Chapter XI

A Reference Model for Strategic Supply Network Development

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Abstract

Based on rapidly changing market conditions and increasing pressure on cost and productivity, companies in different industries have started to concentrate on their core competencies and to decrease vertical range of manufacture. This resulted in an increasing dependency between the producing companies and their suppliers. Enterprise networks are formed creating the necessity to focus on the strategic development of supply network partners. While currently strategic purchasing mainly deals with direct suppliers' future, strategic purchasing needs to deal with flexible and dynamic supply networks. This results in a paradigm shift in the domain of strategic sourcing from a supplier-centric to a supply network scope. In order to support the paradigm shift, the development of a reference model specifying the organizational and functional implications is necessary. This chapter therefore introduces a reference model for the domain of strategic supply network development extending the traditional frame of reference in strategic sourcing to a supply network perspective.

Introduction

Driven by drastically changing market conditions, companies are facing an increasingly complex competitive landscape. Decisive factors such as globalization of sales and sourcing-markets, shortened product life cycles, innovative pressure on products, services and processes and customer requests for individual products are forcing companies to undergo a drastic transformation of business processes as well as organizational and managerial structures (Burtler et al., 1997). The shift from a function-oriented to a process-oriented organization with a strong customer focus is essential in order to better adapt to fast changing market requirements and to become more flexible while meeting individualized customer demands (Osterloh & Frost, 2003, pp. 28-31). Within an enterprise, the core business processes (Prahalad & Gary, 1990) need to be identified, improved and (partly-) automated, while at the same time other processes are outsourced to business partners. As a consequence, business processes concerning, e.g., product development, market research, sales, production, delivery and services, are affected and have to be adjusted and integrated not only within a single company but also with external partners, spanning multiple tiers of suppliers. As already recognized by Malone (Malone & Lautbacher, 1998, pp. 151-152), “the boundaries between enterprises will become much less important. Transactions within organizations will become indistinguishable from transactions between organizations and the business processes, once proprietary, will freely cross organizational boundaries.” Companies recognize that the source of their competitive strengths does not only lie in their core competences, but also in the cooperative relationships with their business partners (Jarillo, 1988, p. 31). To an increasing degree, traditional organizational structures are nowadays evolving towards *hybrid* and *network structures* (Malone & Lautbacher, 1998, p. 166; Picot et al., 2003, p. 289), taking advantage of complementary competences of their external partners.

In *hybrid organizational structures*, cooperation (Picot et al., 2003, pp. 303-304) describes the dependency between two firms, which are coequal and collaborate in order to exchange or share information, products or services. Cooperation has a symbiotic character, can take a variety of forms, such as strategic alliances, strategic partnerships, strategic cooperations, operative cooperations and joint ventures and occurs across vertical and horizontal boundaries. Cooperation mainly occurs as a result of outsourcing nonspecific activities—necessary for the production of a product or service—which are of medium strategic relevance. If instead, idiosyncratic activities with low strategic relevance are outsourced to business partners, the degree of autonomy between the partners may change, depending on the level or importance of the single enterprises.

If two or more companies are involved in inter-organizational collaboration, an *enterprise network structure* is created. Enterprise networks are formed to better fulfill specific customer requests providing customized products on time in the right quality and for a competitive price. Such networks can span over several tiers, especially in large manufacturing companies, e.g., in the automotive industry. Even if enterprise networks have been introduced many years ago by Jarillo, Malone and Miles, (Jarillo, 1988; Malone et al., 1987; Miles & Snow, 1984; Thorelli, 1986), there is no single, broadly accepted definition of an enterprise network today. Several expressions exist to define different, or sometimes similar, types of enterprise networks. Terms such as *strategic networks* (Gulati et al., 2000), *alliance networks* (Gulati, 1998), *economic webs* (Hagel III, 1996), *business webs* (Tapscott et al., 2000), *value*

webs (Herman, 2002), *virtual networks* (Malone & Lautbacher, 1998) or *dynamic networks* (Pine et al., 1993), can be found in the literature. As defined by (Gulati et al. (2000, p. 203), “*strategic networks* potentially provide a firm with access to information, resources, markets, and technologies; with advantages from learning, scale, and scope economies; and allow firms to achieve strategic objectives, such as sharing risks and outsourcing value-chain stages and organizational functions.” Gulati uses strategic networks in a quite general manner, assigning several types of networks—which are composed of inter-organizational ties—e.g., strategic alliances, joint ventures and long-term buyer-supplier partnerships to this term. More precisely, Gulati defines *strategic alliances* (Gulati, 1998, p. 293) as “voluntary arrangements between firms involving exchange, sharing, or co-development of products, technologies, or services.” The authors of economic webs, business webs, value webs, virtual networks and dynamic networks all discuss the same basic idea of supporting enterprises by means of information and communication technology, primarily the Internet, in order to “shed functions in which they are not competitive to service providers and partners that may have far greater expertise, scale or geographical reach” (Herman, 2002, p. 35). Malone (Malone & Lautbacher, 1998, pp. 146-148) mainly sees the increasing importance of “ad-hoc structures,” where single business units join together into *virtual and temporary network-companies* in order to produce or sell goods and services, and as soon as such projects finish, the temporary companies would become obsolete. Hermann (2002, p. 31) envisions, that “the traditional value chain, which optimized as sequence of functions for one business, is transforming into a global *value web*, which can optimize the supply, demand, and product design activities for an entire network of partners. ... Rather than think in terms of a linear value chain, we think of a value web where material, information, and money flow in parallel, taking multiple separate path through a complex network of suppliers, service providers, distributors, and customers.” Pine additionally adds a *dynamic* aspect to the enterprise networks in order to make mass customization work, saying that “companies must break apart long-lasting, cross-functional teams and relationships and form dynamic networks” (Pine et al., 1993, p. 114). In mass-customization, where, for example, processes, technology and products need to be reconfigured in order to fulfill the individualized demands of customers, the corresponding enterprise networks cannot remain fixed, but need to be adjusted dynamically.

Considering the network definitions introduced above, we use the term *strategic supply network* in this chapter in order to define in the manufacturing industry (e.g., in the automotive industry) a network of *suppliers* spanning over several tiers and communicating among each other using the Internet. The network has a *fixed* part, namely the original equipment manufacturer (OEM), and a *dynamic* part, the suppliers, allowing *flexible* extension and modification of the network when additional competencies are needed. The OEM has a *higher degree of autonomy*, since it is the requestor for specific products and therefore the initiator of the identification of the network partners. The network has *strategic* relevance and focuses only on long-term relationships.

Supply networks are gaining more and more importance, especially in the automotive industry. For example, Dodel (2004) cites in his research on the logistic criticality in the automotive industry a logistics manager of DaimlerChrysler AG, who states that “the processes and skills of the direct suppliers are well known. What is missing is the transparency on the complete supply network, which serves behind the direct suppliers. If a supply problem occurs, great efforts have to be taken to identify the cause of the problem.” Additionally, in spring 2004 DaimlerChrysler had to call back 1.3 million cars due to problems with the

integration of system modules provided by different supply partners. Jürgen Schrempp, CEO of the company, stated during an interview prior to the annual general meeting, “the company underestimated the complexity of networking partners, who deliver complete system modules.”

In order to gain competitive advantage in such supply networks, the selection, development, management and integration of respective suppliers, located not only in tier-1 but also in the subsequent tiers, are of major relevance. Modern information and communication technologies—like the Internet, semantic standards, distributed applications, component based, and respectively service-oriented architectures—are necessary in order to sustain the creation and management of supply networks (Kopanaki et al., 2000). However, at present IT-enabled networks can be largely found in form of rather small, flexible alliances of professionalized participants. The support of large networks with multiple tiers of suppliers still causes considerable difficulties. The high degree of complexity resulting from dynamic changes in supply networks is the main reason for the lack of practical implementation that is connected with the identification of supply network entities and the modeling of the supply network structure, as well as with the high coordination effort, as described by Lambert and Cooper (2000). Despite the fact that those are basic principles in order to succeed in supply networks, many research efforts have been based on more operative tasks primarily focusing on the optimization of forecast and planning accuracy and the optimization of material flows over the whole supply chain (Houlihan, 1985; Jones & Riley, 1985). Current enterprise resource planning (ERP) systems build the fundamentals for the management and controlling of supply networks but there is a lack of functionality to support dynamic identification, evaluation and qualification of competent partners (Angeli, 2002).

In order to analyze the basic principles, such as network modeling, it is necessary to focus primarily on strategic tasks such as long-term supplier development before dealing with operative tasks of supply chain management. Strategic tasks have not been widely discussed in a network perspective yet, even if current research work, such as Carr and Smeltzer (1999), give an extended interpretation of supply chain management partly considering supplier relationships as part of that management. Therefore, the domain of *strategic supply network development (SSND)*, which extends the traditional frame of reference in strategic sourcing from a supplier-centric to a supply-network scope, has been developed and described in a *reference model*, specifying the implications for the construction of the supporting IT-infrastructure.

A reference model is understood as an information model, which is developed or used to support the construction of application models. Since this definition gives a very wide description of the reference model concept, a classification is needed in order to better understand the development and the purpose of a concrete reference model. The classification provided in ???, differentiates between reference models describing existing real world business aspects and reference models describing theoretical constructs of business challenges. The paradigm shift from a supplier-centric to a supply network perspective is an implication which became necessary due to massive changes in current markets. As described above, existing information models and systems do not sufficiently support the basic principles of the network perspective. The SSND reference model, as a *theoretical construct*, provides the relevant information for modeling complex and dynamic changing supply networks and builds the basis for the development of information systems for those value networks. Fettke (Fettke & Loos, 2004, p. 332), divides the class of reference models

as a theoretical construct additionally into several sub classes. One of the sub classes defines *reference models as a technique* used for building supporting information systems in order to improve business efficiency such as increasing product quality and reducing costs and product development time. The SSND reference model is a contribution to this sub class since it describes functional, data and process aspects in strategic sourcing in order to optimize the purchasing function in a network perspective. The SSND reference model is therefore not based on empirical studies, but, as a first step, the efficiency of the model is evaluated by a prototype implementation.

The work presented in this chapter summarizes different aspects of the SSND reference model, which have already individually been published in Albani et al. (2004a), Albani et al. (2003a, 2003b), Albani and Müssigmann (2005), Albani et al. (2004b), and focuses on two functional aspects, the *strategic demand planning* and the *modeling of strategic supply networks*. An overall description of the domain is introduced and an extract of corresponding process models and data diagrams of the functions mentioned is given. Additionally, the prototype implementation of SSND is shortly described.

The Domain of Strategic Supply Network Development

The relevance of the purchasing function in enterprises has increased steadily over the past two decades. Until the 70s, purchasing was widely considered an operational task with no apparent influence on long term planning and strategy development (McIvor et al., 1997, p. 166). This narrow perspective was broadened by research that documented the positive influence that a targeted supplier collaboration and qualification could bring to a company's strategic options (Ammer, 1968). In the 80s, trends spurred the recognition of the eminent importance of the development and management of supplier relationships for gaining competitive advantages. Such trends were, e.g., the growing globalization, the focus on core competencies in the value chain with connected insourcing and outsourcing decisions, as well as new concepts in manufacturing. As a result, purchasing gradually gained strategic relevance on top of its operational and tactical relevance (Kaufmann, 2002).

Based on these developments, purchasing has become a core function in the '90s. Current empirical research shows a significant correlation between the establishment of a strategic purchasing function and the financial success of an enterprise, independent from the industry surveyed (Carr & Pearson, 1999, p. 513). One of the most important factors in this connection is the buyer-supplier relationship. At many of the surveyed companies, a close cooperation between buyer and supplier led to process improvements and resulting cost reductions that were shared between buyer and suppliers (Carr & Pearson, 1999, p. 516).

In practice, supplier development is widely limited to suppliers in tier-1, i.e., the direct suppliers. With respect to the superior importance of supplier development, as mentioned above, we postulated the extension of the traditional frame of reference in strategic sourcing from a supplier-centric to a supply-network-scope (Albani et al., 2004a; Albani et al., 2003b; Albani et al., 2004b). That means the further development of the strategic supplier development to

Figure 1. Functional decomposition diagram for strategic supply network development

a strategic supply *network* development. This shifted the perspective in the field of strategic sourcing to analyze multi-tier supplier networks instead of single suppliers.

The tasks within the strategic supply network development can be grouped into three main areas as illustrated in Figure 1: *Strategic demand planning*, *strategic supply network modeling* and *strategic supply network qualification* (Albani et al., 2004a).

Those tasks are derived from the main tasks in strategic sourcing. The most evident changes apply for functions with cross-enterprise focus. Within the function *strategic demand planning*, a corporate framework for all purchasing-related activities is defined. This framework consists of a consistent and corporate-wide valid purchasing strategy (*define purchasing strategy*), a strategic demand planning and demand bundling function (*plan strategic demand*) and the definition of methods and tools to control performance and efficiency of purchasing and to establish a conflict management concept (*define operational framework*).

The function *strategic supply network modeling* provides a methodology for the *identification* (identify strategic supply network), *evaluation* (evaluate strategic supply network) and *selection* (select strategic supply network) of potential suppliers, not only located in tier-1 but also in the subsequent tiers. Using evaluation criteria such as lowest cost, shortest delivery time or best quality, and corresponding evaluation methods, the identified supply networks are evaluated. If there is a positive result on the evaluation, the supply network is selected and contractually linked to the company.

Within the function *strategic supply network qualification*, the quality of a performing supplier network is evaluated using evaluation criteria and evaluation methods (*evaluate quality of supply network*). Dependent on the result of the evaluation, sanctions may be used to improve the quality of the supply network (*improve quality of supply network*).

Figure 2. Function decomposition diagram of the function strategic demand planning

Strategic Demand Planning

Due to the positive effect that long-term and high-quality supplier relationships contribute to the success of a company (Ammer, 1968), the purchasing function was divided into a strategic and an operational domain. The field of responsibility of strategic purchasing comprises not only the selection and qualification of strategic suppliers but also the long-term strategic activities for demand planning. The paradigm shift in strategic purchasing has influenced the strategic tasks and led to different characteristics in the area of strategic supply network development.

Figure 2 shows the sub- and elementary-functions of *strategic demand planning* which are described in detail in the following sub-sections.

Define Purchasing Strategy

The purchasing strategy (a) describes the purchasing policy of the company, (b) determines whether consumption-oriented or safety-based purchasing will be accomplished and (c) declares the basic principles of the purchasing and sourcing strategy respectively (see elementary function in Figure 2).

The corporate *purchasing policy* defines responsibilities and approaches, which need to be followed by the entire purchasing organization of a company (Strache, 1983, p. 76). This policy consists of the specification of a corporate purchasing organization, the definition of a consistent approach for, e.g., demand consolidation, and the adoption of corporate operational guidelines for implementation. An important task thereby is the creation of a corporate directive for agreements regarding the cooperation with suppliers and the propagation of business risks to suppliers in strategic supply networks. So far it was sufficient for strategic

purchasing to check direct suppliers with regard to critical regions or political impact. Now all nodes of a strategic supply network have to be verified. Furthermore, it turned out that an involvement of strategic suppliers in product design and product development led to process improvements and increased efficiency for both the buyer and the supplier (Carr & Pearson, 1999, p. 513). Additionally, efficient agreements for environmental protection and recycling are needed. Environmental needs as well as the protection of fundamental living conditions obtain more and more importance. Hence, efficient agreements comply not only with legal requirements but avoid cost significantly. All nodes of a supply network need therefore to be involved in an environment-friendly purchasing strategy, including the usage of environmentally sound goods and transportation facilities as well as reusable packages and fillers. Criteria on environmental protection and recycling need therefore to be considered while selecting supply networks.

Another important task of the purchasing strategy is the *definition of a consumption or safety strategy*. Consequential use of a company's demand power on the purchasing market results in favorable prices and best conditions, whereas it is important to assure availability of purchasing goods (Jahns et al., 2001, p. 40). The decision whether a consumption or safety purchasing strategy is applied has an impact on the composition and development of supply networks. If the main focus is set on supply safety, then long-term and stable relationships with supply networks are desirable. In the case of a consumption strategy, it is important to identify comparable supply networks in order to select the one that fits best in the sense of prices and conditions in a concrete purchasing situation. Such a consumption strategy is used especially for standardized goods, allowing a good comparison of supply networks.

In order to *define a concrete sourcing strategy*, it is necessary to distinguish between different sourcing strategies, e.g., single sourcing versus multiple sourcing, local sourcing versus global sourcing or insourcing versus outsourcing. Single sourcing defines the supply of a good without using a contest between different supply networks. It is possible for strategic purchasing to ensure good prices, for example, by establishing long-term contracts with entire supply networks as it is managing direct suppliers. Multiple sourcing is aimed at the competition of existing and potentially new supply networks. Depending on which decision criteria (e.g., price, availability, lead time and quality) are used while comparing supply networks, the process of selecting a supply network is much more complex than selecting a single direct supplier. Local sourcing restricts purchasing on markets in the company's home country—cost savings (e.g., because of a shorter route of transport) and higher reliability because of stronger control possibilities are the main advantages (Large, 1999)—whereas global sourcing describes international purchasing activities using worldwide resources. In the case of global sourcing, opportunity and risk profiles need to be elaborated. It is reasonable to use the strategic decision on local or global sourcing as a parameter while identifying and modeling supply networks. Decisions on make or buy (in- or outsourcing) need to be considered while sourcing entire modules or even systems (Large, 1999). Such a decision has significant influence on the company's vertical range of manufacture and permits drastic reduction of internal costs.

Choosing the right strategy for a purchasing good depends on the importance of the good for the corporate goods and services. With high quality, non-standardized goods the safety and single sourcing strategy is desirable. On standardized goods with low complexity a company may choose a consumption strategy and use a multiple sourcing strategy to achieve low

purchasing prices. Another important task area of strategic purchasing is the reduction of complexity and variety of goods while at the same time transparency needs to be increased. This can be achieved by using standardized goods and a corporate classification system.

Calculate Strategic Demand

In order to consolidate demands, the purchasing goods need to be categorized into a corporate classification system. The *classification of purchasing goods* therefore needs to be performed for goods which are already in use as well as for all new goods. Fuhry et al. (2002) suggests to classify the purchasing goods into three groups: indirect material, basic direct material and strategic direct material. Indirect materials are goods and services which are not directly necessary for the production of an end product (e.g., office equipment). The focus of such goods lies, therefore, on the optimization and increase of efficiency of the order management and invoice processes (e.g., by using e-procurement systems). The share of this group is about ten percent of the total purchasing volume. Basic direct materials are directly used in the end product (e.g., raw materials and pre-fabricated parts). With this group of material, the competition can be increased by standardization and transparency in the market, which results in a direct decrease of cost. The use of IT-Systems like online auctioning or automated bidding systems can significantly increase the efficiency of the purchasing process. The share of this group of material is about 30% of the total purchasing volume. Strategic direct materials are complex components, pre-fabricated goods and systems or extensive services, which are used in the end product (e.g., motors and car seats). With this group of material, it is important to develop and maintain long-term and high quality relationships with the suppliers, and therefore with the related strategic supply networks. In addition, it is necessary to involve the suppliers that are participating in such strategic supply networks at an early stage into product planning and product development. The share of this group of material is about 60% of the total purchasing volume.

For the classification of goods it is possible to use classification standards, e.g., eClass and UN/SPSC. The value based share of the purchasing volume of a good can be calculated by using the ABC- or the portfolio analysis (Hirschsteiner, 2000, p. 11).

The extension of the view from a supplier-centric to a supply network approach has significant influence on the purchasing of strategic direct material. In most cases, these goods are purchased with a safety strategy and single sourcing. Selecting and qualifying of appropriate supply networks is hereby an important task. The transparency of a supply network is a prerequisite for the buyer to evaluate and develop a supply network.

Demand consolidation combines demands of several divisions and locations of a company in order to use the appearance on the purchasing market to strengthen the negotiating position. Prerequisites for a successful demand consolidation are the standardization and consistent classification of goods as well as the explicit identification of supply networks. Demand consolidation can improve the purchasing conditions.

Supply marketing has the responsibility to *analyze purchasing markets* and identify powerful supply networks on the supply markets (Schifferer, 2001, p. 68). The bases for it are the basic conditions defined within the supply policy, such as transfer of business risk to supply networks or the compliance with environmental regulations. Adequate supply networks

can be found through Internet search engines, external service providers (e.g., international yellow and white pages) or other data sources, such as up-to-date company profiles and key performance indicators. Based on supplier self service information, a concise profile is generated in order to decide for a supply network. With the help of supply market research, a transparency is established and continuously improved in order to provide information and outlook on future market trends and their interference with the decision strategy. A further task of supply market research is the exposure of competitors and their demand potential for specific services of a supply network. Thus, significant changes in the purchasing price can arise. Further important influencing factors are so called quantity or tool monopoly. It is necessary to recognize whether only one supply network can deliver the amount of goods or whether only one node of a specific supply network can implement and operate a special tool (Strache, 1983, p. 19). Furthermore, it is important to identify the critical path in a supply network in order to take appropriate action for adjustment if a node on this critical path fails.

Define Operational Framework

Methods and procedures for risk management, controlling of purchasing and conflict management are provided by strategic supply network development in order to manage operational purchasing.

The perception of the purchasing market research needs to be applied in order to establish effective *risk management*. Risk management deals with early detection of market, service and financial risks. Based on the business objectives and the purchasing policy of the company, concrete risk strategies are defined (e.g., fundamental risk avoidance or risk degradation strategies). Subsequently, the actual purchasing situation is analyzed, considering risk types, risk areas and risk reasons. Thus, it is examined from which countries and which industries goods are to be purchased in order to identify high-risk regions. These can be countries having high political risk, high inflation rates, high currency risks or even companies with the risk of insolvency. Through the gathering of such information, it is possible to create and evaluate quantitative and qualitative predictions (Das & Teng, 1998, p. 22).

The *controlling of purchasing* accompanies the purchasing process throughout the entire purchasing organization. It consists of the definition of operating figures and their target values. The actual values are periodically measured and compared with the target values. Deviations are analyzed and appropriate action is taken. Controlling therefore ensures the ability of a company to adapt and react as well as to coordinate and innovate. The definition and monitoring of these values is supported by design and safety goals. Regarding design goals, the controlling defines target values in order to reduce the maximum number of supply networks or the purchasing quote related to framework agreements (Schifferer, 2001, p. 62). The target values are monitored by analyzing whether the goods needed in the corporate processes are supplied in the right quantity and the right quality at the right time and the right place. Sample measures are: resource consumption, cost of purchasing staff and cost of handling the purchasing tasks but also adherence to delivery dates, quantity stipulations and the price behavior of supply networks. Furthermore, it is monitored that buying is based on a purchase order. It is recommended to use balanced score cards to compile the operating figures. The method of the balanced score card allows, with a limited number of

operating figures, implementation of a very efficient and flexible mechanism to manage a purchasing organization.

The *introduction of conflict management* processes is necessary in order to avoid conflicts in purchasing. Conflicts can occur while defining tasks and decision competency between the strategic and the operational parts of the purchasing organization. This may apply to selecting supply networks while conducting a single purchasing. A large conflict potential may also arise if operational purchasing does not adhere to strategic instructions, such as cost limitations, amounts or dates. Companies having more than one production facility or having decentralized purchasing divisions may have the same problems while purchasing identical goods. Conflicts may also arise if the purchasing staff does not stick to corporate framework contracts with supply networks due to individual connections to suppliers. An effective incentive system helps to implement the objectives of strategic purchasing. This can be established by using the extensive data gathered by controlling. It is measured how the supply objectives are achieved. The cost savings reached by the employees involved are the basis for a bonus system. Besides the cost savings, a strategic purchaser can be measured as well on the quote of newly negotiated framework contracts. An operational purchaser can be measured on the adherence to supply lead time or the securing of a specific quality level on purchased goods (Schifferer, 2001, p. 90).

Strategic Demand Planning: Business Process and Data Models

The elementary function *classify purchasing goods* (see Figure 2) is used to illustrate how the process organization is established and which information objects are used in the domain of strategic supply network development. The business processes for introducing material group codes and planned conversion of material strategies are modelled in Figure 3 and Figure 4, whereas the data model for purchasing goods can be found in Figure 5. For modeling the business domain, the ARIS (Scheer, 1999) method has been used.

The classification of purchasing goods in the company builds the basis for a material-specific purchasing strategy and is a prerequisite for effective purchasing marketing, for a consolidation of demands as well as an optimized supply network management. Initially, all purchasing goods are listed in order to decide whether a proprietary material code is being used or whether a standardized method like eClass or UN/SPSC needs to be introduced (Figure 3). It is important that all existing and new goods are grouped with a consistent material code. While working with supply networks, the material code needs to be based on a standard such that all nodes of the supply network adhere to the same method. If it is necessary to use a proprietary material code, this code has to be distributed to the entire supply network. It may be necessary to provide assistance to the nodes of the supply network in order to show how to implement and use the material code.

According to the strategic decision for a material group code, either a standardized method is adapted (preferred while working with supply networks) or a proprietary material group code is defined. This material group code is then implemented in the entire purchasing organization. The purchasing divisions are now asked to classify all purchasing goods with this material group code. In doing so, purchase controlling needs to observe the progress

Figure 3. Business process for the introduction of a material group code

of this process (e.g., supported by a balanced scorecard). Besides the material group code, other criteria, e.g., the purchasing volume or the importance, are used to further group the purchasing goods. The process of structuring goods according to their share of the total purchasing volume and starting specific actions is illustrated in the process flow *plan conversion of material strategies* in Figure 4.

The consistent classification of purchasing goods allows for the standardization of products and recognition of product correlations. Such a consolidation of the material master can

Figure 4. Business process for planning conversion of material strategies

Figure 5. Semantic data model for purchasing goods

reduce the variety of goods, which are required in the company. Purchasing goods are of different importance for the success of a company. Therefore, purchasing goods are grouped according to their relevance and their purchasing volume in three groups: indirect material, basic direct material and strategic direct material. For each of the groups, individual activities are deduced. While purchasing indirect material, for example, it is important to design the purchasing process as efficiently as possible. This can be achieved by the use of e-procurement processes and systems. While purchasing basic direct material, a minimization of the purchasing costs can be achieved by arranging auctions or biddings. While purchasing strategic direct material, the main focus is set on the development and maintenance of long-term relationships with supply networks. Therefore, the modeling and qualification of supply networks is of great importance. In order to describe the information objects of the strategic supply network development, a semantic data model is created within the scope of this reference model. An extract, showing the information objects of the process flows illustrated above, is presented in Figure 5 in an entity relationship diagram.

Starting with the specification of the demand of a *customer*, e.g., the demand for strategic direct material, data are collected not only from the direct suppliers but also from all upstream suppliers in order to support the strategic supply network development. The specific *demand* (as shown in the upper center of the picture) consists either of *services*, *purchasing goods* or other requirement types which are subsumed to the term *requirement type*. Every requirement type has *features*, such as *structural shape*, *weight*, etc. A purchasing good belongs to exactly one *material group*, which is identified by a material group code. Features as well as material groups are provided by *standardization information*. A requirement type belongs to a *classification*, e.g., strategic direct material. A classification is defined by different *criteria*. The *purchasing volume* of a requirement category as well as the material groups or the purchasing goods can be criteria for the classification of requirement categories. The objects, which are shadowed, will later on be found again in the extension of the semantic data model.

Figure 6. Function decomposition diagram of the function model strategic supply networks

Figure 7. Example for result of identification process

Strategic Supply Network Modeling

To model a supply network in a structured way, potential supply networks need to be *identified*, *evaluated* and then *selected*. Figure 6 shows the sub- and elementary-functions of *model strategic supply networks*, which are described in detail in the following sub sections.

Identify Strategic Supply Networks

For the identification of potential supply networks, a specific strategic demand for an offer to a product to be built is *specified* and *communicated* from the OEM to *existing and/or potential suppliers*. Figure 7 illustrates an example for an identification process and its results.

In the example, the OEM is connected to a potential network of suppliers as shown in the left part of Figure 7. It is assumed that the OEM needs to order two products externally, product 1 and product 2. During the identification process, the OEM sends out demands for these products to its strategic suppliers in tier-1. In the example, it is assumed that supplier 1-1 and supplier 1-2 get the demand for product 1 while supplier 1-3, supplier 1-4 and supplier 1-5 receive the demand for product 2. These suppliers check whether they can fulfill the demand internally and, if not, send out subsequent demands to their respective suppliers. Each node executes the same process as described until the demand has reached the last tier. The requested information is then *split-lot transferred* to the OEM, *aggregated* and finally *visualized* as a supply network, in which each participant of the supply network constitutes a network node.

This process may result in the identification of several possible supply networks as shown in the right part of Figure 7, where, for example, product 1 can be provided by two supply networks, supply network 1 (root node S1-1) and supply network 2 (root node S1-2), whereas product 2 can only be provided by supply network 3. It is now up to the OEM to decide which of the potential strategic supply networks (in the example above for product 1) will be selected to fulfill its original demand. The basic information needed for the selection results from the evaluation of potential networks.

Evaluate Strategic Supply Networks

Based on *defined evaluation criteria*, potential networks are evaluated. Evaluation criteria may span from simple facts to highly complex considerations. One of the simplest criterion is the minimum number of nodes in the supply network, which can be used to minimize overall complexity of supply networks. Criteria with more complex calculations, for example, are the shortest total delivery time, the minimum total cost or the regional only sourcing (indicating, that only those suppliers are selected which are located within a certain region). Complex criteria are maximization of product quality or delivery time liability, since these criteria implicate the evaluation of past experience. While considering critical areas in the supply network, it is also of main importance to know which nodes have absolute monopoly with their supply value or which are involved in more than one potential supply network (see S2-2 and S3-1 in the example in Figure 7).

After having specified the evaluation criteria, the next step is to *define the evaluation method*. In most cases, a method is represented by an algorithm which itself is related to the selected evaluation criterion. For example, the criterion minimum number of nodes involves a simple algorithm counting the nodes in potential tree graphs, comparing the results and selecting the tree (supply network) with the least number of nodes. Assuming that the identification process will provide several possible supply networks for different products, the function *select supply network(s)* will select the supply networks related to a specific product in order to *evaluate* them using the evaluation criteria and methods as just introduced above. The result of the evaluation process is a rated list of all supply networks related to a specific product. This list can therefore be *visualized* and used for the selection of strategic supply networks in order to produce the specific product.

Select Strategic Supply Networks

Based on the evaluation results of potential supply networks, *target suppliers* are *identified for negotiation*. In order to *close a contract* with those suppliers, *contract negotiations* are conducted first in order to *specify the contract terms* relevant for ordering the required goods. Those elementary functions highlighted in white in Figure 6 express that the steps cannot be automated and therefore need face-to-face communication in order to be executed.

Figure 8. Semantic data model for the function strategic supply network modeling

Strategic Supply Network Modeling: Business Process and Data Models

The semantic data model, introduced in Figure 5 has been extended with data objects used for the identification of supply networks.

The extension of the model can be found in Figure 8. The objects, which are shadowed, connect the different semantic data models to each other (see Figure 5 and Figure 10). Starting from the demand of a *customer*, it is relevant to collect data not only from the suppliers in tier-1, but

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Figure 10. Semantic data model for the identification of strategic supply networks

needed to evaluate different complex monitoring objects of the supply network. Different *evaluation methods* are defined by different *evaluation criteria*.

The whole process of modeling the supply network for a specific demand sent by a customer is shown in Figure. 9. The process modelled holds for each company in the network. Requests from a customer may arrive (*contract offer requested*) for a specific product, or different contract offers from one or more suppliers (*contract offer stated*) may be sent to the company examined. If the company has received a request for a specific product, a *bill-of-material-explosion* is produced in order to identify the products, which need to be ordered from suppliers. Contract offers need therefore to be *requested* from the respective suppliers. A request for one and the same product may be sent to different suppliers. The company examined *waits* for the different contract offers of the suppliers in order to *evaluate* them and *conclude* their own contract, containing the contract aspects of all suppliers involved. The contract is then *offered* to the requesting customer. Since each node in the network performs the process just described, the contract offered to the customer includes all contract aspects of the supply network.

The semantic data model introduced in Figure 5 and Figure 8 has been extended with the contract information objects shown in Figure 10.

Each node in the network is a *company*. A company can either be a *customer* or a *supplier*. One and the same company can be a supplier for a specific product, and at the same time a customer ordering goods necessary for production of the requested product. A company concludes *contracts* with their customers and suppliers for a specific product. An *assembly* defines a *product*, which may contain additional products. A contract has different states. Each contract, which has been received from a supplier, is an *offered contract*. Such a contract is then evaluated with *evaluation methods*, reaching the state of an *evaluated contract*. Evaluated contracts with good evaluation results may become *potential contracts*, which

Figure 11. SSND supply network for an electronic motor

are then *concluded* and accumulated to a *concluded contract*, which again is offered to the requesting customer.

Prototype Implementation of SSND

For proof of concept, the prototype tool SSND has been implemented providing the functionality for the identification and dynamic modeling of strategic supply networks. A sample view of a supply network with detailed information about every supplier contributing to an example demand for the production of an electronic motor is shown in Figure 11. Only a selected area of the whole supply network is shown. The rectangles represent the different companies of the supply network visualized with important information about the node contributing to the supply network of the electronic motor. Relevant information for the requestor about the suppliers is, for example, name of the company, material group the supplier is producing, minimum volume necessary to be ordered and capacity per day. The companies are visualized in the SSND prototype in different colors, differentiating between (a) suppliers who are able to deliver the product and amount requested, (b) suppliers who are not answering to the demand sent, (c) suppliers who are not online or where a communication problem exists and therefore can not be reached and (d) suppliers who do not have enough capacity for producing the required product, or where the volume required by the client is too low.

The tool provides different modes of visualizing the network—adding more detailed information to the nodes, showing just parts of the network, etc.—in order to support the client with all necessary information for developing the strategic supply networks.

Conclusion

Challenges in today's economy are more and more transforming formerly closely-linked value chains into flexible networks, thus significantly changing the buyer/producer-supplier relationship. As laid out in this chapter, this is especially true for the field of strategic purchasing, where an extension from a supplier-centric to a supply network perspective is required. In order to accomplish this extension, complexity issues connected with the modeling of supplier networks have to be overcome. Having identified the need for managing the complexity of supplier network modeling, a reference model for the domain of strategic supply network development has been developed. It contributes to the class of theoretical constructs of potential business challenges and describes functional, data and process aspects in strategic sourcing in order to optimize the purchasing function in a network perspective. In this chapter, an overview of the reference model has been given detailing the functions of demand planning and identification of supply networks. Additionally, a prototype of the model has been implemented in order to evaluate the described concepts.

Since the reference model is classified as a theoretical construct, and the prototype implementation has until now only been evaluated in small examples, additional work needs to be investigated in validating the concept in practice. Additionally, the prototype needs to be extended in order to allow additional product classifications next to eClass. Such an enhanced version of the existing prototype, based on a consistent and validated reference model, would constitute a basic component in an IT-infrastructure that enables companies to efficiently develop and maintain their strategic supply networks.

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