Electronically Integration of Supply Chains

Sindre Bolseth

Department of Production and Quality Engineering
Norwegian University of Science and Technology, NTNU

ABSTRACT

This paper discusses the concept of Supply Chain Management (SCM) and how Information and Communication Technology (ICT) can contribute to integrate the supply chain. Several ICT applications and technologies (both intra- and inter-enterprise systems) will be presented and shortly discussed. Results from an on-going case study from a 1st tier supplier to an Original Equipment Manufacturer (OEM) will also be presented. The case study focuses on how to electronically integrate both upstream and down stream actors in the value chain by combining different ICT systems into one efficient, simple and customized solution. The ICT systems are combined in order to achieve a solution that can offer full-spectrum visibility and real-time management.

INTRODUCTION

According to Browne et al. [(Browne et al, 1995) and (Browne and Zhang, 1999)] the manufacturing systems today are subject to tremendous pressure of the ever-changing marketing environment. Browne et. al (1999) concludes that individual companies have to work together to form inter-enterprise networks across the product value chain in order to survive and achieve business success. There are many ways to arrange and manage these inter-enterprise networks across the value chain, such as the concepts of Supply Chain Management (management of supply chains), Extended Enterprise (long-term business cooperation) and Virtual Enterprise (temporary network of independent companies). These three concepts are thorough discussed and compared in literature, among others by Browne and Zhang (1999) and Jagdev and Thoben (2001).

Supply Chain Management (SCM) is based upon cooperation and coordination, and the key is the integration of processes, both up- and down-stream, in the supply chain. Information and Communication Technology (ICT) is an important enabler for this integration process, and thereby for SCM. Much of the current interest in SCM is motivated by the possibilities that are introduced by the abundance of data and the savings inherent in sophisticated analysis of these data (Simchi-Levi et al, 2000). According to Huang and Nof (1999) the impact of modern ICT on enterprise systems can be classified into three categories: 1) Speeding up activities, 2) Providing intelligent and autonomous decision-making processes, and 3) enabling distributed operations with collaboration. The introduction and utilization of integrated ICT for managing the supply will enable companies to gather vital information along the whole supply chain and quick act upon it and be in advance on market changes, and thereby gaining competitive advantages (Narasimhan and Kim, 2001).

Based on this, SCM have for the recent years become a buzzword in ICT industry. Many ICT vendors are competing in the market, and are offering SCM solutions based on different technologies and principles. After the author's opinion there is, unfortunately not, no such thing as a universal SCM ICT-application that can offer the requested functionality and give the desired outcome. It is therefore crucial to be familiar with the different solutions

(applications and technologies) in the market, know their limitation, weakness and advantage, and last but not least; How to combine these solutions.

SUPPLY CHAIN MANAGEMENT

The concept of Supply Chain Management (SCM) is well documented in literature; see Christopher (1998), Bowersox and Closs(1996), Schary and Skjøtt-Larsen (2001), Simchi-Levi et al. (2000), Jagdev and Thoben (2001), and Mentzer et al. (2001). SCM can be defined as (Christopher, 1998): "*The management of upstream and downstream relationships with suppliers and customers to deliver superior customer value at less cost to the supply chain as whole*". Each company in a supply chain is dependent on each other, and, yet, paradoxically by tradition does not co-operate very closely with each other. Supply chain competitiveness can be achieved through chain integration and process re-design that decrease waste through unnecessary activity, reduction of stocks as well as faster response times. The goal is to get everyone in the supply chain onto a common platform of logistics transactions and information systems for greater interorganizational "seamlessness" or transparency resulting in faster system response time (Boysen et al., 1999).

Forrester effect

A typical effect in a less integrated supply chain is how small changes in downstream demand are dramatically amplified upstream. This is known as the Forrester or bullwhip effect [Forrester (1958), McCullen and Saw (2001), Alfnes and Strandhagen (2000) and Simchi-Levi et al. (2000)]. Burbidge (1987) has called this the "Law of Industrial Dynamics": *If demand for products is transmitted along a series of inventories using stock control ordering, the demand variation will increase with each transfer".* McCullen and Saw (2001) point outs four principles on how to avoid the Forrester effect: 1) Control system, 2) Time compression, 3) Information transparency and 4) Echelon elimination. ICT systems contribute greatly in the process of avoiding the Forrester effect and take an important part in all four principles. By using a centralized ICT system, each stage of the supply chain can use the actual customer demand data to create more accurate plans and forecasts, rather than relying on the orders received from the previous stage, which can vary significantly more than the actual customer demand.

ELECTRONIC INTEGRATION OF SUPPLY CHAINS BY USE OF ICT SYSTEMS

ICT both enables and dominates the supply chain. It has changed business operations through the flow of information, control over operations remote in distance and across organizational boundaries and by automation of processes. ICT can no longer been seen upon as a search for efficiency alone, but as an enabler of new opportunities (Schary and Skjøtt-Larsen, 2001). The most important contribution of ICT in supply chains is to bring visibility to the entire supply chain.

According to Simchi et al. (2000) the goals of ICT systems in supply chains are:

- Collect information on each product from production to delivery or purchase point, and provide complete visibility for all parties involved
- Access any data in the system for a single-point-of-contact
- Analyze, plan activities, and make trade-offs based on information from the entire supply chain

In order to achieve these three goals, ICT systems must be able to support strategically, tactical and operational activities, both internally in the company and externally in the supply chain. It can therefore be reasonable to divide the ICT systems into two types: 1) intra-enterprise systems and 2) inter-enterprise systems. As the names indicate, the intra-enterprise systems have an internal focus, and the inter-enterprise systems an external focus. Each company has ICT (intra-enterprise) systems internally that support the three activities, and there is a flow of transactions and information (data) between the companies and thereby also between the ICT systems. The inter-enterprise ICT systems operate in the intersection between the companies in the supply chain, providing channels for information exchange and a platform for real-time interactions between the companies.

Intra-enterprise ICT systems

The far most dominant system in this category is the Enterprise Resource Planning (ERP) systems. An ERP-system is a standard application program, which support execution of business processes throughout the whole company. The ERP-system has functionality that makes the company able to replace many of their applications with a single seamless system with one common database.

The existing solutions of ERP software packages are mainly centralized, company specific customized, inheterogene in the own organization an inflexible to adapt new conditions. Only a few solutions do support process-oriented structures in the own organizations, however, not to mention external organizational processes (Hieber and Alard, 1999). Hieber and Alard (1999) points out that it should be possible to extend the functionality of the ERP systems out of the enterprise and into the whole supply chain. Such an ERP system should incorporate five crucial activities of every business:

- Configuration - the ability to model and configure the supply chain to link different partners for an optimal customer solution
- Planning - the ability to anticipate the future and respond to changing situations by providing an integral end-to-end view
- Optimization - the ability to find the best solution for the whole supply chain
- Execution - the ability to standardize and automate the daily business within the supply chain
- Control - the ability to identify the weak chain and locate the possible impacts on the common business

As a response to such demands the ERP vendors are now offering ERP II (www.gartner.com) and ECM (Enterprise Commerce Management) (www.amrresearch.com) solutions. ERP II expects companies to thoroughly integrate outward-facing application, such as Customer Relationship Management (CRM) and SCM, into back-office ERP systems. ECM promotes an integration architecture that provides a layer between individual ERP modules and Business-to-business (B2B). Typically ERP II vendors are SAP, Oracle, PeopleSoft and Baan, while i2, Ariba and Siebel systems can be classified as ECM systems. According to Gartner (www.gartner.com) ERP II breaks down the barriers of traditional ERP, forcing solutions to offer functionality that extends beyond the four walls of an organization. An ERP II system is based on value chain participation, it is web-based and can be accessed both internally and externally. Typically modules/applications within an ERP II system are (www.sap.de): SCM, CRM, Supplier Relationship Management, Product Life Management, Human Resources, Financials, Business Intelligence, Enterprise Portals and Exchange. The SCM module is built on an APS (Advanced planning and scheduling) solution and offer functionality to plan for

demand, supply, and production functions for the extended supply chain and also to support plant scheduling and global available-to-promise functions. The focus of these SCM applications is still mainly on the planning side rather the execution side (Hieber and Alard, 1999).

Inter-enterprise ICT systems

In this section ICT systems/tools for interaction between different companies will be presented and discussed.

Traditionally *EDI* (Electronic Data Interchange) has been the only way to electronically integrate two or more companies. EDI is defined as the exchange of data between heterogeneous systems to support transactions. This is not simply the exportation of data from one system to another, but the actual interaction between systems (Fürst and Schmidt, 2001). EDI allow trading partners to ship electronic transactions instead of paper when performing purchasing, shipping and other transactions. These transactions will typically be between two ERP systems in different companies. However, the implementation of EDI is both difficult and costly, and requires (in most cases) a unique solution for each pair of trading partners. It is therefore mostly the larger companies, with many transactions, who have implemented EDI.

Throughout the last years, *XML* (extensible Markup Language) has got attention as a new way to transmit and interact electronically between companies. XML is a universal data format that allows computers to store and transfer data that can be understood by any other computer system (Fürst and Schmidt, 2001). It provides a robust, non-proprietary, persistent, and verifiable file format for storage and transmission of text and data both on and off the web. The internal ICT systems of the different companies in the supply chain are not equal, and it is necessary to extract the relevant data for the new system from these systems (from the databases) and convert the data locally into the XML format to make it available for all parties. XML allows groups of companies to create their own customized (markup) applications for exchanging information.

Another promising way to interact and communicate between companies is through the web. Companies use Internet standards internally, *intranets*, as well as externally, *extranets*. The difference between these solutions is explained mostly by who is allowed access to the system. Intranets allow companies to implement internal applications without having to develop custom interfaces and avoid incompatible types of hardware and special dial-in procedures. Internet applications typically allow unlimited access, but extranets allow limited access by restricted partners and customers from outside the company to certain applications and data (Simchi-Levi *et al.*, 2000). Of these three solutions, the extranet is the most suitable system for supply chain integration. Through an extranet, actors in the supply chain can access both static information (like information regarding products, pictures, contact addresses and telephone numbers, agreements and contracts etc) and more operation information (like production plans, inventory levels, work in progress etc), in addition to conduct actual transactions (like purchase and/or order products). The extranet can be built on XML technology, which allows the extranet to interchange with different databases.

By customizing the Internet (and in this case extranet), *portals* emerge. A portal is a gateway to web access, or a hub from which users can locate all the web content that they commonly

need. According to Gulledge and Sommer (2000) today's integrated portal technologies may be classified into three categories:

- Integrated Messaging Portals - the purpose is to translate many different messaging standards (EDI, XML, HTML) and move the translated file to the destination (usually to an ERP system)
- Business-to-Business (B2B) Electronic Trading Exchange - Establish a direct link between customers and suppliers without the traditional (and costly) layers of intermediaries
- Business-to-Consumer (B2C) Electronic Stores - provide customers with greater product varieties and background information than traditional retail outlets, and eliminates many of the wholesale intermediaries

Depending on location in the supply chain, different portals will be most suitable. At the end of the supply chain (facing the customer) a B2C-portal will be appropriate, and further downstream in the supply chain a company can establish a B2B-protal towards its suppliers.

CASE

The purpose with this case is to give an example on how a company can integrate its supply chain with help of different ICT systems. The case tries to illustrate how it is possible to combine separate and independent ICT systems, working on different levels in a company, in order to get a simple, efficient, powerful and customize solution that offer full-spectrum visibility and real-time management.

Introduction

Raufoss Technology (RCT) is a part of the Raufoss group, and is developing and manufacturing aluminium alloy chassis components for automotive industry. Due to a larger contract with General Motors (GM), RCT has built a new plant at Raufoss and are building a similar plant in Canada. Start Of Production was January 2002 at the Raufoss plant, and is scheduled to be June 2003 at the Canada plant. The manufacturing in each plant is organized in two fully automated manufacturing lines: one for front control arm, and one for rear (each with a capacity of 1,4 million finished products per year). There are 14 different assembled parts from 7 different suppliers in addition to the aluminum part. Extruded aluminum profiles are delivered from two different suppliers. Suppliers are located in Europe and USA. Even though there is only one customer, there are call offs from 7 GM plants in Europe, and a similar number of plants in USA. Logistically this acts as different customers.

SCM projects

Parallel, and in participation with the process of developing the production facilities on Raufoss and in Canada, there have been conducted a series of projects in order to integrate the supply chain (some project are still in progress). The background for these projects was several: 1) Avoiding the Forrester effect; All production and procurement throughout the supply chain are based on forecasts, and not on actual demand. By sharing information they hope to avoid unnecessary fluctuation in the supply chain. 2) Achieving desired and required delivery performance towards customer. The deliveries are Just-in-Time (with a short time frame between call-offs and delivery), with absolute requirement regarding delivery precision and it is crucial to have online access to information from the customer. 3) Reducing cost associated with inventories. By sharing information, safety inventories can be reduced. The goal for these projects has been to achieve a transparent, visual and (electronically) integrated supply chain.

A central element in these SCM projects has been the work with establishing a control model (see (Alfnes and Strandhagen, 2000)) for production and logistic within RCT and its supply chain. One of the most important results of this work is the decision to establish a Supply Chain Coordination Center (SCCC), who will be responsible for all interaction throughout the supply chain. The SCCC will be responsible for following processes at RCT: 1) order acceptance towards customers, 2) Delivery towards customers, 3) production and inventory control internally at RCT and 4) procurement towards suppliers (see figure 1).

ICT projects

Another result is to establish an Intranet for RCT. This Intranet is based on the work done in the Control Model project, and it is a description of the Control Model for RCT as well as a planning and execution tool for the production and logistics activities (extracting information from among others the ERP and data-mining system). The intranet will be up and running at the end of June 2002. See figure 1 for information about the Control Model and how the intranet is organized.

In additional to this Intranet project, there have also been other ICT projects that aimed to integrate the supply chain:

- Implementation of an ERP system
- Integration process towards the suppliers
- Integration process towards the customer

After considering different ERP vendors, RCT decided to implement an Oracle 11i ERP system. This system is now operating, but it is mostly used as an order-transaction and finance application. According to the Control Model project the ERP system are kept out of most of the production and logistics activities, in order to simplify the processes as much as possible. But it is supporting the intra/extranet with online real-time operational information.

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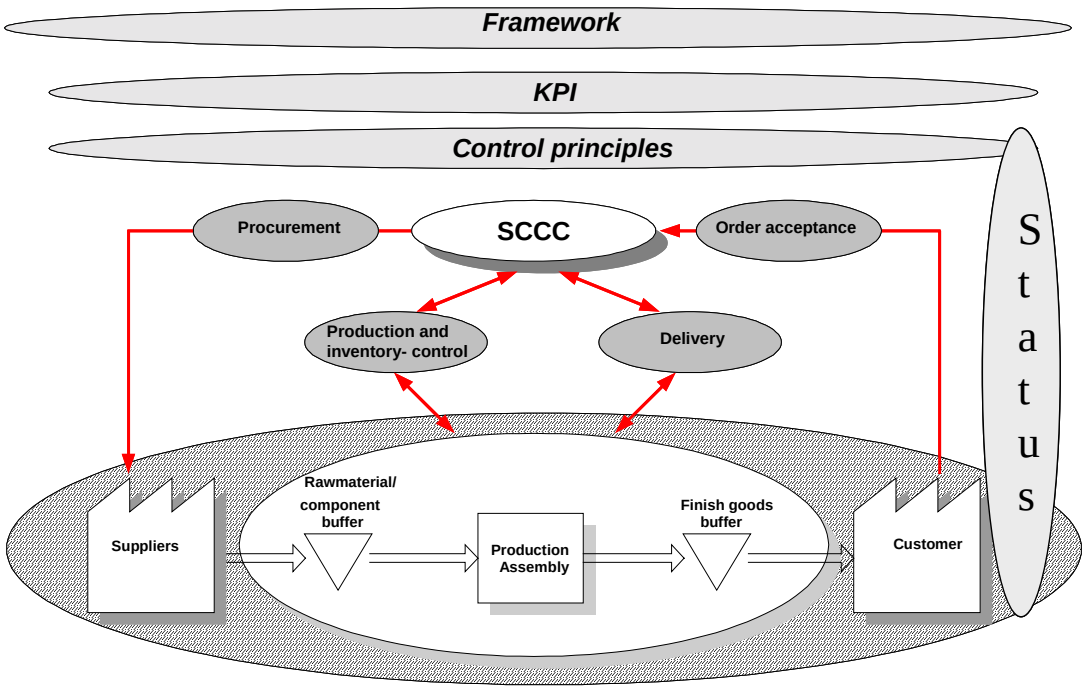

Figure 1.: Control Model and Intranet

The extranet/portal towards the suppliers will in principles be based on the intranet, and will offer the same form of functionality for the suppliers as the intranet does internally in RCT. Suppliers can access real-time information regarding production and demand plans, inventory levels, KPI's etc and the extranet will be replacing the order-process between RCT and suppliers. The extranet are planed to be operative by the end of 2002.

The integration towards the customer (GM) is specified trough the contract RCT has signed with GM. Year plan, forecasts and call-offs are transmitted electronically from GM to RCT via EDI, and GM has established a mandatory supplier portal (www.gmsupplypower.com) for transmission and access of other information. Both of these processes are operating.

Solution

Figure 2 sums up the different projects and illustrates how RCT tries to integrate its supply chain electronically. This solution is based on both intra-enterprise and inter-enterprise ICT systems. The ERP system and the Intranet are mainly supporting the tactical and operational (and in some degree strategically) processes in the individual companies, while EDI, XML and the Extranet/portal support communication and interaction between the companies and the intra-enterprise system.

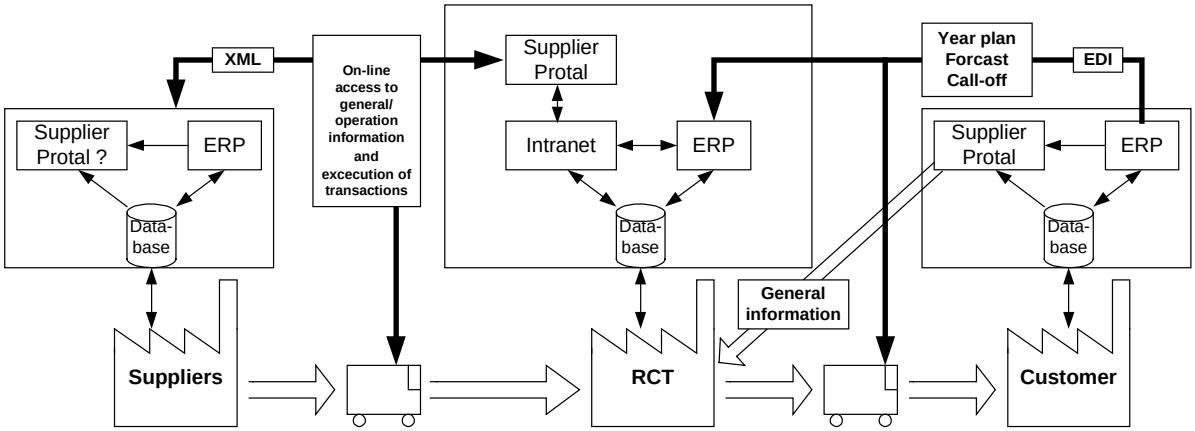

Figure 2.: Electronically integration of supply chain

CONCLUSION

The paper has pointed out that there is a need for a better integration of supply chains, in order to cope with the increasing market pressure and to stay competitive. ICT can make an important contribution to integration of processes in a supply chain, and thereby reducing the Forrester effect. Both intra- and inter-enterprise ICT systems play an important role in the integration process. A case form a Norwegian 1st tier supplier to the OEM industry is used to illustrate how different actors in a supply chain can be electronically integrated by usages of different ICT technologies and applications.

REFERENCES

Alfnes, E. and Strandhagen, J. O., 2000, Enterprise Design for Mass Customization: The Control Model Methodology, in International Journal of Logistics: Research and Applications, Vol.3, No.2

Bowersox, D. J, and Closs, D. J., 1996, Logistical management: the integrated supply chain process, McGraw-Hill, New York

Boyson, S., Corsi, T.M., Dresner, M.E. and Harrington, L.H, 1999, Logistics and the Extended Enterprise Benchmarks and Best Practices for the Manufacturing Professional, John Wiley & Sons, inc., New York

Browne, J., Sackett, P. J. and Wortmann, J. C., 1995, Future manufacturing systems - towards the extended enterprise, Computers in Industry, Vol. 25, pp 235-54

Browne, J. and Zhang, J., 1999, Extended and virtual enterprises – similarities and differences, in International Journal of Agile Management Systems Vol. 1 No 1

Burbidge, J.L., 1987, Automated Production Control with a Simulation Capability, Proceedings of IFIP conference WG5-7 in Copenhagen

Christopher, M., 1998, Logistics and Supply Chain Management: Strategies for reducing costs and improving service, Pitman Publishing, London

Forrester, J.W., 1958 Industrial dynamics: A major breakthrough for Decision Makers. Harward Business Review, 36(4)

Fürst, K. and Schmidt, T., 2001, Turbulent markets need flexible supply chain communication, in Journal of Production Planning & Control, Vol. 12, No. 5, 525-533

Gulledge, T. R. and Sommer R. A., 2000, Integrated Portal Solutions, Proceeding of the IFIP Conference WG5-7 in Tromsø

Hieber, R. and Alard, R., 1999, Next generation of information system for the extended enterprise, Proceeding form the IFIPWG5.7 Conference in Berlin

Huang, C.Y. and Nof, S. Y., 1999, Enterprise Agility:A View From the PRISM lab, in International Journal of Agile Management Systems Vol. 1 No 1

Jagdev, H. S. and Thoben, K. D., 2001, Anatomy of Enterprise Collaboration, in Journal of Production Planning & Control, Vol. 12, No. 5, 437-451

Mentzer, J. T., DeWitt, W., Keebler, J. S., Min, S., Nix, N. W., Smith, C. D. and Zacharia, Z. G, 2001, Defining Supply Chain Management, In Journal of Business Logistics, Vol. 22, No.2

McCullen, P., Saw, R., 2001, Designing the Agile Supply Chain, p. 129 – 136, Proc. of The International Symposium on Logistics, Salzburg Austria

Narasimhan, R. and Kim, S. W., 2001, Information system utilazation strategy for supply chain integration, in Journal of Business Logistics, Vol. 22, No.2

Simchi-Levi, D., Kaminsky, P. and Simchi-Levi, E., 1999, Designing and Managing the Supply Chain – concepts, strategies and case studies, MacGraw-Hill, Boston

Schary, P. B. and Skjøtt-Larsen, T., 2001, Managing the Global Supply Chain, Copenhagen Business School Press, Copenhagen