supply for air cargo space are quite unseparable. In addition the Alias-effect is playing a role according to the carriers: it is not possible to make a clear cut distinction between different parties in this business network. Some forwarders act like carriers by buying large bulks of capacity and then reselling it. As a result of these conflicting interests it was concluded that there is no viability for the system if the parties concerned refuse to cooperate.

Figure 2 below depicts the evolution of IT initiatives in this sector. As can be seen systems were first used for internal purposes only as efficiency tools, later in the 1980s they were increasingly used as trade support systems, while most recently in the 1990s in particular systems that provide pre-trade information such as electronic markets are being developed. Each of the systems described above can be placed in this phasemodel.

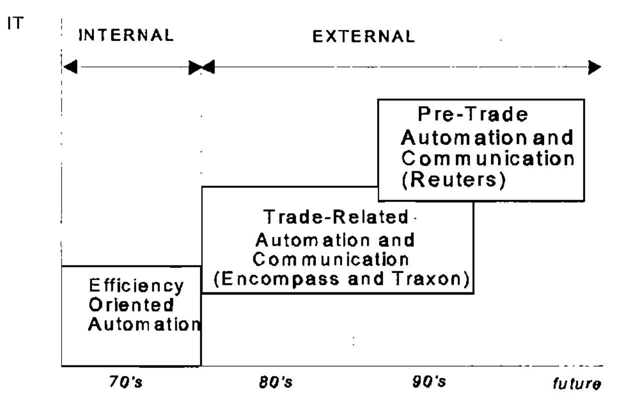

Figure 2: Automation in the air cargo distribution chain

5. Determinants of IT initiatives/failures

Summing up the reasons behind the failures, we argue that in these cases the complex, interdependent institutional and technical choices were not conceptualized by the initiators of the system in terms of their competitive implications. The instability of the social structure in this business network and the dynamics of this particular market were inadequately represented in the design of the systems, which each to a large extend where aiming to derive benefits from the reduction of market intransparency. The systems were inadequately embedded in the social systems they would have to support which was illustrated by the conflicting interests of the various parties involved. The existing competitive structure of the business network that needed to support the development and operation of these global initiatives significantly inhibited the operation and success of these systems. The institutional dimensions of the context of implementation added complexity and inertia which made the implementation more complex than the initiators of the systems would wish. The technical capabilities of the systems were not the factors that inhibited the cooperation of the parties in the business network but the competitive environment with its work practices, commitments, and routines were not taken into account. From our research to the use of Information Technology in the air cargo community has clearly turned out that in the present-day situation information systems do not really match with the structure of the air cargo process and the needs and wishes of the air cargo parties. We will now discuss some key determinants we believe are underlying these global systems failures.

Determinant 1: Information Asymmetries Between Air Cargo Parties

The air cargo market is characterized by a high degree of intransparancy which creates substantial market inefficiencies. However these market intransparencies as we discussed are in the interset of some of the parties in this market place. The existence of information asymmetries represent the structure of power relationships in this industry and implies that air cargo parties are focused on taking advantage of the disposal over information that other parties do not have. Especially concerning price information, the air cargo community is characterized by mysteriousness. Among air cargo parties is great fear for disclosure of prices and this has resulted in a strong refusal of every system that is focused on providing price information in the air cargo community such as the Reuters initiative. Forwarders in particular are deriving their main reason for existence from these intransparencies which was one of the reasons to hold up the logistic service system Encompass. In the present-day situation the forwarders still have a far more extensive knowledge of the distribution process as shippers do. The information asymmetry is in this case clearly in favour of the forwarders.

In the case of the Reuters initiative we argued based on previous research (Bakos 1991, 1993) that electronic markets usually favor the buyers and reduce sellers' profits and market power. From this point of view it is predictable that sellers would want to stay away from systems that emphasize price information. Besides objections of the sellers in this case also the buyers had stakes that the system would interfere with. Altogether there was a lot of uncertainty involved in particular regarding the outcomes of the system.

Initiators of the Reuters-initiative noticed that the carriers fear for losing control over the market. Carriers obviously don't want to be pushed back to a homogeneous or commodity market. They are afraid the system will lower their margins even further. In general, theory states that an EMP usually benefits the buyer, because of decreasing total search costs.

Determinant 2: Conflicting Business Strategies

A second determinant of global systems failures can be found in conflicting business strategies. Through time, the degree of vertical competition has heavily increased, caused by the enormous growth in the number of operating parties in the air cargo community and the overcapacity in this industry. Not only has the number of forwarders and carriers grown, but moreover the diversity in service offering parties has largely increased. Next to the increasing vertical competition, we have also discussed an increasingly upcoming *horizontal* competition, which means competition between different modes of transport. An important aspect in this is that there is presence of an increasing variation of transport modes within one transportation process. An example is the more and more upcoming sea-air concept. There has already been mentioned that a very important development that has taken place can be found in the integration between different phases in the distribution chain. This means that parties try to get control over a larger part of the distribution chain and are meeting eachother in competition in the market place.

These developments of horizontal and vertical competition and integration are responsible for complicating the air cargo information process, and therefore for complicating the automation of this process. One important problem is formed by the air waybill. In fact, the electronic air waybill is an exact copy of the traditional paper air waybill and is thus purely focused on the airport-to-airport transport of goods. This is conflicting with the clear observable trend in the direction of door-to-door strategies controlled by one single air cargo party. This means that the (electronic) air waybill is based on an "old" situation in this distribution chain.

It can be concluded that at this moment there is a very complex market structure, which creates market inefficiencies and makes is hard to design systems that support the information flows between parties in this network. This complexity will in our opinion still be strengthened since parties in the air cargo market will certainly continue adapting their business strategies in the near future. The integration process is a still continuing phenomenon and the question of how this can be supported by IT becomes increasingly important

Determinant 3: Discrepancy Between Physical Air Cargo Flows And Information Flows

In our opinion, one of the most important underlying causes for the fact that the information systems in the air cargo community often show functional shortcomings can be found in the discrepancy between the physical flows of air cargo products and related information flows. This discrepancy mainly concerns the complexity of the structure of the (air) cargo transport related information flows as opposed to the structure of the physical flow of goods. This complexity makes it extremely difficult to develop an information system that functionally fits the air cargo market. In figure 3 both the physical flow of goods as well as the information flows in the (traditional) air cargo distribution chain are depicted. This figure shows that the movement of the physical flow of goods is a (almost) straight forward process. However, whereas physical goods follow a one way, sequential path, the information flows related to these products have an unstructured, multi-directional character. This complicated nature of the flows of information causes serious barriers for the automation of the information process with concern to air cargo transport. First, in advance of the development of information systems it is crucial to have insight in the organization of the information process that has to be automated. The complicated nature of the information flows in the air cargo community hamper the insight in the entire information process related to air cargo transport. An example of this unstructured nature can be found in the absence of standardization of bookings.[6] There is no existence of a standard air cargo booking. Even if all different handling possibilities are input in an information system, it is possible that shippers have deviating wishes.

[6] On the issue of standardization of aircargo services (see also Forster and King 1994)

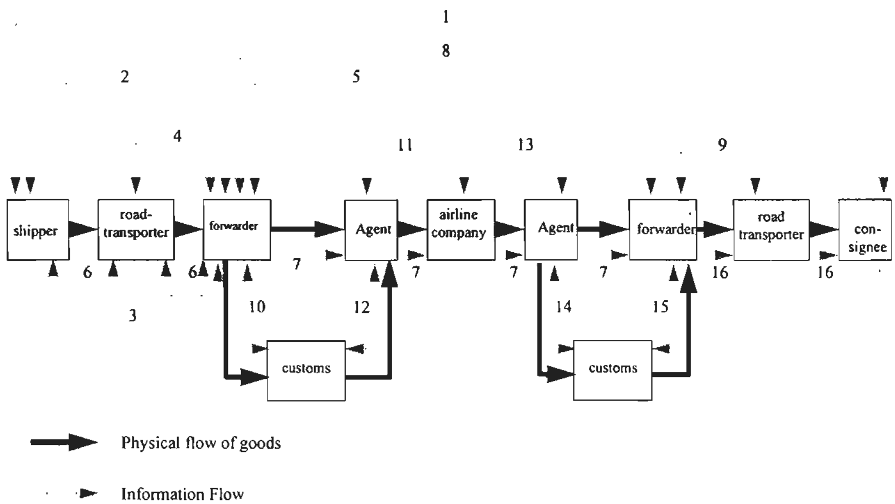

Figure 3: Information flows in the traditional intercontinental air cargo chain (Adapted from Zijp (1995): 'telematics in air cargo')

1. Consignee places an order at the shipper and he confirms the receipt of the order;
2. Shipper places a transport order at the forwarder and the confirms the receipt of the order;
3. Shipper passes on shipping instructions to the forwarder;
4. Forwarder reserves and books freight capacity at the road transporter and he confirms the reservation and booking;
5. Forwarder reserves and books freight capacity at the airline company and he confirms the reservation and booking;
6. Forwarder makes up the bill of lading for road transporter and this document goes with the freight during the road transport;
7. Forwarder makes up an AirWay Bill and this document goes with the air freight from one airport to the other;
8. Forwarder gives an assignment to the forwarder at the airport of destination, to reserve and book freight capacity at the road transporter and he confirms the receipt of this assignment;
9. Foreign forwarder reserves and books freight capacity at the road transporter and he confirms the reservation and booking;

10. Forwarder supplies information about the air freight sending (at 'House AirWay Bill'-level) at the customs and the customs provides the forwarder with de necessary documents;
11. Airline company provides the agent with a bookinglist of a specific flight;
12. Agent gives information about the load of a specific flight to the customs and the customs gives a confirmation to the agent;
13. Airline company provides agent with details about the load of a specific flight on the airport of destination;
14. Agent at the airport of destination gives details about the load of a specific flight to the customs and the customs gives a confirmation back;
15. Forwarder at the airport of destination provides the customs there with details about the load and gets information about this from the customs in return;
16. Forwarder at the airport of destination makes up a bill of lading for road transporter there and this document goes with the freight during the road transport.

The black arrows refer to the fysical movement of cargo between the parties in this network while the grey arrows refer to the information flows between members in this network. It should be clear that the movement of cargo is of a sequential nature and that the information flows can be done parallel. An example might be the clearing of goods at customs, often mentioned as a bottle neck during fieldwork by parties in the network. The administrative information flows related to customs do not necessarily have to take place parallel to the fysical movement of cargo. In other words there can be a flow of information parallel to the flow of goods within this chain.

6. Concluding remarks and suggestions for further research

Figure 4 below depicts how each of the systems described in this paper attempts to control/ provide a particular part of the information flows in the aircargo distribution chain. An important observation is that increasingly parties outside the direct business network are trying to address the gap between supply and demand for information services in this network.

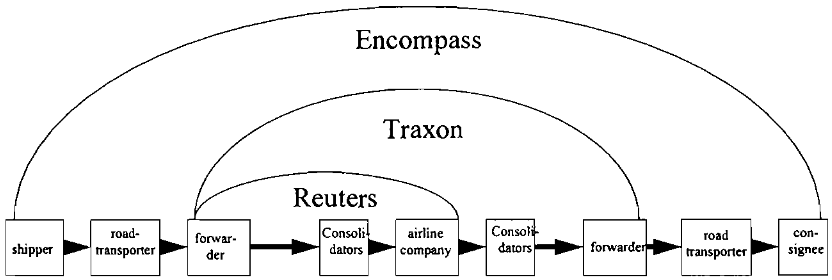

Figure 4: IT initiatives in the global air cargo chain

The situation scetched in this paper poses several important questions and provides many opportunities for future research. The following research suggestions we consider as the most important ones:

The first important issue concerns the possibility of designing a single system for this complex community. The complexity of the community and the competitive environment might make it hard to develop a system that meets all parties' needs and stimulates involvement and disclosure of necessary information. This raises the question: Is it possible to design a system that will support the information flows and that will be supported by the parties in this network? Forster and King note: "*The aircargo community operates on a manner predicated on a heterogeneous and flexible network of alliances and competitive practices. Any attempt to build an infrastructure that fails to conform those practices that embody the economic rationality of the industry will almost certainly fail*" (King and Forster 1995d). The question remains how do you build such a system and what would be the requirements?

Another important issue is: What will be the role of local government in global competition? In global competition in aircargo, a certain airport or region might lose its importance if a relatively nearby community offers cheaper and more efficient cargo handling facilities. This might have far-reaching consequences for a country and /or its competitive positioning. Should governments introduce standards and enforce cooperation among parties or should this be totally left to the market? Examples like the Tradenet system (King and Konsynski 1991) that in Singapore link together all the 3000 air, land and sea forwarders, carriers and agents doing business in Singapore, used a powerful authoritarian government as important implementer. The system however is strictly local and cannot be compared to globally operating CCSs with multiple governments involved.

Would there be a difference in obtaining acceptance of systems that are more oriented towards trade related information instead of pre-trade related systems? Might it be easier to get acceptance for a trade related system that, as opposed to a pre-trade system, does not contain any price information and therefore has fewer competitive implications? A government institution might want to decide to leave pre-trade system initiatives to the market while actively trying to stimulate trade systems that make the distribution of cargo services more efficient and effective.

A related issue is: Who should be in control of the information flows and what could be the consequences? Can the success of the integrators be explained by the fact that they have full control over their own (internal) information flows supporting their door-to-door strategies? Are there hardly any coordination or transaction costs and inefficiencies involved since there is full control over internal information flows?

Our exploratory description of the aircargo community and its systems might raise more questions than they solve. We see this exploratory fieldwork however as a necessary step in doing more rigorous testing of some of the here posed questions and hypothesis. We hope that this paper will stimulate further discussion and empirical research along these lines.

References

Anonymous, " Opening Lines of Communication", *Air Cargo World*, July 1st, 1992.

Bakos, J.Y.; *Reducing buyer search costs: implications for electronic markets*; Graduate School of Management; University of California, Irvine; July 1993

Bakos, J.Y.; *Information Links and Electronic Marketplaces: The Role of Interorganizational Information Systems in Vertical Markets*; 1991

Balakirsky, J.R.; Een uitdaging voor banken: Electronic Data Interchange (in Dutch); *Bank- en effectenbedrijf,* december 1990

Bauer, A.; Head Business Unit IT; KLM Cargo (personal interview april 1994)

Beck, S.; Project manager; Martinair (personal interview march 1995)

Been, J. and Diepen, T. van; *Information Technology in the Air Cargo Community, A research to the explanations for systems 'failures'*; Unpublished paper; july 1995

Blommestein, F.B.E.; Berenschot Informatica; Senior advisor; Stress Congress; May 10th, 1995

Bouw, Drs. P.; *Het Tiende Internationale Forum voor Luchtvracht* (in Dutch); KLM; september 30th-october 3th

Bruin, K.J.; Business Analyst; KLM Cargo (personal interview may 1994)

Buck Consultants International; *Netwerken en ruimtelijke patronen van bedrijvigheid: een sectorale benadering*

Cargonaut; *Cargonaut "Hoe het werkt" een verkennend onderzoek naar informatienetwerken en werknemersbelangen* (in Dutch); Uitgave van: het FNV Steunpunt Technologie; March 1991

Christiaanse, E.; *Strategic Advantage and the Exploitability of Information Technology, An Empirical Study of the Effects of IT on Supplier-Distributor Relationships in the US Airline Industry*; june 15th 1994; Thesis Publishers Amsterdam 1994

Clemons, E.K. and Kimbrough, S.; Information Systems,Telecommunications, and their Effects on Industrial Organization; *Proceedings of the Seventh International Conference on Information Systems*; San Diego; CA; December 1986; pp. 181-194

Cooper, J., Browne, M. and Peters, M.; *European Logistics, Markets, Management and Strategy*; Second edition

Crombach, K.J.; Channel Manager IT; KLM Cargo (personal interview april 1994)

Gastwirth, J.L.; *On Probabilistic Models of Consumer Search for Information*; Unpublished paper; 1971

Gorsuch, J.; EDI: The Buzz-Phrase Acquires True Meaning AtLast; *Air Cargo World*; December 1993

Grin, B.; Ontwikkelingen in de luchtvracht; *Tijdschrift voor Vervoerswetenschappen* (in Dutch);1990, 03/26

Grin, B.; Director Cargo Development; KLM Cargo (personal interview march, april 1994, march 1995)

Hamerslag, R. en Weenink, A.J.H.; *Vervoerslogistieke Werkdagen 1989* (in Dutch); Congres-centrum Maaspoort te Venlo; october 10th and 11th 1989

Hoitink, a.; Director of Cargonaut (personal interview may 1994)

Hoogstraten, P.W.M.A.; KPN Multimedia; Vice President; Stress Congress; may 10th, 1995

Huigen, J.; Information and communication technology in the context of policy networks; *Technology in Society*; Vol. 15; pp. 327-338; 1993

IATA; *IATA World Air Transport Statistics*; 1993

King, J.L.; Forster, P.W.; *Information Infrastructure Standards in Heterogeneous Sectors: Lessons from the Worldwide Air Cargo Community*; 1994

King, J.L., Gurbaxani, V., Kraemer, K.L.; Institutional Factors in Information Technology Innovation; *Information systems Research*, December 1993

King, J.L.(a); First Steps; *Cargovision*; KLM Cargo; january1995

King, J.L.(b); Considering the Community; *Cargovision*; KLM Cargo; february 1995

King, J.L.(c); The Heart of the Matter; *Cargovision*; KLM Cargo; march 1995

King, J.L.(d); Only connect; *Cargovision*; KLM Cargo; april 1995

Kroezen, C.W.; Andersen Consulting; Manager Consumer Products; Stress Congress; may 10th, 1995

Ligon, G.C., e.a.; Technology Strategy: EDI and Global Air Express; *International Journal of Physical Distribution & Logistics Management*; Vol.22 No.8, 1992; pp.43-48; MCB University Press; 0960-0035

Lang, L.; EDI Systems Work Well, But Not With Each Other; *Air Cargo World*; december 1th, 1991

Maaren, Drs. H.C. van and Gelpke, Drs. P.A.; EDIFACT De integratie van transportinformatie (in Dutch); *Tijdschrift voor vervoerswetenschappen*

Mann, P.; Programmer Analyst; KLM Cargo (personal interview may 1994)

McCarthy, D.; Airfreight forwarders; *Transportation Quarterly*; 1986; 97-108

Nas, J.C..; Rabobank Netherlands; Telematica business group; Stress Congress; may 10th, 1995

O'Connor, W.E.; *An Introduction to Airline Economics*; Praeger; New York; 1978

Oosterhuis, P.C.; IBM Holland; Program Manager European Dial Services; Stress Congress; may 10th, 1995

Rijn, R. van; System developer; Martinair (personal interview march 1995)

Ritz D. “The Strart-up of an EDI Network- A Comparative CaseStudy in the Aircargo Industry. Unpublished doctoral dissertation, number 1675, Bamberg, 1995.

Roos, Prof. Dr. H.B.; *"Halen!"* (in Dutch); KPMG Klynveld Management Consultants; june 5th 1992

Roos, Prof. Dr. H.B.; *Op de hoogte van Luchtvracht* (in Dutch); Department of Airline economy; Universiteit van Amsterdam; Amsterdam, februari 1993

Roos; Prof. Dr. H.B.; Department of Airline Economy UvA; (personal interview april 1994)

Rosenkötter, H.G.; Electronic Banking in de praktijk brengen (in Dutch); *Bank- en effectenbedrijf*, october 1989

Rossum, I.K.M. van ; Area Manager (a.i.) Europe and Africa; KLM Cargo (personal interview may 1994)

Rothschild, M.; Searching for the Lowest Price When the Distribution Price is Unknown; *Journal of Political Economy* (82); 1974; pp. 689-711

Salop, S.; Monopolistic Competition with Outside Goods; *Bell Journal of Economics*; 10; 1979; pp.141-156

Shaw, S.; *Airline Marketing and Management*; Pittman; London; 1985

Smith, P.S.; *AIR FREIGHT Operations, Marketing and Economics*; 1974; Faber and Faber Limited; London

Soekkha, H.M., Bovy, P.H.L., Drewe, P., Jansen,G.R.M.; Telematics - Transportation and Spatial Development; *Proceedings of an International Symposium organized under the auspices of the Centre for Transportation Engineering*; The Netherlands, The Hague, April 14-15, 1988

Stelt, H. van der and Leenen, M.R.; Effectief vernieuwen met informatietechnologie (in Dutch); *Bank- en effectenbedrijf*; september 1994

Stroeken, J.; Informatietechnologie bevordert integratie banken en bedrijven (in Dutch); *Bank- en effectenbedrijf*, june 1994

Swagerman, D.M. and Linden, G.F. van der; Electronic banking in 1988 (in Dutch); *Bank- en effectenbedrijf*; october 1988

Tanja, P.T. and Smook, J.; Telematica en logistiek Een analyse van informatiesystemen in het vervoer geplaatst in de logistieke omgeving (in Dutch); *Nederlandse organisatie voor toegepast natuurwetenschappelijk onderzoek*; Instituut voor Ruimtelijke Organisatie TNO; Delft; may 1989

Vervaat, S., van der Laan, D.H., Roos, H.B.; *De economische betekenis van Schiphol* (in Dutch); Department of Airline economy; Amsterdam; 1992

Vervaat, S.; *Concurrentie & Transparantie in Luchtvrachtmarkten, een onderzoek naar de toegenomen concurrentie en de effecten van meer transparantie in luchtvrachtmarkten* (in Dutch); Department of Airline economy; UVA; Amsterdam, march 1994

Vroom, Drs. P.; De hoge vlucht van de luchtvracht (in Dutch); *Tijdschrift voor Vervoerswetenschappen* 1990, 26/3

Werkhoven, L.; Network manager Cargonaut; Cargonaut (personal interview march 1995)

Wit, J.G. de & Gent, H.A. van; *Vervoers- en verkeerseconomie* (in Dutch); Stenfert Kroese; Leiden; 1986

Wit, J.G. de; *Integrators, de logistieke comakers van de toekomst ?* (in Dutch); 's-Gravenhage, Rijksluchtvaartdienst; 1989

Zegwaart, E. & Jurg, P.; Het Internet in meer detail (in Dutch); *Informatie en Informatiebeleid*; page 19-40; 1994 No.4

M. Zijp , "Telematics in Aircargo" Report for the Dutch Ministry of Transportation 1995.

EDI: Electronic distribution of information products

Bas H.P.J. Vermeer

Eindhoven University of Technology, P.O. box 513, 5600 MB Eindhoven, The Netherlands, bve@tm.tue.nl
Bakkenist Management Consultants, P.O. Box 23103, 1100 DP Amsterdam, The Netherlands, bvermeer@bakkenist.nl

Abstract

Although EDI is finally becoming successful, the massive use of EDI creates new problems like orders with outdated article numbers, price differences between expected and received invoices etc. These problems result from the poor synchronization of product information in business chains. Synchronization requires product information to be communicated between the different parties in the chain. Since this is another kind of communication than transaction communication, it should also be treated that way. In this paper a different approach to the communication of product information is introduced, based on the electronic distribution of information products. This approach is currently applied in a project considering an information warehouse.

1. Introduction

1.1 Bad synchronization of product information

Goodsflows in business chains are becoming highly automated using Electronic Data Interchange (EDI) and scanning. For instance, in a modern supermarket groceries are registered at the check-out with the aid of scanners. The check-out automatically produces a bill, that can be electronically paid with the use of Personal Identification Code cards (PIN-cards) or credit cards. At the end of each day, total sales are electronically sent to the Distribution Centre, that automatically generates new (EDI) orders for the manufacturers. The use of EDI and scanning techniques has resulted in an enormous acceleration of the goodsflow in the food chain, shortening the averaged lead-time between the sale in the outlet and delivery to less than 24 hours today!

This process doesn't stop at the supermarket. Also the chemist's, the DIY (Do It Yourself) shops, the book shops and the CD shops are using scanning and EDI. Apparently, EDI and scanning are finally becoming massively used instruments in business chains.

However, the massive use of scanning and EDI in business chains also creates new problems. In supermarkets, for instance, arguments between customers and cashiers about errors in the cash-out bill have not vanished. These errors do not result from typing errors of the cashier, but because of the use of EDI: The product information in the Product Look up tables (PLU's) inside the cash-outs do not match the scanned product. This means that cash-outs use the wrong prices, or just do not recognize the product. As a result customers are becoming unsatisfied and distrust the new technology.

A short field study in the fast moving consumer goods sector (Vermeer1995.1) reveiled that inside the business chain problems with the poor quality of product information are even more manifest. Some examples are:

- Suppliers who receive orders referring to outdated, or even non-existent, products;
- Retailers ordering 5 pallets of beer and instead receiving 5 truckloads of it;
- Warehouses having a dynamic stock allocation system that allocates a box of tomatoketchup to a full palletplace; Or even worse, the other way around.

A full list of problems that were found is shown in table 1.

1. Orders with outdated product numbers
2. Missing numbers in product look up tables (PLU') or product databases
3. Indistinctnesses about packing units
4. Processing of order updates because of product- or packing unit problems
5. Lagging behind with entering price lists
6. Reception of different goods than ordered
7. Price differences between expected and actual invoice
8. Problems due to differences in internal codes and standard EAN-product identification codes

Table 1: Problems with product data in the fast moving consumer goods sector

The reason these problems exist is that the product information at the different stages of the supply chain is not synchronized, meaning that different parties in the supplychain, who are referring to the same product, do not have the same information about that product.

1.2 Practical solutions

To solve this synchronization problem of product information several solutions are currently investigated. The international EDI standardization organizations have developed the PRICAT message (PRIce-CATalogue). With this message organizations in a business chain are now able to electronically communicate product and price information. However, the field study showed that the poor quality of the product information resulted from the fact that (Vermeer, 1995.1):

- product and price updates are hardly ever on time, in the right format, or complete;
- organizations are overflowed with product information they do not need;

The use of an electronic product message will not prevent this from happening because it by no means guarantees that the product information is right, nor does it provide for synchronisation mechanisms on chain level to guarantee that it is delivered on time or in the right format. In fact, the PRICAT message is nothing more than an electronic vehicle to transport the product information.

A more chain oriented approach of the problem is intended by the creation of national product databases. However, since these databases contain both product and price information, this leads to great resistance from parts of the business chain because it means that the market could become undesirable transparent. a customer, for instance, can easily check which supplier delivers which product at what price. That would lead to, for suppliers undesirable, shopping which means that the supplier-customer relation is disturbed. These (supposed) fears restrict the application-possibilities of these databases. Even worse, they hamper a structural solution.

Therefore, although several solutions are currently under investigation, non of them is expected to solve the synchronisation problem of product information in business chains. However, this is very important, because if the product information is not synchronised, the quality of the information at the different stages in the business chain remains poor. Together with the increasing use of EDI, this will result in an increasing number of failed transactions.

Since transactions are the basis for doing business, this problem is a direct threat to the further deployment of EDI.

The focus of this paper is to find solutions that effectively deal with the problem of synchronization of productinformation in business chains, thus supporting transaction communication.

1.3 Structure of this paper

The paper is structured as follows: First, the difference between object communication and transaction communication is introduced, which causes the problem of synchronisation in business chains. Then we present our approach to the problem, which is based on the distribution of information products. The basics of this approach were applied in the Information Warehouse project which is desribed in section 4, after which conclusions follow.

2. Object communication

2.1 Transaction communication versus object communication

For years the focus of EDI was on the implementation of electronic messages. Van de Vlist for instance defines EDI as the automated, electronic interchange of standardized and normalized *messages* between computer systems of different organizations (Vlist1991).

However, focusing on messages is not enough to realize effective inter-organizational information interchange. Eltink emphasizes the relation of EDI with the business process by defining EDI as a business tool to support the realization of the business strategy (Eltink1992). Davenport also stresses the importance of information to the business process (Davenport1993). Therefore, EDI should be extended by introducing:

- Business logic. Messages originate from business processes, which means that for designing information interchange in business chains the business processes should be the major input. This viewpoint is the basis for the Open EDI reference model, that is currently defined by the international EDI standardization bodies (ISO/IEC JTC 1/SC30,1995);

- Communication logic. Messages are not independently communicated, but there is always some kind of logical sequence between them. Hofman introduces this communication logic in EDI communication by using communication protocols (Hofman1994).

Since the basic element of interaction between business processes are transactions, we define the direct communication between business processes as transaction communication. Although these concepts will improve transaction communication, they will not solve the problem of synchronizing product information in business chains. Synchronization means that the product information itself has to be communicated in the business chain. This kind of communication is not the same as transaction communication. The difference is that the goal of this kind of communication is not about exchanging data about real world objects, but in fact about exhanging the representation of a real world object as it is defined and recorded in the information systems of an organization. Communicating this objectinformation could be looked at as sharing the view on the real world between computer systems of different organizations. This kind of communication guarantees that communicating business processes attach the same meaning to the information they are exchanging and therefore guarantees the semantics of the data interchange. Thus, communicating object information is not the same as transaction communication. In fact it supports transaction communication because the transactions are referring to the product information.. We will define the communication of objectinformation between business processes that serve as a reference point for transactions to guarantee the semantics of the data interchange as object communication. The difference between object communication and transaction communication is illustrated by figure 1.

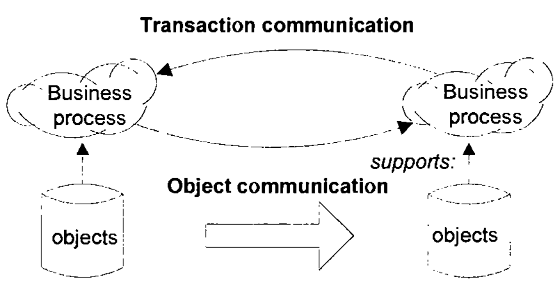

Figure 1: Object communication versus transaction communication

2.2 Characteristics of object information

The main problem with object communication is that the subject of the communication, which is the object information, has three characteristics, that we currently do not account for in the communication process.

- First of all, the object information is owned by a party, namely the supplier. This means that the information is not freely available, since the supplier has an interest in what happens with it.
- Secondly, the object information has a certain quality. This quality is determined by the degree the object information is in conformity with the specifications of the receiver;
- Finally, the object information itself is strongly dependent on the business process it is used in. Although this seems trivial in practice it is not. In today's business chains the ordering process for instance can be divided in at least two sub processes:
    - The process of assortment management, where a purchaser decides to add or delete products;
    - The call off process, where a stock management system generates new orders.

  For the first process completely different product information is needed as for the second process. A purchaser wants specific information about new products, prices, and discounts. Also, he might need visualised information to make a good decision. The stock mangement system only needs the product number, the ordering quantity, the packing unit and, depending on the specific contract, the price. However, in our current product information communication processes, this distinction is not made. This means that the intention of the communication is no longer clear, which implies that the owner of the product information will not release it. This also implies that the quality of the object information is difficult to establish. Therefore, object information should be well defined.

As a result the communication of object information in business chains is strongly hampered because we do not account for the existence of these 3 characteristics.

3. A different approach: distribution of information products

In our research we propose a different approach to the problem of object communication in business chains. A first impulse of this approach was earlier described in (Vermeer, 1995.2).

3.1 Information products

The essence of the approach is to view the problem of communication of objectinformation in business chains from a different viewpoint. As we saw before, object information is owned by a party, it has a certain quality and finally, it needs to be clearly identified and defined. These are all characteristics typically related to physical products. Therefore, the approach starts with considering object information as a special kind of products: informaiton products. This is depicted in figure 2.

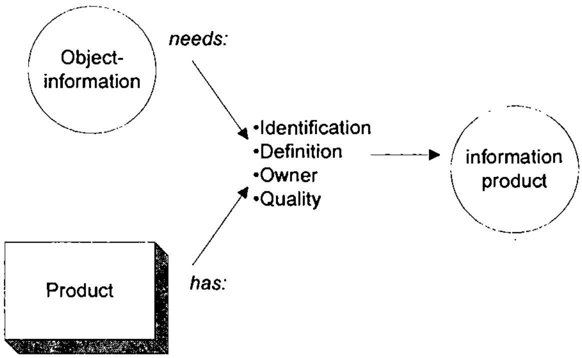

Figure 2: Information products

The concept of information products makes it possible to consider the problem of object communication in a business chain as a distribution problem of information products. This makes it a common, day to day problem, that the different parties in the business chain are familiar with.

3.2 The distribution process

Considering object communication in business chains as a distribution problem of information products provides us with some important concepts that are common knowledge in normal distribution processes. These concepts are:

- the concept of customers. This makes us realize that there is not one 'standard' customer, but in fact there are many different customers who all have different requirements for the same information products. For instance, a small hometown shopkeeper probably has a different way of ordering products than a major retailer, and therefore may have different requirements for the same kind of product information;

- the concept of production. This means that suppliers have to perform some kind of effort to produce the required information in the specified form, before it is distributed. This concept provides a supplier with the possibility to outsource 'production', depending on the costs and the importance of the information;
- the concept of contracts. Contracts mean that a supplier and a customer make an explicit agreement under which conditions the information will be delivered. This means that the customer now is able to explicitly specify what he wants. However, even more important is the fact that a contract forces both parties to explicitly consider how the information will be delivered, meaning that they have to consider what procedures have to be followed.

Together, these 3 concepts form basic elements in the distribution process of information products, which is depicted in figure 3.

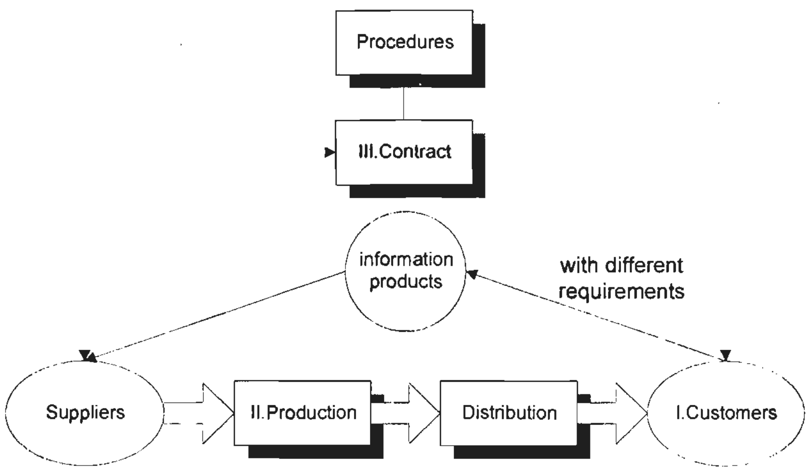

Figure 3: The distribution process of information products

3.4 A method for designing communication infrastructures

The proposed approach is a useful starting point for designing infrastructures for object communication in business chains. The design method we propose consists of 3 steps:

- In the first step the information products are identified, which means that the required object information flows between different parties are explicitly defined;

- In the second step the logical design of the object information flow is established, which means that the production and distribution structure of each flow is organized. Here contracts are defined, procedures are established, different distribution structures are evaluated etc.
- In the third step, the technical design is established, which means that a matching communication infrastructure is defined. In this step the network and protocols are chosen, messages are established, required hardware is selected etc. In fact, this last step is a translation of the logical design in infrastructural requirements.

This design method is represented by figure 4.

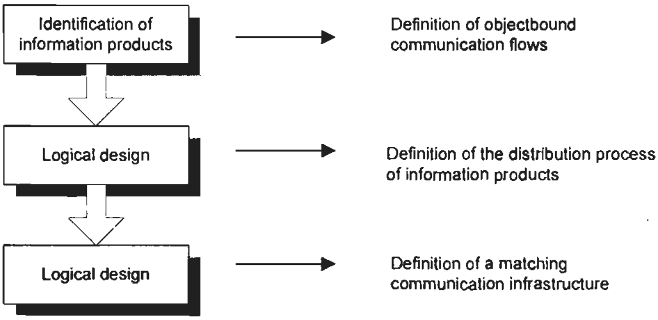

Figure 4: Design method for object communication

The main advantage of considering object communication as a distribution problem of information products, is that it translates the technical problem of how to connect computer systems in a business chain for object communication using EDI into an organizational problem of how to manage information flows. In fact, this suggests that EDI should stand for Electronic Distribution of Information products instead of Electronic Data Interchange.

4. Applying the concept: the Information Warehouse project

4.1 Project outline

The Dutch pharmaceutical sector for some time now uses EDI in the ordering process, mainly between suppliers and wholesalers. In this sector the problem of inconsistent product databases at different stages in the supply chain is well known. Especially the wholesalers are having problems with inconsistencies in product information, because their warehouses are highly automated. Therefore a Dutch company, ACF Holding N.V. has started a pilot project with 5 suppliers to deal with this problem. In the project the principles of our approach have been applied.

4.2 The solution: an Information Warehouse

The problem with synchronization of product information in the business chain was redefined using the design method for object communication.

Identification of the information product

As we saw before, it is very important to relate object information to what it is intended for, which means we unambiguously have to define what exactly we mean with product information. First of all, the problem with inconsistencies in product information appears mainly in the ordering process, which in the pharmaceutical sector is mainly triggered by a stock management system. Therefore, the product information is narrowed to just the product information that support the automatic generation of orders by computers

However, a further distinction is necessary between basic product information and commercial information, such as prices and conditions. We define basic product information as only the information that is on the package of the product. The same basic product information is needed by many different customers, while commercial information is customer specific. Thus basic product information implies multilateral communication, while commercial information implies bilateral communication, which means that both require a different distribution method. This narrowing process is represented by figure 5.

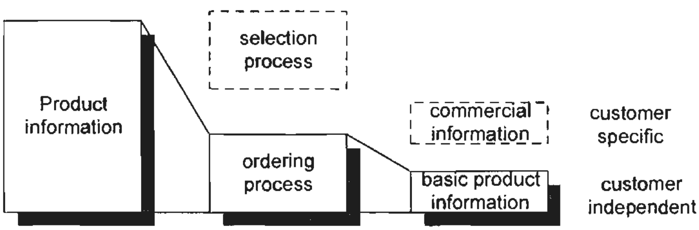

Figure 5: Narrowing the definition

Logical Design

in the logical design phase we have to determine how the information product will be generated and distributed. Also the contracts and the resulting procedures are examined. To

establish the production and distribution structure, we can use the concept of Customer Order Decoupling Points (CODB), which is the point from where production is determined by customer orders [Bertrand, 1990]. In fact, at the CODB production meets demand.
Using this concept we can determine 3 different structures (see figure 6):

- Make to order
  In this structure the supplier produces the basic product information exactly to customer requirements, meaning that the customer may define exactly how he wants the basic product information generated (in what form, what quality and even which attributes), and how it is delivered (how often, only items he is interested in);
- Make to stock
  In this structure production is standardized, which means that the basic product information is generated in a standardized form against a standard quality. Only distribution is still customer specific;
- Production and distribution to stock
  In this structure the customer receives all basic product information in a standardized form a fixed number of times per month. Furthermore, the information also needs to go through a final filtering process.

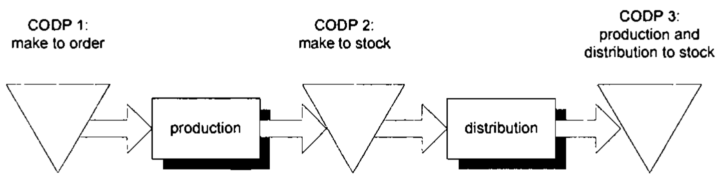

Figure 6: Three different structures

In our situation the make to stock structure seems to provide the best solution. Since commercial information is left out, the basic product information itself is very much the same for all the parties in the sector. Also because the information is used by the stock management system, the required quality of the information is very high for every party. However, each party may have many different requirements concerning the delivery of the information. For instance, the frequency of use determines how often the information is required, which can be very different for each party. Also, each party only wants update information on their own assortment, which also requires customized distribution. Therefore in the project the

Information Warehouse was proposed, which functions as a decoupling point between information suppliers and customers.

In short, the working of the information warehouse is as follows:
Each supplier places its entire assortment in the warehouse and is responsible for maintaining their own information. Each customer can indicate for which products they want to receive updates, which normally is the total assortment the customer has. It should be noted that the supplier is also able to indicate who may or may not receive their basic product information. This logical concept is depicted in figure 7. A more extensive description of the information warehouse is provided by Aerts [Aerts, 1995].

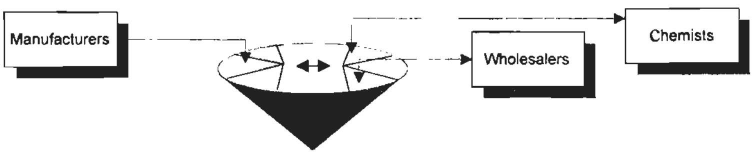

Figure 7: The logical concept of the information warehouse

The main advantage of placing the CODP between supplier and customer is that suppliers and customers do not have to make a contract for each bilateral contact, which greatly simplifies the required procedure. In fact, each supplier needs to use 1 standard procedure to deliver the product information to the warehouse. Each customer has a specific procedure with the information warehouse.

Technical design
In the project the information warehouse is physically realized as a central database. However, whether this is the best solution is not clear. Maybe an index database, or even a completely decentralized structure may give better results. Therefore the information warehouse project will be evaluated to determine the costs.

4.3 Discussion

So far we found the following advantages of the information warehouse concept:
1. The Information Warehouse guarantees that the basic product information, used in transactions is synchronized through the whole business chain. Especially the natural gap between the manufacturer and the chemist's is bridged over;
2. Procedures are significantly simplified;

3. In fact the information warehouse provides for an infrastructure, which through the concept becomes a shared responsibility of all parties in the business chain.

However, it should be realized that the information warehouse does not support commercial product information exchange, which is absolutely necessary to effectively support the ordering process. Without a proper solution for this aspect, the automatic ordering process is still unstable.

5. Conclusions

In today's business chains EDI and scanning finally are becoming accepted tools in business chains. However, this also leads to new kinds of problems, resulting from the poor synchronization of product information in business chains.

Currently studied approaches, such as the PRICAT message or national product databases, however do not solve this problem. The main reason is that no distinction is made between transaction communication and object communication, which supports the transactions between business processes. Object communication has 3 characteristics, namely, an owner, quality and a clear definition that our current EDI communication processes do not account for. Since these characteristics are similar to product characteristics, we propose a different approach to the problem through defining object information as an information product. This means that the problem is redefined as a distribution problem of information products.

This approach promises good results because it transfers the problem of poor synchronization of product information in business chains to a well known situation, namely a common distribution situation. The approach is currently applied in the information warehouse project. As a first result it appears that redefining the problem is easy, which means that the approach is in fact applicable. Furthermore, the approach resulted in a clear narrowing down of the problem, and also provided 3 possible distribution solutions.

Therefore it is concluded that the approach appears to be useful, because the concepts in the approach provide management with an instrument to clearly define and discuss the problems with object communication, thus transferring the technical problem of how to synchronize product information in business chains to an organizational problem.

References

Aerts A.T.M., Pustjens M.J.H., Veth A.F.L.; *Improving the quality of information exchange in a business chain;* paper presented at the workshop on ..in Trontheim

Bertrand J.W.M., Wortmann J.C., Wijngaard J.; *Production control and material management*; Stenfert Kroese, Leiden, The Netherlands; 1990 (in Dutch).

Davenport T.H.; *Process innovation: reenginieering work through Information Technology;* Harvard Business School Press; Boston Massachussets; 1993

Eltink P.; *The EDIal supplier, A model for extending your EDI communication process;* Final thesis at the school of Enschede, section business informatics; The Netherlands; 1992

Hofman W.J.; *A conceptual model of a business transaction management system*; Tutein Nolthenius; Den Bosch, The Netherlands; 1994

ISO/IEC JTC 1/SC30; *Numbered version of ISO/IEC CD 14662 Information Technology - Open EDI Reference Model* -; Working Document; maart 1995

Vlist P. van der *et al.*; *EDI in trade;* Samson Bedrijfsinformatie; Alphen aan den Rijn, The Netherlands; 1991 (in Dutch)

Vermeer B.H.P.J.; *Products are not alike! - Analysis of non-consistent product information in the fast moving consumer goods sector;* Research paper, Eindhoven University of Technology, 1995; ref 1 (in Dutch)

Vermeer B.H.P.J., Jansen M.H.; *Distribution of product information in business chains, a case study;* paper presented at the CIMMOD/CIMDEV conference 'CIM at work', Eindhoven, the Netherlands; 1995; ref 2

Virual corporations in transport

Willeke Van der Werf

Ministry of Transport, Public Works and Water Management, Transport Research Centre (AVV), Freight Transport Division (VLG), P.O.Box 1031, 3000 BA Rotterdam, The Netherlands, Tel: +31 10 2825687, Fax: +31 10 2825643

Abstract

Telematics/EDI reduces the impact of time and place on business processes. This has consequences for the relevance of organisational boundaries, the business process and for the working-organisation as well, since this leads to ad hoc policy following every incoming order (Vervest 1994). New competitive advantages are enabled by this new business-process. Because of the increasing importance of telematic linkages between organisations in logistic chains, emerging of organisations playing a role in linking organisations by telematics, so called virtual organisations, seems to be obvious in transport, where transport links' organisations. This paper firstly describes the virtual organisation phenomena, based on literature-study. Secondly, assumptions are made on the impact of virtual organisations in the transport sector, to regenerate more specific research questions.

1. Introduction

In transport, companies deal with the pressure of foreign competition because of ongoing internationalization. Searching for new strategies, companies started in the eighties a policy called 'Back to Core Business.' Outsourcing was one of the major activities in answer to new market demands like efficiency, speed and quality to reach more customer service. Logistic innovations were implemented, like door-to-door-delivery and just-in-time-management. Also stimulated by the rise of the European Community, with a decreasing interest of European internal frontiers, a need is felt reconsidering strategic positions. To strengthen the position of Dutch transport, strategies of specialisation and alliances seem to be the most successful

(ATKearney 1993; Van Riet 1993). Alliances in the value-chain arose. These alliances were both supported and enabled by telematics. Since EDI enables organisations to link their administrative organisation, it is assumed that EDI plays a major role in this field.

2. Objectives and research questions

Not much is known about the future impact of virtual organisations on the transport sector. Therefore a study that explores developments connected with virtual organisations is useful for policy decisions. The main objective of this research is to find out whether the Dutch Ministry of Traffic and Transport should reconsider their policy on telematics in goods-transport. This policy aims at increasing the competitive position of Dutch transport companies, especially by supporting the use of telematics. This research wants to find a better understanding of the importance of virtual organisations in transport, and the role of telematics in it.

In this paper, I will try to answer the following questions, based on literature-study. This is difficult due to lack of information about the virtual organisation phenomena in transport. As this paper proceeds, questions for further research will be formulated, as a guide to the actual research project.

1. What is a virtual corporation?
2. What will be the impact of virtual corporations on future transport? (market-structure, logistic demand, telematic needs, cultural aspects and competitive position)

3. Virtual corporations

3.1 Definitions of virtual corporations

There are many definitions of virtual organisations. The United Communications Group (1993) defines a virtual organisation as:

> An enterprise created by linking, via information technology, businesses, suppliers, customers and/or partner companies to take advantage of specific business opportunities.

Nagel and Bhargava (1994) define a virtual organisation as:

> A means of responding to market opportunities with minimum dedicated resources and diversified risk. It is an aggregation of the requisite expertise and facilities that are transparent to functional departmentation and corporate confines.

Wexler (1993) defines a virtual organisation as:

> 1. An association of employers and employees not united at all times by a physical work environment
> 2. An association of different companies able to come together temporarily through benefit of communications technology to achieve a common mission.

Nagel and Allen (1993) define a virtual organisation as:

> A network of independent companies linked by the free flow of information.

Hopland (1993) defines a virtual organisation as:

> An enterprise that can marshal more resources than it currently has on its own, using collaborations both inside and outside its boundaries.

3.2 Two approaches to virtual organisations

As shown from the definitions of Hopland versus Nagel and Allen there are two ways to look at virtual organizations. The first one is from an organizational point of view: What type of organisation is a virtual organisation? What are the characteristics of a virtual organisation?

Secondly, a virtual organisation can be looked upon from the purposes' point of view. This leads to the question: 'For what strategic purposes are virtual organisations created'? This makes it possible to distinguish developments to virtual organisations and a network approach.

3.2.1 An organisation-type approach

Approaching virtual organisations from the 'organisation-types' point of view leads to the following characteristics. Virtual organisations are network-organisations. They are flat and flexible and use short communication lines to fullfil speed demands (Vogt 1994). Virtual organisations work on a project base. The result is a task-orientated working organisation following every incoming order. A comparison can be made with the characteristics of flexible organisations (Kuipers 1995). Virtual organisations not only enclose flexibility on the product-organisation level, but also on logistics, information technology and cultural factors such as work-organisation and labour.

On product-organisation virtual organisations have the following characteristics. Virtual organisations have no means of production of their own. Depending on the order or the marketing-idea a chain of organisations, or an interorganisational network is created to meet market-demands.

Logistics Daskin (1995) may be defined as: 'the design and operation of the physical, managerial and informational systems needed to allow goods to overcome time and space'. To virtual organisations, logistics are part of a network-chain that as well as the product-organisation is subjected to the principles of customer services. The availability of information about products and processes is inevitable to provide customer service.

Information Technology plays a role in enabling organisations to realize the organisational goals by providing the systems that links organisations together. In these linking, new shapes of customer services can be developed or innovated. Since the virtual organisation is a network-organisation, it is highly dependent on information technology. This information technology is not only applied in supply and demand of resources and products, but also in the administrative process, research and development etcetera. Controlling information-flow enables controlling the flow of goods as well as the business-process and logistics.

Cultural factors, ideas about management and work, decide the structure of the virtual organisation. In virtual organisations organisation-structures are flexible and ad hoc. 'Ad-hocracy' is a leading management idea. Therefore, there is no middle management, although recently there is a revival of the important role of 'some' middle management. In practice, this means that workers in virtual organisations are highly responsible for their work. This responsibility not only involves the quality and speed of the work, but also the working conditions of work and the gaining of work, since virtual organisations 'hire' people on project-basis. In working relations there is much equality, caused by the fact that different partners in a virtual organisation have an agreement on task division in the project.

Conclusions on aspects in the area of product-organisation, logistics, information technology and cultural factors are the tendency to flexibilisation. This way, virtual organisations are the summit of flexible organisations. Compared to indicators to decide the level of flexibility (Kuipers 1995), a virtual organisation appears to be an idealtype.

From an organisation level the virtual organisation is the director of a chain withdrawn from a network. Here the virtual organisation has no means of production of its own (Figure 1). From a network level a virtual organisation also encloses organisations with means of production. The virtual organisation with only directing activities plays a part in the chain as well as all other organisations. Therefore, the virtual organisation can be mentioned as an idealtype. A network is always formed for strategic purposes. Organisations are more or less virtual depending on a stage of development to virtual organisation (next paragraph) or choose to specialize on core business, with remains of the means of production. Not all organisations can develop to virtual organisations according to the idealtype, because somewhere the work has to be done.

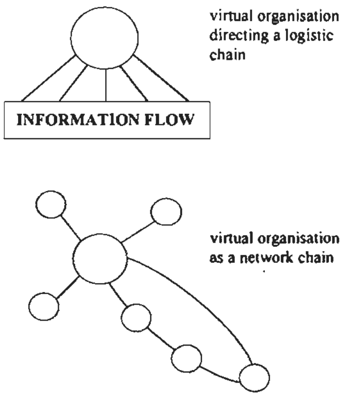

Figure 1

3.2.2 A strategic-purposes approach

From the purposes' point of view virtual organisation can be seen as a management tool to reach competitive advantages as more customer services. A virtual corporation is seen as the management model of the future. In this way, outsourcing is only the first step to spontaneous partnerships (Byrne 1993). If a virtual organisation is seen as an idea for strategic goals, flexibilisation plays a major part in it. The organisational structure of virtual corporations enables alliances, though ad hoc composition of organisations linked together may vary from project to project.

Looking upon the existing organisations as organisations which have different virtual characteristics, a development raise apparently elusive virtual organisations can be recognized (see figure 2).

According to Venkatraman (1994) there is a development in information systems from localized exploitation (island automation) to internal integration of information technology systems, to business process redesign, to business network redesign, to business scope redefinition. This shows the development from automation as a tool for administrative processes to information technology as a tool for strategic ideas. In this way, a virtual organisation is an organisation that is most adapted to reach customer service.

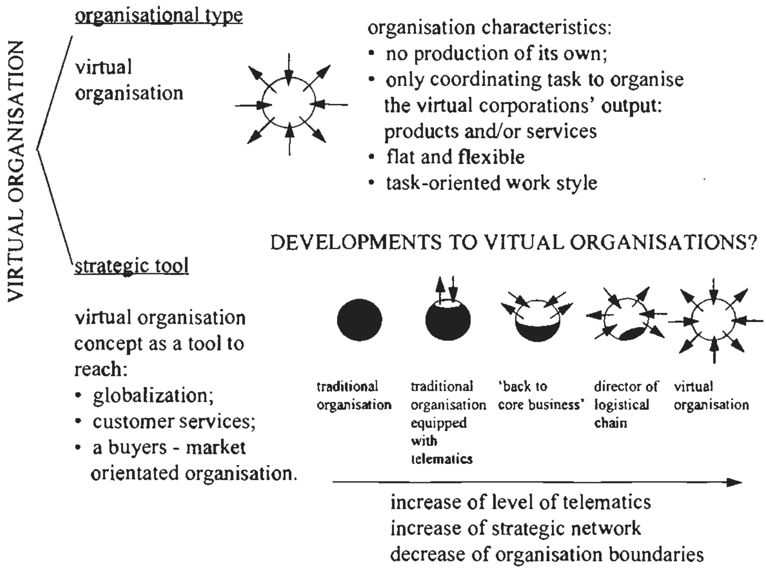

Figure 2

Virtual organisations can use two main tools to achieve their strategical goals. First, competitive advantage can be reached by arrangements in the organisation structure. This is the case in product-organisations as well as in organisational structure and labour-arrangements.

Secondly, competitive advantage can be reached by technological improvements.

Both organisational structure and technological quality decide not only competitional strength, but also the corporations' possibilities in logistics.

As to strategy by organisation structure, arrangements in the product-organisation have reference to the possibilities to influence the speed, diversity and quality of the production by changes in the production-process or in the network-chain.

Arrangements in the organisation-structure in relation to labor is aimed at flexibilisation of the work-force. This means flexibility in organisation-structures as well as in communication-lines and attention to quality in skills and creativity of the members of a project-team. In the political and societal context must be a positive attitude towards these developments to formulate supportive legislation.

As to strategy by information technology, virtual corporations depend on two main aspects. First they depend on the level of cooperation with other organisations. This decides the size and quality of the network on which the virtual organisation depends. Secondly, the quality of the technological system, used by the virtual corporation for information-handling and links with other corporations.

3.3 Workdefinition of a virtual organisation

Since this paper aims at developments connected with the emerge of coordinating organisations, the workdefintion of a virtual organisation in this paper is:

An organisation that increasingly:

- controls cargo-flow by controlling information-flow
- controls information-flow to innovate customer-service
- is highly dependent on information technology
- is operating in an interorganisational network
- is highly flexible.

4. Virtual organisations and transport

4.1 Characteristics of Dutch (international) transportation

In Dutch transport, a small group of companies has a very large market share. These companies have modern management. Most examples of successful application of information technology can be found in this category. These companies aim at improving their services, often by specialization.

On the other hand there is a large group of very small companies that are often traditional family-run companies. There is almost no application of information technology in this group.

Dutch transport companies have an excellent quality of services. On the other hand transport costs are high because of this high standard of service.

Information technology in transport has so far been applied on electronic systems for delivery services as booking services, giving information on the status of the freight (tracking and tracing) and electronic orders. It is also applied on stock-keeping and administrative actions.

4.2 Virtual organisations, a few examples in relation to transport

Do virtual organisations exist? And do they exist in transportation? Here follow a few examples. For a large period, shipping-agencies have offered services in the area of gathering and co-ordinating of information. Because of the services of the shipping-agencies, there was no need for freight-forwarders to look for a ship for the cargo or for shipowners to look for cargo. This kind of customer-service to freight-forwarders has not always been supported by telematics. The other elements of the workdefinition of virtual organisations however are applicable. Ever since the introduction of information technology in shipping agencies, they can be seen as virtual organisations according to the workdefinition.

A director of a logistic chain in transportation is often a road haulage company structured by specialization strategy. The organisation still supplies freight transportation as a basic service, but specialized on one kind of freight. Whenever specialized, they try to expand and innovate the costumers-service in the logistic-chain from manufacturing enterprise to retail traders. The chain director takes care of the whole process of transportation and added values. According to the workdefinition of this paper, a director of a logistic chain is a virtual organisation.

In transportation is a rise of strategic alliances. A kind of strategic alliance is co-makership. This is the case if two (or more) organisations link together for a determined period to achieve competitive advantage. The question is whether or not co-makership relations fit in the idea of a virtual organisation. According to the workdefinition of virtual organisations these organisations dealing with co-makership are flexible than a director of a logistic chain. The structure of the co-makershiprelation implies less flexibility because the agreement to cooperate covers a determined period. Though co-makershiprelations are less flexible than ad hoc relations, an advantage can be reached by such a relationship. The tendency up to strategic alliances fits, as well as the tendency to use more information technology, in the virtual organisation concept.

Because of the emerge of strategic alliances in interorganisational networks organisational boundaries disappear. A director of a logistic chain in transport can still have an own transportation unit. It is also possible that they specialize in directing tasks and become a virtual organisation as in the idealtype. This organisation can easily add manufacturing tasks to the organisational network. On the other hand, manufacturing industries can easily add logistic services to their organisational network. Either way, there is a tendency towards the loosing relevance of organisational boundaries. With the rise of the virtual organisation concept the old concepts as 'manufacturing industry' and 'transport company' loose their relevance. Instead in future there will be '...-manufacturing-orientated industries' and '...-transport-orientated companies'.

4.3 Assumed implications of virtual organisations on transport

In this paragraph I will generate some questions (possible research topics) in order to support the decision-making on the final research questions.

4.3.1 Implications in the area of information technology

To find technologic advantage, the virtual organisation (transport or non-transport) has to solve difficulties in the following area.

- the structure of the electronic messages
- the capacity, speed and flexibility of the Information Technology System
- the tuning of different information systems of organisations linked together.

Not only different information systems, but also different organisational structures can stand in another organisations' perspective: In virtual organisations, it is not always easy to overcome interoperatability problems, especially between organisations of dissimilar architectures (United Communications Group 1993).

Whenever a virtual organisation is seen as an idealtype in flexibility, the problems these organisations will have on implementation of new telematics will probably be comparable with those of non-virtual organisations in this area. The need for telematics will also be comparable.

4.3.2 Logistic implications

Some questions to pay attention to in relation to logistic implications:

- In a chain of organisations dealing with virtual activities, it is not always clear who is responsible for what part of the product or service, especially when the product or service contains much ideas. Not only the technological system needs securing, but also the regeneration of ideas. Whenever two people from different virtual organisations in one logistical chain working together to develop an idea, who can be held responsible for faults. Who will become the credits?
- Are there differences in power between virtual organisations? What possibilities for negotiation do depend virtual organisations have? Does real equality exist between virtual organisations once they are working on a project, or is there as much competition and dependency as there is in the phase of acquiring a project?
- The idea of innovating customers services ask for more transport-movements. So it is likely that the emerge of virtual organisations, aiming at innovating customer-services, goes along with a rise of transport movements. A rise of transport-movements may also occur because of the elusive character of virtual organisations, or will the efficiency in information technology probably solve this problem?

3.4.3 Cultural implications in relation to virtual organisations

Virtual organisations ask an interorganisational entrepreneurship from their employees. As noticed, this asks much creativity and responsiblity from employees. This may lead to more equality among employees. On the other hand, not every worker probably can behave like an entrepreneur in a project. The part of the workforce that can not cope with the severe demands of entrepreneurschip in a virtual organisation might find them in remains of traditional organisations, directed by virtual organisations. Their working conditions might destabilize in confrontation with the ad hoc policy of the directing virtual organisations, leading to a lot of short lasting or flexible work-arrangements.

Advantages from the workers point of view are more flexibility in executing the job and more equality among partners in a virtual organisation.

Disadvantages from the workers point of view are: less certainty about the continuation of work and income. They become highly dependent on ad hoc policy, which may effect in changing working-relationship and the loss of depending social structures.

Conclusion is that a virtual organisation asks for a new cultural interpretation of the place and impact of work, in an organisational context, as well as in societal and political context.

3.4.4 Impact on the structure of future transport market

The impact of virtual organisations on the structure of the future transport market seems to be most relevant for small transport companies. Large companies may acquire a place in the interorganisational network between virtual and non virtual companies, especially when the latter has a system for electronic communication with the former. Because of the lack on information technology in small transport companies, it seems, certainly in the long term, to be a potential problem especially for those companies with no telematics at all.

3.4.5 Impact on competitional strength of Dutch Transport

Some questions.

- The question arises whether a virtual organisation will really benefit from its concept. Application and implementation of information technology are very expensive. The investments are not always paying. They are especially not paying in case of contradictive workers'attitudes.
- Another question is if a virtual organisation is the addition of another layer on top of the existing system, only pushing op the prices, because service always has a price.

5. Research activities

At this stage the activities still are supporting the discussion on the final priority-setting in research topics.

References

Alter A.E.: Getting your assets in gear. *CIO* vol 6 (1993) nr 7, SS3-SS5.

ATKearney: *Logistics Excellence in Europe* (1993).

Byrne J.A.: The futurist who fathered the ideas. *Business Weekly* (1993), iss. 3304, Febr 8th 1993, p.103.

Daskin, M.S.: Logistics: An overview of the state of the art and perspectives on future research. *Transport Research-A* 19A (1985), nr 5/6, 383-398.

Egeraat D.H. van: Revieuw of Dutch Telematics Policy 1990/1991. In: *Advanced Transport Telematics, Proceedings of 19th Seminar on European Transport, Highways and Planning.* (1991)

Gopal C., Cahill G. *Logistics in Manufacturing.* Illinois, 1992.

Hopland, in: United Communications Group

Nagel R., Allen D.: Virtual Winners. *International Management* Vol 48 (1993), nr 5, June 1993, p.64.

Kuipers, B. *Flexible Production-organisations: Operationalisation.* (Flexibele Productie-organisaties: operationalisering) (unpubl.), Transport Research Centre, Rotterdam, 1995.

Nagel R., Bhargava P.: Agility, The Ultimate Requirement for World-Class Manufacturing Performance. *National Productivity Review,* Summer 1994, 331-340.

United Communications Group: Making Alliances and Partnerships Work. *(I/S Analyzer)* vol 31 (1993), nr 10

Van Riet J. c.a.: *The Transporter of the Future,* (De vervoerder van de toekomst) TNO, Delft, 1993.

Vervest, P.H.M., *Communication, no automation,* (Communiceren, niet informatiseren) (inaugur.) Erasmus Universiteit, Rotterdam, 1994.

Venkatraman, N.: IT-enabled business transformation: from automation to business scope redefinition. *Sloan Management Review,* winter 1994.

Vogt G.G.: The virtual company (De Virtuele onderneming). *PEMselect* vol. 10 (1994), nr 3.

Wexler, J.M.: Ties That Bind. *Computerworld,* june 28, 1993.

Obstacles for the development of open electronic commerce[7]

Roger W.H. Bons*, Ronald M. Lee* & René W. Wagenaar**

* Erasmus University Research Institute for Decision and Information Systems (EURIDIS) & Rotterdam School of Management, Dept. of Decision- and Information Sciences, Erasmus University Rotterdam, PO Box 1738, 3000 DR Rotterdam, the Netherlands, Tel. 31-10-4082601, Email: <first initial>.<lastname>@fac.fbk.eur.nl

** Free University Amsterdam and KPN Research, Leidschendam, The Netherlands, Tel: 31 70 3325365, Fax: 31 70 3326166, E-mail: R.W.Wagenaar@research.kpn.com

Abstract

Although the developments in information and communication technology offer tremendous opportunities for companies to engage in open electronic commerce, some issues still need to be resolved. First, the necessity to establish a bi-lateral agreements before the first electronic message can be exchanged should be minimised. Second, it should be possible to exchange legally binding documents (performatives). Finally, the increased commercial risk introduced by trading with unknown partners should be covered as well. This paper presents how our research contributes to the work on Open-edi and discusses some tentative research results to enable the exchange of electronic performative documents. Also, some directions towards the establishment of electronic documentary credit procedures are given. Finally, some conclusions are drawn and further research directions are given.

1. Introduction

The current developments in information and communication technology, such as Electronic Data Interchange (EDI) and the massive growth of inter-company electronic networks (for example Internet) will offer tremendous new possibilities for international trade. The search

[7] This paper has also been presented and published at the ninth international conference on EDI-IOS in June 1996, Slovenia

costs for new trading partners are being decreased continuously, enabling companies to participate in global electronic trading. Especially small and medium enterprises (SMEs) could benefit from these new opportunities.

Open electronic commerce refers to a situation in which traders can conduct business with each other electronically without the need to first specify detailed bi-lateral agreements to govern the exchange of information. Such agreements are currently still needed to connect each other's technical systems, but also to cover security and legal aspects. Furthermore, conducting business over an electronic network implies that parties must be able to create commitments by exchanging electronic messages. Finally, finding new trading partners is easier through the use of information and communication technology implies that the commercial risks of payment and delivery may become higher. This paper contributes to remove these obstacles in the development of open electronic commerce.

The first obstacle we address is the current need for the Interchange Agreement. In such an agreement, parties specify how they will exchange EDI messages. The Interchange Agreement therefore includes stipulations on the requirements on the technical implementation, the types of message to be used, security issues, etc. (Mitrakas 1995). Although model agreements could be used to speed up this negotiation process, parties still have to negotiate using conventional communication means before they can start conducting their business electronically. Clearly, this does not encourage a truly open electronic environment.

The second obstacle addressed in this paper is of a more legal nature. In international trade the purpose of sending documents is not only to exchange information (*informative*), but may also be to change the commitments among parties. The latter type of communication is referred to as *performative*, introduced by Austin (1962) and extended by Searle (1969). Furthermore, in some cases the possession of a document entitles the holder to some specific right, for example the right to claim goods. This right can then be transferred by transferring that document. These types of performative documents are referred to as *negotiable*. Since the possibilities to copy electronic documents are unlimited, new solutions have to be found to implement electronic performative and/or negotiable messages.

The third obstacle deals with the commercial risks caused by trading in a more open fashion. Traditionally, the buyer's risk of not getting the products and the seller's risk of not getting paid are covered using the 'documentary credit procedure'. Unfortunately, this procedure is still mainly paper-based. The underlying principle however could very well be used for open electronic commerce as well.

Section 2 deals with the need for the bilateral Interchange Agreement. Section 3 deals with the exchange of electronic performative documents. Section 4 combines the solutions from Section 2 and 3 and discusses some issues for the establishment of electronic documentary credit procedures. Finally, conclusions are drawn and directions for further research are given in Section 5.

2. The need for a bi-lateral Interchange Agreement

In many cases long and costly negotiations are necessary between trading partners before they can exchange their first EDI message[8]. One of the reasons for the complexity of this negotiation process is the fact that parties have to know about each others' 'way of doing business' before they can start exchanging data electronically. Extra knowledge about the preferred way of doing business of one trading partner has to be conveyed to the other; in other words, the parties have to agree upon the *trade procedure*[9] they are going to follow.

One approach to decrease the negotiation costs is to define standard trade procedures. Although EDI *messages* can be structured using an international standard like UN/EDIFACT or ANSI X.12, there are no standards yet for the semantics and context of those messages, i.e. the business *scenarios* that describe the trade procedures used by the several parties involved in a business transaction[10] (Wrigley et al. 1994). For example, the legal status of sending a purchase order can differ depending on previous communications. The same 'stream of bits'

[8] Baker (Baker 91) gives an example of the size of such negotiations: *'At one conference on EDI law, James Pitts, a purchasing manager at R.J. Reynolds, said he spent 18 months negotiating a single trading partner agreement. That left him with only 349 other trading partners to go'.*

[9] It should be noted that although we call these agreements 'trade procedures', the principle is applicable to other societal areas than trade. The main focus of this paper however is electronic commerce which explains the term 'trade' in the definition.

[10] We use the term 'procedure' to refer to the formalized, computable sequence of document exchanges and related deductions; the term 'scenario' is used in a more informal and generic sense, referring not only to such procedures, but also to related informal explanations and contextualizations.

may be regarded as an acceptance (if the other party previously sent a quotation) or as an offer (if no other offer preceded the sending of the purchase order). An ISO/IEC sub-committee (ISO/IEC JTC1/SC30) is working on the definition of standard, EDI based, business scenarios. This initiative is called 'Open-edi'[11]. It should be noted that this standardisation effort does not influence the actual content of the messages exchanged; i.e. parties still have to negotiate about price, delivery terms etc. Open-edi merely minimises the set-up costs for new EDI linkages.

The main goal of Open-edi is to develop standards that lower the barriers for the establishment of EDI links between business partners by minimising the need for multiple, bilateral Interchange Agreements. The Open-edi Reference Model (ISO 1994) identifies two views: the Business Operational View (BOV) and the Functional Service View (FSV). Standards will be developed for each view. The BOV related standards will mainly focus at the representation of business aspects, such as the legal implication of messages and the modelling of the externally observable behaviour of organisations. FSV related standards will focus on information technology aspects such as security issues, inter-operability of the information systems of the parties etc. SC30 produces those standards that are not already available, such as the UN/EDIFACT standard (ISO 9735) or the Open Systems Interconnection (OSI) standard (ISO 6523).

In the Open-edi Reference Model (ISO 1994) the concept of Open-edi Scenario, Roles and Information Parcels are introduced to model business transactions, organisational behaviour and the exchange of information respectively (Open-edi Scenarios consist of a set of roles exchanging information parcels with each other). For a further specification of these concepts the interested reader is referred to (ISO 1994). These concepts are part of the Business Operational View in the Reference Model. Each of these concepts have to be modelled using formal description techniques in order to avoid ambiguities and to facilitate computer supported interpretation and/or processing.

Our research contributes to the development of such formal description techniques. We found Petri Nets as being one of the few acceptable candidates that offer both a graphical representation and a formal basis for the verification of various properties of these nets

[11] Open-edi is 'EDI among autonomous, multiple participants using public standards and aiming towards inter-operability over time, business sectors, information technology systems and data types, capable of multiple, simultaneous transactions, to accomplish a explicit shared business goal' (ISO 1994).

(Peterson 1981; Petri 1962; Murata 1989). The main advantage of the Petri Net formalism, in addition to its capability to graphically model both concurrency and choice, is that it offers various kinds of both formal and informal analysis methods, which make Petri Nets especially suitable for modelling 'Discrete Dynamic Systems' (Van der Aalst 1992). We have extended the classical Petri Net formalism to satisfy the formal, notational and verification requirements. This resulted in the Documentary Petri Net (DPN) formalism (Lee et al. 1994; Bons et al. 1995). The DPN formalism is one of the candidate representation techniques to model Open-edi Scenarios.

A business transaction modelled in the DPN formalism consists of a set of separate Petri Nets, each representing a role in the transaction. The focus of the models are those interactions among roles that are externally observable (the exchange of goods, funds and information). Special types of 'places' are used to model these goods, funds and information parcels. Finally, several kinds of labels can be added to reason about the modelling of legal constructs such as obligations and rights. The DPN formalism is discussed more extensively in other publications (see for instance Lee et al. 1994 and Bons et al. 1995).

These DPN models are built using the CASE tool Case/Open-edi, a modelling tool developed by Lee (1992). Case/Open-edi offers a graphical user interface with which Documentary Petri Nets can be drawn. Furthermore, since Case/Open-edi is developed in Prolog, rule-bases can be added to a Documentary Petri Net model, allowing automatic reasoning about modelled trade procedures. Formal properties of trade procedures, such as liveness and boundedness, can be analysed using algorithms based on the formal properties of Petri Nets. A previous Petri Net based representation, combined with the functionality of Case/Open-edi, has allowed reasoning about control issues in the research conducted by Chen and Lee (1992).

Case/Open-edi can not only be used to draw Documentary Petri Nets, it also offers the possibility to simulate and/or animate trade procedures modelled by these nets. Each role description is represented as a separate Documentary Petri Net and has its own window on a screen. A view of the total trade procedure can be achieved by opening all windows containing the role descriptions. The communication between the roles is done by exchanging data among these windows. Internally, the exchange of goods is implemented as a data exchange to be able to simulate the exchange of goods among the roles in a computer environment. These roles can be distributed over multiple machines connected with an electronic network to facilitate a more realistic gaming/simulation environment.

3. Legal issues

Documents used in international trade are typically of a performative nature, i.e. the exchange of those documents causes a change in commitments (rights and obligations) between parties. The performative aspect of such business information poses extra requirements on the exchange through an electronic network. Even more difficult is the exchange of negotiable documents, since the electronic version needs to be treated in a different manner then their paper equivalents; the distinction between an 'original' and a 'copy' of a document disappears completely in an electronic environment.

3.1 Performative electronic documents.

General requirements on the exchange of performative documents are non-repudiation, authentication, security and integrity.

- **Non-repudiation:** It should always be possible to prove that a specific information exchange did or did not take place. Two possible disputes can arise in this area:
    - An actual information exchange took place but one of the parties denies it; or,
    - Information exchange did not take place but one of the parties claims it did.

  In both cases the receiver or the sender may make the false claim.
- **Authentication:** The ability to verify the identity of the parties involved. In contract formation the most important aspect of authentication is making sure that a certain document has been sent by the party specified in the document as the sender.
- **Confidentiality:** The ability to prevent third parties to access the information.
- **Integrity:** The ability to rely on the underlying communication network that when a message is sent, the content is not modified during the transfer of the message.

In general, two types of solutions can be proposed to satisfy these requirements: a technical solution using encryption technology and an organisational solution involving trusted third parties. It seems that the combination of these two types of solutions satisfies all four requirements. Thus, all performative messages are encrypted using the public key of the receiver (confidentiality) and the secret key of the sender (authentication or digital signature).

Furthermore, a trusted third party (such as a Value Added Network provider (VAN)) keeps track of the communications through his network. Since the messages are encrypted the VAN cannot access the actual information being sent without the co-operation of the parties involved.

It should be noted that the latter is a feature which is impossible in a paper-based scenario, since it is hardly possible to witness and store these communications without actually seeing the information (an envelope must be opened before the content can be copied; therefore, instruments such as registered mail can only partially fulfil the same functionality as the electronic equivalents in this respect). This would solve the non-repudiation problem. The integrity problem should be solved by the underlying network and/or the calculation of checksums in the encryption algorithms used.

3.2 Negotiable electronic documents.

The electronic implementation of negotiability is complicated by the fact that there is no distinction between originals and copies of *electronic* documents. When an electronic document is transferred to another party, the first owner will still have an identical copy. When documents are printed on paper, several protection mechanisms are in place to guarantee the uniqueness of a document (signatures, seals, watermarks etc.). In an electronic environment, three directions may be chosen to solve the problem:

- there may be a technical guarantee that there is at all times only one document, i.e. the remaining copy is automatically erased beyond the control of the owner/sender
- a database could be maintained by an independent, trusted third party to serve as a registry to provide information about who owns a specific right
- the negotiable document is replaced by a non-negotiable equivalent.

A technical solution has to be used to physically erase the original when a document is sent. This can be implemented using smart-card technology. This technology could guarantee that when a specific set of data is transferred from one smart-card to the other (preferably over an electronic network), the original data are automatically deleted by the programs implemented on the smart-cards.

The second solution involves the introduction of a trusted third party in the form of a registry. This registry would serve as an agent for all parties involved; both the issuer of the right and the holders of the right will benefit from the registry. The registry would maintain a database containing the current holder of the right. Two functions are provided by this database. First, it will provide the issuer of the right with the knowledge to verify whether a party may claim that right. Secondly, if the right is transferred, it will provide the new holder of the right with the knowledge to verify whether the 'seller' of the right was entitled to sell it. It should be noted that the information maintained in this database should be minimised, because a party governing such a database may otherwise be able to deduce information about the trading and exploit this commercially beyond registration purposes. This minimal amount of information contains only a reference number to the actual data (and not the data itself) and the identity of the current holder.

Finally, it might be possible to circumvent the problem by using another type of document which is non-negotiable. For example, in many cases it is possible to replace a Bill of Lading by a Waybill. A Bill of Lading entitles the holder or bearer to claim the goods, whereas a Waybill stipulates a physical address where the goods should be delivered. Whether it is possible to make such a replacement evidently depends on the context in which the negotiable instrument is used and the business customs and practices of those parties using the instrument.

All these solutions have their merits and disadvantages. If the negotiable document can be replaced by a non-negotiable document this is in many cases the cheapest solution (assuming the exchange of performative messages is taken care of as discussed in Section 3.1). However, such a replacement is not always possible. If the negotiable instrument is a key requirement in the execution of the trade transaction, one of the other solutions should be taken. The main advantage of the smart-card solution is the independence of third parties other than the initial issuers or manufacturers of the smart-card; when two parties decide to trade a right by exchanging the negotiable document evidencing that right, they are not depending on the performance of a third party that serves as a registry. On the other hand, the smart-card technology poses constraints on the reachability of the parties involved and it introduces extra administrative overhead within the organisations to keep track of the smart-cards in relation with the transactions these smart-cards belong to. These disadvantages do not exist when a trusted third party is involved as a registry.

4. Electronic Documentary Credit Procedures

The work on Open-edi will eventually allow parties to exchange EDI messages with only minimal extra negotiations required to set up this exchange. Thus, after global information services may have supported companies in finding new business partners, Open-edi will allow the establishment of incidental EDI linkages between these parties and the exchange of the relevant business data. Since in many cases these parties will not have traded with each other previously, and may be situated in different countries, the risk of not getting paid or not getting the goods is very real. To eliminate this risk the banking community introduced the so-called "documentary credit procedure". This procedure starts with the buyer obtaining a *letter of credit* (L.C.) with his local bank. This L.C. stipulates which documents (such as a Bill of Lading and an invoice) the seller needs to provide to prove that his part of the deal has been accomplished. The L.C. is specified based on the underlying sales contract between buyer and seller. The issuing bank contacts a bank in the seller's country (the corresponding bank). This bank will advice the seller about the credit. If the seller agrees with the terms and conditions in the L.C., he will get his money from the corresponding bank upon presentation of all documents stipulated in the L.C. The corresponding bank has to check whether these documents comply. If they are accepted, they are forwarded to the issuing bank. This bank checks the documents on behalf of the buyer. If they accept the documents the corresponding bank is reimbursed and the buyer has to pay the issuing bank. If something is wrong with the documents, the buyer is notified. The buyer may still accept the documents if there are minor problems, or reject them. Of course, the issuing bank should be able to prove that there are discrepancies between the documents and the L.C. It is the task of the corresponding bank to advice the seller in obtaining the correct documents. This procedure is depicted in Figure 1.

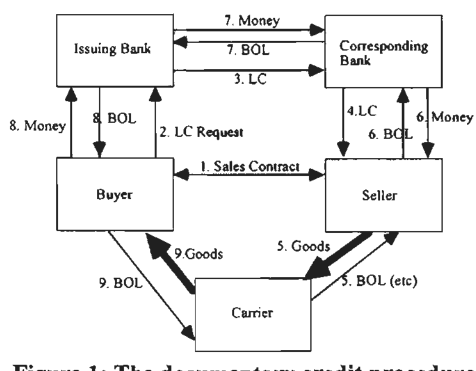

Figure 1: The documentary credit procedure

If the exchange of performative negotiable documents is possible through an electronic network, the documentary credit procedure could be implemented electronically. The behaviour of the several roles in the procedure could be defined in Open-edi standards as well. A description of the corresponding bank role is given in Figure 2.

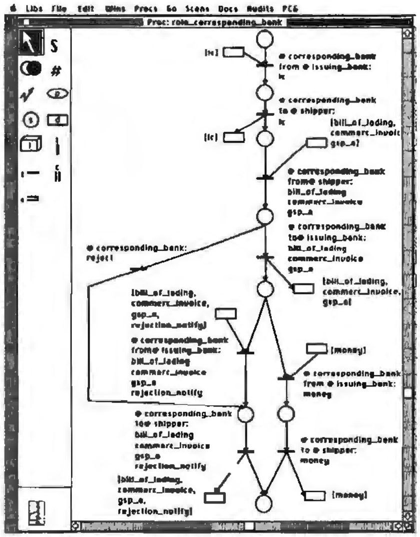

Figure 2: A DPN model of the corresponding bank role

The establishment of electronic documentary credit procedures offer the following advantages over the traditional paper version:

- The error rate in the execution of the procedure can be decreased. Since the documentary credit procedure uses the 'strict compliance' clause, even the smallest deviations of specified text may lead to the failure of the procedure. For example, if a seller ships '10 Widgets, colour red' instead of '10 red Widgets' the bank may reject the documents. This type of errors could easily be avoided using EDI, since the re-entering of data can be eliminated. Furthermore, since the parties can use a computer interpretable description of the procedure, they will be provided with guidance to avoid procedural errors (for example, if a shipper first ships the goods and then wants to obtain a certificate of origin, he is not able to do so since the goods may already be on sea!).
- The timeliness of the document processing can be increased. If all documents are exchanged electronically, the banks can automate the routine checks (such as the strict compliance rule) and implement expert systems to support the processing of the

documents. Evidently, the possibility to send performative documents through an electronic network instead of the regular mail will increase the document processing time tremendously.

- The procedure could be made less costly. Since the banks will be able to process the electronic documents more cost-effectively, the price of the documentary credit procedure may be lowered to make the procedure feasible for smaller trades as well.

5. Conclusions and future research

The current developments in information and communication technology will enable parties to participate in open electronic commerce. Three main obstacles in the establishment of open electronic commerce were identified in the paper: the current necessity to establish bi-lateral Interchange Agreements, the possibility to exchange legally binding electronic messages and finally the introduction of commercial risks by trading in an open manner.

The Open-edi initiative will allow parties to engage in electronic trade with minimal negotiations necessary to set-up the EDI link. Our research contributes to the Open-edi initiative by developing a formal description technique called Documentary Petri Nets (DPN) to specify Open-edi scenarios. Furthermore, we have developed a CASE tool called Case/Open-edi which can be used to model and analyse these scenarios using AI techniques and simulation and gaming techniques.

Solutions to facilitate the exchange of legally binding messages ('performative messages') were presented involving the introduction of trusted third parties, encryption technology and smart cards.

Issues in the development of an electronic version of the documentary credit procedure were presented to cope with the increased commercial risk in open electronic trading.

Future research has to show if the solutions proposed are acceptable to international business. We are currently involved in the EC EDIBOL project which focuses on the Electronic Bill of Lading and the INCOMAAS project in the Port of Rotterdam, which focuses on the role of information and communication technology to handle massive flows of containers.

Furthermore, we actively participate in the ISO subcommittee SC30 to support the Open-edi work. In that direction we are investigating how the introduction of formal description techniques such as Documentary Petri Nets (Bons et al. 1995) and CASE tools may help to design new trade procedures and/or improve current ways of doing business.

Acknowledgements

We would like to thank Professors Steven Kimbrough (Wharton, University of Pennsylvania) and Clive Wrigley (McGill University) for many stimulating discussions and debate on topics of deontics and performatives in electronic commerce. The authors would also like to thank Prof. Aernout Schmidt (University of Leiden) and Herman Roos and Taco de Vries (KPMG Management Consultants) for the challenging discussions about EDI law and security in the EDIBOL project.

The research has been partially funded by the ESPRIT III Basis Research Working Group no. 8319 Modelage and the TEDIS II project EDIBOL no. 56561.

References

Aalst, W.M.P. van der, "Timed coloured Petri nets and their application to logistics", *PhD thesis Eindhoven University of Technology*, 1992

Ahlsen, M., Pelkonen, H., Walseth, S. "Concepts and Notations for Open-edi Scenarios", *Dedicate Project Report No 8*, Swedish Institute for Systems Development SISU, February 1994

Austin, J.L. "How to DO things with words", *Harvard University Press*, Cambridge, MA, 1962

Bons, R.W.H., Lee, R.M., Wagenaar, R.W. and Wrigley, C.D. "Modelling Inter-organisational Trade Procedures Using Documentary Petri Nets", Proceedings Hawaii International Conference on System Sciences (HICSS) 28, Volume 3, pp. 189-198, Hawaii, USA, January 1995.

Cathomen, I. "EDI Security Services in International Trade", Working Paper Competence Center Electronic Markets, University of St.Gallen, Switzerland, 1994

Chen, K.T and Lee, R.M. "Schematic Evaluation of Internal Accounting Control Systems", *EURIDIS Research Monograph*, RM-1992-08-1, Erasmus University Rotterdam, August 1992.

Dewitz, S. K. and Lee, R. M. "Legal Procedures as Formal Conversations: Contracting on a Performative Network", *Proceedings of International Conference on Information Systems*, Boston, December 1989, pp. 53 - 65

EDICC, "Model form of Electronic Data Interchange Trading Partner Agreement and Commentary", *prepared by the Legal and Audit Issues Committee of the Electronic Data Interchange Council of Canada*, 1990

Genrich, H.J. and Lautenbach, K. "System Modelling with High-level Petri Nets", *Theoretical Computer Science*, Vol. 13 pp 109-136, New York: North-Holland, 1981

ICC, "Incoterms 1990", *International Chamber of Commerce publication 461*, 1990

ICC, "The Uniform Customs and Practices for Documentary Credit Procedures", *International Chamber of Commerce publication 500,* Paris, France, January 1994

ISO, "The Open-EDI Reference Model", *Working Draft document N075*, ISO/IEC JTC1/SC30, 1994.

Kimbrough, S.O. and Lee, R.M. "On Illocutionary Logic as a Telecommunications Language", *Proceedings of the International Conference on Information Systems* (San Diego; December, 1986)

Lee, R.M. , Dewitz, S.D. and Chen, K.T. "AI and Global EDI," *Hawaii International Conference on System Sciences*, January, 1991

Lee, R.M. "A Logic Model for Electronic Contracting", *Decision Support Systems,* Vol. 4, No. 1, 1988, pp. 27-44

Lee, R.M. and Dewitz, S.D. "Facilitating International Contracting: AI Extensions to EDI", *International Information Systems*, January, 1992.

Lee, R.M. and Dewitz, S.D. "Finding International Contracting Opportunities: AI Extensions to EDI," *Proceedings of the International Conference on Information Systems*, Copenhagen, Denmark, December 16-19, pp. 1-13, 1990.

Lee, R.M. "International Contracting -- A Formal Language Approach", *Proceedings of Hawaii International Conference on Systems Sciences,* Kona, Hawaii, January 1988 (Vol. I, Applications, ed. by R. H. Sprague), pp. 69-78

Lee, R.M., Bons, R.W.H., Wrigley, C.D. and Wagenaar, R.W. "Automated Design of Electronic Trade Procedures Using Documentary Petri Nets", Proceedings Fourth

International Conference on Dynamic Modeling and Information Systems, Noordwijkerhout, September 1994.

Lee, R.M.: "Dynamic Modeling of Documentary Procedures: A CASE for EDI", *Proceedings of Third International Working Conference on Dynamic Modeling of Information Systems*, Noordwijkerhout, NL, June 1992

Mitrakas, A. "Ways to draft an interchange agreement", Euridis Working Paper, February 1995, WP95.0203.

O'Hare W.L. "An Introduction to Documentary Credits", The Chartered Institute of Bankers, UK, 1990

Ong, Kay Liang and Lee, Ronald. "A Formal Model for Maintaining Consistency of Evolving Bureaucratic Policies: a Logical and Abductive Approach", Euridis Research Monograph (RM 93.01.01), January, 1993.

Peterson, J. L. "Petri Net Theory and the Modeling of Systems", *Prentice-Hall*, 1981

Petri, C.A. "Kommunikation mit Automaten", *PhD thesis University of Bonn*, Germany, 1962.

Searle, J. "Speech Acts: An Essay in the Philosophy of Language", *Cambridge University Press*, London, 1969

Streng, R.J. "Dynamic Modelling to Assess the Value of Electronic Data Interchange", *PhD thesis University of Delft*, Netherlands, November 1993

Wagenaar, R. W. "Business network redesign - Lessons from the Port of Rotterdam Simulation game", *Proceedings Conference on interorganizational systems in the global environment*, Bled, 1992

Williamson, O. E. "The economic institutions of capitalism", *Free Press*, New York, 1985

Wrigley, C.D., "EDI transaction protocols in international trade", *Proceedings Conference on interorganizational systems in the global environment*, Bled, 1992

Wrigley, C.D. and Wagenaar, R.W. and Clarke, R.A. "EDI in International Trade: Frameworks for the Strategic Analysis of Ocean Port Communities", *Journal of Strategic Information Systems*, Volume 3, number 3, 1994

Expected costs and benefits of EDI in the modular supply chain[12]

Martijn R. Hoogeweegen*, Wim J.M Teunissen*, Peter H.M. Vervest* & René W. Wagenaar**

* Erasmus University Rotterdam, Rotterdam School of Management, P.O. Box 1738, 3000 DR Rotterdam, The Netherlands, Tel.: 31 10 408 2031, Fax: 31 10 452 3595, E-mail: m.hoogeweegen@fac.fbk.eur.nl

** Free University Amsterdam and KPN Research, Leidschendam, The Netherlands, Tel: 31 70 3325365, Fax: 31 70 3326166, E-mail: R.W.Wagenaar@research.kpn.com

Abstract

In this paper we examine how the adoption of EDI can increase the flexibility of a modular supply chain of organisations to match customised demand, and how expected costs and benefits of such the adoption are distributed among these organisations. Within a modular supply chain, organisations form process module networks in response to customised demand. These networks indicate in what order process modules need to be operated, how they are linked to each other, and how many resources they use. We have developed the modular design approach to support the design of process module networks. By means of an automated tool, called Chain Moduling, costs and lead times of several designed networks can be computed and compared. The first application of Chain Moduling demonstrates how the adoption of EDI impacts a specific process module network. In this paper, the approach, the tool, the first application and future research are discussed.

1. Introduction to research problem

Organisations face the ongoing pressure of customised demand. The range of products and services should be increased, without creating longer lead times and higher costs. An increase of flexibility at the point of customer contact is needed to meet customised demand (Davis

[12] This paper also has been published in the proceedings of the 29th Hawaii International Conference on System Sciences, 3-6 January 1996, Hawaii, U.S.A.

1987, Jarvenpaa & Ives 1994, McCutcheon et al. 1994, Pine 1993, Vervest 1994). Flexibility in this context refers to the ability to quickly respond to customised demand. Bahrami (1992) divides this ability into the following two distinct aspects: (1) agility, which refers to the ability to respond quickly, and (2) versatility, which refers to the ability to produce the required variety. Close co-operation is required within the supply chain in order to achieve the desired flexibility (see for instance Eloranta et al. 1995). The supply chain encompasses each element of the production and supply processes from raw material to the end-customer (Scott & Westbrook 1991:23).

In order to measure the current level of flexibility within the supply chain and to find ways to increase this flexibility, we model supply chain members, i.e. the organisations that form the supply chain, as modular entities. The modular supply chain consists of a large set of process modules of which relevant modules can be linked instantly in a process module network after a customer places an order (Grünwald & Fortuin 1992, McCutcheon et al. 1994, Pine 1993) . A process module is the 'smallest possible core unit at which production can be replicated and repeated' (Quinn & Paquette 1990:67). The faster process modules can be linked (agility) in a large variety of combinations (versatility) the better the modular supply chain can match customised demand.

An increase of flexibility at the point of customer contact requires an optimisation of information exchange between the organisations that form the modular supply chain. Porter & Millar (1985) argue that information technology (IT) can be an important enabler in optimising linkages between organisational units as well as links to the outside of the organisation. In particular, Electronic Data Interchange (EDI) can be useful for the optimisation of inter-organisational information exchange, because it enables information to be exchanged faster and more accurate (Emmelhainz 1993). Therefore, EDI may be considered as a key enabler to increase flexibility of the modular supply chain. Supply chains may benefit significantly from the adoption of EDI (Dearing 1990, Clarke 1992, Rochester 1989, Scala & McGrath 1993). However, expected costs and benefits of EDI still remain unclear. Moreover, it is expected that the distribution of these costs and benefits among supply chain members may be unbalanced (Mukhopadhyay 1993, Riggins & Mukhopadyay 1994). This may explain why organisations are still reluctant to implement EDI.

The adoption of EDI is expected to have the highest benefits when it is applied as an enabler for business process redesign (see for instance Benjamin et al. 1990). Several authors stress the capabilities of IT and EDI for redesigning business processes (Davenport & Short 1990, Hammer 1990). This paper deals with EDI enabled business process redesign at the supply chain level. Venkatraman (1994) calls this business network redesign. We propose an approach to determine how EDI could facilitate business network redesign by means of an increase of flexibility. This approach, which we refer to as the modular design approach, also allows us to assess expected costs and benefits and the way they are distributed among supply chain members.

To illustrate the approach we will focus in this paper on a case taken from the air cargo transportation sector. This case deals with a three-staged modular supply chain in which a forwarder, a road carrier and an air carrier fulfil air cargo transportation from shippers to consignees (see figure 1).

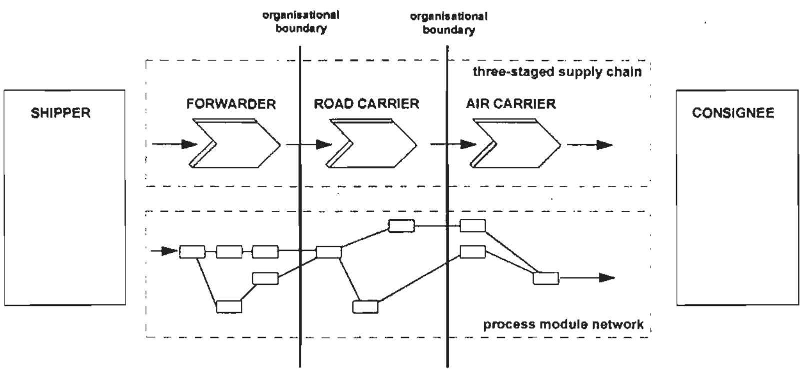

Figure 1: A three-staged modular supply chain

The paper is organised as follows. In section 2 the theoretical background of the research will be discussed. Next, the modular design approach is introduced, which is used to model modular supply chains (section 3). Also in this section, the automated tool Chain Moduling is introduced. This tool is based on the modular design approach and can be used to assess the expected costs and benefits of EDI at the supply chain level. In section 4 we elaborate on the different ways how EDI may be adopted in modular supply chain. In section 5 we illustrate the aforementioned approach and tool in a fictive example. In section 6 some conclusions are drawn and directions for further research are discussed.

2. Theoretical background

The research problem has been approached from the point of view of how economic activities can be best organised within an inter-organisational context. In this respect, the transaction cost economics approach, developed by Williamson (1975, 1985), considers two alternative forms to organise economic activities: markets and hierarchies (first introduced by Coase (1937). The unit of analysis is the transaction, which occurs 'when a good or service is transferred across a technologically separable interface' (Williamson 1985:1). Transaction costs are determined by three structural characteristics: asset specificity, uncertainty and frequency. Asset specificity refers to the degree to which an asset (like machines, people, etc.) can be redeployed to alternative uses and by alternative users without causing significant additional costs and without losing its value. Uncertainty refers to whether one can exactly predict the outcomes of a transaction in advance. Frequency refers to whether a specific transaction occurs frequently or rarely. The general statement within the transaction cost economics approach is that the hierarchy as organisational form will be more beneficial than the market when production costs of a supplier combined with the costs of transacting with the supplier exceeds the costs of internal production.

Transaction cost economics considers only the market and the hierarchy as two extreme forms of organising economic activities. Recently, attention has been paid in literature to intermediate, or hybrid, organisational forms between, or next to, markets and hierarchies. One of these forms is the network (Antonelli 1988, Cunningham & Tynan 1993, Jarillo 1988, Miles & Snow 1992, Powell 1990, Thorelli 1986). Different reasons are proposed why networks may outperform markets and hierarchies. For instance Antonelli (1988) argues that when both the costs of using the market and the hierarchy are high and economies of scale are low, networks may emerge (p. 53). Jarillo (1988) argues that the network may become economically feasible when specialisation of each supplier decreases total costs and when it can be sustained by closing long-term bonds that lower transaction costs (p. 39). In this respect a network should be able to find the 'optimal' allocation of activities (or: process modules) to be performed within the network. An allocation of activities among network members is cost optimal when production costs and transaction costs are minimised. Given certain constraints, like the availability of process modules, the optimal allocation can be approximated or realised. Miles & Snow (1992) introduce the dynamic network in which optimal allocations of activities may change according to the nature of the end-customer's demand. They describe that 'for the dynamic network to achieve its full potential, there must be numerous firms (or units of firms) operating at each of the points at the value chain, ready to be pulled together for a given run and then disassembled to become part of another temporary alignment' (pp. 66-67). Others describe this process as thinking in reverse (Jarvenpaa & Ives 1994) or customer-value networking (Vervest 1994).

It is expected that the adoption of EDI may change transaction costs, since it refers to the communication between organisations. However, how the adoption of EDI may facilitate either the market, hierarchy or network form as the most preferable one, still remains unclear. The rise of electronic markets is, amongst others, advocated by Malone et al. (1987), while Antonelli (1988) and Johnston & Vitale (1988) argue that electronic hierarchies will become the economically feasible organisational form. Antonelli (1988) argues that as long as no *open* EDI-networks exist, the investment in EDI will lead to an increase in asset specificity which contributes to the hierarchy as favourable organisational form (see also Holland et al. 1992:549, Ribbers et al. 1994).

All contributions discussed here, demonstrate that the question how activities (or process modules) should be allocated between supply chain members to minimise total costs (divided in production costs and transaction costs), still has not been answered satisfactorily. However, an important issue has been raised by a number of authors (amongst others Jarvenpaa & Ives 1994, Miles & Snow 1992, Vervest 1994) that supply chain members should be able to operate in dynamic networks in which they look for optimal coalitions in response to customised orders. The underlying premise is that any set of process modules can be produced (customisation) by any supply chain and that any allocation of process modules among the supply chain members is possible (economic optimisation). This paper elaborates on this premise. Our objective is to assess whether the flexibility of modular supply chains can be increased by adopting EDI in such a way that the optimal allocation of process modules between supply chain members can be chosen. Moreover, we want to assess the effects of such an EDI adoption on expected costs and benefits for each supply chain member. In the next section we introduce the modular design approach to find these allocations and assess the impact of EDI on these allocations.

3. The modular design approach

In this section the modular design approach will be described. The approach can be used (1) to translate an incoming order into a process module network and (2) to determine costs and lead time of this network.

Before the modular design approach can be applied, participating organisations have to identify which service elements they can deliver and which process modules produce these elements. Service elements are specific parts or characteristics of the total product and service range offered by an organisation or a supply chain. The identification of service elements should be conducted from the end-customer's perspective. Service elements enable end-customers to describe their specific preferences as accurate as possible. Process modules can be identified by considering the primary production and information processes within an organisation or a supply chain.

In the modular supply chain a co-ordinator is required, responsible for the translation of an order into a process module network. This co-ordinator can be either: (1) the end-customer; (2) one of the participating organisations in the supply chain; or (3) a new organisation entering the supply chain (for instance a value adding services organisation).

The modular design approach consists of four steps (see figure 2). In consultation with the supply chain members the supply chain co-ordinator can execute all these steps or only parts of them.

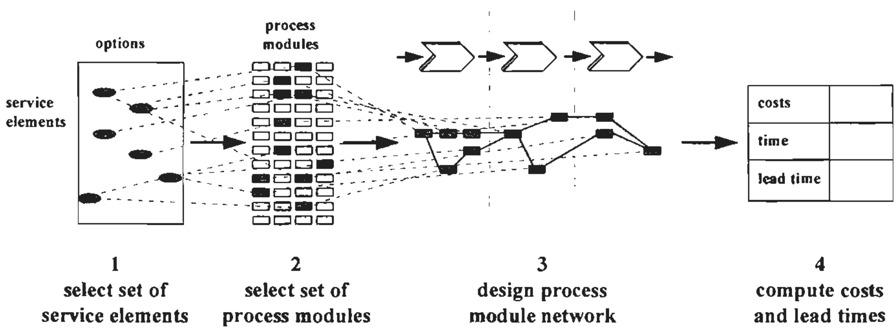

Figure 2: The modular design approach

The first step consists of the translation of a customer order into a set of service elements. The second step is the translation of the selected set of service elements into a set of process modules. Relationships between service elements and process modules can be either fixed or variable in terms of costs and times that accrue. In the case of the air cargo transportation sector, an example of a fixed relationship is the preparation and sending of a facsimile message 'confirmation of order' in response to an incoming order. The preparation and sending of this message will usually take the same time and incur the same cost, regardless whether the order deals with perishables (e.g. flowers), special cargo (e.g. living animals) or commodities (goods with no special attributes or characteristics). An example of a variable relationship is the translation of the service element 'way of delivery' into the process module 'intake of goods'. Goods can be either delivered loose, palletised or on a Unit Load Device (ULD). Since delivered goods need to be packed into ULDs before they enter the plane, the process module 'intake of goods' will differ in costs and times depending on the service element selected (loose, palletised or ULD) and the amount of goods delivered. The third step is to link the set of process modules in a network. This network indicates in what order the process modules need to be performed in order to fulfil the customer's order. The network can be designed after dependencies between process modules have been defined. For instance, the process module 'intake of goods' at the air carrier's site can only be performed after the goods have been transported from the shipper's site to the air carrier. The fourth step is the computation of operating costs, operating time and lead time. Operating costs are those costs which are directly related to the fulfilment of an order, such as production costs and information processing costs. Operating time refers to the *total* time needed to perform a process module network regardless the critical path within the network. Lead time is the net time span between the order placed and the order fulfilled and corresponds with the critical path within the process module network. Lead time can be computed when the selected process modules are linked in a network.

The modular design approach enables us to design several different process module networks which refer to the same order. The differences between such networks, for instance a network based on EDI versus a network not based on EDI, may demonstrate either a change in operating costs (showing an additional cost in case of increased operating costs, or a benefit in case of decreased operating costs) or a change in lead time (which is an indicator of agility). Alternative process module networks can be compared to the process module network which represents the current way of working, and can be classified in a 2x2 matrix as indicated in figure 4.

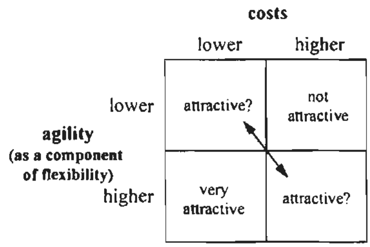

Figure 4: Agility (as a component of flexibility) versus costs

The figure does not take the versatility concept into account. Also not included is the question how costs and benefits are distributed among the members of a modular supply chain. However, the figure does capture the tension between agility and reduction in costs as the ultimate aim of an EDI adoption.

The modular design approach has been automated in a tool called Chain Moduling. This tool facilitates the process of defining and comparing alternative process module networks, which are either based on EDI or not. The comparison of the networks results in the expected benefits with are in fact savings in terms of operating costs and lead time. In addition, Chain Moduling demonstrates how these benefits are distributed among supply chain members.

Before an fictive application of Chain Moduling is presented, we will first discuss how EDI may change the design of process module networks.

4. The role of EDI in process module networks

The first experiences with applying Chain Moduling indicate that EDI can be used to (1) increase efficiency by decreasing operating costs of process modules; (2) increase effectiveness by reducing lead time of a process module network; (3) change organisational boundaries within a process module network by moving the execution of a certain process module to another organisation in the supply chain (strategic issues). In table 1 these categories of effects are summarised. A simplified process module network depicted in figure 5 will serve as an example to clarify these three categories of EDI effects.

	category of EDI effect		
	efficiency	effectiveness	strategic
operating cost reduction	•	•	•
operating time reduction	•	•	•
lead time reduction		•	•
change in process module network design?	no	yes	yes
change in the roles organisations play?	no	no	yes

Table 1: Three categories of EDI effects on process module networks

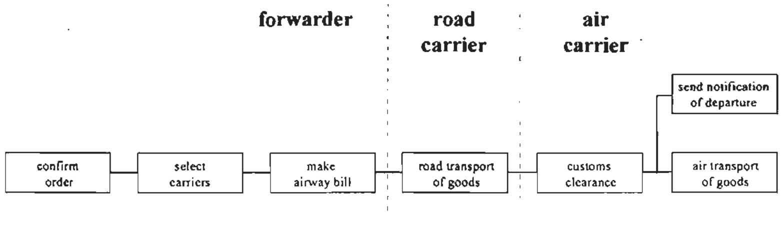

Figure 5: A simplified example of a process module network

The first category of EDI effects (efficiency) refers to the decrease of costs and time incurred to operate a process module, regardless whether the module is part of the critical path. The module 'send notification of departure' is an example of a process module of which cost can be decreased when EDI is used, and which is not part of the critical path. The module is executed after the plane has departed and therefore runs parallel with the module 'air transport goods'. Through the adoption of EDI, the message can be sent electronically which will save a large part of the operating costs made.

The second category of EDI effects (effectiveness) refers to the reduction in costs and times of those process modules which are part of the critical path or those that will be removed from the critical path. In this case, not only costs but also lead time can be reduced, which is considered as an increase of agility. For instance, the process module 'customs clearance', which was formerly executed after goods have been transported by road, can now be executed concurrently with 'road transport of goods' when an EDI-message 'pre-arrival notification of goods' has been sent by the road carrier (see figure 6(a)).

The third category of EDI effects (strategic) refers to the re-allocation of process modules, by means of EDI, among supply chain members, regardless whether these process modules have been altered as discussed before. In this case, organisational boundaries will shift in the process module network, because EDI changes transaction costs and, possibly, also production costs. A possible re-allocation is given in figure 6(b). In this alternative a bigger role has been assigned to the road carrier. To find better allocations of process modules among supply chain members, transaction costs have to be included in the analysis. This is one of the issues discussed in section 6.

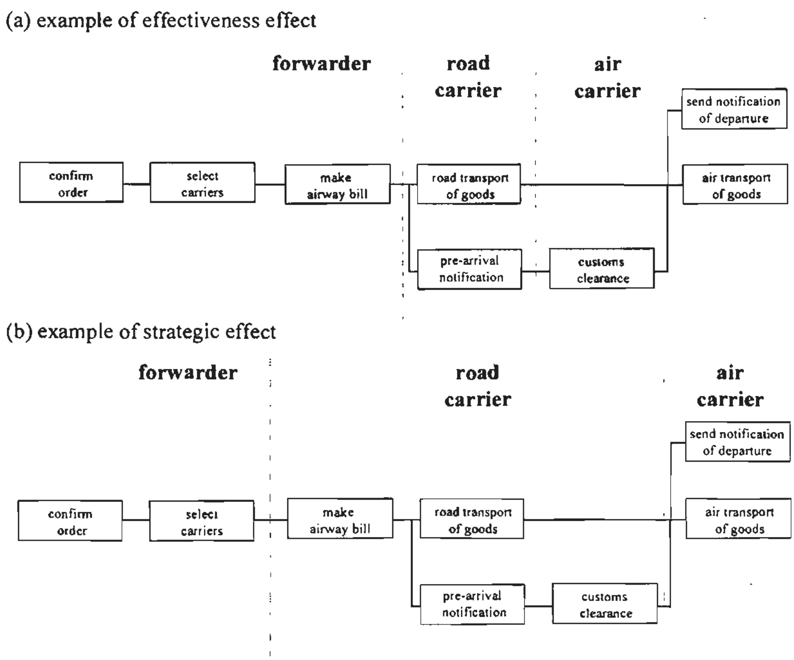

Figure 6: Example of how EDI may alter process module networks

5. An example

In this section we discuss a fictive example to demonstrate how Chain Moduling can be applied to assess the impact of EDI on process module networks. The application discussed here is based on fictive data and encompasses the supply chain introduced in the first section (see figure 1). The forwarder acts as the supply chain co-ordinator and arranges road and air transportation on behalf of the shipper. After the service elements have been selected, the supply chain co-ordinator allocates subsets of the set of elements to participating organisations, i.e. the forwarder, road carrier and air carrier. Note that the forwarder, in the role of supply chain co-ordinator, allocates part of the order to himself as being a participant of the supply chain. Each participant translates the subset of elements into a set of process modules which together form a process module network.

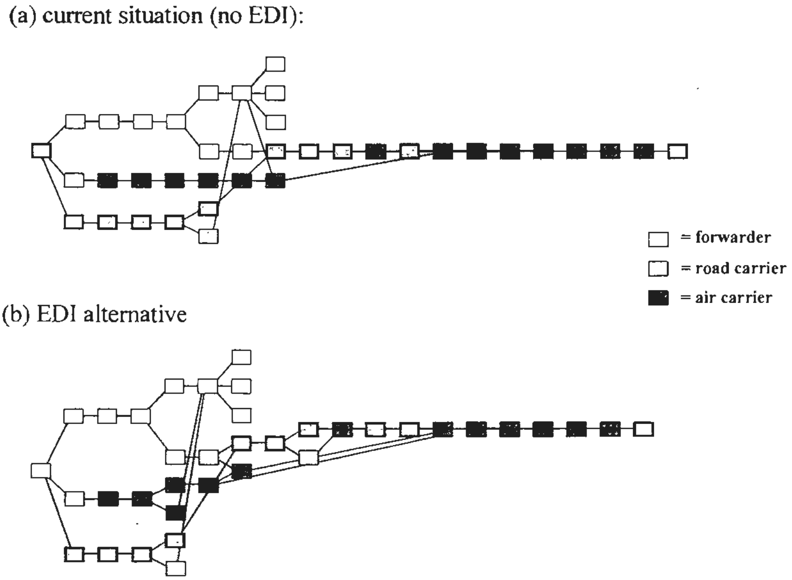

Figure 7: Two process module networks, one not based on EDI (a) and one based on EDI (b)

Figure 7(a) depicts the process module network. The thick marked boxes represent process modules which are part of the critical path. This network represents the current way of working, in which EDI is not used. Once the process module network without EDI has been designed, alternative networks can be defined in which EDI is used. We have defined an alternative in which EDI is used for: (1) allocating suborders (i.e. the subsets of the selected service elements) by the supply chain co-ordinator to the participants; (2) invoicing and payment activities; (3) customs clearance; and (4) sending the air waybill. The first two changes can be denoted as first category EDI effects, while the last two changes belong to the second category of EDI effects (see previous section). The new process module network is depicted in figure 7(b).

After both process module networks have been designed, we can compare them on operating costs, operating times and lead time. The relative improvements made with the EDI based network compared with the network not based on EDI, are depicted in figure 8. This figure indicates that this particular alternative process module network fits in the lower left quadrant of figure 4. It appears that:

1. lead time can be decreased using EDI and therefore contributes to the increase of (end-customer) flexibility;
2. every participant benefits of EDI (although EDI investments have not been included in the analysis);
3. benefits are not equally distributed (in percentages);
4. the forwarder enjoys the highest relative benefits, which is not surprising because his main activity is information processing (both as forwarder and as supply chain co-ordinator).

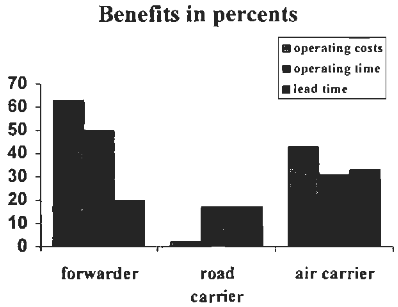

Figure 8: Comparison

We now can repeat the procedure to evaluate other alternative process module networks. Other process module networks may be based on a different supply chain co-ordinator, a different use of EDI, etc. We can even apply the modular design approach to analyse the use of other enablers than EDI, such as mobile satellite communications, teleconferencing and electronic markets.

6. Conclusions and directions for further research

In this paper we have introduced the modular design approach. The approach is used to analyse how the adoption of EDI enables modular supply chains to match customised demand by increasing its flexibility in terms of reduced lead times (agility) and increased variety (versatility). Moreover, the approach also can be used to assess whether operating costs can be reduced by the adoption of EDI and how a cost reduction is distributed among modular supply chain members. The modular design approach is automated in a tool called Chain Moduling.

An application of Chain Moduling illustrated how flexibility in terms of agility can be increased by decreasing the lead time of the process module network. It also showed a reduction in operating costs and the way this reduction is distributed among the modular supply chain members. The versatility aspect of flexibility was not included, because this aspect refers to the total number of different customer orders which can be handled by a modular supply chain. The current approach only considers one order at the time. In order to analyse multiple orders at the same time the approach has to be extended with an analysis of all relevant subsets of service elements (and corresponding process module networks) organisations and/or modular supply chains can produce. Relevant subsets are those subsets which match the preferences of end-customers and which modular supply chains are able to produce. An increase in versatility (for instance by means of EDI) is realised when the of number relevant subsets of service elements has been increased.

An other issue which remains to be addressed is how modular supply chains are formed within dynamic networks. A dynamic network encompasses a set of organisations which form different modular supply chains to perform different process modules. The adoption of this dimension in the modular design approach will raise complexity significantly, because: (1) all organisations within the network should be modelled in terms of service elements supported, process modules supported and their operating costs and times; (2) all transaction costs per relevant combination of organisations (one-to-one relationships) have to be known; and (3) all switching costs, which are costs of switching from for instance a road carrier to another road carrier, have to be known. Further research is required to analyse this additional dimension.

After resolving these issues, we should be able to assess the impact of EDI in a modular dynamic network in terms of increase of flexibility, costs and benefits and possible shifts in organisational boundaries.

References

Antonelli, C. (1988), *New Information Technology and Industrial Change, The Italian Case*, Kluwer Academic, Dordrecht, 1988

Bahrami, H. (1992), The emerging flexible organisation: perspectives from Sillicon Valley, *California Management Review*, Summer 1992, pp. 33-52

Benjamin, R.I., D.W. de Long, M.S. Scott Morton (1990), Electronic data interchange: how much competitive advantage?, *Long Range Planning*, 23, 1, pp. 29-40

Clarke, R. (1992), A contingency model of EDI's impact on industry sectors, *Journal of Strategic Information Systems*, 1, 3, pp. 143-151

Coase, R. (1937), The nature of the firm, *Economica*, 4, pp. 386-405

Cunningham, C., C. Tynan (1993), Electronic trading, inter-organisational systems and the nature of buyer-seller relationships: the need for a network perspective, *International Journal of Information Management*, 13, pp. 3-28

Davenport, T.H., J.E. Short (1990), The new industrial engineering: information technology and business process redesign, *Sloan Management Review*, 31, 4, pp. 11-27

Davis, S.M. (1987), *Future Perfect*, Addison-Wesley, Reading, MA, 1987

Dearing, B. (1990), The Strategic Benefits of EDI, *Journal of Business Strategy*, 11, 1, pp. 4-6

Eloranta, E., A. Lehtonen, K. Tanskanen (1995), Fast, flexible and co-operative supply chains - key issues for the survival of European industry, *Production, Planning & Control*, 6, 3, pp. 238-245

Emmelhainz, M.A. (1993), *EDI: A total management guide*, Van Nostrand Reinhold, USA

Grünwald, H.J., L. Fortuin (1992), Many steps towards zero inventory, *European Journal of Operational Research*, 59, 3, pp. 359-369

Hammer, M. (1990), Reengineering work: don't automate, obliterate, *Havard Business Review*, July-August 1990, pp. 104-112

Holland, C., G. Lockett, I. Blackman (1992), Panning for Electronic Data Interchange, *Strategic Management Journal*, 13, 7, pp. 539-550

Jarillo, J.C. (1988), On strategic networks, *Strategic Management Journal*, 9, pp. 31-41

Jarvenpaa, S.L., B. Ives (1994), The global network organisation of the future: information management opportunities and challenges, *Journal of Management Information Systems*, 10, 4, pp. 25-57

Johnston, H.R., M.R. Vitale (1988), Creating competitive advantage with inter-organizational information systems, *MIS Quarterly*, 12, 2, pp. 153-165

Malone, T.W., J. Yates, R.I. Benjamin (1987), Electronic markets and electronic hierarchies, *Communications of the ACM*, 30, June, pp. 484-497, 1987

McCutcheon, D.M., A.S. Raturi, J.R. Meredith (1994), The customization-responsiveness squeeze, *Sloan Management Review*, Winter 1994, pp. 89-99

Miles, R.E., C.C. Snow (1992), Causes of failure in network organisations, *California Management Review*, Summer 1992, pp. 53-72

Mukhopadhyay, T. (1993), Assessing the economic impacts of Electronic Data Interchange Technology, in: *Strategic Information Technology Management: perspectives on organisational growth and competitive advantage* (R.D. Banker, R.J. Kauffman, M.A. Mahmood, eds), Idea Group Publishing, London

Pine, B.J. (1993), *Mass Customization: the new frontier in business competition*, Harvard Business School Press, Boston, Massachusetts

Porter, M.E., V.E. Millar (1985), How information gives you competitive advantage, *Harvard Business Review*, July-August 1985, pp. 149-160

Powell, W.W. (1990), Neither market nor hierarchy: network forms of organisation, *Research in organisational behaviour*, 12, pp. 295-336

Quinn, J.B., P.C. Paquette (1990), Technology in services: creating organisational revolutions, *Sloan Management Review*, Winter 1990, pp. 67-78

Ribbers, P.M.A., C.F. Ekering, M.G. van Zutphen (1994), EDI increases transaction cost (in Dutch), *Bedrijfskunde*, 66, 2, pp. 66-72

Riggins, F.J., T. Mukhopadhyay (1994), Interdependent benefits from interorganizational systems: opportunities for business partner reengineering, *Journal of Management Information Systems*, Fall 1994, pp. 37-57

Rochester, J.B. (1989), The strategic value of EDI, *I/S Analyzer*, 27, 8, pp. 1-16

Scala, S., R. McGrath Jr. (1993), Advantages and disadvantages of electronic data interchange, *Information & Management*, 25, pp. 85-91

Scott, C., R. Westbrook (1991), New Strategic Tools for Supply Chain Management, *International Journal of Physical Distribution & Logistics Management*, 21, 1, pp. 23-33

Thorelli, H.B. (1986), Networks: between markets and hierarchies, *Strategic Management Journal*, 7, pp. 37-51

Venkatraman, N. (1994), IT-enabled business transformation: from automation to business scope redefinition, *Sloan Management Review*, Winter 1994, pp. 73-87

Vervest, P.H.M. (1994), *Communication, not information: an ad hoc organisation of the value chain*, Inaugural lecture, Erasmus University Rotterdam

Williamson, O.E. (1975), *Markets and hierarchies: analysis and antitrust implications*, The Free Press, New York

Williamson, O.E. (1985), *The economic institutions of capitalism*, The Free Press, New York

The consequences of EDI and PDI in the building industry

Hans Voordijk

Tilburg University, Post Box 90153, 5000 LE Tilburg, The Netherlands, Tel: +31-13-4662188, Fax: +31-13-4663377, E-mail: hvoordijk@kub.nl

Abstract

This paper investigates the consequences of EDI and PDI for the structure of the building industry from the perspective of transaction cost economics. The dynamic perspective is taken by making a difference between consequences on the short and on the long term. This paper states that information technologies as EDI and PDI will on the short term result in a decrease of the fragmented structure of the building industry. Reason for this development is the transaction-specific character of investments in these information technologies. On the long term two scenarios are possible. These two scenarios are related to the decrease of ex ante and ex post transaction costs. On one hand, EDI and PDI result in a decrease of ex ante transaction costs and a growing transparency of the market. In that case the existing fierce price competition in the industry and the fragmented sector structure, partly the consequence of this price competition will endure. On the other hand, network relations that were the result of the transaction-specific character of EDI and PDI will endure if transaction costs are lower than traditional market relations. In that case information technologies support the rise of strategic networks between designing and constructing parties.

1. Introduction

Several market developments demand for a flexible organisation of firms. Characteristic for recent developments is that part of this flexibility is searched in an integration of business processes of different firms. This tendency is narrowly related to the application of information technologies as Electronic Data Interchange (EDI) and Product Data Interchange (PDI) (Ahmad et al. 1995). These technologies are directed towards the external integration of computerised systems of different firms in supply chains and a more efficient communication between these parties. Difference between EDI and PDI lies in the character of messages that are interchanged. EDI is used for the interchange of administrative data, such as orders, tenders and invoices. When product data, specifications and drawings are interchanged one speaks of PDI. Even in a more traditional industry as the building sector, EDI and PDI are used on a growing scale (Betts et al. 1991; O'Brien & Al-Soufi 1993)

Several articles have been publicized about consequences of these technologies for the structure of the industry (Almad et al. 1995; O'Brien & Al-Soufi 1993; Bröchner 1990). Bröchner (1990) shows that information technologies in construction reduce information costs. This reduction results in new types of firms: specialized contractors working on a global market, management contractors co-ordinating the specialist subcontractors and locally working construction firms. O'Brien and Al-Soufi (1993) analyze the possible impact of EDI on the structure of the construction industry. The main finding is that EDI is a technology that has the capability of altering organisational interfaces to such an extent that it will change the structure of the UK construction industry. Ahmad et al. (1995) focus on the integration of design and construction activities by IT. The three main IT capabilities to achieve integration in the construction industry are communication, data accessibility and common systems designed to process data.

This paper will focus on the consequences of IT for construction too but adds the dynamic perspective and uses consequently one specific theoretical framework. Consequences of EDI and PDI are analyzed from the perspective of transaction cost economics on the short and on the long term. This dynamic perspective is taken because it is expected that there are differences between the consequences in the structure of sector on the short and on the long term. The use of EDI and PDI can result in significant changes because of the fragmented character of this sector (Almad et al. 1995; O'Brien & Al-Soufi 1993). The results of this analysis can have wider relevance than only the building industry because described developments will not be unique for this industry only. The consequences of a so-called external integration by information technology in the building industry can be exemplary for developments in other fragmented industries, for example the transport industry. Besides this, the consequences of a standardized electronic communication can correspond with the introduction of for example Total Quality Systems in chains of firms. Such quality systems can be considered as standards for the communication about quality.

This paper starts with the description of characteristics of traditional building processes. The fragmented structure and the temporary character of relations between firms will be stressed. Then is discussed how EDI and PDI will influence the structure of the building industry on the short term. Consequences for the structure of the industry on the long term are described in the next part. Conclusions are drawn in the final part.

2. The traditional building process

Although various different building processes are distinguished, the traditional organisation is a dominant way to organize building processes. Production in the building industry is characterised by production on location, project teams made up of many diverse actors and the one-off nature of the work. In the traditional building process design and production are executed by different parties (Pries 1995). The architect produces a design for a customer. The contractor than executes the design, assisted by suppliers and subcontractors. In the traditional building process a contractor gets a building project by tendering. The client chooses the contractor who offered the lowest price. Because of the cost-driven nature of the industry, the contractor who gets the project tries to get on his turn the lowest prices from suppliers and subcontractors. This price competition, in combination with the one-off nature of a building project, means that at every project on behalf of the representative of the client (a contractor or architect) several bilateral different contracts are negotiated between him and one of the parties involved.

This bilateral contracting results is a suboptimal coordination because every firm locates his resources according to his contract. These contracts are not tuned to each other. Every actor is only responsible for his specific input. Tendering means that at every project new constructing and designing parties have to learn to work with each other. A lot of problems occur because parties differ from each other in volume, market environment and culture. Designing, constructing and supplying parties speak all their own language and have all their own approach to the project. There is often no structured communication between these firms and as a result approximately 40% of the costs of building are somewhat related to the transfer of information and the control of communication processes (Pries 1995). The temporary character of relations (during the building process parties build up a temporary coalition) stimulates opportunistic behaviour (Winch 1989). A party tries to get as much as possible out of his contract. As a result, the organisation of the traditional building process can be described as organisational distrust.

Firms work together in constantly changing coalitions at different projects. After the completion of a project the coalition disperses. This one-off nature of the work has resulted in a culture in the building industry where the emphasis in on projectmanagement and improvisation on the building site. Strategic management hardly exists. Solving problems during the building process on location is preferred above planning before building starts. Working with a vision on the longer term is often absent at these firms. This `improvisation-culture' is an important obstacle for investments in new information technologies, investments that demand for strategic management. The temporary partnerships and the diversity of parties, inherent to the one-off nature of building projects, impede the implementation of information technologies as EDI and PDI, technologies where several parties during the building process have to communicate with each other on the same standard (O'Brien & Al-Soufi 1993).

3. The fragmented industry structure

Besides the temporary character of relations, the structure of the industry is a second important obstacle for the implementation of new information technologies as EDI and PDI. The industry structure is dominated by the great number of small enterprises: fragmentation is the key characteris-tic (O'Brien & Al-Soufi 1993). A dominant firm does often not occur. When `industry-wide' information systems are implemented in other industries, big firms often take the initiative. In construction there is no clear market leader that can take this role and push a potential standard for information technology, to which the building industry conforms. In this respect, the Dutch building industry differs from the French, where big contractors have an enormous influence on technological developments in the sector. The biggest contractor in Holland, the Hollandsche Beton Groep (HBG) is relatively small from a European perspective. When looking at the yearly turnover, HBG takes the 20th place on the list of the biggest European contractors. Besides this, big Dutch contractors often consists of a lot of smaller autonomous operating companies.

Absence of a dominant company in the industry is an obstacle for the rise of a uniform standard for productcoding, an important condition for an efficient electronic communication of messages. In practice, every manufacturer of building materials has his own productcoding. Even relative simple products are not standardised at this moment. In some cases, the contractor can compel the supplier to use a standard code. When the contractor is a big client, the supplier will adapt in order not to loose a part of his turnover. One can speak of a uniform standard for the electronic exchange of messages when all parties in construction agree about the standard to use. The fragmentation of the industry structure impedes this development.

Result of the temporary project organisation of the building process and the fragmentation in the structure of the industry is that the development of automation in construction is characterised by isolated applications (Augenbroe 1991). The computer is used in many ways in construction, but this concerns mainly standard application in functions as design, calculation and accounting. When these applications were introduced within firms hardly nothing changed in the organisation structure, the acceptance went very quickly and the advantages were clear. Information technologies as EDI and PDI are more difficult from this perspective. These technologies are directed to the communication between firms which means that they can only be used when several disciplines, for example the contractor and the architect, want to work with the same technology and adapt their work to each other. Diffusion of this type of technology can result in this way in more integration on the level of building projects. Implementation of EDI and PDI affect in this way the structure of the industry. The transaction specific character of investments in EDI and PDI on the short term points in that direction (Williamson 1975, 1985). Transaction specificity, an important concept from transaction costs economics (TCE), can be used for the analysis of the conditions and consequences of EDI and PDI for the industry structure on the short term.

4. Transaction specificity

The basic unit in TCE is the transaction laid down in a contract between two trading partners. Transactions are characterised by three dimensions: uncertainty, frequency and asset specificity (Williamson 1975). The most important of these three dimensions, asset specificity, is defined as the degree to which durable transaction specific investments are incurred (Joskow 1988). Asset specificity is important as a result of human opportunism, which can eventually lead to hold-ups in ongoing transactions and the exploitation of investors. Because of this possibility of opportunistic behaviour, resources will be spent on contractual and organisational safeguards.

According to Williamson 'asset specificity' is the 'big locomotive to which transaction cost economics owes much of its predictive content' (Williamson 1985). According to the transactional view a transaction can take place in the institutional framework of the market (using the price mechanism), or of a hierarchy (which requires a coordination of efforts). When production costs dominate, contracting will be used (the market), whereas internalisation will prevail for high transaction costs (a hierarchy). Intermediate modes are often referred to as `hybrid modes' (Williamson 1991). Williamson (1975) discusses three key transaction costs: costs of informing traders (information costs), the costs of reducing bargaining to the terms of trade (bargaining costs) and the costs of enforcing the terms of the trade (enforcement costs).
Concepts of the TCE-framework can be related to developments in the field of information technologies. The minimalization of transaction costs partly accounts for the growing use of EDI and PDI networks in the building industry. EDI-systems create possibilities for a faultless initiation, control and settlement of transactions. The exchange of messages can be done more efficiently by EDI. This reduction of transaction costs is an important reason for implementation of EDI-systems in supply chains in the building industry. Due to the fierce price competition, firms in the building industry want to offer their products for a lower price. When EDI and PDI are instruments to lower costs firms will implement these technologies.

On this moment, the transaction specific character of investments in EDI and PDI impede a broad diffusion of these information technologies in the building industry. Transaction-specific investments are directed towards the realization of specific transactions with specific partners. This specificity is related to investments in hardware and software. One reason for the transaction specific characteristic of EDI and PDI-investments in the building industry are the different standards for communication. Because there is no generally accepted standard, a specific standard makes a standardized communication between firms of only a part of an industry possible. It is impossible for such firms to communicate electronically with firms outside that part of an industry. This is called a `community system': communication is open to all members of a part of the industry (Ribbers et al. 1994). Especially EDI-systems in the building industry have this community character due to the fact that investments in EDI are always directed towards the realization of specific transactions with specific partners. The development of PDI in the building industry finds itself in an experimental phase which means that existing PDI-systems have not even a community character. Only a few partners can communicate with each other by these systems. PDI-systems are an example of `closed' information systems.

Because EDI is not so broadly diffused in the building industry this technology can only be used efficiently when there is a critical mass of messages. This is one of the reasons why the implementation of EDI-systems between traders and manufacturers is a success. In this link relations between firms are characterized by agreements for the longer term and a lot of short messages are exchanged. The temporary character of relations between other firms in the building industry impede investments in EDI and PDI systems. Especially in the relation between contractors and manufacturers, there are many obstacles for the implementation of these systems. First, in the relation manufacturer-contractor information flows are incidental. In that case EDI has no real added value for firms. Second, in this link often non-standardized products are exchanged which cannot easily be codified. Product codification however is an important condition for efficient electronic communication.

Especially big firms invest in EDI and PDI. These firms have to process a lot of information. They can use EDI and PDI-systems efficiently and compel their suppliers to invest in these transaction specific technologies too. In the Dutch building industry EDI was originally initiated by big contractors and primarily directed towards information exchange between contractors and manufacturers of building materials. A strengthening of bilateral relationships between these parties resulted. But investments in EDI-systems resulted in this way in new inflexibilities too. Striving to efficient use of EDI was for a lot of firms a motive to use these technologies only in firm-relations which are already characterised by a frequent exchange of messages. This results in a further deepening of existing relationships and means that investments in EDI are really `relation-specific' (Grossman & Hart 1986). Parties have invested in a specific technology to communicate electronically with other partners and will not immediately stop this relation when there are problems.

At this moment, only bigger firms invest in EDI. Smaller firms wait before implementing EDI till this technology is supplied at the market in such a form and price that not using it will be less efficient. A problem is that especially small contractors are not experienced in automation and IT. Another problem is that smaller firms do not want to take the risk of being `locked in' or `locked out'. Transaction-specific investments mean that it can be difficult to change partners because of high switching costs. The existence of community systems means that potential partners have to consider which system will be chosen. A long pay-back period of an investment in a community system means that actors who have opted for one information system, are more or less `locked in' for a certain period. This is especially the case when firms do not have the financial resources to invest in another system. For these firms, it is quite difficult to do business electronically with firms that use another information system. A solution could be for a collective body to construct and exploit an open information system. If an information system is global anyone can participate and hardly any asset specific investments are needed. In that case smaller firms can use EDI too without any risks. Recent cooperation between EDI-organizations in the Dutch building industry is a starting point for this development.

5. Increasing fragmentation

A further development of EDI and PDI standards for communication can in the longer term result in a global system when there is a worldwide acceptance of general standards for communication. This system is often called an electronic market (Malone et al. 1987). Any firm can participate in this system. Consequence is a more efficient information-exchange between designing and constructing parties. Electronic communication makes an international tendering of orders possible. In the future, a customer sends his request to several building firms who make their offers. On their turn, building firms can demand electronically offers of manufacturers and traders of building materials. All these offers of the suppliers return at the building firms. For these firms it will become extremely easy to identify the lowest cost suppliers and subcontractors (Betts et al. 1991). Widely accepted PDI-standards facilitate the exchange of drawings with other CAD-systems. Subcontracting of the further processing of drawings and inherent to it further communications between several parties will grow.

On the longer term new information technology results in a lowering of ex ante and ex post transaction costs. Ex ante transaction costs are costs related to the search of business partners and collection of information, costs of informing potential partners and costs related to the writing of the contract (Williamson 1975). First, a broad diffusion of new information technologies does lower the search costs which means that ceteris paribus the market gets more transparent. It will become easy to identify contractors and suppliers with the lowest price. On the part of the client or contractor there is no extra cost in requesting seven or seventy quotes. Without EDI it would be difficult to identify possible contract partners with the lowest price, with EDI it becomes quite easy. Second, costs related to informing potential clients are lowered. A supplier using EDI can easy deal with a high number of responses. These responses on requests can be done semi-automatically by an EDI-application. Third, the costs of writing a contract are lowered too by EDI. The content of the specifications, the description of the building project and related conditions, are an important part of the contract between contractor and the representative on behalf of the client. Electronic communication of the specifications makes a strong simplification possible when this important part of the contract has to be written.

A broad diffusion of new information technology results in a decrease of ex ante transaction costs. An increase of price-competition in the building industry is the result of the growing transparency. The existing fragmentation on the level of building projects and the structure of the industry, partly the result of this strategy, is strengthened. This continuing price competition will especially occur where building projects are simpler and smaller with a limited duration. These projects can especially be found in utility and house building. Characteristic is that resource capacities are relatively easy to find externally (Melles & Wamelink 1993). Performing the required tasks at the construction site demand only for routine methods.

6. Strategic networks

New information technologies can result in a decrease of ex post transaction costs too. Ex post transaction costs consists of adjustment costs because the contract has to be adjusted to changed conditions and costs needed to monitor the agreements. EDI and PDI increase the ability to subject building processes to continuous monitoring (Bröchner 1990; Zajac & Olsen 1993). The costs of inspection are lowered, which makes it easier to enforce contracts with other firms. PDI improves the methods of translating changes into design in changes in construction technology and production activities. Both technologies enhance feedback between parties when technical problems are encountered and reduce response times.

From TCE perspective, network relations which are the result of 'relation-specific' information technologies will endure if transaction costs are lower than traditional market relations, even when information technologies as EDI and PDI have lost their transaction specific character. This is the case when networks result in less uncertainty and opportunistic behaviour. Network relations ease the transfer of expertise and enhance feedback between parties (Winch 1989). When several partners in a logistic chain transfer information with each other, opportunities are provided to revise and redefine production processes. In this manner, an established relationship reduces organisational uncertainty. Continual feedback facilitates necessary adjustments and reduces complexity. The continual relation ensures that a firm will not behave opportunistically in the short term because in that case it will be worse off in the longer term. As a result monitoring costs and the costs of the enforcement of contracts are lower. Adjustment costs, part of transaction costs, are reduced too. Especially when different firms are involved in complex and uncertain production processes transaction costs of networks are lower compared with market relations. In that case, network relations between designing and constructing parties economize on bounded rationality as a result of uncertainty and complexity.

Logistics networks, consequence of transaction specific investments in EDI and PDI, can be interpreted as a cooperative form of organization not only directed towards minimizing transaction costs, but striving for joint value maximization too (Jarillo 1988; Zajac & Olsen 1993). Cooperation between designing and constructing parties in logistics networks makes it possible to present a 'total product' with quality guarantees to the market. On the longer term, opportunistic behaviour can be replaced by mutual trust. Instead of bounded rationality, knowhow is transferred between firms for product development. These network forms of organisation (or `quasi-firms'), with their emphasis on lateral forms of communication, are particularly well suited for this transfer of specialized know-how (Johanson & Mattson 1987; Powell 1990). As a result, EDI and PDI can provide a better service to customers by integrating functions of several firms through data partnerships. In that case, new information technology can result in a shift from a cost to a differentiation strategy. The nature of competition in the building industry is fundamentally altered.

7. Conclusion and discussion

Investments in information technologies as EDI and PDI result on the short term in closer relationships between firms because of their transaction specific character. Firms in supply chains commit themselves to specific relationships and will become more tightly coupled. Investments in EDI and PDI function as triggers for the rise of co-makership relations (O'Brien & Al-Soufi 1993). Major problem is that smaller firms do not want to take the risk of being `locked in' or `locked out'. A long pay-back period of an investment in a community system means that actors who have opted for one information system, are more or less `locked in' for a certain period. This is especially the case when firms do not have the financial resources to invest in another system. For these firms, it is quite difficult to do business electronically with firms that use another information system. A solution could be for a collective body to construct and exploit an open information system. In that case smaller firms can use EDI too without any risks. Recent cooperation between EDI-organizations in the Dutch building industry is a starting point for this development.

Traditionally, contractors are inclined to accept work for every type of project. The only difference is on one hand projects in home and office building and on the other hand projects in infrastructure. Within these two market segments contractors want to build anything. In the traditional tendering process the contractor with the lowest price gets the project. As a result the dominant strategy of contractors in the building industry is in Porters' strategy-typology a low cost strategy for all segments of the market. Logistics networks, consequence of transaction specific investments in EDI and PDI, can provide a better service to customers by integrating functions of several firms through data partnerships. As a result, new information technology can result into a shift from this the low cost strategy for all market segments to a differentiation strategy for one or a few market segments. In that case, the nature of competition in the building industry is fundamentally altered.

This shift towards the strategy for product differentiation (triggered by EDI and PDI) can have far reaching implications for the structure of the industry. Contractors don't feel committed anymore to traditional and institutional borders of the building industry. Instead of executing one task for all sorts of projects contractors want to execute all tasks for a certain group of projects, for a specific segment of the market. The traditional task specialisation becomes product specialisation. In different segments of the building market characteristics of contractors will show more outspoken differences. Instead of one building industry with a structure based on tasks and occupations, and with firms that execute one task for all sorts of projects, there will be in future an industry with sectors which are very different from each other. In each sector firms are active that design and construct the same sort of products.

References

Ahmad, I.U., Russell, J.S. and Abou-Zeid, A. (1995) Information technology (IT) and integration in the construction industry, *Construction Management and Economics*, vol. 13, 163-171.

Augenbroe, G. (1991) R&D View on Integration in the Building Industry, *Handout ESPRIT Workshop on Computer Integrated Building*, Amsterdam, 23 april.

Betts, M., Cher, L., Mathur, K. and Ofori, G. (1991) Strategies for the construction sector in the information technology era, *Construction Management and Economics*, vol. 9, 509-528.

O'Brien, M.J. and Al-Soufi, A. (1993) Electronic data interchange and the structure of the UK construction industry, *Construction Management and Economics*, vol. 11, 443-453.

Bröchner, J. (1990) Impacts of information technology on the structure of construction, *Construction Management and Economics*, vol. 8, 205-218.

Grossman, S.J. and Hart, O.D. (1986) The Cost and Benefits of Ownership: A Theory of Vertical and Lateral Integration, *Journal of Political Economy*, vol. 94, 691-719.

Harrigan, K.R. (1988) Strategic Alliances and Partner Asymmetries, *Management International Review*, Special Issue, 53-72.

Jarillo, J.C. (1988) On Strategic Networks, *Strategic Management Journal*, vol. 9, 31-41.

Johanson, J. and Mattson, L.-G. (1987) Interorganizational relations in industrial systems: A network approach compared with the transaction-cost approach, *International Studies Organization*, no. 1, 34-48.

Joskow, P.L. (1988) Asset Specificity and the Structure of Vertical Relationships: Empirical Evidence, *Journal of Law, Economics, and Organization*, vol. 4, 95-117.

Malone, T.W., Yates, J. and Benjamin, R. (1987) Electronic Markets and Hierarchies, *Communications of the ACM*, vol. 30, 484-497.

Melles, B. and Wamelink, J.W.F. (1993) *Production control in construction*, Delft University Press, Delft.

Powell, W.W. (1990) Neither Market nor Hierarchy, *Research of Organizational Behaviour*, vol. 12, 295-336.

Pries, F. (1995) *Innovation in the construction industry*, Erasmus University Rotterdam.

Ribbers, P.M.A., Ekering, C.F. and van Zutphen, M.G. (1994) EDI verhoogt de transactiekosten, *Bedijfskunde*, vol. 66, no. 1, 66-72.

Teeuw W.B., Liefting J.R. and R.H.J. Demkes (1994) *Product Data Interchange - Towards successful introduction of PDI in practice*, Telematica Research Centre, Enschede.

Williamson, O.E. (1975) *Markets and Hierarchies: Analysis and Antitrust Implications*, Free Press/Collier Macmillan, New York/London.

Williamson, O.E. (1985) *The Economic Institutions of Capitalism: Firms, Markets, Relational Contracting*, Free Press/Collier Macmillan, New York/London.

Williamson, O.E. (1991) Comparative Economic Organization: The Analysis of Discrete Structural Alternatives, *Administrative Science Quarterly*, vol. 36, 269-296.
Winch, G. (1989) The construction firm and the construction project: a transaction cost approach, *Construction Management and Economics*, vol. 7, 331-345.
Zajac, E.J. and Olsen, C.P. (1993) From Transaction Cost To Transactional Value Analysis: Implications For The Study Of International Strategies, *Journal of Management Studies*, vol. 30, 131-145.

Positive and negative effects of electronic markets

Eric van Heck and Piet M.A. Ribbers[13]

Tilburg University, Department of Information Systems and Auditing, and CentER, P.O. Box 90153, 5000 LE Tilburg, The Netherlands, Phone: +31-13-4662188, Fax: +31-13-4663377, E-mail: evanheck@kub.nl

Abstract

This article aims to promote a better understanding of the economic effects of electronic markets. The central questions are: what are the main economic effects of electronic markets and what factors can explain these effects? A framework to evaluate electronic markets has been developed. Analytical aspects of the framework are: motives of participants, mode of cooperation, trust, entry barriers, electronic market structure, electronic market functionality, and economic effects of electronic markets on different stakeholders. Empirical evidence was found in four cases in two industries: the Dutch flower industry and the European transport industry. The results show that electronic markets can produce negative and positive effects. These effects can differ between the participating stakeholders. The results indicate that there is empirical evidence that convergent motives and high trust among the participants are essential for positive effects for all stakeholders. The other design aspects (mode of cooperation, entry barriers, structure and functionality of the electronic market) are, as a single aspect, not related

13 Acknowledgement: Previous versions of this article were presented in:
(1) Van Heck, E. and P.M.A. Ribbers, Effects of Electronic Markets: An Analysis of Four Cases in the Dutch Flower and Transport Industries, in: J.F. Nunamaker and R.H Sprague (eds.), Information Systems - Organizational Systems and Technology, *Proceedings of the Twenty-Ninth Annual Hawaii International Conference on System Sciences*, volume IV, IEEE Computer Society Press, Los Alamitos, p. 407-415, 1996;
(2) Van Heck, E. and P.M.A. Ribbers, Electronic Markets in Value-Added Chains: An Analysis of Four Cases in the Dutch Flower and Transport Industries, in: J.H. Trienekens and P.J.P. Zuurbier (eds.), *Proceedings of the 2nd International Conference on Chain Management in Agri- and Food Business*, Wageningen Agricultural University, Wageningen, p. 325-338, 1996;
(3) Van Heck, E. and P.M.A. Ribbers, Positive and Negative Effects of Electronic Markets: Four Case Studies in the Dutch Flower and Transport Industries, in: J. Dias Coelho, W. Konig, H. Krcmar, R. O'Callaghan, M. Saaksjarvi (eds.), *Proceedings of the 4th European Conference on Information Systems*, Lisbon, volume II, p. 1327-1339, 1996.
We would like to thank the anonymous referees for their guidance.

to positive effects. The combination of design aspects will lead to positive effects for all stakeholders. Three successful combinations of design aspects are distinguished. The results of the analysis and the framework itself illustrate the various complex issues that arise in the design and implementation of electronic markets.

1. Problem specification

Electronic markets (EM) are emerging in the international economy. With the help of electronic markets one can sell and buy products such as financial stocks, cotton, pigs, used cars, and flowers. Generally speaking, economies have two basic mechanisms for the coordination of the flow of materials or services through adjacent steps in the value-added chain: markets and hierarchies. Markets coordinate the flow through supply and demand forces and through transactions between independent individuals and firms. Market forces determine the design, price, quantity, and target delivery schedule for a given product that will serve as an input into another process [17]. Markets provide buyers and sellers with a venue for the exchange or the transfer of property rights from one party to another. Hierarchies coordinate the flow of materials through adjacent steps by controlling and directing it at a higher level in the managerial hierarchy. Transactions, under both markets and hierarchies, are affected with a variety of costs, uncertainties, and risks. In recent literature especially the element of trust, as a result of possible opportunistic behavior, has received considerable attention [5].

New Information Technologies (IT) have been used and will be used in the coordination of goods and services, resulting in electronic markets and electronic hierarchies. This article explores the economic effects of electronic markets. We define electronic markets as interorganizational information systems that allow the participating buyers and sellers to exchange information about prices and product offerings [2]. The firm operating the system, is referred to as the intermediary. In electronic markets, screen-based trading - with the help of data bases, Electronic Data Interchange (EDI), and Artificial Intelligence (AI) applications - supports: (i) establishing the price, (ii) the dissemination of information on prices, quantities and qualities of products and services, and (iii) buyer and seller identities. IT will have an influence on trust. The closing of business deals through the (exclusive) use of databases and telecommunication as intermediary media, poses specific requirements on the perceived trustworthiness of the business partners.

Research on the effects of IT on exchange organizations and processes is relatively new. Early research applied transaction costs and agency theory to predict shifts from hierarchies to market form of organizations [8,17]. The central argument of this line of research was that IT would improve communication, search, monitoring and information sorting capabilities, thereby reducing transaction costs and enabling purchasers to take advantage of production economies available in markets. A critical drawback inherent in this analysis was the definition and treatment of markets in abstract economic terms (i.e., markets coordinate economic activity through a price mechanism). In reality, different market structures exist, e.g. direct search, brokered, dealer and auction markets. Each of these structures organizes the trading process and related information processing activities in different ways. Thus the role and impact of IT can vary across types. The literature provides some examples. Konsynski et al. [14] provided a descriptive case study of an electronic market in used cars. Clemons and Weber [3] examined the effects of computerization on the London Stock Exchange. Hess and Kemerer [9] tested the Electronic Market Hypothesis (EMH) against the empirical results of five case studies in the home mortgage market. Ribbers et al. [21] concluded that EDI will increase transaction costs by transaction specific investments and predicted a shift towards hierarchies. Kambil and Van Heck [11] showed the role and impact of IT on the Dutch flower auction markets. Lee [16] identified two types of electronic markets - electronic brokerage and electronic auction.

Due to the convergence of IT and telecommunication, and the proliferation and availability of bandwidth, the impact of electronic markets is expected to grow rapidly. Their effectiveness, however, is dependent on their design. Existing research in this new area provides examples of relevant issues supporting an effective design. What is lacking, however, is a systematic classification of various complex economic issues that arise when designing and implementing electronic markets. Such a classification must pay special attention to:

- routines and procedures to handle and possibly reduce uncertainties and risks caused by opportunistic behavior;
- different economic effects of electronic markets for different stakeholders, in different market settings;
- differences between the design of electronic markets and their underlying infrastructure.

This article provides a conceptual framework for analyzing the merits of electronic markets. The central questions are: what are the main economic effects of electronic markets and what factors can explain these effects? We use the framework to evaluate four electronic markets in the Dutch flower industry and the European transport industry.

The rest of this article is organized as follows. Section 2 discusses the conceptual framework. Section 3 provides basic data and economic effects of the four electronic markets. Section 4 provides a discussion on empirical evidence. Section 5 gives the conclusions.

2. Conceptual framework

The conceptual framework of this paper consists of seven analytical or design aspects: motives of stakeholders, mode of cooperation between participants, trust, entry barriers, electronic market structure, electronic market functionality, and economic effects.

Motives of Stakeholders

Stakeholders in organizations and markets behave in a bounded rational way. They are motivated by their goals and by satisficing behavior [18]. Stakeholders will often pursue different, and sometimes conflicting goals. Their decision to enter an electronic market will be based on the perceived contribution of the electronic market to their individual goals. We propose:

Proposition 1: If an electronic market can contribute to the driving goals of the stakeholders as perceived by stakeholders (convergent motives), then the electronic market will have positive effects for all stakeholders.

Mode of cooperation

Mechanisms to coordinate economic transactions are markets and hierarchies. They are, however, opposite extremes of a range of possibilities. Firms may decide to engage in various forms of (longer term) cooperation governed by contractual engagements. Swedish economists developed the network approach as an extension of the market-hierarchy dichotomy [10][20]. Network types of coordination reduce uncertainty. Consequently, distributed or network organizational forms emerge as the organization of the future [6]. We propose:

Proposition 2: Under conditions of high uncertainty, network forms of cooperation will emerge; electronic markets will then have positive effects for all stakeholders.

Trust

In markets, buyers and sellers may be confronted with opportunistic behaviors. Without sufficient trust between the business partners, adequate governance of the flow of materials and services will be severely hampered. This may especially apply to electronic markets where the only contact between buyers and sellers may be the contact through the databases and the telecommunication network. How does one know, whether the required quality can be delivered, whether the required amount can be delivered on time, and whether payment will be received as agreed? Then special emphasis is put on the perceived trustworthiness of the business partners. We propose:

Proposition 3: Trust in electronic markets will have positive effects for all stakeholders.

Entry Barriers

Special procedures and regulations, serving as entry barriers [1], provide safeguards against entrants who are not trustworthy. We propose:

Proposition 4: Adequate entry barriers to electronic markets will have positive effects for all stakeholders.

Electronic Markets Structure and Functionality

The Information Management approach discusses the structure and functionalities of IT architectures and infrastructures. A so-called reach/scope framework for IT infrastructures is defined [12][19]. In this paper, this framework is used in the electronic market context. It is proposed that effective electronic markets with a high reach (e.g., a relatively open structure allowing many participants) will have a low scope (simple functionality). Agreeing on a highly complex functionality with many participants is simply too difficult to accomplish. Electronic markets with a low reach (relatively closed structure, resulting in few participants) may have a high scope (complex functionality). The question is, which of the combinations of number of participants (reach) and functionality (scope) will provide positive effects. We propose:

Proposition 5: Electronic markets with a closed structure (few participants) and a complex functionality or a simple functionality (low reach/high scope; low reach/low scope) will have positive effects for all stakeholders.

Proposition 6: Electronic markets with an open structure (many participants) and a simple functionality (high reach/low scope) will have positive effects for all stakeholders.

Economic Effects of Electronic Markets
Successful electronic markets will stimulate potential participants to enter. Participants will enter the electronic market if it will support their economic objectives. To give a more detailed analysis of the effects of electronic markets, a closer look at objectives set by the stakeholders is required. We distinguish three types of stakeholders: buyers, sellers, and intermediaries.

In the exchange of goods and services, buyers and sellers are primarily interested in price, quality, amount, and timeliness of delivery. For each of these measures, minimum and/or maximum requirements exist, with both the buyer and the seller. Effects of electronic markets have to be related to these measures: prices may be adequate, but the quality or the delivery may be unreliable; there may be sufficient demand for the seller, but he/she is not sure that his/her bill will be paid on time (or anyway). Electronic markets will have positive effects when they enable buyers and sellers to accomplish their objectives (assuming satisficing behavior) with regard to those measures. Intermediaries, who arrange the electronic market, are particularly interested in the economic performance of that market. Economic performance may be reflected by total revenue, profit realized by the intermediary, and number of transactions.

3. Four case studies

Four cases were studied to show empirical evidence for the proposed framework. Cases were used for so-called analytical generalization (not to be confused with statistical generalization) [23]. The case study method was used because it enables 'reality' to be captured in considerably greater detail than other methods do, and it also allows the analysis of a considerably greater number of variables. Two cases were chosen in the Dutch Flower industry: the Aalsmeer Sample-Based Auction System and the Holland Supply Bank System. Two cases were chosen in the European Transport industry: the European Teleroute System and the Dutch/German Transport Management System. Table 1 summarizes the basic data about these four cases.

The cases were chosen because they represent different electronic markets, and detailed data are available. In each case, interviews with key officials were held. Relevant reports were analyzed, and archival data were obtained. Table 2 summarizes the economic effects of the electronic markets for the different stakeholders in the four cases. It clearly shows that the four electronic markets investigated differ in their characteristics and their effects.

Table 1: Basic Data of Four Cases.

	Case 1 Aalsmeer Sample Based Auction System	Case 2 Holland Supply Bank System	Case 3 European Teleroute System	Case 4 Dutch/Germ. Transport Man.System
Year started (Year Ended)	1994 (1994)	1993	1986	1992
Product	Potted Plants	Potted Plants	Transport Capacity	Transport Capacity
Sellers Intermediaries	Growers Flower Auction Aalsmeer	Growers Flower Auction Holland	Transporters Wolters Kluwer Publ.	Transporters Informore + Edeka Fruchtkontor
Buyers	Wholesalers	Wholesalers	Forwarders	Edeka Fruchtkontor + Supermarkets
Price Discovery	Dutch Auction Clock	Negotiable Posted-off Pricing	Negotiable Posted-off Pricing	Negotiable Posted-off Pricing

Case 1: The Aalsmeer Sample-Based Auction System

The first case deals with Dutch flower auctions. They are the world's leading price discovery and trading centers for cut flowers and potted plants. Holland is also the world's largest exporter and distributor of cut flowers and potted plants. The traditional Dutch flower auction is the place where supply meets demand in the industry. Dutch auctions use a clock for price discovery, as follows. The computerized auction clock in the room provides the buyers with information on the producer, product, unit of currency, quality, and minimum purchase quantity. The flowers are transported through the auction room, and are shown to the buyers. The clock hand starts at a high price, and drops until a buyer stops the clock by pushing a button. The auctioneer asks the buyer by intercom; how many flowers of the lot he will buy. The buyer provides the amount. The clock is then reset, and the process begins for the next lot, until all units of the lot will be sold. Buyers have to be physically present in the auction room. In practice it turns out that the Dutch auction is an extremely efficient auction mechanism: it can handle one transaction every four seconds. The auction provides a central location for buyers to meet; it creates efficient quality control and logistics of product redistribution. Problems are related to the growth of the flower and potted plant trade. The growth causes capacity problems and creates negative economic externalities. The current auction facilities have limited space for expansion; traffic flows generated by the auctions, cause delays and traffic jams in the transportation network feeding the auctions. One solution, developed by the auctions, is to uncouple logistics from price discovery. One of the latest developments in that respect is the set up of a sample-based auction or so-called 'informatieveilen' for trading potted plants initiated by Flower Auction Aalsmeer auction [7][11][24]. In a sample-based auction, growers send a sample of the product to the auction house along with information on the quantity and quality of the product. Buyers bid for the product, and they specify requirements for product packaging and delivery. Growers package the product as specified by the buyer, and the next day they deliver it to the buyer location in the auction complex or to a buyer warehouse.

The Sample-Base auction system started in January 1994 and ended in September 1994. The system had a negative effect on the functioning of growers, the auction house and buyers. The sample-based auction system ended up in a complete failure.

Case 2: The Holland Supply Bank System

In recent years more cut flowers and potted plants have been distributed through the Mediation Office or 'bemiddelingsbureau' instead of via the traditional Dutch auction clock system. In the Mediation Office an auction employee acts as an agent for the growers, and negotiates between growers and buyers in a forward market. Prices, product specification, number of lots, and delivery specifications are specified in a contract, which is legitimized and monitored by the Mediation Office. Flower Auction Holland, situated in the villages of Naaldwijk and Bleiswijk, developed the Holland Supply Bank ('Holland Aanbod Bank'), which is a database with the supply of potted plants of the growers, including 2,000 electronic product pictures [4]. Buyers can enter the system electronically, search for relevant products, and use the information to buy and sell those products. Buyers can order products electronically too.

Table 2: Economic Effects of Electronic Markets in the Four Cases

Economic effects for each of the stakeholders	**Case 1 Aalsmeer Sample Based Auction System**	**Case 2 Holland Supply Bank System**	**Case 3 European Teleroute System**	**Case 4 Dutch/Germ. Transport Man.System**
. sellers	Growers did not favor this market because product prices decreased dramatically after the introduction. Some changes to the auction rules (price floor of 70% of the average price, increase of lot size) have stabilized the market. Growers received no extra compensation for modifying packaging and delivery practices to suit the buyer. Growers also perceived they got lower prices in a slower auction. Better prices were obtained for the representative lots themselves (which were auctioned in a second round). As a reaction, growers would split the same product into different sample lots, hoping this would lead to higher prices during the auction.	The Holland Supply Bank System has a positive effect on growers. If growers could meet the very specific requirements made by buyers, they could get higher prices.	Transporters have mixed feelings about Teleroute. On one hand they favor it, because it is cheap to get, and easy to use. It reduces search costs and it can help to reduce the number of empty truck trips and a more efficient use of the fleet of trucks. On the other hand it results in lower prices.	Transporters did favor the system, because they could plan return freights in advance with fewer waiting hours and an increasing truck load.
. intermediary	The number of transactions per hour decreased as buyers had to specify terms of delivery. While the auction expected 45% of the supply of potted plants to be transacted in the sample-based auction, only 10% of the product was transacted this way. Thus, sample-based auctioning did not effectively reduce storage requirements at the auction.	Trade volume and product prices increased after the system was introduced. The auction house was satisfied with this new new brokerage system for their growers, because the auction house (owned by the growers) still is a concentration point of supply.	Wolters Kluwer perceive Teleroute as successful. In total there are 20,000 users all over Europe, there is a growth of 20 to 25% per year.	The system has a positive effect on Informore. They agreed to develop the system on an no cure no pay base. The success of the system makes it profitable. Informore can show it to other transporter - forwarder groups as a successful example.
. buyers	Buyers did not favor this system either because trade volume decreased as a result of lower prices and resulted in uncertain supply. The lack of strong functionality in dealing with tracking and tracing meant the system did not bring buyers and sellers competitive	Buyers did favor this system because they could order to specific requirements (quality, quantity, delivery time). Strong functionality in dealing with tracking and tracing is another advantage.	Also forwarders have mixed feelings about Teleroute. Most forwarders prefer network modes of cooperation. There is an unwillingness by forwarders to pass on loading to another forwarder and the fear of relinquishing more loading than someone has advantage.taken over [19:137].	Edeka (buying organization and supermarkets) mentions an increase of efficiency, reductions of transport costs and a higher service level.

The Holland Supply Bank System was introduced in 1993, and since then it has been regularly updated. The System has a positive effect on the functioning of growers, the mediation office, and buyers. Trade volume and product prices increased after the system was introduced. A better tuning of supply and demand, especially for specific orders, created competitive advantages for growers and buyers.

Case 3: The European Teleroute System

One of the examples of an electronic market in the transport industry in Europe is Teleroute, introduced by the Dutch Wolters Kluwer Publishing company [15]. Teleroute is an international, electronic transaction system for freight and vehicle space all over Europe, to be used by forwarders and transporters, but not by shippers. Forwarders represent the shippers. They plan the transported goods. Freight forwarders and transporters are directly connected to the Central Teleroute computer based in Lille (France). The database gives a picture of freight and vehicle space availability across Europe. Teleroute was initially developed by the French company Lamy, a subsidiary of Wolters Kluwer, and was introduced in 1986 in France using Minitel as a basis. Next applications were introduced in Belgium and Luxemburg (1986), The Netherlands (1988), Germany (1989), Switzerland and Italy (1990), Spain and Portugal (1991), Great Britain (1992), and Denmark (1993).

In total, there are 20,000 users all over Europe; there is a growth of 20 to 25% per year. There are approximately 20,000 national and international freight offers per day, and about 12,500 accesses per hour [15]. The advantages of the system for the forwarder are that it saves time and money; the advantages for the transporter are a reduction in the number of empty truck trips and a more efficient use of the fleet of trucks. Some statistics, to support these advantages, are: Europe has about 1,000,000 trucking units, driving 100,000 km per year, 38% is driving around empty, average cost 1 ECU/km [15]. Most forwarders prefer cooperations based on long term agreements. In addition, due to increasing competition, forwarders do not wish to pass on loading to another forwarder [15]. Another disadvantage is the suspicion that Teleroute will increase competition and increase the transparency of the market, which reduces margins. Higher utilization of trucks will not compensate those reduced margins. Teleroute supports the driving goals of transporters and forwarders, by offering immediate and possible transport. Lower prices (a disadvantage) overcompensates fewer empty truck trips.

Case 4: The Dutch/German Transport Management System

Edeka Fruchtkontor Benelux GmbH is a buying organization for a similarly named German retailer. Edeka exports on demand from the Dutch vegetable and fruit auctions to 50 distribution centers in Germany, and then to 10,000 supermarkets. Buying at the auction is done by commissioners. In 1992 Edeka redesigned the fruit and vegetable chain by decoupling logistics and information streams and by using Electronic Data Interchange (EDI). They invited Informore, a Dutch logistics and IT value-added service supplier, to develop and maintain the Transport Management System (TMS) [13].

TMS has a positive effect on the functioning of Edeka, its commissioners, repackers and transporters, and Informore. Edeka mentions increased efficiency, reduced transport costs, and higher service level. Transporters were also happy because they could plan return freights in advance, with fewer waiting hours and an increasing truck load. Informore has succeeded in re-engineering the Edeka fruit and vegetable value chain and in decoupling the logistics from the information streams.

4. Empirical evidence

Given these four case studies in electronic markets, what can be said about the crucial elements in the design of these electronic markets? Appendix 1 summarizes the four case studies. The case study results are presented in table 3.

This table shows that the Aalsmeer Sample-Based Auction System (case 1) has a negative effect on the functioning of sellers, auction and buyers (lower prices for growers, less trade, and therefore uncertain supply for buyers). The Auction System got into a death spiral, and it was finished in 1994. It seems to be that divergent motives of stakeholders and a profound lack of trust between growers and buyers caused these negative effects. Also a lack of functionality of the electronic market might cause negative effects. In case 2, one sees that the Holland Supply Bank has medium functionality with an open structure in a market mode of cooperation, which results in positive effects for all stakeholders. The Holland Supply Bank System has a positive effect on the functioning of sellers, mediation office, and buyers. Convergent motives of stakeholders, a market mode of cooperation, and a high level of trust between growers and buyers, combined with an open electronic market structure, resulted in those positive effects. The European Teleroute System (case 3) was moderately positively received by transporters and forwarders. The Teleroute case shows that even medium functionality of electronic markets architectures can create positive effects (lower prices for forwarders and efficient use of the fleet by transporters). Although in this case negative effects are reported (lower prices for forwarders are negative for transporters), important conditions seems to be low entry barriers and an open structure. The Dutch/German Transport Management System (case 4) has very positive effects on the functioning of transporters, Informore, and Edeka Fruchtkontor. This system shows that a closed and high functional architecture in a network cooperation mode with high entry barriers can result in very positive effects for all stakeholders (lower cost and higher service for Edeka, efficient use of fleet for transporters).

Proposition 1: Convergent motives will have positive effects

Proposition 1 is supported by all cases. Case 1 indicates the reverse, e.g., divergent motives will lead to negative effects for all stakeholders. In case 3 mixed effects were reported, but specific negative effects are compensated by positive effects (lower prices versus efficient use of fleet for transporters, and lower prices versus uncertainty for forwarders).

Proposition 2: Network forms of cooperation will have positive effects

Proposition 2 is supported by case 4. In that case, a network mode of cooperation could be distinguished, which corresponds with positive effects of the electronic market for all stakeholders. In cases 1, 2, and 3 one has to deal with market modes of cooperation.

Proposition 3: Trust will have positive effects

Proposition 3 is supported by all cases. Case 1 indicates the reverse, e.g., low trust will lead to negative effects for all stakeholders. The trustworthiness of the sample, as a representation of the lot, was questioned by the buyers. In case 3 low levels of trust lead to mixed effects for all stakeholders (uncertainty by the forwarder about the reputation of the transporter).

Table 3: Summary of the Four Case Results.

Analytical Aspect		**Case 1 Aalsmeer Sample Based Auction System**	**Case 2 Holland Supply Bank System**	**Case 3 European Teleroute System**	**Case 4 Dutch/Germ. Transport Man.System**
Motives of Stakeholders		divergent	convergent	convergent	convergent
Mode of Cooperation		market	market	market	network
Trust		low	high	low	high
Entry Barriers		medium	medium	low	high
EM structure		closed	open	open	closed
EM functionality		medium	medium	low	high
Economic Effects					
. Sellers		-lower prices -uncertain demand	+lower risks +higher prices	-lower prices +efficient use of fleet	-lower prices +efficient use of fleet
. Intermediary		-less transactions -lower prices	+concentration of supply +more transactions	+more users +more transactions	+no cure/ no pay +more transactions
. Buyers		+lower prices -uncertain supply -late delivery -uncertain quality	+specified requirements and better quality -higher prices	+lower prices -uncertainty about transporter	+lower prices +higher service
Proposition 1	Motives	*yes	yes	yes	yes
2	Network mode	no	no	no	yes
3	Trust	*yes	yes	yes	yes
4	Entry barriers	no	yes	yes	yes
5	Closed EM	no	no	no	yes
6	Open and Simple EM	no	no	yes	no

Note: Negative effects: -, Positive effects: +, Reverse proposition with negative effects: *.

Proposition 4: Adequate entry barriers will have positive effects

Proposition 4 is supported by cases 2, 3 and 4. In case 1 medium barriers are related to negative effects.

Proposition 5: Closed structure will have positive effects

Proposition 5 is supported by case 4. In case 1 the closed system architecture with medium functionality was not successful. In cases 2 and 3 one has to deal with open architectures.

Proposition 6: Open structure with simple functionality will have positive effects

Proposition 6 is supported by case 3. In cases 1 and 4 closed architectures were reported. In case 2 an open architecture was related, not to low but medium functionality; it resulted in positive effects.

5. Conclusions

The analysis of four cases in the flower and transport industries, using the proposed framework, supports the following conclusions.

Electronic markets can produce negative and positive effects. These effects can differ between the participating stakeholders. In case 1 negative effects were reported for all stakeholders, e.g., lower prices, fewer transactions, and uncertain supply. In cases 2 and 4 positive effects were reported for all stakeholders, e.g., lower risks, efficient use of fleet, more transactions, and better product quality and service. In case 3 mixed effects for transporters and forwarders were reported, but overall the effects were perceived positively.

It is argued from a theoretical point of view that the motives of stakeholders, the mode of cooperation, trust, entry barriers, the structure of the electronic market and the functionality of the electronic market play a significant role in explaining the main economic effects.

Propositions were formulated and four case studies were performed to search for analytical generalization.

The results indicate that there is empirical evidence that convergent motives and high trust among the participants are essential for positive effects for all stakeholders. The other design aspects (mode of cooperation, entry barriers, structure and functionality of the electronic market) are, as a single aspect, not related to positive effects.

Indeed, we conclude that the combination of design aspects will lead to positive effects for all stakeholders. We distinguish three successful combinations of design aspects. The first type of electronic market is characterized as a market mode of cooperation, combined with medium entry barriers, an open structure, and medium functionality. The second type of electronic market is characterized as a market mode of cooperation, combined with low entry barriers, an open structure, and low functionality. The third type of electronic market is characterized as a network mode of cooperation, combined with high entry barriers, a closed structure, and high functionality.

References

1. Bain, J.S., *Barriers to New Competition*, Harvard University Press, Cambridge, Mass., 1971.
2. Bakos, J.A., A Strategic Analysis of Electronic Marketplaces, *MIS Quarterly*, 15, 3, p. 295-310, September 1991.
3. Clemons, E. and B. Weber, London's Big Bang: A Case Study of Information Technology, Competitive Impact and Organizational Change, *Journal of Management Information Systems*, 6, p. 41-60, 1990.
4. De Boer, B.P., *De behoeften aan uitwisseling van elektronische aanbodsinformatie in de afzetketen van potplanten*, Flower Auction Holland/Wageningen Agricultural University, Delft, 1993. (in Dutch)

5. Fukuyama, F., *The Social Virtues and the Creation of Prosperity*, New York, The Free Press, 1995.
6. Galbraith, J.R. and E.E. Lawler, *Organizing for the Future: the New Logic for Managing Complex Organizations*, Jossey-Bass, San Franscisco, 1993.
7. Griffioen, A., Informatieveilen moet de stagnatie overwinnen, *Vakblad voor de Bloemisterij*, nr 7, p. 56-57, 1994. (in Dutch)
8. Gurbaxani, V. and S. Whang, The Impact of Information Systems on Organizations and Markets, *Communications of the ACM*, 34, 1, p. 59-73, 1991.
9. Hess, C.M. and C.F. Kemerer, Computerized Loan Origination Systems: An Industry Case Study of the Electronic Markets Hypothesis, *MIS Quarterly*, p. 251-275, September 1994.
10. Johanson, J. and L.G. Mattson, Interorganizational Relations in Industrial Systems: A Network Approach compared with the Transaction-Cost Approach, *International Studies of Management & Organization*, 17, 1, p. 34-48, 1987.
11. Kambil, A. and E. van Heck, *Information Technology, Competition and Market Transformations: Re-engineering the Dutch Flower Auctions*, New York University, Department of Information Systems, Working Paper Series, Stern IS-95-1, New York City, 1995.
12. Keen, P.G.W., *Competing in Time: Using Telecommunications for Compatitive Advantage*, Cambridge, Mass., Ballinger Pub., 1988.
13. Kooi, A.P., Case Informore B.V. - Edeka Fruchtkontor GmbH: Intermediair Informore als katalysator bij de aansturing van de externe logistiek van Edeka, *Handboek Logistiek*, C5020-1/9, 1994. (in Dutch)
14. Konsynski, B., A. Warbelow, J. Kokuryo, *Aucnet: TV Auction Network System*, Harvard case study 9-90-001, Harvard Business School, Boston, 1989.
15. Krcmar, H. and B. Schwarzer (eds.), *The Impact of Information Technology on the European Transport Sector*, Gabler Verlag, Wiesbaden, 1995.
16. Lee, H.G., Electronic Brokerage and Electronic Auction: The Impact of IT on Market Structures, in: J.F. Nunamaker and R.H Sprague (eds.), Information Systems - Organizational Systems and Technology, *Proceedings of the Twenty-Ninth Annual Hawaii International Conference on System Sciences*, volume IV, IEEE Computer Society Press, Los Alamitos, p. 397-406, 1996.
17. Malone, T.W., J. Yates and R.I. Benjamin, Electronic Markets and Electronic Hierarchies, *Communications of the ACM*, 30, 6, p. 484-497, 1987.

18. March, J.G. and H.A. Simon, *Organizations*, John Wiley, New York, 1958.
19. Nielen, G. C., *Van informatie tot informatiebeleid*, Samsom Bedrijfsinformatie, Alphen a/d Rijn, 1993 (in Dutch).
20. Powell, W.W., Neither market nor hierarchy: network forms of organization, *Organizational Behavior*, 12, p. 295-336, 1990.
21. Ribbers, P.M.A., C.F. Ekering, M.G. van Zutphen, EDI verhoogt de transactiekosten, *Bedrijfskunde*, 66, 2, p. 66-72, 1994 (in Dutch).
22. Williamson, O., *The Economic Institutions of Capitalism: Firms, Markets and Relational Contracting*, The Free Press, New York, 1985.
23. Yin, R.K., Research Design Issues in Using Case Study Method to Study Management Information Systems, in: J.I. Cash and P.R. Lawrence (eds.), *The Information Systems Research Challenge: Qualitative Research Methods*, volume 1, Harvard Business School, Boston, 1989.
24. Van Heck, E. and T.P. Groen, Towards an Electronic Flower Auction?, in: G. Hagelaar (ed.), *Management Studies and the Agri-business 1994: Management of Agri-Chains*, Wageningen Agricultural University, Wageningen, p. 218-233, 1994.

Appendix 1: Description of Cases.

Analytical Aspect	**Case 1** **Aalsmeer** **Sample Based** **Auction System**	**Case 2** **Holland** **Supply Bank** **System**	**Case 3** **European** **Teleroute** **System**	**Case 4** **Dutch/Germ.** **Transport** **Man.System**
Motives of stakeholders	The different stakeholders expected a number of different benefits. By uncoupling logistics and price discovery, the growers and the auction expected the number of transactions per hour to increase. Growers would like to obtain a better price for their products. Buyers would like to specify requirements (package material) for their customers prepared by the growers.	Growers provide supply information to obtain the best price and reduce risks compared with the traditional Dutch auction clock. The auction house develops and maintains the system because they would like to concentrate supply for their growers. Buyers would like to get up-to-date reliable and complete information to speed up their purchasing processes and make them more efficient. Buyers can obtain more specific products with this system, compared with the traditional Dutch auction clock system.	Transporters want to reduce empty truck trips and promote a more efficient use of the fleet. Forwarders want to save time and money by finding quickly a transporter. The intermediary would like to have many sellers and buyers at their system. For transporters efficient use of fleet compensates the effect of lower prices. For forwarders lower prices compensates the uncertainty about the transporter's reputation.	Edeka would like to improve the efficiency of the internal organization and the communication with external relationships (commissioners, repackers, transporters) by using EDI. They would like to increase there service level: orders processed before 16:00 on day A, goods delivered in Germany before the supermarket opens the next day. Informore was involved on a no cure no pay base. Transporters want to promote a more efficient use of fleet, more certainty in ordered transport capacity and faster transport.
Mode of cooperation	The relationship between growers and buyers can be characterized as a market mode. Growers cannot negotiate during the price discovery process.	The relationship between growers and buyers can be characterized as a market mode. Growers and buyers can negotiate during the price discovery process.	The relationship between transporters and forwarders can be characterized as a market mode. Transporters and forwarders can negotiate (by telephone) during the price discovery process.	The relationship between the transporters and Edeka can be characterized as network mode. They have a long term contract but can negotiate during the price discovery process for specific transports.
Trust	The level of trust between growers and buyers is low. Buyers have the idea that the samples did not represent the quality of the lots. Growers have the idea not being compensated for fulfilling special request by buyers.	The level of trust between growers and buyers is high. Buyers and growers can negotiate on price, quality, quantity, and delivery time and these are specified in contracts.	The level of trust between transporters and forwarders is low. Forwarders are never sure about the capabilities of the transporter and transporter are not sure about for example the trustworthiness of the forwarder.	The level of trust between transporters and Edeka is is high, because there are global contracts between them. For each transport they can negotiate about specific requirements.

Appendix 1: Description of Cases. (to be continued)

Analytical Aspect	**Case 1 Aalsmeer Sample Based Auction System**	**Case 2 Holland Supply Bank System**	**Case 3 European Teleroute System**	**Case 4 Dutch/Germ. Transport Man.System**
Entry Barriers	Entry barriers are medium. Growers have to be members of the auction organization and have to deliver their products via the Dutch auction clock, the mediation office or the sample-based auction. Buyers must be registered if they are to become trading partners.	Entry barriers are medium. Growers have to be members of the auction organization and have to deliver their products via the Dutch auction clock or the mediation office. Buyers must be registered if they are to become trading partners.	Entry barriers are low. In Europe every transporter and forwarder can use the system and it is offered at a very low price: hardware Dfl 300, subscription Dfl 915 per year. There is a marginal quality check before transporters are allowed to enter.	Entry barriers are high. Edeka selects its transporters. Other user-groups can use TMS but they use it independently from Edeka and can be supported by Informore.
EM structure	The architecture has a closed character and is only suitable for the direct participants therefore it can be characterized as low reach.	The architecture has an open character and can be approached by all growers and buyers of auction FAH. Buyers can read the supply data by using a supply book, a supply diskette or an electronic link with the supply bank.	The architecture has an open character and can in principle be approached by all forwarders and transporters in Europe.	The architecture has a closed character an can only be used by Edeka and commissioners, repackers, and transporters.
EM functionality	The scope of the architecture is medium. No specific functionality was created in the system for tracking and tracing the products. The focus of the system was on efficient price discovery and requirements specifications.	The functionality is medium. Growers, auction, and buyers are happy with the current architecture which provides actual reliable, and complete supply information. Coupling with the auctions tracking and tracing system provides competitive advantage. There is no strong electronic integration with the logistical and financial systems of the buyers.	The functionality is low. Mostly, the system is used to determine freight and vehicle space availability. It offers additional services like exchange rates, cost price calculations, and country regulations. Teleroute does not offer functionality for bargaining and contracting or services dealing with tracking and tracing.	The functionality is high. The offered services deal with structuring the transporters' logistic process, processing the operational information (checking and confirming booking and instruction), translating bookings into transportation orders and tracking and tracing the transported goods. TMS generates management information for performance measurement and cost reduction.

Electronic commerce: Towards a reference model

Wout J. Hofman

Bakkenist Management Consultants, P.O. Box 23103, 1100 DP Amsterdam, The Netherlands, whofman@bakkenist.nl

Abstract

As we all know, there are several problems to be solved when implementing Electronic Commerce. It requires the support of standards for electronic communication. These standards need to be implemented in one way by all actors that want to participate in Electronic Commerce. However, not all actors are fully automated and, if they are, they do not use identical subsets of standards. We present several elements that compose an EDI Reference Model that serves as the basis for developing, maintaining and implementing Electronic Commerce. The EDI Reference Model is based on modelling techniques. It shows what to do and how to do it. The version presented in this article is limited to structured data and can be extended with other types of data like pictures, music, and voice.

1. Background

As all new technologies, Electronic Commerce consists of both an organisational part and a technical part. With respect to Electronic Commerce, an open environment is required in which actors can freely perform business. Therefore, the technical aspects for creating such an open electronic environment are of great importance. The specification of an Open EDI Model by the ISO [1] is one of the first steps.

With respect to the possibilities of achieving an open electronic environment, one can distinguish between the following degrees of automation, which differ slightly from the once introduced by Nolan [2]:

- poorly automated organisations

A great many organisations are poorly automated or not at all. Possibly, they have PC's to perform text processing. They are not able to process structured data.

- *internal automated organisations*

  It concerns organisations that have software to support their internal administration. They produce paper output internal to the organisation and to communicate with other organisations.

- *administrative EDI*

  These organisations have software and are able to communicate externally by means of electronic messages. They are able to produce or consume for instance purchase orders and invoices electronically. Most often, EDI is replacing documents. Technically, these messages are always handled by one application.

- *business EDI*

  EDI is used to support services and products, e.g. an insurance product, a financial product, or a transport service. This type of EDI is to control the execution of business processes (process control). Technically, the service or the product may be supported by more than one application. An organisation must be able to define new services, independent of its application software infrastructure. Businesswise, most of the external and internal communication is routine and can be handled automatically, e.g. 80% of the business of for instance forwarders is routine.

Business EDI is the ultimate objective to support Electronic Commerce. Business EDI can be further refined, e.g. towards EDI to support *routine business* and EDI to support a *dynamic business process*. An example of a dynamic environment is the process of curing patients, where the cure is depending on for instance the diagnosis and one or more lab researches. This distinction is of importance to an organisation and is a requirement of an EDI Reference Model.

Business EDI is to objective to be achieved by an EDI Reference Model. Such a model will result in software components that can be used by organisations with a different degree of automation to implement Electronic Commerce. Only the functionality of these components will be discussed; their use in a certain environment depends on for instance organisational, legal, and political aspects. They may result in central and decentral implementation, e.g. a central database containing product data and decentral ordering systems.

The EDI Reference Model consists of a methodology for developing systems to support Electronic Commerce, supporting tools, and an EDI Information Base. These aspects are presented in the next sections.

2. EDI methodology

2.1. Concepts

The EDI Reference Model is based on the modeling of communicating information processes to manage the execution of a business process (figure 1). Examples of business processes are in customs, transport, health care, insurance, and finance [3].

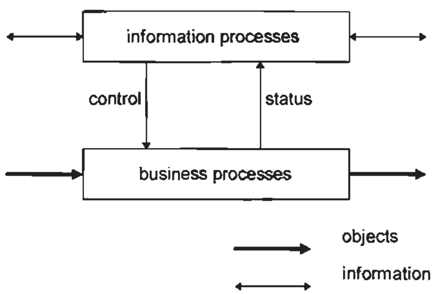

Figure 1: Information processes that control business processes

The information processes have a view of the business processes that they are to manage. This view is represented by a data model. The information processes themselves can be decomposed in persons, organisations, and organisational units that communicate and exchange information regarding the structure and the status of the business process.

The results produced by the method, have to be independent of any configuration of the information processes and the business processes. Thus, the method has to result in models that can be applied by all persons and organisation(al units) that have a relation with a particular business process. One is able to model its own business process and use available models. The method is applicable to both batch and interactive EDI [4]. It supports routine transactions and an open market [5].

The business objective of the method is the standardisation of concepts to specify the *statics* of external communication that is to manage the *dynamics* of the execution of business processes. Concepts that specify the dynamics of both business processes and external communication are only used to illustrate how to apply the structural aspects as one of the deliverables. The static aspects of external communication can be applied to control the execution of any business process. An overview of static and dynamic concepts is shown in table 1.

	statics	**dynamic**
business process	process/service	activity
	task	action
	object type	object
information process	protocol	transaction
	message type	message
	processing rules	transaction tree, scenario
	procedure	job

Table 1: Overview of the concepts

A brief explanation of these concepts is given hereafter.

Each actor is to tackle the problem of the *dynamics* of its business process, e.g. where are my goods at a given time. Therefore, information is exchanged with other actors. EDI messages are used to exchange information regarding objects: their *identity* (e.g. container number, patient identification, and article number), the *place* or *stage* in which they are, the *time* at which they are in that place or stage, and their *value* (e.g. a twenty foot container with cargo, a patient with certain features that indicate an illness, and an article with a certain weight).

Information that actors exchange is related to the structure or the behaviour of a business process. A price catalogue message is for instance related to the statics, although it may change, whereas an order is part of the dynamics of a business process. All *messages* that are exchanged between actors to control a particular aspect of the dynamics of a particular business process are part of a *transaction*. Examples of transactions are consignment handling in transport and order processing in retail or automotive.

The messages of a transaction can only be exchanged in a particular sequence that is agreed between actors, e.g. a despatch advice does not have a meaning without an order. The sequence is governed by a *protocol*. A protocol can be visualized by *a state transition diagram*. Each of the state transitions can be triggered by the exchange of a message between two actors that is of a certain *message type*, e.g. a particular order is of the message type 'order'.

Figure 2 shows a data model that specifies the relationships between both statics and dynamics of the EDI Reference Model. This data model is a metamodel and can be used as the basis for a tool to model EDI Reference Models. Figure 2 only shows the main entities, the attributes of these entities have to be added.

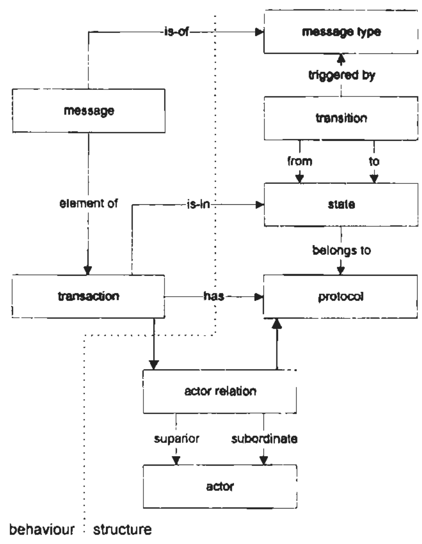

Figure 2: data model containing statics and dynamics

Business processes can be controlled by two or more actors, e.g. many actors can be involved in the transport of goods from the Far East to Europe or in the curing of a patient. The rules to link transactions to chains are called *transaction processing rules*. The relation between actors in these chains can be visualized by a *transaction tree*. A transaction tree is stored by the 'actor relation' entity of figure 2. The sequence of messages in a transaction can be visualized by a *scenario*. One possible sequence is governed by both the protocol and the transaction processing rules. A scenario is not shown in figure 2, but can be derived from the behaviour.

The transaction processing rules have to be implemented by each actor that participates in a transaction tree. The implementation of these rules results in a *procedure* for producing a service or a product. The same service or product can of course be produced in different transaction trees, e.g. the same transport service from the Far East to Europe can be offered to different clients. The actual delivery of a service or a product results in the execution of the procedure for that service or product. This is called a *job*. The concept of procedure, service and job are explained in more detail by the author in [3]. Adding these concepts to the data model shown in figure 2 needs further refinement of this figure.

2.2. Phases

The EDI Reference Model for a certain situation is developed in three phases. These phases reflect the work performed by UN/EDIFACT/WE-EB/T5 (Business and Information Modeling [6]). The deliverables of our method with respect to these boxes are shown in table 2.

	data modelling	process modelling
Business Analysis Phase	object model data model	actor model business process model protocols
EDI Requirements Phase	transaction data model message data model	transaction types message types transaction trees scenario's
EDI Implementation Phase	model mapping message framework message structure database design translation table generation	transaction protocol software user interface software EDI translation software etc.

Table 2: Overview of the deliverables with respect to phases

The production of these deliverables is discussed in the next pages. The relation between the EDI Requirements Phase and the EDI Implementation Phase is discussed in detail in a separate document produced by UN/EDIFACT/WE-EB/T5 (Business and Information Modelling - part 6: Guidelines for Developing UN/EDIFACT Messages from the BIM process [7]).

In addition to table 2, figure 3 shows an overview of the deliverables and their technical relationship.

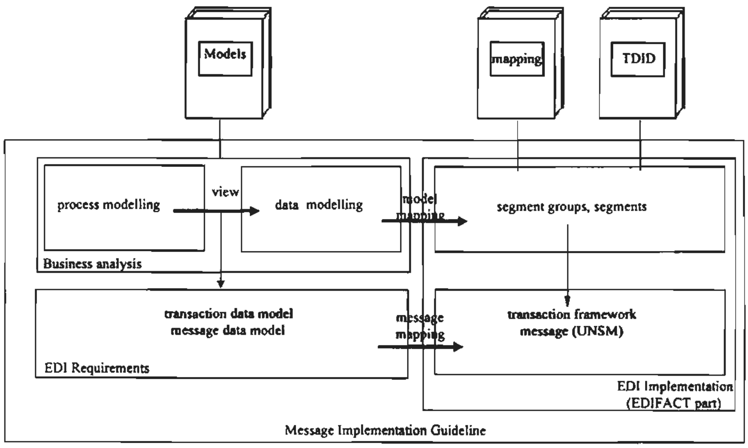

Figure 3: The technical relation between deliverables

Figure 3 only shows the EDIFACT part of the EDI Implementation Phase. The other parts, such as the generation of EDI software like translation tables and end-user interfaces, use the results of the other phases. Figure 3 shows that the result of the EDI Reference Model is a MIG (Message Implementation Guide) comprising both functional and technical aspects.

Figure 3 shows three books that represent repositories. A well-known repository is the *TDID* (Trade Data Interchange Directory). It contains all standard EDIFACT elements. The *model repository* will contain the results of modeling and the *mapping repository* the relation between the TDID and the model repository. The content of these repositories can be developed at for instance international level, whereas they will be used to define national or bilateral implementations.

MIG's can be decomposed in different chapters, whereas each chapter serves a particular interest groups. A MIG can have a chapter for the end-users containing the scenario's and the hierarchical message structures consisting of entities and attributes, and a chapter for the implementors containing the EDIFACT message structures. Software developers may use all products of the method to develop/generate new application software.

Each MIG consists of a data model and at least hierarchical message data structures (see also figure 5). These are used as input to the mapping process. Furthermore, process models consisting of scenario's can be used as input. These scenario's are the result of a so-called actor model and possibly transaction trees showing the relation between actors (figure 4). Transaction trees can be used to visualize the responsibilities of actors involved in processing a business transaction.

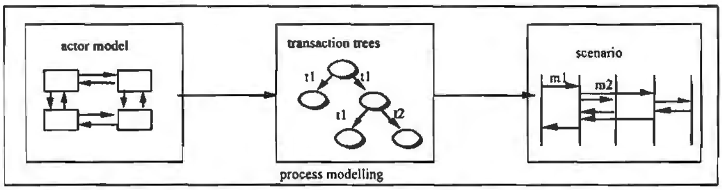

Figure 4: Process modelling: actor models, transaction trees and scenario's

Figure 4 shows that there are three steps possible. The end-deliverable of the third step, but also all other deliverables have to serve as input to message development. Each transaction in a transaction tree has a specific protocol and a data structure. The data structure is a view on a data model (transaction data model). Each message in a scenario is of a type that has a data structure (message data structure). Mapping of the different data structures can be visualized as:

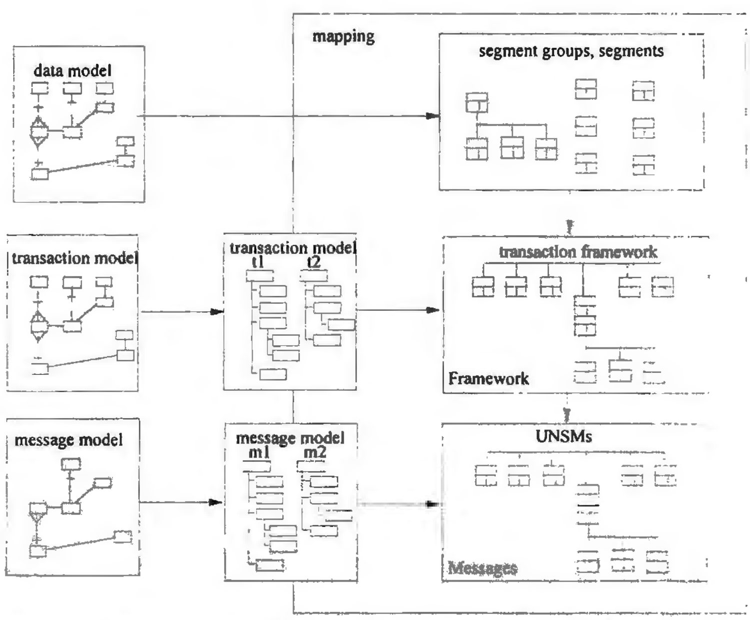

Figure 5: Visualisation of the mapping process to the EDIFACT syntax

Figure 5 shows that input to the mapping is an hierachical data structure. These hierarchical data structures are required if a mapping to a syntax with a hierarchical structure is needed. EDIFACT (EDI For Administration, Commerce, and Transport, [8] and [9]) is such a syntax. SQL (Structured Query Language) is a syntax that supports the exchange of relational tables. Both are international ISO standards. EDIFACT is most often used for external communication and SQL for access to Database Management Systems.

A data model to support EDI can be transformed directly into SQL-statements for creating a database. Messages can be formulated as queries or updates on this database (see also the next section). Each entity corresponds to a table. Implementation choices have to be made during such a transformation from a conceptual to an implementation model.

Besides the documentation of MIGs, the EDI Implementation Phase also supports the construction or generation of the following software components:

- *database*
  A database structure can be generated for storing information for managing transactions like transit declarations. The data model is converted to a syntax for a DBMS.
- *GUI (Graphical User Interface)*
  A user interface with generic user interface functions like update, delete, archive, and print, can be generated. It consists of flexible screen definitions for manipulating for instance transaction data and messages.
- *reports*
  Reports for documenting and reporting data either to a user or another actor can be generated. Reports have to be routed to a destination like a printer device, directly to a communication partner, or by using a mailbox facility for communication with another actor;
- *procedures*
  Procedures for handling routine transactions can be constructed. They are based on transaction protocols that can be execute using a standard software functions for procedure and exception handling.
- *translation tables and EDI software*
  Translation tables for existing or newly to be developed translation software can be generated. The interface between the EDI software and internal applications should be identical to the structure of the internal database of an application.

The functionality of these generic software components given here is described in 'A Conceptual Model of a Business Transaction Management System' by the same author [3].

The concepts can be applied for both batch and interactive EDI. The relation between these concepts and the interactive EDI concepts is as follows:

- the concept of a *transaction* is similar to the concept of a *dialogue* that is defined in interactive EDI.
- the concept of a *transaction tree* is similar to the concept of a *scenario* that is defined in interactive EDI.

3. Development and maintenance tools

Currently, the following tools available to support the method:

- EDIT: EDI Development and Implementation Tool for developing data models and mapping message structures to EDIFACT;
- a tool to support chain modeling;
- a tool to support the implementation by producing for instance translation tables and test messages for conformance testing;
- BTMS generator that generates the user interface of Business Transaction Management Systems.

EDIT and the chain modeling tool can be used to support message development and documentation. The chain modeling tool also has to produce 'procedures' that support products and services. The BTMS generator can be used to demonstrate the functionality of messages, can be used for prototyping, and can serve as an internal application to those organisations that are poorly automated.

We will give some details of the functionality of EDIT and the new module. The chain modeling tool is still in development (ready at the end of 1995) and will be able to support process modeling. The BTMS generator is currently in pilot testing and is operational in October 1995. It can be used to generate client applications extended with a server database according to the model developed by the Gartner group. The server database can not yet be generated.

EDIT supports the functionality shown in figure 5. Its main features and output are:

- *modeling*

  Data models, transaction data models, and message data models can be entered and documented. The Entity-Relationship method is used, distinguishing domains, entities, and attributes.
- *TDID*

  All versions of the TDID are available in EDIT. They can be changed and extended. Special features are the distinction between 'normal' data elements, qualifiers, and specifiers. The EDIFACT rules are implemented and can be checked.
- *mapping*

  The different levels of mapping distinguished earlier in this paper are supported.
- *completeness/correctness*

  The MIGs that are produced, contain message specifications that have to be used in an operational way. First of all, they have to adhere to the EDIFACT UNSMs. This is called *completeness*: all mandatory data elements and segments have to be used in the MIG and repeating factors may not be higher. Secondly, there are a number of mapping rules that have to be obeyed, e.g. no two attributes may have the same mapping or the attributes of a repeating entity may not be mapped to segments at the same nesting level. This is called *correctness*.
- *Directory Maintenance Requests (DMRs)*

  DMRs can be managed by EDIT. One is able to enter and change the status of a DMR. Starting points for creating a DMR is a business requirement, e.g. a change in for example the transit procedures. Such a business requirement may have impact on data structures, the TDID, and the mapping between both.
- *subsets*

  Based on the international MIGs, subsets can be created.
  - *language support*

  Language support by EDIT is twofold:
  - the tool itself is available in at least the Dutch, the English and the French language. If required, it can be translated in other languages.
  - the databases of the tool support several languages, e.g. the translation of one MIG can be contained in the databases. It means for instance translating a data model in both English and French, whereas these data models have identical mappings. It eases maintenance of different translations of MIGs.

- *test messages*

  One is able to enter real life data using all details of a MIG. The test message can be documented functionally and in EDIFACT format (compressed file) and can be exported on disk or on a network.
- *EDIFACT conformance testing*

  One is able to enter test messages and add them to an existing interchange or create a new interchange. Each of these messages may contain upto 15 errors, e.g. missing UNZ, wrong value of the message count, and missing mandatory data element.
- *translation tables*

  Once a MIG is correct, one is able to generate translation tables or a generic file that can be used by an implementor to generate translation tables. Currently, we support the generation of translation tables for two EDI translation software packages.

A great many documents can be produced, e.g. complete MIGs containing for instance an hierarchical representation of a functional message specification and its mapping to EDIFACT. These documents can be imported in text processing software using the RTF (Rich Text Format) syntax. Their lay-out, headers and footers can be changed using text processing software.

The MIGs have to be implemented by different actors that want to support Electronic Commerce. If actors are automated, they will probably have database structures that differ from the data models developed to support Electronic Commerce for specific business processes. Therefore, these application specific database structures have to be mapped to the common data models. Based on these mappings, translation tables to support the translation between databases and EDI messages can be generated.

The common data model can also be implemented in the translation software. Thus the common data model is the interface between actors involved in Electronic Commerce. As long as the protocols are implemented identical by all actors involved, the message structures need not to be specified at all. The exchange of tables is sufficient. One is thus enabled by formulating its own query on a database of another actor (of course authorisated access is needed). Figure 6 shows the role of the common model.

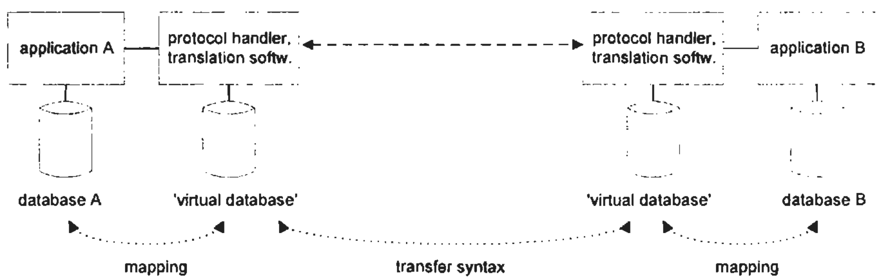

Figure 6: the common model to support Electronic Commerce

In fact, the internal application serves as the interface to a user. If the internal interface is not available, it can be generated by the BTMS generator. Figure 6 shows the mapping and the use of one transfer syntax. The mapping is a maintenance aspect and is supported by a function of EDIT that is under development.

4. Operational tools: implementation aspects

Implementation aspects are already briefly discussed in the previous sections. The main aspects are in the flexibility of the interface of so-called EDI translation software. By using EDIT and generic EDI translation software, one is able to obtain flexibility in EDI message development and interfacing to internal applications (see also previous section). This will ease the overall implementation of EDI and will reduce maintenance costs.

Figure 7 shows the structure of EDI software as we envisage it. It can be implemented in every environment, e.g. also in a client-server environment.

The main part of the conversion between data structures is part of record conversion. It can translate between any syntax. Syntax dependend aspects are handled by a separate component, e.g. EDIFACT conversion handles compression and expansion of EDIFACT data structures. Syntax handling handles all interfaces, selects a script and executes the script. A script contains information regarding the functions to be executed and the sequence in which they are to be executed.

The design of the EDI translation software is modular. New functions can be plugged in 'syntax handling' and new scripts can be inserted. The maintenance of scripts and translation tables can be part of a registration module of EDIT.

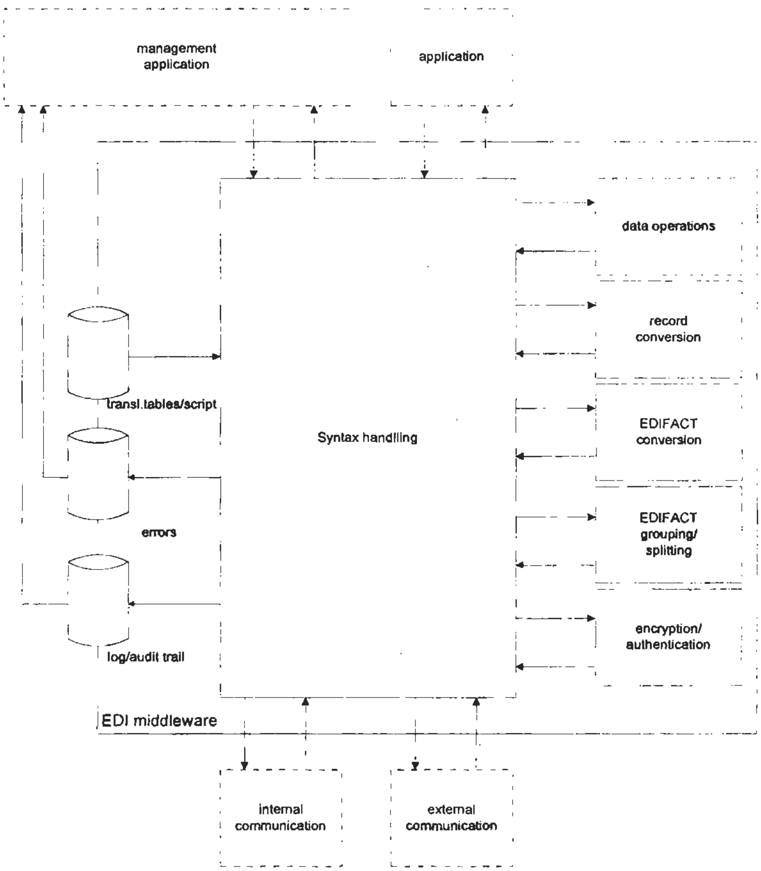

Figure 7: Structure of EDI translation software

Based on such a design of EDI translation software which includes maintenance functions, the impact on existing applications will be minimal. The design can functions as a reference for implementation.

5. EDI Information Base

An EDI Information Base can serve many purposes. For instance, it can be used to store documents received from other parties involved in standardisation, like the WEEB/TAG or the WEEB/TCC, and (inter)national user communities like EAN International and EAN

Netherlands and Odette Europe and Galia (Odette France). Another purpose can be to maintain messages developed in local, national, or international projects.

In general, one can say an EDI Information Base serves as a collection, maintenance, and retrieval tool.

Collection of data can be from the following sources:

- *EDI standardisation organisations*
  It concerns organisations active in the framework of the Western European Edifact Board (WEEB), Committee of European Normalisation (CEN), etc. They produce all types of documents like the TDID (Trade Data Interchange Directory), Directory Maintenance Requests (DMRs), results of WEEB/TAG meetings, documents of JRT meetings, CEN documents regarding EDI standardisation, etc.
- *international (EDI) organisations*
  A number of international EDI organisations is active in developing and promoting the use of EDI. During the EDI development, implementation and operation they produce several documents, amongst others MIGs.
- *national EDI organisations*
  National EDI organisations are also active in the same area as the international organisations. Therefore, they also produce several documents that have to be available both to end-users and to international organisations.
- *end-users*
  End-users can be distinguished with respect to for instance their degree of automation and their size and annual turn-over. Large (multi)national organisations will have their own personnel to develop and implement EDI. They either develop their own models or use existing models. Smaller organisations will make use of existing models.

The data produced by these parties needs to be maintained. They will produce several versions of these documents, in which case the latest version, or even one previous version, must be maintained in the EDI Information Base.

Retrieval of data concerns all types of documents. We can make the following distinctions:

- *active or upon request*
  The data stored in the EDI Information Base is actively distributed to several parties, e.g. boiler plates of EDIFACT messages used in MIGs are actively distributed to parties involved. Data can also be made available upon request.

- *internal versus external*
  The data can be made available within an organisation or externally to other organisations.
- *structured versus unstructured*
  One can distinguish between structured data like UNSMs, TDIDs, and data models, or unstructured data like reports, minutes of meetings and other types of documents. The structured data can be of added value to the parties that are going to implement EDI. For instance, if a MIG is available in a structured way, it is possible to produce automatically translation tables.
- *electronic medium versus paper medium*
  The output can be produced electronically, e.g. a MIG can be produced as a message and can be distributed via a network like Internet or by means of floppy disk, or on a paper medium, e.g. a report can be reproduced on paper and distributed by postal mail. Another way of making information available is via WWW or distributing it actively or upon request via HyTime [10] or SGML [11].

With respect to collection, maintenance and retrieval of data contained in the EDI Information Base, we also need to make a distinction between data that can help to ease EDI implementation *directly* and data that can serve be a *support* during implementation. The first type of data needs to be structured and management of retrieval and distribution of the data is of importance. Therefore, it needs to be contained in a database and distributed electronically. The second type of data can remain unstructured, only access to the data can be simplified by using hyperlinks and making it available to external parties by for instance a WWW server.

We can envisage EDIT to act as a database for storing structured EDI information like MIGs, datamodels, and TDIDs, and a document management system to contain the (unstructured) documents. A query facility needs to be created on top of EDIT to access the contents easy and to produce the required output. A groupware product can be used to share the information between persons working in the same environment. Electronic communication facilities (an EDI interface) can be used to share information with external parties. The groupware and/or the query facility and the communication software needs to contain functionality regarding the authorised persons that have access to the data contained in the EDI Information Base.

6. Concluding remarks

We have presented quite a number of aspects of an EDI Reference Model. These aspects support the development, maintenance, and implementation of such a model. Applying the concepts and the tools that we have presented results in a technical open environment. In such an environment, an EDI Information Base and the communication between different installations of such these Information Bases is a pre-requisite for Electronic Commerce. Data models, protocols, and message structures have to be accessed before one is able to do business electronically.

Once such an open environment with all tools is available, the next generation will be focussing on an information base containing products and services and their supporting technology can be envisaged. Such information bases are oftenly called Information Warehouses.

References

[1] ISO/IEC JTC 1/WG 3 N255, Open-EDI Reference Model Standard - Working Draft 1993.

[2] Nolan, Richard L, Managing the crises in data processing, Harvard Business Review 57, March-April 1979.

[3] Hofman, W.J., A Conceptual Model of a Business Transaction Management System, Tutein Nolthenius, 's Hertogenbosch, 1994.

[4] UN/ECE WP.4 GE.1, Recomendation on Interactive EDI, version 3.1, October 1992.

[5] Williamson O.E., Markets and Hierarchies: analysis an antitrust implications, Free Press, New York, 1975.

[6] UN/EDIFACT/T5 - 1, Business and Information Modelling Guidelines, Working draft version 2.2a, july 1993

[7] UN/EDIFACT/T5 - 6, Business and Information Modelling Guidelines - part 6: Guidelines for Developing UN/EDIFACT Messages from the BIM process, version 1, 1995.

[8] ISO 9735, Electronic Data Interchange for administration, commerce and transport (EDIFACT) - Application level syntax rules, ISO, 1988.

[9] ISO CD 9735:1993(E), Electronic Data Interchange for administration, commerce and transport (EDIFACT) - Application level syntax rules, United Nations, 1993.

[10] ISO (1992), Information Technology - Hypermedia/Time-based structuring Language (HyTime), ISO/IEC 10744-1992(E), International Organization for Standardization.

[11] ISO (1986), Information Processing - Text and office systems - Standardized Generalizd Markup Language (SGML) ISO 8879 -1986(E), International Organization for Standardization.