Information Transfer in Supply Chain Management

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Abstract

The paper deals with integration of supply chains and specifically concentrates on the importance of distribution of information among various companies in the chain. It summarizes the most important concepts of supply chain management. Both technological changes and organizational improvements are essential for effective integration of supply chains. Therefore the paper shows how business process modelling can be used to analyze the existing processes and help in renovation and integration of those processes, with a special emphasis on an inter-organizational level. It is shown on a practical example, how sharing and strategic utilization of information in a supply chain can radically improve execution of vital business processes and help integrate processes in different companies. That leads to shorter cycle times, lower costs and inventory levels and better quality for the final customer.

Keywords: supply chain management, information sharing, business process renovation, business process modelling, integration.

Introduction

In the modern world the main focus of competition is not only between different companies but also between supply chains. As the satisfaction of the final customer is of utmost importance for the successfulness of the whole chain, effective management of those processes is crucial.

Many new technological solutions and organizational concepts have developed in recent years, however, only a few companies are using them strategically in a supply chain to achieve full competitive advantage, while many others are developing and implementing inappropriate e-business solutions (Cox, Chicksand & Ireland, 2001). Practical experience has shown that the root cause for this is not technological problems, but is connected with organizational and process aspects (Jaklic, Groznik & Kovacic, 2003).

Therefore the main idea of this paper is to show that full strategic advantages can be realized, especially if the two items below are considered, while e-business and IT solutions alone can bring certain improvements in the overall business performance,:

1. business process modelling is a prerequisite for business process management (BPM) and renovation (BPR),
2. successful operation of a supply chain is only possible with effective BPM.

While different approaches to BPM and BPR are possible, none of them is feasible without prior detailed knowledge about an internal and external business process. Models of business processes play an important role in different phases of business process (re)design regardless of the methodology used (Desel & Erwin, 2000).

Business process management should not only be applied locally but also at the supply-chain level. Many of the changes are directly or indirectly connected with the flow and utilization of information, where e-business and Internet play a vital role as an enabler of cheap, quick and efficient transfer of information. Successful utilization of information, however, is dependent on efficient business processes as shown in the remainder of this paper.

The structure of this paper is as follows: the next chapter analyses the main concepts and challenges of SCM. Special attention is paid to the importance of information sharing and measurement of SC successfulness. Then the role of business process modelling in effective SCM is analyzed. Finally, the theoretical findings are shown with an example of possible business process renovation and integration in a two-tier supply chain. The benefits of those changes are shown with AS-IS (current version) and TO-BE models (improved version) of procurement process.

Supply Chain Management (SCM)

Supply chain is a linked set of resources and processes that begins with the sourcing of raw materials and extends through the delivery of end items to the final customer (Bridgefeld Group ERP/Supply Chain Glossary, 2004).

While the separation of supply chain activities among different companies enables specialization and economies of scale, there are many important issues and problems that need to be resolved for successful SC operation – this is the main purpose of SCM.

According to the definition of SCM by the Global Supply Chain Forum (GSCF), SCM is ‘‘the integration of key business processes from end user through original suppliers that provide products, services, and information that add value for customer and other stakeholders’’ (Chan & Qi, 2003). We can only talk about SCM, if there is a proactive relationship between a buyer and supplier and the integration is across the whole supply chain, not just first-tier suppliers (Cox, 2004).

There are several important problems in SCM that need to be resolved for efficient operation. Most of those problems stem either from uncertainties or inability to coordinate several activities and partners (Turban, McLean, & Wetherbe, 2004).

One of the most common problems in supply chains is the so-called bullwhip effect. Even small fluctuations in the demand or inventory levels of the final company in the chain are propagated and enlarged throughout the chain. Because each company in the chain has incomplete information about the needs of others, it has to respond with the unproportional increase in inventory levels and consequently even larger fluctuation in its demand to others down the chain (Forrester, 1961; Forrester 1958). There are many practical examples from various industries that support this finding (see e. g. Jones & Simmons (2000) for an example of food industry or Naim, Disney & Evans (2002) for automotive sector).

It was shown however that the production peak could be reduced from 45% to 26% by transmitting the information directly from the customer to the manufacturer (Forrester, 1961; Holweg & Bicheno, 2002).

Another problem is that the companies often tend to optimize their own performance, disregarding the benefits of a supply chain as a whole (local instead of global optimization).

Additionally, human factors should also be studied: decision-makers at various points in the supply chain are usually not making perfect decisions (due to the lack of information or their personal hindrances). Those two problems are also interconnected as employee reward systems often focus simply on growing sales or on gross margins (McGuffog & Wadsley, 1999).

A detailed review of other SCM-related problems can be found in (Holweg & Bicheno, 2002).

E-business can be defined as the term covering both e-commerce (buying and selling online) and the restructuring of business processes to make the best use of digital technologies (eEurope2005, 2005).

Internet and e-business offer many possibilities for effective information sharing that enable seamless flow of transactions in the supply chain. They can also facilitate relationships by their ability to transfer information (Wagner, Fillis, & Johansson 2003). Newly developed relationships can drastically change the underlying business processes and different new approaches are emerging, such as vendor managed inventory (VMI), computerized point-of-sale (POS) systems, material requirements planning (MRP), manufacturing resource planning (MRP II) etc. (see Turban, McLean, & Wetherbe, 2004 for more details).

However it should be noted that information technology alone is not a panacea for all SC problems. Even more: the most often quoted problems of online purchasing are not related to technology but rather to logistic and supply chain problems (Hoek, 2001). This is even truer for traditional companies that are usually even less prepared for new e-commerce related challenges.

The efficiency of supply chains can generally be improved by e.g. reducing the number of manufacturing stages, reducing lead-times, working interactively rather than independently between stages, and speeding up the information flow (Persson & Olhager, 2002). It was shown that electronic data interchange (EDI) could reduce swings in inventory and safety stock levels. The simulation results showed that (among other improvements) the standard deviation of the stock level was reduced from 749 to 272 tons, leading to 400,000 $ annual savings (Owens & Levary, 2002).

Once again: only the implementation of new technology without changes in company's operation will realize only part of all possible benefits. The continuation of the paper therefore mainly deals with changes in business processes that have improved the flow of information as one of the main consequences. That leads to reduction of lead times and better collaboration between participating companies.

Information Sharing in the Supply Chain

In recent years numerous studies have emphasized the importance of information sharing within the supply chain (e.g. Barrat, 2004, Lambert, & Cooper, 2000; Lau & Lee, 2000; Stank, Crum & Arango, 1999). Indeed information sharing is a prerequisite for successful operation of the SC (Mason-Jones & Towill, 1997).

While there is no doubt about the importance of informing in the supply chain and about the fact that information technology (especially various Internet applications) can greatly reduce the costs, strategic planning of this process and utilization of information is crucial. Information should be readily available to all companies in the supply chain and the business processes should be structured in a way to make full use of this information.

It should be noted that the use of information technology, networks and e-business applications alone is not sufficient to realize the benefits. It was found that Internet adoption alone has demonstrated no benefits in terms of reduced transaction costs or improved supply chain efficiency in Scottish small and medium enterprises (Wagner et al., 2003), and has not led to a decrease in the inventory level in Slovenian small and middle-size enterprises (Trkman, 2000). Additionally, only sharing of information will not lead to improvements, but also coordination of activities is crucial (Disney, Naim & Potter, 2004). While it should not be claimed that Internet alone reduces certain costs, strategic utilization of the information is of the utmost importance and business process modelling and renovation (shown in the remainder of this paper) can be of great help in achieving this desired coordination.

Sharing of information can obviously be a problematic issue as the companies in a supply chain may not be prepared to share their production data, lead times, specially when those companies are independent of each other (Terzi & Cavalieri, 2004). Indeed, the lack of trust between business partners is one of the main hindrances to collaboration in the supply chain context (Barrat, 2004; Ireland & Bruce, 2000).

The main contribution of this paper is to show how business process modelling (specifically process maps) can be used in order to develop such business process models that will lead to improvements in sharing the information and integration of processes. Appropriate business processes are a prerequisite for the strategic utilization of information (otherwise sharing of information can only lead to an overload of information without much benefits for anyone involved). Business modelling techniques are of great help to get fully acquainted with the processes in question and to improve them.

Obviously the implementation of those concepts and possible benefits of integration of a supply chain is similar in various industrial and service branches. Although the exact possibilities vary from industry to industry (see e.g. (Baer & Davis, 2001) for auto industry or (Persson & Olhager, 2002) for telecommunications), the main business process integration concepts, presented in the continuation of the paper, can be applied with minor modifications regardless of the industry in question.

Measures of SCM Successfulness

The most important measures of SCM successfulness can be the final level of service, customer satisfaction and SC competitiveness and profitability as a whole. However as these are difficult to measure or use as a guideline to monitor improvement, more operational measurement methods and indexes were developed.

On a more operational level the key performance indicators are total costs, quality and lead times in the SC (Persson & Olhager, 2002). Survey of performance measures (Beamon, 1998, 1999) showed that cost and customer responsiveness dominate as the most often mentioned measures.

Different performance measures can be classified in resource (e. g. cost, inventory), output (most importantly customer service) and flexibility measures (ability to respond to changes in the environment) (Persson & Olhager, 2002). Similarly Chan (Chan & Qi, 2003) emphasizes the importance of measuring the inputs (time, costs) and outputs (quality, reliability and innovativeness of the products/services) of the process. Composite measures, which include all of the above, are productivity, efficiency and utilization of resources.

A survey of top management showed that throughput, lead-time, and utilization are considered among most important (Tatsiopoulos, Panayiotou, & Ponis, 2002).

As shown above, different authors emphasize slightly different aspects of those measures. However the common conclusion from the above-summarized papers can be that achieving high customer satisfaction with low costs, combined with flexibility to react to unforeseen changes, is crucial.

While the final customer is mostly interested in the total quality and effectiveness of the supply chain as a whole, changes in a single company should also be studied. A company is unlikely to participate in a integration project if it does not also bring benefit to that company.

Sometimes individual companies may even sacrifice their internal efficiency to overall chain optimization – the main question then obviously is how to compensate them.

As local optimums in single companies will almost certainly not lead to the global optimum, the performance measures should include the entire chain in the measurement system. The foundation for cooperation (and measurements) is mutuality of benefit, rewards and risk sharing together with the exchange of information with each other (Barrat & Oliveira, 2001; Stank, Crum & Arango, 1999).

Additionally, the performance measures should be integrated across different departments and all companies in the supply chain (Barrat, 2004; Lengnick-Hall, 1996). Otherwise the concentrated effort towards the realization of those goals is not possible.

Ideal performance measures would both facilitate the improvements and enable the measurements of achieved results. A common approach to predicting and measuring the effects of SCM is the use of simulations (see Bosilj-Vuksic, Indihar Stemberger, Jaklic, & Kovacic, 2002 for an example of simulating the effect of business process renovation and Terzi & Cavalieri, 2004 for a coherent review of literature about this topic).

Role of Business Process Modelling in SCM

Business Process Renovation

Regardless of the industry, the number of companies involved or the technological solution used in integrating a supply chain, it should be emphasized that successful implementation of SCM is not possible without extensive renovation of business processes. Namely, the fundamental of SCM is to manage and integrate key processes (Chan & Qi, 2003). Business process orientation is crucial for reducing conflict and encouraging connectedness in the SC, while improving business performance (McCormack & Johnson, 2000). Enhanced SCM can then lead to cost savings across a wide range of business processes (Horvath, 2001). Studies have shown that successful supply chain projects can lead to 10-50% overall supply chain cost improvement (Cross, 2000).

However, the connection of existing processes in different companies is rarely possible without thorough redesign, realignment, simplification and standardization of current business processes. The cost-benefit study of those changes is one of the vital questions for further research on this topic.

Business Process Renovation integrates the radical strategic method of Business Process Reengineering (Hammer & Champy, 1993) and more progressive methods of Continuous Process Improvement (CPI) with adequate Information Technology (IT) infrastructure strategies. Process renovation is a re-engineering strategy that critically examines current business policies, practices and procedures, rethinks them and then redesigns the mission-critical products, processes, and services (Prasad, 1999). It is also a method of improving the operation and therefore the outputs of organization (Kettinger & Grover 1995). It means analyzing and altering the business processes of the organization as a whole and requires careful change management. In SCM terms another important aspect is to guide BPR with the idea to simplify and improve processes in such a way that they can be easily integrated with other companies.

Business process management (BPM) combines renovation and process management methods with automation of activities and workflow systems. It is a blending of process management, usage of workflow management systems and applications integration.

The difficulties of formulating and adopting new process, a lack of cooperation between vendors, and the sheer difficulty of inter-organizational coordination present the major difficulties in SCM. Supply chains that will be able to find better answers to these challenges will achieve considerable competitive advantage.

On the other hand, CPI integrates methods such as industrial engineering, systems analysis and design, socio-technical design and total quality management (Davenport, 1993; Galliers, 1998). Continuous improvement refers to programmes and initiatives that emphasize incremental improvement in work processes and outputs over an open-ended period of time (Davenport & Beers, 1995). Several researchers (Tenner & DeToro, 1997) suggest that using CPI techniques dramatically increases competitive advantage. Furthermore, it is particularly suggested that TQM should be integrated with BPR (Al-Mashari & Zairi, 1999).

In the 90s, BPR focused on internal benefits such as cost reduction, the downsizing of a company and operational efficiency, which are more tactical than strategically focused. Nowadays, e-business renovation (BR) strategies focus on the processes between business partners and the applications supporting these processes. These strategies are designed to address different types of processes with the emphasis on different aspects (Kalakota & Robinson, 2001; Phipps, 2000): customer relationship management, supply chain management, selling-chain management, and enterprise resource planning. Recent BR research papers demonstrate the critical role of information technology in business process restructuring (Arora & Kumar, 2000; Grant, 2002).

Business Process Modelling

A prerequisite for efficient BPR in the supply chain is obviously that the main business processes in all involved companies are well known and fully understood. This is especially important since lack of understanding of core processes throughout the SC causes distortion of both demand and supply patterns. Process and demand visibility is a prerequisite for supply chain synchronization (Holweg & Bicheno, 2002).

Process modelling tools must be capable of showing interconnections between the activities and conducting a decomposition of the processes. These tools must help users to conduct "what-if" analyses and to identify and map no-value steps, costs, and process performance (bottleneck analysis). They should be able to develop AS-IS and TO-BE models of business processes, which represent both existing and alternative processes. They must be validated and tested prior to implementation. They can be used to predict characteristics that cannot be directly measured, and can also predict economic and performance data that would otherwise be too expensive or impossible to acquire.

Many different methods and techniques can be used for modelling business processes in order to give an understanding of possible scenarios for improvement (Ould, 1995). IDEF0, IDEF3, Petri Nets, System Dynamics, Knowledge-based Techniques and Discrete-Event Simulation are only some examples of widely used business process modelling techniques (Eatock, Giaglis, Paul, & Serrano, 2000). As noted by (Hommes & van Reijswound, 2000) the increasing popularity of business process modelling results in a rapidly growing number of modelling techniques and tools. The list of the available business process modelling tools supporting simulation includes over 50 names (Hommes, 2001). This makes the selection of the proper tool very difficult. In (Kettinger, Teng & Guha, 1997), an empirical review was made of the existing methodologies, tools, and techniques for business process change. The authors also developed a reference framework to assist the positioning of tools and techniques that improve re-engineering strategy, people, management, structure, and the technology dimensions of business processes (Kettinger et al., 1997).

Process Maps

The modelling technique used in our example was process maps. Process maps are commonly used by many organizations, especially for business process modelling and analysis. They represent the standard modelling and analysis method for enterprise engineering and support particular reengineering activities such as simulation modelling. One of the major advantages of Process Maps is that little training is required for people to create and evaluate the process models (Chen, 1999). Another major advantage of this technique is that it helps identify the crossing of organizational boundaries, as it shows which company and which organizational unit is responsible for each activity.

A Process Map technique provides a method of communicating information about activities that happen during the operation of a process, i.e. it shows how a group of people or an organization gets a particular task done. Modelling elements are connected with links, which describe the process flow. Figure 1 shows the modelling elements of the Process Map technique.

	Symbol	Indicates	Examples
1		Start / finish	Receive sales report Customer arrives
2		Activity	Check merchandise Prepare customer invoice
3		Decision point	Approve / Disapprove Accept / Reject
4		Delay	Waiting for customer's response
5		Sub process	Ship merchandise
6		Organizational unit	Sales department Marketing
7		Process flow	

Figure 1: Basic modelling elements of the Process Map technique

The symbols mentioned above are also used in all further figures.

While the main idea of this paper could be illustrated with different tools, iGrafx Process [Corel] software was selected as the tool for business process and simulation modelling using previously defined Process Maps. Process Maps are described by activities placed in one or more departments e.g. the organizational units performing these activities. Each activity can set or determine information regarding inputs, resources, tasks and outputs. The activities could be defined in detail by several attributes, such as: types and number of resources performing the activity, duration of the activities (constant or stochastic) and different types of costs. The costs of the resources utilization can be defined by different elements, such as hourly rates, rates per use, and overtime rates. Schedules for resources and event generators can be fully customizable. All the above-mentioned and other possibilities offer a detailed cost and time analysis of business processes (Indihar Stemberger, Jaklic, & Popovic, 2004).

The experience of using different business process modelling and simulation tools (ARIS, Income, iGrafx Process) shows that due to the high insensitivity of communication with employees, simplicity and understandability could be assumed as one of the most important advantages of the modelling technique. This advantage is even more crucial, when modelling the processes across the whole supply chain, as it is important that all the involved fully understand the whole process in question.

Process maps used by iGrafx Process provide a graphical interface to a behavioural modelling system, which requires no knowledge of a programming language; even unskilled people in business process modelling can easily understand and use this technique (Bosilj-Vuksic et al., 2002).

While having own systems and processes in order is undoubtedly a prerequisite for successful implementation of SCM Concepts (Feller, 2000), we mostly concentrate on the possible use of process maps for a better explanation of inter-organizational integration of business processes (more about renovation of processes within one company can be found in (Bosilj-Vuksic et al., 2002).

The business processes across the whole supply chain have to be simplified and standardized across the whole supply chain in order to realize all possible benefits (McGuffog & Wadsley, 1999).

Case Study

The main concepts of business process reengineering in the SCM context can be illustrated by the following case study. The goal of the case study is to show the practical implementation of most important concepts explained in the previous sections, especially business process management and importance of information sharing.

This case study includes two participating companies – the retailer (e. g. a large grocery store) and the supplier (that supplies the needed product). The processes are deliberately simplified in order to emphasize the most important aspects (more detailed modelling can be used if needed – see Bosilj-Vuksic et al, 2002 as an example). However studying alternative SC designs does not require such detailed planning as manufacturing system optimization (Persson & Olhager, 2002).

The presented models can easily be extended with the inclusion of additional companies or processes and analyzed with the same methodology.

As can be seen from figure 2 and 3 the AS-IS model consists of two separate processes – the procurement process at the retailer's and the order-fulfilment process at the supplier's. While both processes are certainly interconnected (e.g. the activity No. 12 in the retailer model is a direct consequence of activity No. 15 in the supplier model) and some exchange of information between those two processes exist, it is evident from those two models that:

- there are several unnecessary delays in the process (for example the process at the supplier's can only start after the end of activity No. 4 at the retailer's),
- relevant information is not readily available and several delays and unnecessary activities are needed as a consequence. The typical example is that the retailer has to wait for the supplier to confirm the order. This is a consequence of limited information (the retailer is unaware of current supply capabilities of its partner) and leads to severe delays in the process, especially if the supplier cannot fulfil the order as reconciliation is then needed,
- quick and flexible responses to changes in end customer's demand are either not possible or very costly. This is due to long cycles (from identification to fulfilment of the need), higher inventory levels and insufficient information about customer needs and changes in these needs at all levels in the supply chain,
- one company has no possibility to influence the processes of the other one, although they are mutually dependent on each other,
- it is hard to measure cycle times and costs of the supply chain as a whole, but only at each single company

The usual solution to these problems is obviously the increase in stock levels that leads to well-known problems (Thomas, 1980) and additional increase in costs.

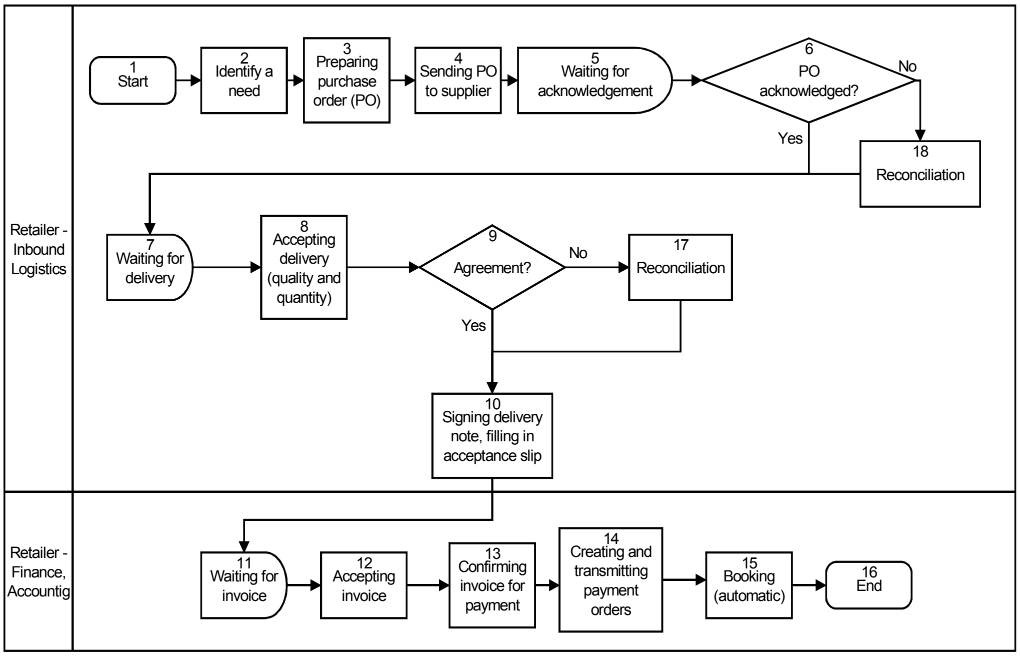

Figure 2: Retailer AS-IS model

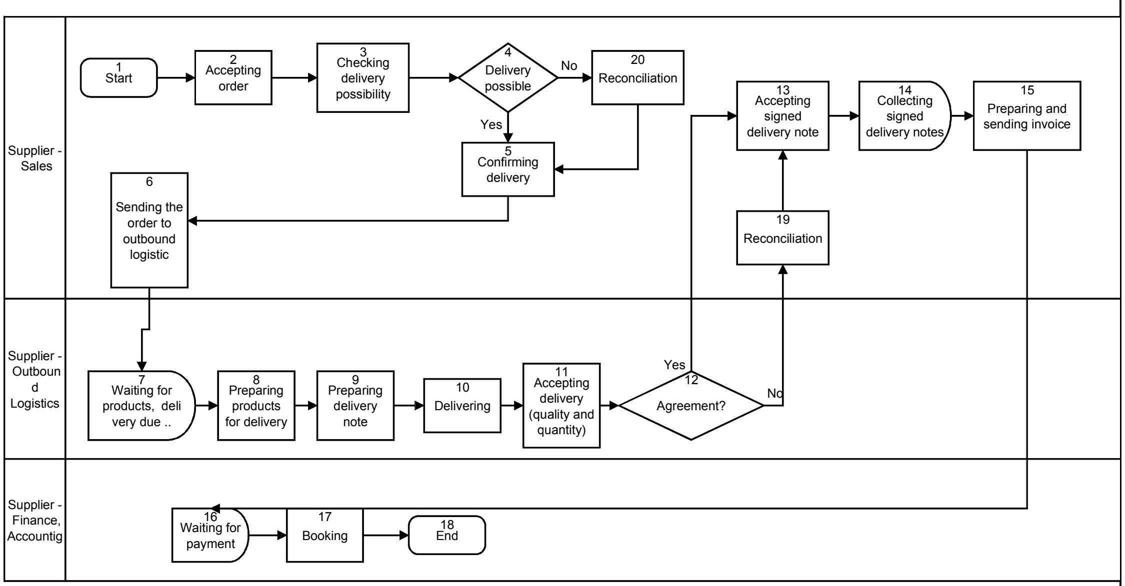

Figure 3: Supplier AS-IS model

Therefore the current processes have to be renovated in order to achieve greater efficiency. The renovated systems are then strongly supported with effective use of information technology as shown in the continuation.

Based on the process maturity model (Lockamy & McCormack, 2004) the AS-IS model at both companies can be classified at the second level of the 5-level scale (Defined; all processes are documented, as shown on figures 2 and 3 above. However, no real integration or information sharing exist between the companies). The TO-BE model is on the 4th level (Integrated), because all cooperation between both companies is taken to the process level. Both organizational structures and jobs are based on processes.

The transformation to the 5th level (Extended) is not immediately possible as deep mutual trust is a prerequisite, although the investment in site-specific assets can increase mutual trust between parties (see e. g. Handfield & Bechtel (2002) for both literature review and further research on the impact of mutual trust on cycle times and supply chain effectiveness as a whole).

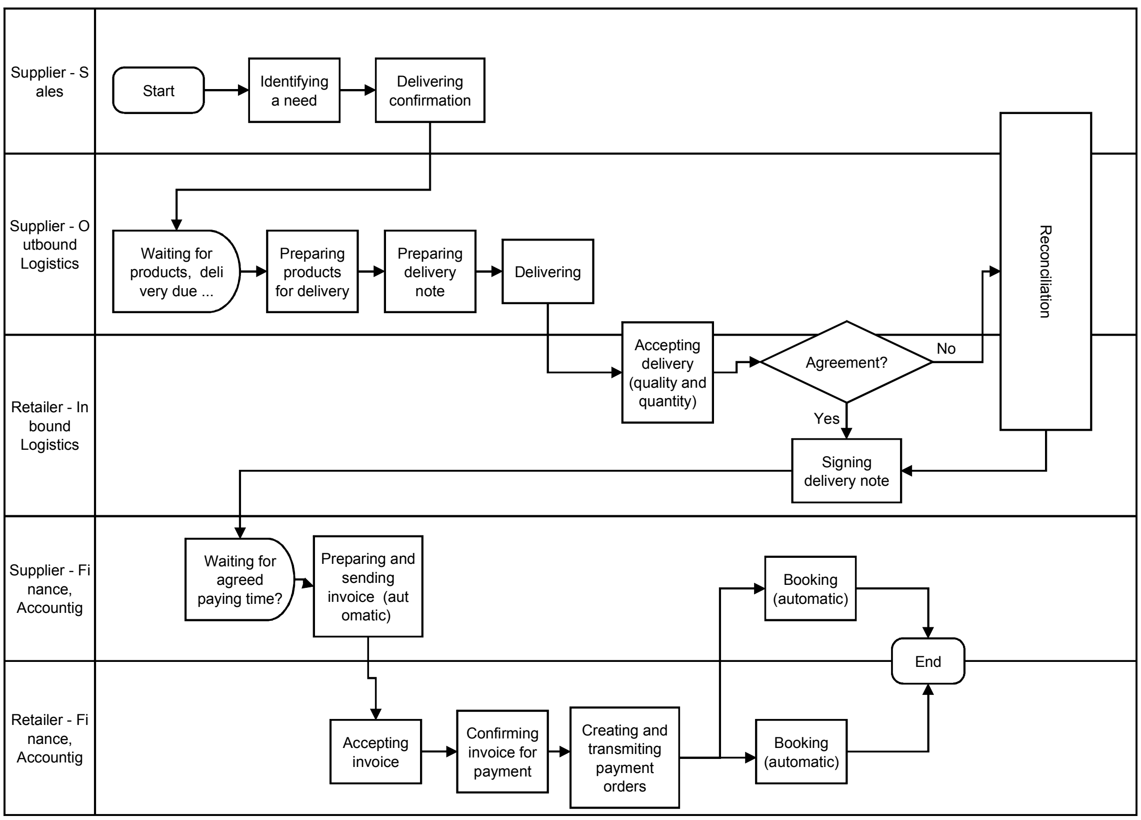

Figure 4: TO-BE model

The TO-BE model (Figure 4) shows the integration of both processes into one process that spans across various departments of both companies. The main changes enabling this integration are:

- long-term contracts and e-business connections are established between the retailer and the supplier – long-term partnership is definitely a prerequisite for the necessary investment in business renovation and new solutions, as these investments can be quite costly and the return period can be considerably longer than the usual length of short or medium-term commercial contracts,

- an integrated SCM system is introduced supporting the entire process and is available to all involved departments at the supplier's and retailer's side,
- vendor-managed inventory (VMI) (similar approaches are sometimes described as co-managed inventory (CMI), distribution requirements planning (DRP), and continuous or efficient replenishment planning (CRP/ERP) (McGuffog & Wadsley, 1999)) is introduced in the process. The supplier has full information about the inventory state and future needs of the retailer and is therefore in charge of timely deliveries,
- consequently the starting point of the integrated process is different and is in the supplier's company. The supplier identifies the procurement need and starts the process of fulfilling it,
- the integration of the processes also enables the supplier to better plan its processes, avoid bottlenecks in production and reduce safety stocks as the information of future demand is more readily available. Consequently the supplier also realizes considerable benefits,
- the final solution is an integrated supply-chain management system that supports the entire process and is available to all involved departments at the supplier's and the retailer's side.

Those changes lead to the radically improved process with considerable benefits for all involved companies and improve the added value for the final customer and consequently also the competitiveness of the supply chain as the whole. They also considerably reduce the lack of information and enable much better coordination.

Other possible improvements on a more tactical/operational level can be (these are the changes that are more technologically than process-oriented and can also bring some benefits to all companies involved):

- automatic performance of some activities (such as preparing invoice, delivery note or booking), that can also reduce costs, times and number of mistakes,
- providing electronic delivery tracking that further enhances available information to all companies in the supply chain – information is available more timely and in a cheaper way, quicker response to changes or unforeseen problems are possible,
- introduction of e-payment system that considerably reduces the time and effort needed for billing.

While the TO-BE process enables shorter cycle-time and lower costs of transactions, it also means the reduction in inventory levels (safety stock) for both (all) companies in the supply chain without increasing the danger of stock-outs. Because many activities were eliminated from the process and others were considerably shortened, the amount of employees´ work is considerably reduced, allowing them to focus on other more strategic or value-adding activities.

Beside these advantages on the operational/tactical level, some strategic advantages can also be realized. Quicker identification and response to long-term changes in demand patterns, improved customer service, better and quicker response to unexpected events and also introduction of new products or services are much easier in the new model.

Once again it has to be emphasized that the main cause for those improvements is not the implementation of e-business itself, but rather renovation and integration of business processes that can be enabled by e-business solutions.

Conclusion

The paper shows, how sharing of information, enabled by e-business applications, can radically improve business processes and consequently the performance both of a single company and supply chain as a whole. Business process modelling can be used as a tool for both analyzing and planning future developments.

The findings were illustrated with a two-tier supply chain study. The renovated TO-BE model enables a quicker, more efficient and better execution of one business process that is crucial for the successfulness of both companies.

It should not be forgotten that even an excellent TO-BE model is not the final stage in supply chain development, but that all companies have to be constantly alert and react proactively to changes in the business environment with constant improvements.

The main focus of further research will be the use of simulation techniques to facilitate and measure changes and improvements in quality, cost, lead-times and resource utilization more precisely.

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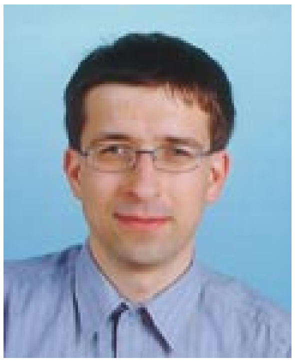
Biographies



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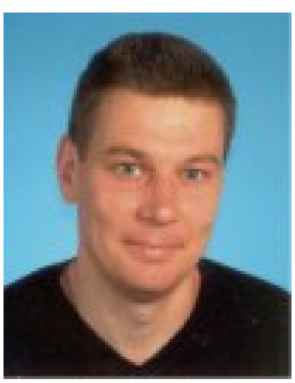

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