Enterprise Resource Planning Systems of First Tier Suppliers in a Networked Demand Chain

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Abstract

Business is developing at a fast pace and companies need to identify their core competence and develop a supplier network to provide other technology. There are many challenges in collaboration between individual companies and we must understand that each company has a globally unique position as a member of several networks. Besides common long term objectives, networks need easy connectivity with regard to information systems.

Easy connectivity must be backed with efficient information systems that provide support to the individual companies' internal operations and are able to support network-wide information integration and visibility by integrating downstream information flows and distributing them upstream. Products are what matter here as all information is centred on the structure of the final assembly. Therefore product data should be up to date in the ERP system, yet they seldom offer adequate features for product data management.

We investigate existing theories to present frameworks for analyzing a collaborating network. We apply these frameworks in our case –network to highlight the challenges in ERP in a networked manufacturing company.

Keywords

networking, ERP, collaboration

Introduction

Increasing competition in the marketplace has driven many companies to narrow the scope of their product portfolio and to expand their geographical market area to reach economies of scale while benefiting from focusing on a core technology. Meanwhile, these brand-owner companies have organized their supplier networks and outsourced manufacturing of complex modules to first-tier suppliers. In this study we focus on a production network, its leader and its first tier suppliers. These suppliers are continuously being pushed to achieve better performance in productivity, quality and timeliness.

Streamlining material flows in a network eventually leads to a demand-oriented supply chain, i.e. a demand chain. In a demand chain, production capacity is planned according to a forecast, but production is executed only according to customer orders. With complex end-products this is often an effective solution, as the customer might experience increased value in the possibility to order a tailored configuration to a specific need. Unfortunately this will

normally cause a delay from customer order to product delivery. To decrease this waiting-time and to increase stock-turn, attention must be paid to shortening production lead-times.

Companies that have partially outsourced manufacturing activities of some complex modules, need to be able to perform capacity planning not just internally, but they need to know if the suppliers can keep up the pace. Therefore it is important that the customer can plan and rely on the total supplying capacity of the whole supplier network. (Vollmann et al. 2005)

Sharing forecasts can be seen as one of the first steps towards collaboration between companies. It means that the operations that actually provide plans and forecasts remain in-house, while the output is shared with partners. This poses a great challenge for the suppliers, as they should be able to provide effective capacity and production planning and reliable forecasts. Knowing and controlling internal and external resources is a vital component in the entire planning system, in Enterprise Resource Planning.

Many notions have been made in previous research regarding the bullwhip effect and ways to avoid or reduce it (Disney & Towill 2003; D`Amours et al. 1998; Lee et al. 1997). It is all about information flowing in the supply chain; batching orders and processing incoming signals to outgoing signals. Each node receives information from the nodes downstream, processes that information and finally distributes the processed information to the nodes upstream.

Supplier networks often include SMEs that sometimes possess limited resources with regard to business process development and information systems. According to several studies (Brynjolfsson 2005, 27-35; Brynjolfsson & Hitt 2000, 45; Umble et al. 2003, 247), Investing in IT and especially in enterprise systems will not produce any return, unless it is connected to a change in work flows. Bharadwaj (2000, 186) claims IT is an organizational capability created by the combination of IT resources with other organizational resources and capabilities. Therefore it seems that businesses should be looking into better utilisation of information systems, regardless of if they are new or already existing systems.

Thus, integrating a supply chain vertically requires horizontal integration inside the supply chain members. Integration needs to be multi-tiered to support integration on different planning spans. Collaborating companies need to integrate their strategic views and goals to steer the network to the chosen direction in the long run. Collaborating companies share different views of the environment, but should be able to reach an agreement on the requirements from their partners. A balance between the levels of capabilities and requirements is a desirable state.

Integration is needed on the tactical level to ensure efficient production- and inventory scheduling. To support smooth daily operation we need to focus on integration on the lowest level: transferring operational information such as orders, invoices and payments. Simply automating order-delivery and invoicing processes does not mean effective business. It is essential that companies in the network can process the information they receive and spread it on to their own supplier network. Successful implementation of an ERP –system will help to do that, but integration of heterogeneous systems remains a challenge.

Assessing the entire network, it seems that merely defining the interfaces between companies and their systems is not enough. Something must be done to make selection and implementation of ERP –systems to SMEs a lot easier to make sure they have systems supporting not only internal processes, but network-wide business.

State of art of ERP systems in SMEs

Choosing and implementing an information system that fully supports the core business processes of an organization is a big challenge for the SME manager restricted to a limited budget and a complex operating environment. Supporting networked business is essential in keeping up with competitors pace. Integrating information in a network will not be possible unless all members of the network have integrated internal information flows to be able to process incoming information flows and distribute them further upstream. The supplier needs to be able to support its own operations while providing support to the network as a whole.

Even large companies operating with predefined processes are facing challenges with exceptions to their routines. In an SME –context exceptions are routines, and it might be difficult to describe and manage the processes in an organized manner. Therefore the level of control from the enterprise system should be adapted to provide support to both routine and ad hoc processes. Furthermore, an unnecessarily complicated controlling procedure prohibits use of the system that in turn deters controllability. Again, adapting to a reasonable level of complexity in the user interfaces is essential.

Many ERP -packages have standardized (such as EDIFACT, X12 or UBL) interfaces for message transmission. It is seemingly easy to integrate these ready-made packages to one another using the standardized messages. Most ERP-vendors targeting SMEs offer no support to true integration on higher levels of collaboration. Implementing electronic messaging is not integrating business processes, but automating an existing process.

Starting from scratch to design and implement an IT infrastructure into a supplier network will be an enormous project for the leader of a production network. Management has to sell the initial idea to the network. They must audit current systems to make sure suppliers are capable of automating even simple messaging processes. An ERP–system is, however such a crucial part of a company's operations that it will not be easy for a customer to really get a picture of the state of the system. Many SMEs have struggled with their implementation projects and might continuously face challenging problems in ERP. Admitting this to a customer might seem like admitting you as a manager are unable to perform your job. On the other hand, suppliers still want to protect information stored in their information systems. Letting a client audit the system might reveal information related to pricing, costs etc.

A network leader hoping to develop network –wide information integration must be able to present concrete financial benefits to its suppliers. Zheng et al. (2003, 38) claim that SMEs evaluate IT investments just like any other investments they make. They seldom see IT as a tool for strategic development that would justify an investment that is not likely to return profits in the near future. Kelle & Akbulut (2005) show that a system forced by one single supply chain partner can lead to a much higher total operating cost than a coordinated system policy. Therefore it is important that all network members have an internal vision of how they

want their systems to function, what kind of information they need and then collaborate with partners to make sure the information transferring policy provides support to all parties.

Challenges in collaborating networks

For a long time, purchasing was considered to be a resource –wasting operation that was only to build up costs and no benefit to core business. However, the table has turned and many companies consider their supplier network as their most valuable asset. Co-operation is turning into collaboration and network leaders are taking care of their smaller suppliers even below first tier to make sure they will all be in profitable business in the long run. (Gadde & Håkansson 2001, 16)

Figure 1 reflects the complex structure of networked businesses. It is obvious that there is not one supply- or demand chain for that matter, but multiple demand –chains are interconnected through multiple companies operating as network nodes. Every company in the network has a different view of the network, and therefore each company should consider its own position in all the networks it is involved in. Furthermore, each company is affected by changes in other companies in the same network, and even by changes in other companies' environments. Therefore each node is connected to nodes several steps away. (Gadde & Håkansson 2001, 33–34)

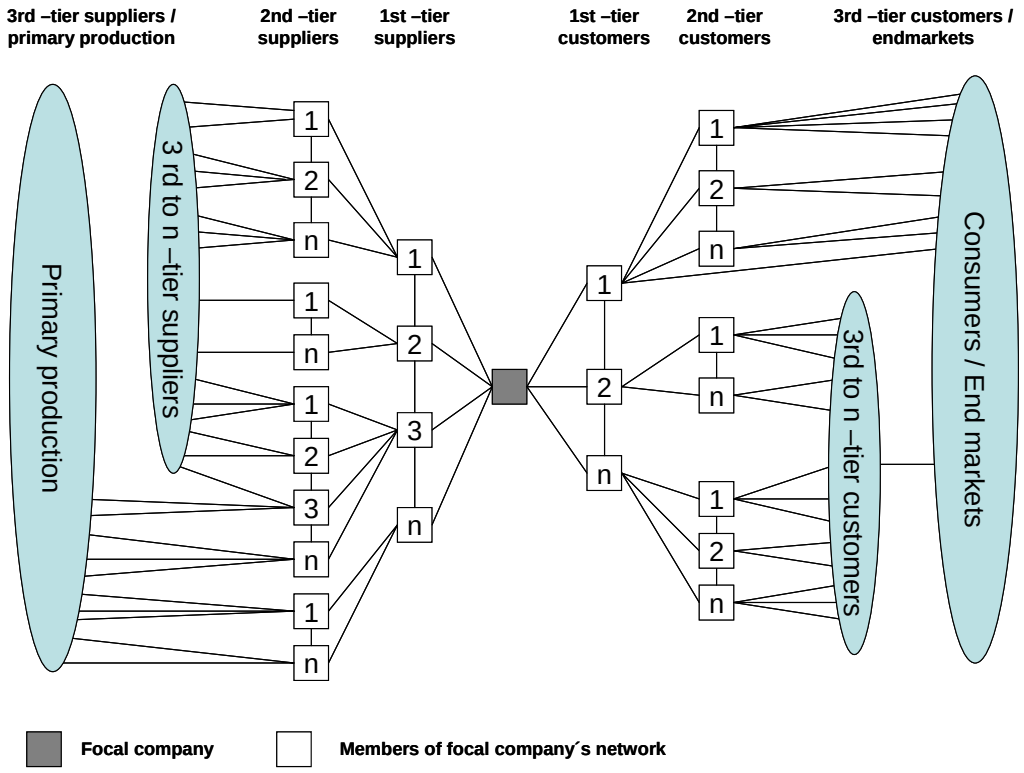

Figure 1. Network structure

This presented model does not represent the quality of the relationship or the flows of material, finances or information between the members. It however emphasises the number of

interfaces there are to handle, even when looking no more than two tiers away from each company. With regard to information integration, there are several aspects to consider (figure 2). Each company must start by integrating internal information flows to support internal information logistics. Only then can a network proceed to integrating network-wide information flows. Information flows between partners are different in bandwidth; some partners share a lot more information than others. Therefore solutions for integration should support various levels of data transferred. In a truly collaborating network, there is intra-tier integration as well. A great challenge lies in the diversity of applications companies use internally, and the challenge to find one solution to integrate all suppliers. (Themistocleus et al. 2004, 402) Close collaboration will lead to a co-evolution of its members in the long run. Companies will start to recognise changes in each others capabilities, strategies and roles and should be able to adapt to and provide support for these changes.

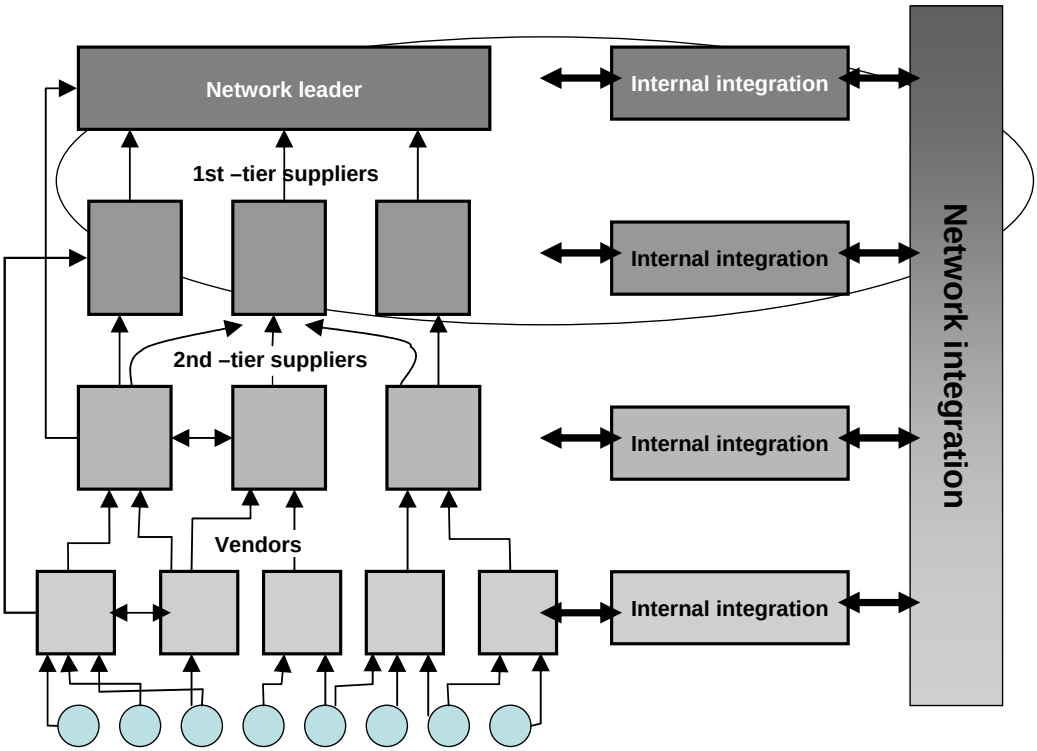

Figure 2. Integration in a network

To manage its relationships, a company needs to identify its position in a network by assessing its capabilities in relation to other members in the same network. A company must benchmark its functionality, level and capability of automation and infrastructure against other network members on the same tier. These activities should lead to the company finding its current position as well as the desired position that is to be achieved in a certain time-frame. The path (figure 3) to this desired position should be followed using certain metrics that are to be selected to make guidance as effective as possible. The metrics for the whole network should be aligned with the requirements accepted by all members.

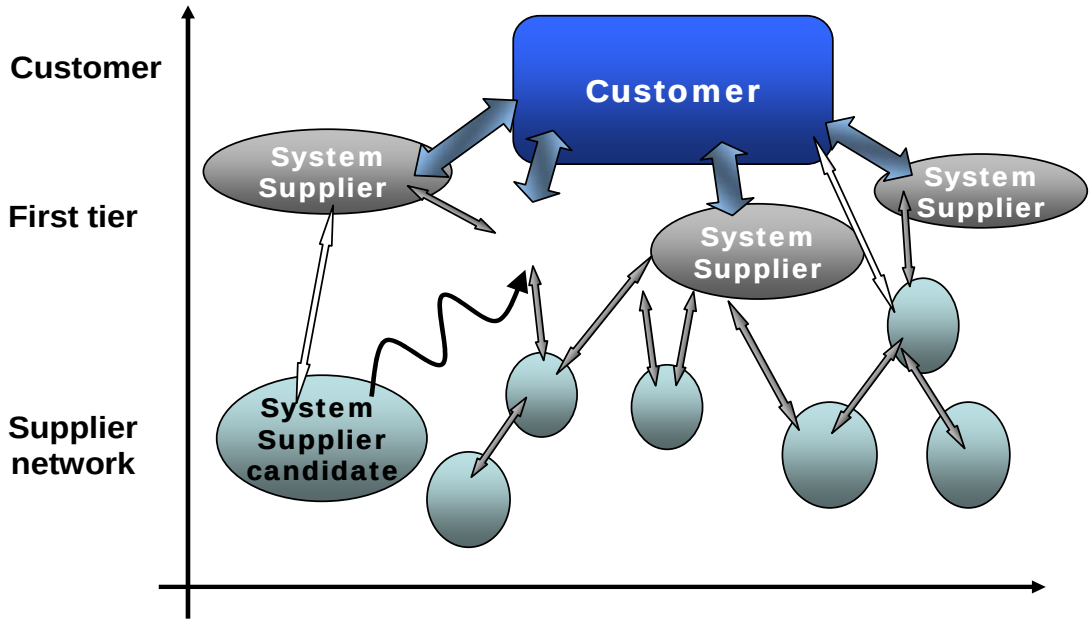

Figure 3. Path to the desired position

For the network leader it is important that some suppliers are able to develop their capabilities to be not just first-tier suppliers but system-suppliers that bear responsibility of a system module of the end-product and coordinate their own supplier base. By giving manufacturing responsibility to its system-suppliers, the leader can focus its assets on developing more service –oriented businesses. Developing a supply network requires not only alignment of business-targets and business information, but also development of business information interchange.

A collaborating network should not focus on collaborating just vertically between customers and suppliers but also horizontally between companies on the same tier. System suppliers should be able to collaborate in product development activities with suppliers of other modules that interface with each other in the final assembly. The supplier must identify its position in the network through the customer's end-product to be able to find out who it needs to collaborate with. In an information systems context, it requires awareness of other system suppliers' capabilities for horizontal collaboration.

Strategic networks must plan collaboration on all levels of operations. Operating in strategic collaboration requires definitions on several levels of collaboration. Partners must be able to define what kind of business transactions they are conducting with each other, what are the processes that implement these transactions, what kind of frameworks do these processes belong to, what kind of ICT –services they are employing, what kind of information flows are included in the collaborative processes and what are the information systems that handle the communication.

As presented in the *model of business collaboration*, collaboration must start from the strategic level, where individual companies become partners by setting up an objective they wish to achieve with the strategic alliance. Clear definitions of earning logics and well defined contracts will help in describing what is agreed in strategy. When long term objectives are aligned, processes and information alignment follow. The last stage is

implementing a communication infrastructure, be it EDI, ebXML, SOAP, BizTalk or any other technology.

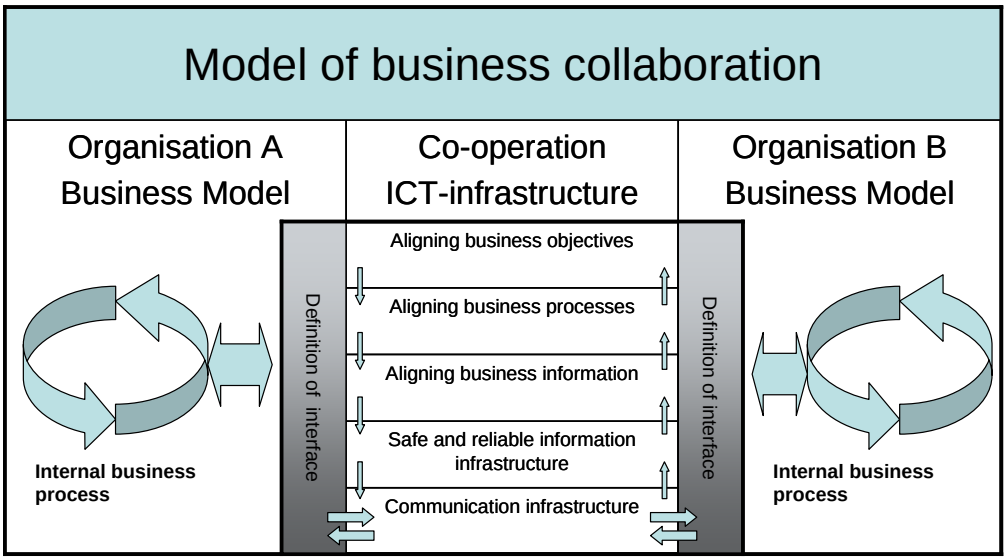

Figure 4. Model of business collaboration from an ICT point of view

Modelling the interface

There is an extensive set of tools developed by both academia and the business community for enterprise modelling (EM). These tools are EM languages of which some can be utilized in modelling interoperability as well. They provide an externalised model of the enterprise, its resources, processes, information and material flows, architecture and system infrastructure. An enterprise model can then be utilized in making decisions to improve enterprise performance. None of the existing modelling languages are able to provide tools and metrics for examining all levels of collaboration. We provide an overview of two languages: ebXML and GRAI. We also take a quick look at a tool that might have lots of potential in the future: The Supply Chain Operations Reference Model (SCOR).

ebXML provides a comprehensive method to implement collaborative information exchange and unlike EDI, it provides strong support for semantics and process –definitions (ebXML 2005). Referred to the model of business collaboration in figure 4, ebXML standards can handle business process- and information alignment as well as provide tools for message exchange. Unfortunately, understanding of the benefits of ebXML and other toolsets for collaboration is rather low in the SME context, and it would be far fetched even for a big customer to expect its SME –suppliers to move to the ebXML community yet. ebXML standards however provide some useful tools for examining the lower levels of collaboration between companies.

GRAI is a set of methodological modules for enterprise modelling (Belen & Garcia 2004, 105-109). It provides an extensive model for presenting collaboration in a global context (GRAI GRID) as well as a model for focusing on a local description (GRAI NET). The GRAI GRID represents a Collaborative Enterprise (A+B) that consists of the models representing the actual Enterprises A and B. The GRAI NET offers a process level description of a single

decision centre. Referred to the model of business collaboration in figure 4, GRAI can be deployed in describing collaboration in alignment of business objectives and processes. It seems that GRAI cannot, however provide a set of tools for the lower levels of interaction, such as messaging syntax and semantics.

SCOR (Supply Chain Council 2005) is a reference model, i.e. a framework for describing the *as is* state of a process and the desired *to be* state together with the actions needed to take to get there. It is unique in the way it approaches process development from a perspective of business strategy. Huang et al. (2005, 393-394) found it useful in their study yet there aren't many success stories of actual businesses exploiting it. This is probably due to its newness and we expect SCOR to be more widely used in the near future.

It would be important to describe the entire range of collaborative levels within one model with enough accuracy to be able to drill down to the actual processes on each level. We should be able to draw a connection from the higher level strategic decisions into implementations in the messaging infrastructure.

A complete framework for collaboration

Combining the presented models for collaboration and information integration, we present a complete model for examining strategic collaboration between companies from an information –systems viewpoint. Figure 5 presents a framework for assessing levels of collaboration. Note that this is not a framework to describe development of collaborative information systems, but to assess different levels of integration.

Camarinha-Matos (2004, 180-181) suggests that inter-organizational information technology forms a platform for interaction between individuals. The presented model in figure 5 is a general presentation of the structure of collaboration. It depends on the nature of collaboration whether the emphasis is on strategic-, product- or transaction-oriented activities. On top of the framework is the strategic level; all long term collaboration is based on a common long term objective. It is obvious that on this level all interaction is conducted between human beings and can be described *high touch* by nature. On this level, information systems consist of Business Intelligence (BI) systems that are used to analyse data produced by operational-level systems. Vertical integration of BI –systems to the lower-level systems is crucial, but exchanging information with partners relies on personal relationships.

On the next level of collaboration are the *mid-touch* interactions that are based partly on interaction between human beings and partly between machines. Joint product development activities are one example. Partners may be using compatible software to exchange product information, yet the semantics of the design is interpreted by human beings. An electronic medium can also be used in this level to enhance collaborative product development activities.

The lower level of interaction is the level of daily operations. ERP and other operational information systems have taken up this level and interfaces for message delivery are fairly standardized. This level provides support for the long –term planning, yet it is dependent of management development activities. Interactions between partners on this level have been under investigation in several studies and are supported by the biggest amount of standards

and technologies. This is due to the large number of transactions performed and the requirements for rapid information flows in the network. This is a *low touch* level, as it can normally be performed with low- to none interference of human beings.

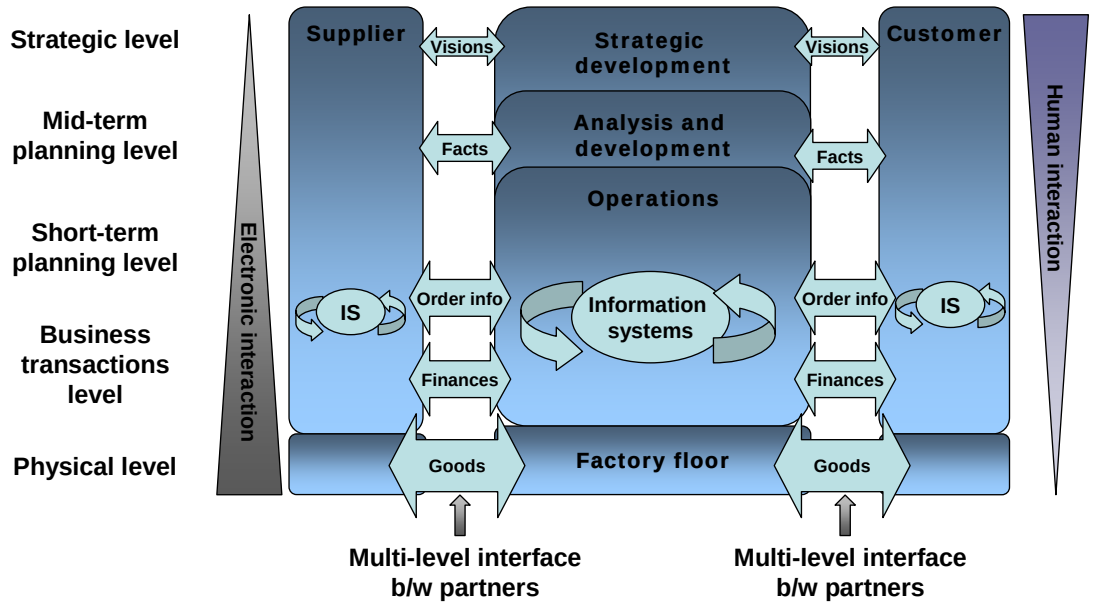

Figure 5. Levels of collaboration

Information integration should be planned in perspective of the entire network, yet it is impossible to utilize one technology or one kind of information in all partner-relationships. Therefore collaboration must also be analyzed from a partnership-perspective. Suppliers that achieve short lead-times and quick response to changes in production, should focus on utilizing actual demand-information and suppliers whose ability to respond is hindered by longer lead-times, should focus on utilizing forecasting information. In the end, reducing lead times should be an objective with all suppliers. (Treville et al. 2004, 625)

Case study

Having studied the generalized models for networking and business-process integration between network members, we now try to apply these models in a case study of a sub-division of a large multinational machinery manufacturer and four of its first –tier suppliers. The machinery manufacturer operates as a division of a Fortune 500 corporation. The sub-division investigated employs approximately 300 staff in one single manufacturing site. Figure 6 illustrates the case focus in light of the whole supplier network.

All four first-tier suppliers investigated are SMEs operating in close geographical proximity of the machinery manufacturer. This group supplies key components and all have a long relationship with the machinery manufacturer. Co-operation with this group is kept close with regular meetings that involve both strategic- and tactical issues. A lot of work has been done to improve compatibility of business processes and the machinery manufacturer has recently decided to establish an EDI-connection with its most important suppliers. This group will be the first to pilot the connection.

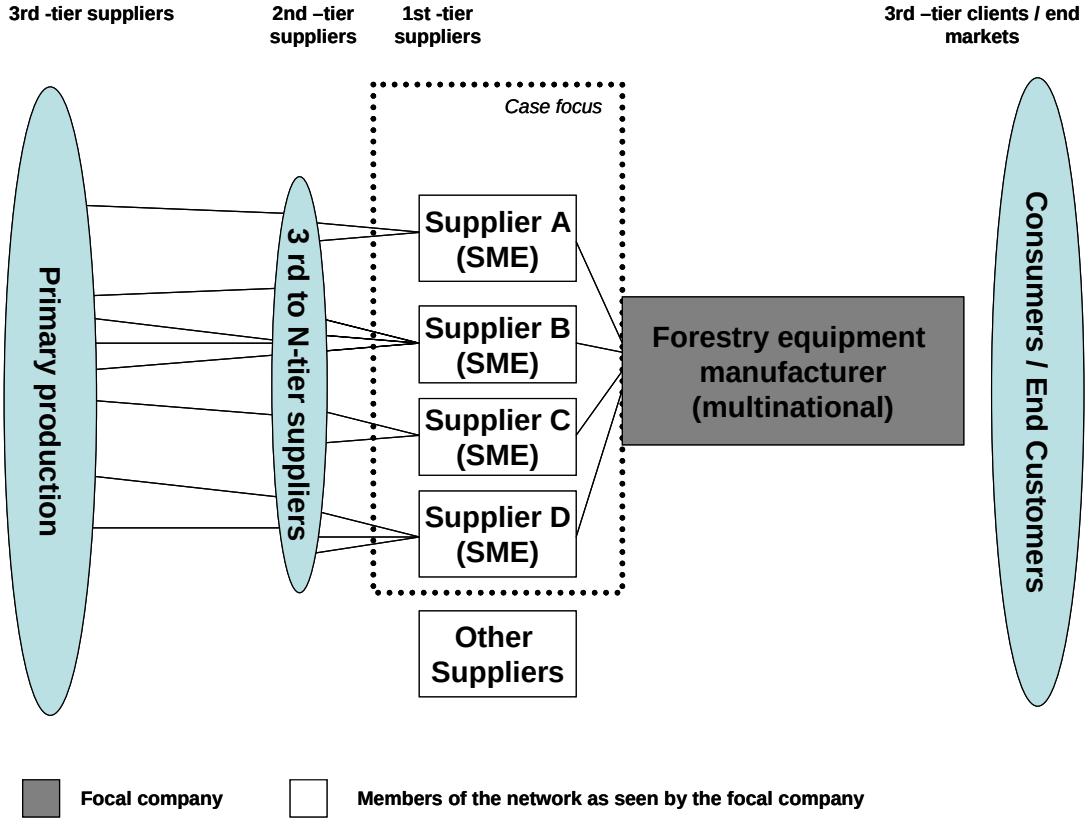

Figure 6. Case focus

The market for the end-products is rather stable, yet developing at a somewhat fast pace. Issues are mainly related to improving manufacturing capacity and ability to respond to increasing demand. Even if the market is fairly predictable, manufacturing to forecast would not be reasonable, as each product will be tailored to a customer specification. To be able to anticipate production schedules and capacity in the mid- to long term, capacity must be planned according to forecast. A specific machine will be frozen into the final production schedule twenty days before entering production. This will not give plenty of time for the suppliers to receive the order, acquire materials, manufacture and deliver to the production line in time. Therefore all of the suppliers investigated are forced to start manufacturing and purchasing according to forecast. The machinery manufacturer is expecting EDI to reduce the lag from customer order to the actual order being forwarded to suppliers to help them implement a more accurate and timely production process to help reduce inventory and therefore cost.

Another issue is forecasting, especially on the first-tier. The machinery manufacturer offers all its suppliers a *supplier schedule* that the suppliers can use to anticipate future demand. Some of the investigated suppliers find it hard to combine forecasts they receive in several formats from different customers. Supplier B is looking for a solution to translate the forecasts it receives to forward it to its own supplier network.

Reducing inventories on the first-tier has been on the agenda for some time. After these four suppliers were chosen to become a key-supplier development group, many efforts have been

made to synchronise manufacturing and order-delivery processes but it seems it is not easy for the SME –suppliers to let go of buffer stock while their customers are extremely strict with delivering on time.

Investigated suppliers

Supplier A is a division of a larger organization manufacturing heavy machines for material handling. The subcontracting division manufactures heavy structures for the machinery manufacturer. Supplier A has potential to increase capacity and it has incorporated a modern ERP –system with capability for electronic connections. At the moment, this system cannot provide support to the subcontracting business due to lack of bills of material. Number of orders is limited and ordered products have little variation. Therefore it may be hard to find economic benefits from electronic messaging at present. Looking into the future with potentially growing business with the machinery manufacture, first steps for developments have been taken.

Supplier B operates in close co-operation with the machinery manufacturer and bears responsibility for direct sales of some spare parts and accessories. Supplier B operates a simple manufacturing resource planning system offering limited functionality with regard to materials management. Final assembly line is controlled by demand, e.g. orders, but pre-production is controlled via buffer inventories. Efforts have been made to streamline manufacturing processes, but growing demand makes development efforts even harder. Supplier B is planning to improve its information systems infrastructure with an implementation of an improved version of its current system offering ERP-characteristics. This in conjunction with up-to-date bills of material will bring Supplier B to fill the minimum level of requirements for EDI-implementation.

Supplier C is a manufacturer of multiple product lines, of which some are for direct sales to the consumer and professional market and most of the business comes from supplying machine and equipment units and systems to its clients. Multiple product lines make it difficult to plan manufacturing resources to a master schedule, which has led to a rather complex method for production planning that is not based on bills of material or a flowline production. To be able to reach benefits from electronic messaging with its clients, Supplier C must update its production planning methods and input bills of material into its ERP-system.

Supplier D has placed itself on the first tier for all of its few clients. This has obviously been a strategic choice. A close relationship with several strong clients turned out to be somewhat of a challenge regarding process integration and electronic messaging. Supplier D is implementing a new ERP-system to support both internal operation as well as electronic connections with its clients.

Implementing EDI

To achieve the perceived benefits the machinery manufacturer is looking for, it is essential that the suppliers are ready to integrate the implemented messaging channel to their production planning and materials management systems. To push suppliers to participate in electronic communication is not an enormous challenge for an important customer. A simple decision to go along with the implementation will not however, be sufficient to make sure that the suppliers really go through the process of integrating information flows.

At first, the suppliers were a bit reluctant to join the EDI –project. Yet after their operations and information systems were investigated and a concrete benefit for each and every supplier was found, it was much easier to reach an agreement of joining in. One supplier is looking to integrate other customers in the same project, one is looking to integrate the forecasting process to its own suppliers and all are looking for savings from automated order-invoice processes. In the end, all investigated suppliers are also focusing on internal information systems development, namely in ERP.

In the process of making decisions related to the method to be used in connecting with the suppliers, the machinery manufacturer has given the suppliers freedom to choose between operators offering middleman translation and transfer services. Finding one operator for all suppliers was an objective to gain negotiating strength for the small suppliers. It turned out that democracy might not be the best way to proceed in doing this, as it is obvious some suppliers have other customers using some services and these suppliers will gain savings if they choose to use the same service. In other words, it requires a great deal of diplomacy in finding a consensus here. The complexity of real-world networks is why it is impossible to find a solution to suit all. All suppliers are focal companies in their own networks and they see the network differently, even if they are members on the first tier of the same network.

EDI-readiness could also be translated to “ERP-effectiveness” as implementing EDI will not help information flows through the network if the information is stuck behind the interface to be handled manually. All suppliers have implemented some information systems with ERP-characteristics, yet none operate a fully functional system providing true backing to business processes. The greatest challenge seems to be related to PDM, as the suppliers generally seem to consider that implementing true PDM including all products and their structures will not produce a return to the investment of time, effort and money. There are exceptions to this, though and some suppliers are realising the connection with automating information flows and the products that are at the heart of a manufacturing organization no matter how small or big it is.

Findings

Collaboration between real-world companies presents numerous challenges. SME –culture is bound from the manufacturing viewpoint. Increasing demand is seen as a positive problem, and SME –management often considers they have been successful being in the growing business. Engineering workshops have traditionally selected their product and services offering based on machinery in house. In the past these now collaborating companies might have been competitors. Therefore these companies growing into first-tier suppliers offering complex modules need to acquire a new way of thinking to overcome mental barriers hindering collaboration.

A powerful customer has both negotiating leverage as well as managerial knowledge. It is relatively easy to dictate required development steps into the supplier network. Thus this is not collaboration, and the real challenge lies in selling the idea of a collaborative network where each member is encouraged to suggest development initiatives related to the products or supporting processes. Despite unbiased negotiating leverage, requirements should be

accepted by all parties and the suppliers should be able to define their own requirements affecting their customers.

In the sense of different levels of collaboration, it seems that this network is taking development steps in all the levels. The key-supplier initiative operates on the higher levels of sharing vision and analyzing past performance and setting future targets. A lot of work has been done to integrate the delivery process to provide support for the flowline production of the machinery supplier. Operational –level information exchange is undergoing a restructuring in the EDI –project.

To ensure effective operational information interchange, network members need to consider what kind of solutions are able to provide support for both internal processes and network-wide processes. At present in the SME-context EDI is a suitable solution for taking the first steps for implementing visibility in the demand chain. But it is only to be seen as the first step, as there are already a lot more effective and flexible solutions, such as ebXML and RosettaNet that provide support for more effective collaboration in the information-sharing sense. An understanding of semantics through ontology is very important in integrating information. In a networked environment where each individual company has other collaboration partners as well, bilateral agreements in semantics are not suitable, but a repository is needed for semantic understanding.

It is paradoxical that rapid market developments make process development harder, as companies are tied to the manufacturing clockspeed to keep up with their customers' schedules. SME –management is in close contact with production and it is hard to step aside for a while to plan information system development. This sometimes leads to unsuccessful IS implementations if management cannot commit and provide enough support to the project. Perhaps the initiative to implement a new ERP –system is related to a customer, and management just wants to please the customer by implementing something that in the end will not return the investment let alone take the company a few steps further.

Conclusions

A theoretical approach was supplemented with empirical industrial investigation to highlight the present-day challenges in collaborating networks from an information systems point-of-view. Some of the investigated suppliers are just taking their first steps in enterprise resource planning and electronic communication with their partners. Even if there are advanced solutions to integrate a supplier network, every supplier needs to start from the bottom and plan moderate sized steps in developing processes and supporting systems.

Taking these development steps must be planned and managed. Incremental improvements in organizational knowledge and piecemeal investments in information systems architecture will help staying on the correct path to success in collaboration. It is essential for all demand-chain partners to incorporate the knowledge to make sure they can participate in the network coordination.

Enterprise resource planning is a wide concept including much more than an information system. An ERP system must be incorporated in the way an organization is planning

utilization of its resources, otherwise it will be useless. Managing the complexity of ERP systems is a great challenge and can be overcome by adjusting the level of implementation to match the level of requirements coming from the collaborating network and its competition with the level of capability of the supplier.

Future research efforts should focus on developing tools to managing the interfaces between networked SMEs. It is important to be able to describe the specific interfaces in light of the whole network while taking account the internal resources of the collaborating companies. The typical SME characteristic of ad hoc processes provides a set of requirements for this kind of tools to be effective.

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