Collaborative Planning 14

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The preceding chapters deal with planning processes within one *planning domain*, e.g. an enterprise (demand planning, master planning) or a factory (production planning). The term *planning domain* constitutes a part of the supply chain and the related planning processes that are under the control and in the responsibility of one planning organization. However, the quality of a plan and the quality of the decision-making process that is based on that plan can often be improved by considering additional information that is beyond the scope of the individual planning domain.

In this chapter, we describe *collaboration processes*, which span multiple planning domains with special emphasis on collaborative planning. The idea is to directly connect planning processes that are local to their planning domain in order to exchange the relevant data between the planning domains. The planning domains *collaborate* in order to create a common and mutually agreed upon plan. Thus, input data is updated faster and planning results become more reliable. Figure 14.1 shows the Supply Chain Planning Matrices of two planning domains that are connected by *a collaboration*.

Collaborative planning can be applied both downstream and upstream, i.e. it may connect planning processes with customers (e.g. sales planning) or suppliers

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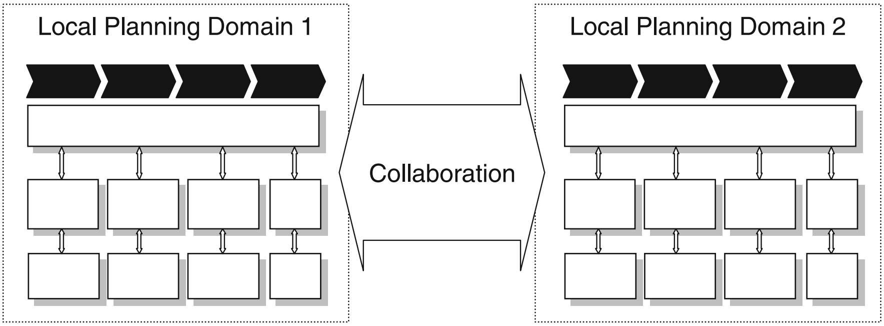


Fig. 14.1 A collaboration connects the planning processes of planning domains

(e.g. procurement planning). According to the planning horizon long-term, medium-term and short-term collaborative planning may exist. Further, collaborations can be distinguished by the objects that are exchanged and collaboratively planned, such as purchase orders for specific items (materials) or maintenance services at certain intervals of time.

A very well-known approach for supply chain collaboration is *Collaborative Planning, Forecasting and Replenishment* (CPFR). It consists of a sequence of steps and corresponding managerial guidelines (see VICS 2004) while collaborative planning software support is not a main issue. Another approach is *Collaborative Development Chain Management* (CDCM), which follows the ideas of simultaneous engineering and focuses on joint development of products by several partners with the use of web-based computer systems (see Becker 2001).

In Sect. 14.1 collaborative planning and the objects of collaboration are introduced by an example. Also, related definitions are discussed. Section 14.2 shows different types of collaborations, then Sect. 14.3 presents the phases of a generic collaborative planning process. Finally, Sect. 14.4 gives an overview of APS-technology that supports collaborative planning processes.

14.1 Introduction

The following example illustrates collaboration processes. Consider a manufacturer of headlight modules for the automotive industry. The manufacturer supplies headlight modules to two car manufacturers. A subcontractor can be employed to cover peak demand situations, providing additional assembly capacity. Headlight modules consist of a body and a glass cover. The body is produced by the manufacturer itself. The headlight glass covers are supplied by an external supplier in a make-to-order process. Bulbs are provided by a second supplier from stock.

Figure 14.2 illustrates the supply chain and gives examples of collaborations:

- The car manufacturers are interested in getting a reliable supply of headlights. Therefore, they provide their demand forecast of headlight modules to the

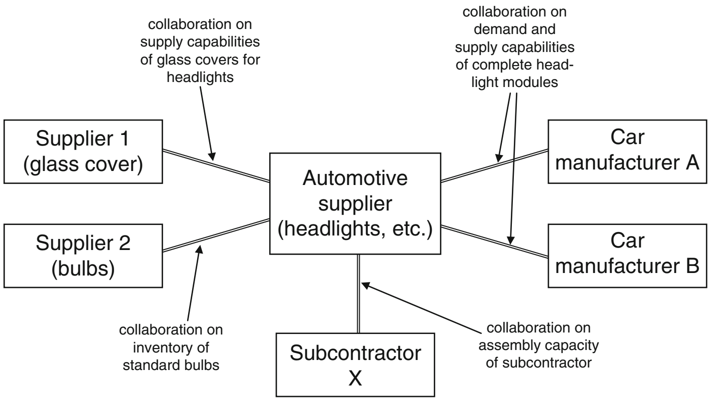


Fig. 14.2 Supply chain structure of a collaboration scenario

headlight manufacturer. From the headlight manufacturer they request a commitment to fulfill the demand forecast and information about the maximum supply capabilities. The latter is needed in case the actual demand exceeds the demand forecast, and in order to catch up fulfillment of the demand in case of a supply shortage (for instance if a die was broken). The headlight manufacturer is interested in getting a minimum demand commitment from the car manufacturer and has to plan its business and provide the appropriate capacity.

- A collaboration between the headlight manufacturer and the supplier of the glass covers helps to plan future demands and the supply capabilities needed.
- Compared to this make-to-order business, bulbs are standard products that are made-to-stock. Both the supplier of bulbs as well as the headlight manufacturer keep a specific safety stock against demand and supply variations. Collaboration on inventory and on demand forecast helps to improve the availability of bulbs when needed.
- The subcontractor matches forecasted production demand with his actual production capacity. Thus, the manufacturer and the subcontractor collaborate on the use of the capacity at the subcontractor's site.

A collaboration is related to specific items, that—as illustrated by the example—may consist of sub-items, forming a hierarchy. For instance, the light system of a specific car model may be a top level item, and the headlight and backlight modules may be second level items. Demand and supply capabilities can be attached to any level. In the example, the demand may be attached to the top level item, expressing the total demand for light systems. This is broken down to the demand for headlight and backlight modules. These modules may be supplied by different suppliers. Thus, the individual supply capabilities of the headlight supplier and backlight supplier are attached to the second level in the item hierarchy.

The example has illustrated some main aspects of *collaboration*: A prerequisite for a collaboration of (at least) two business partners is an agreement regarding the exchange of a specific set of data (like expected future demands) which will improve

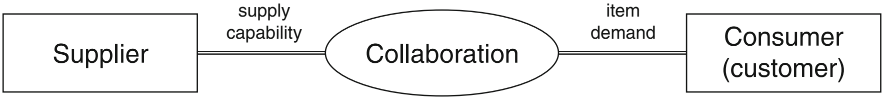


Fig. 14.3 Collaboration as a demand-supply relationship

decision making of both parties. *Collaborative planning* then constitutes the next step of a SC collaboration: Collaborative planning is a joint decision making process for aligning plans of individual SC members with the aim of achieving coordination in light of information asymmetry (Stadtler 2009). Information asymmetry means that SC members do not possess the same information (e.g. about problem characteristics, possible actions, or preferences) relevant for coordinating their activities. Consequently, a central planning approach may be considered unacceptable or even infeasible by the SC members involved. *Coordination* refers to "actions or approaches which lead supply chain partners to act in ways that are best for the chain as a whole ..." (Kouvelis et al. 2006, p. 455). These approaches make use of e.g. price mechanisms (like attractive buy-back prices for perishable goods see Cachon and Lariviere 2005), side-payments or compensations. While in theory "best" often means "optimal", in practice it will suffice that coordination results in an "improved" state compared to "no coordination".

As an example for the first step of collaboration consider an automotive supplier (see Fig. 14.3) calculating and transferring the *item demand* to the suppliers while the suppliers reciprocate by specifying their *supply capability* to the automotive supplier (customer). The next step—collaborative planning—is started in case the automotive supplier (customer) also provides his suppliers with his medium-term procurement plans for glass covers and bulbs. Subsequently, the suppliers of glass covers and bulbs will evaluate the procurement plan in light of their production capacities. Procurement and supply plans may then be amended and exchanged among SC members until a (capacity) feasible or SC optimal plan is reached.

According to a survey in the automotive industry conducted by Landeros and Monczka (1989) a supply chain partnership requires a

- Concentration on preferred suppliers
- Trustworthy commitment of future conduct
- Mutual problem solving
- Exchange of information
- Mutual adaptation to changes in markets.

While a supply chain partnership greatly supports collaborative planning it is not a prerequisite: Cachon and Lariviere (2001) describe a case from the videocassette rental industry where the supplier of videos can specify the conditions of the business relationship with the retailer of the videos (customer) resulting in the maximum profit for the supply chain as a whole. Note, the video retailer decides decentrally about the number of videos to buy that maximizes his own as well as the supply chains profit. Coordination here is achieved by the *supplier* fixing an "optimal" wholesale price *plus* a share of the retailers rental fee (revenue). Given the price and the revenue share are set adequately both parties can achieve a profit which is larger than in a traditional wholesale price setting (with no revenue share commitment). Thus, a revenue sharing contract results in a win-win situation for both parties (for more information about coordinating contracts see Cachon and Lariviere 2001 and Cachon and Lariviere 2005).

14.2 Types of Collaborations

The setting where collaboration or collaborative planning takes place can be classified along multiple dimensions. Three of these dimensions will be described here: Leadership, topography of a supply chain, and objects of collaboration (for a complete list of criteria see Stadtler 2009).

Usually, one of the partners participating in the collaboration has a *leading role*, while the other (or others) are *followers*. As an example take the computer industry: Computer manufacturers like Dell and Fujitsu are in a leading role towards their suppliers of disk drives, memory modules, controllers, etc., but they are in a follower role towards Intel. The leading partner initiates and drives the collaborative planning process, whereas a follower supports the process. Collaborations can be classified according to the leadership in *supplier-driven collaborations* (supplier has the lead) and *customer-driven collaborations* (customer has the lead). This classification corresponds to the notion of leadership in supply chains (as described in Chap. 1).

The topography of a supply chain can be described by the number of tiers: The nodes of the network represent the suppliers and the customers, the directed edges represent the item-relationships connecting suppliers with customers. If the maximum length of any path in the network (following the item-relationships downstream) is one, *two-tier collaborations* have to be considered. In two-tier collaborations the supply chain has no inner nodes, i.e. each node is either a supplier or a customer. If there is a path in the network consisting of two or more arcs, a *multi-tier collaboration* results. Note that in a multi-tier collaboration the inner nodes act both as suppliers *and* customers.

If the supply chain extends over multiple tiers, like in the automotive industry, this may result in a chain of individual two-tier collaborations (see Fig. 14.4). Each collaboration connects one supplier-customer pair. Information about a changed demand-supply situation must be propagated along all collaborations before the entire supply chain works according to the new situation. If for instance the customer and all three suppliers have a weekly planning cycle, it takes 3 weeks until a changed or new demand signal reaches the tier 3 supplier.

In order to speed up the information exchange in the supply chain a *multi-tier* collaboration can be established, directly connecting the customer with the tier 1, tier 2, and tier 3 suppliers. Figure 14.5 visualizes such a multi-tier collaboration. All members of the supply chain work according to the same "beat"; information about demand or supply changes are propagated within one planning cycle to all supply chain members (Kilger and Stahuber 2002).

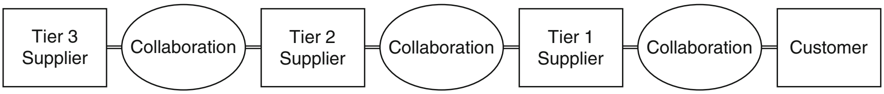


Fig. 14.4 Chain of two-tier collaborations

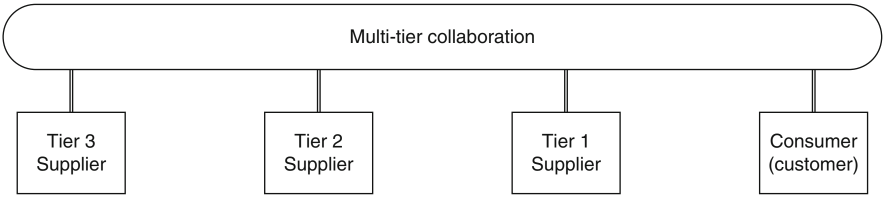


Fig. 14.5 Multi-tier collaboration

One example of a multi-tier collaboration has been implemented by DaimlerChrysler, sharing demand and inventory information of door modules between DaimlerChrysler and tier 1 to tier 7 suppliers (see Graf and Putzlocher 2004).

A successful multi-tier collaboration requires one distinguished supply chain member who is driving the collaborative planning processes and defines the rules and standards of the collaboration. In the automotive industry, this role is usually taken over by the automotive manufacturer, as he is controlling the supplier network.

Common issues of a multi-tier collaboration are different batching rules and inventory policies of the suppliers. For instance, assume the tier 2 supplier shown in Fig. 14.5 has a batching rule telling him to order multiple quantities of 100 from the tier 3 suppliers. The multi-tier collaboration has to know this batching rule, because otherwise the demand signal reaching the tier 3 supplier from the collaboration will be different from the actual demand of the tier 2 supplier.[1]

As already mentioned in the preceding subsection collaborations may be related to specific items (materials) that are provided by a supplier and are used by the customer. Supplier and customer exchange information about the demand and supply of those items. This information may be about the item itself (*material-related collaboration*) or about capacity or services that are required to make the item, to install it, to transport it, etc. (so-called *service-related collaboration*). Consequently, both materials and services may form the object of collaboration which will be described in greater detail in the following.

[1] As a result DaimlerChrysler's information about door module demand and inventory turned out to be of limited value to the suppliers in tiers 2 to 7. Actual planning or collaboration functionality was not provided.

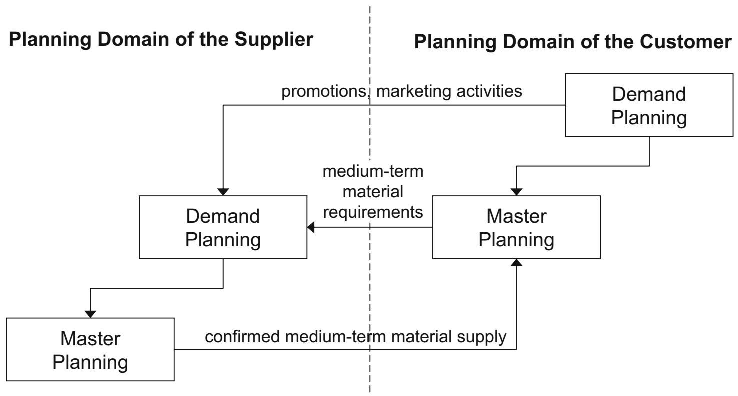


Fig. 14.6 Relationships between the planning domains in a demand collaboration

14.2.1 Material-Related Collaborations

Demand Collaboration. The interface between order-driven and forecast-driven processes in a supply chain is called *decoupling point* (see Chap. 9, p. 181). In a typical supply chain supply processes upstream the decoupling point are driven by demand forecasts. Multiple departments of a supplier are involved in the creation of the forecast, e.g. sales, marketing, product management and enterprise planning. Sales enters the forecast for specific customers or regions, and evaluates the influence of market trends. Marketing adds the effects of marketing activities and promotions to the forecast, and product management provides information about the phase in/phase out of products. Enterprise planning consolidates the plan from an overall perspective. The consolidation of the inputs from the departments is called *consensus-based forecasting*. The statistical forecast serves as a reference and starting point for the human planners (e.g. in marketing). Procedures for the integration of statistical forecasting and the structured judgment of human planners is described in Chap. 7.

The customers—whose demand is being planned—may add valuable input to the forecasting processes. For instance, customers can provide the medium-term material requirements based on their master plan as an input for the demand planning of their suppliers. The suppliers use this information as input to the consensus forecasting processes as described above. Further, the consolidated and approved forecast can be confirmed to the customers (represented as confirmed medium-term supply). In this case a *demand collaboration* is formed between the suppliers and the customers, connecting the forecasting processes of the local planning domains. A demand collaboration is usually driven by the supplier—as he is interested in getting accurate information about future demand. Figure 14.6 shows the connection between the local planning domains in a demand collaboration starting with the customer informing the supplier about expected market demand and planned marketing activities. Furthermore, medium-term material requirements (i.e. the purchase plan) resulting from the customers master plan are transmitted to the supplier. The supplier now can derive his best master plan based on the medium-term material requirements of the customer(s). Usually the customer asks the supplier for a confirmation of the fulfillment of the purchase plan. This simple procedure to align local domain plans—known as *upstream planning*—can be applied even in complex multi-tier supply chains with several partners on each tier. In pure upstream planning the supplier is not allowed to deviate from the purchase plan provided by the customer(s). Consequently, upstream planning may result in high costs for the supplier (e.g. due to the need to use overtime) to meet the purchase plan(s).

The case depicted in Fig. 14.2 (p. 259) provides an example for a demand collaboration: The headlight manufacturer might setup a demand collaboration with both car manufacturers to create a collaborative forecast reflecting expected demand for headlights in the supply chain. Another example of a demand collaboration is collaborative promotion planning: The customer provides detailed information about planned promotions or other marketing activities, the supplier considers this information as input to the demand planning process (for further examples see Smaros 2003).

Prerequisites to enter a demand collaboration are harmonized master and transactional data. Every local planning domain is able to analyze the planning process by custom views. Deviations are reported by alerts and should be discussed and adjusted in cyclic planning meetings. The result of the planning meetings is an agreed demand plan. The quality of past decisions and planned forecasts have to be analyzed ex-post based on historic sales figures.

The demand of a customer participating in a demand collaboration must be treated differently from the demand of other customers not participating in a demand collaboration: Partners in a collaboration are more open and provide better and more reliable input to the collaborative planning processes than other customers.

To avoid shortage gaming (see Chap. 1, p. 24), the demand of partners participating in a collaboration has to be fulfilled with higher priority compared to the demand of other customers.

Inventory Collaboration. Inventory collaboration is a special application of demand collaboration. The customer provides information about his future demand and about the current inventory to the supplier. The supplier uses this information to create the requirements of his own products at the sites of the customer (e.g. factory sites, warehouses). Consequently, the customer no longer needs to create and to send replenishment orders to the supplier. The replenishment of the inventory is automatically planned by the supplier; time-lags due to the replenishment planning and ordering processes of the customer do no longer occur. The replenishment decisions are driven by pre-defined service level agreements between supplier and customer (e.g. expressed as minimum coverage time of the stock level). Inventory collaboration is a service that is usually requested by the customer (or is at least tolerated by the customer). The process itself is driven by the supplier. For inventory

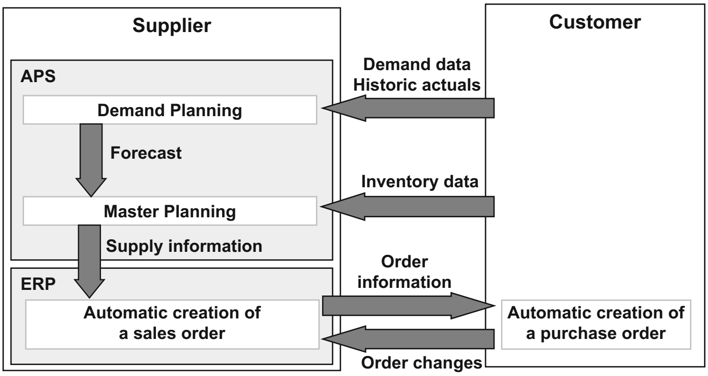


Fig. 14.7 Relationships between supplier and customer in an inventory collaboration

collaborations also the term *vendor managed inventory (VMI)* is used (for different stages of collaborations including VMI see Holweg et al. 2005).

To control his own inventory and his customer's inventory simultaneously the supplier has to be able to access the customer's major inventory levels and forecasts and has to plan with respect to a system-wide inventory. This could be done by using the so-called base-stock-system (Tempelmeier 2012). Modern EDI-techniques support the electronic exchange of the necessary information (e.g. inventory data, demand data, planned replenishments). Usually the supplier automatically generates a sales order in his ERP system based on the replenishment plan. The order information is sent to the ERP system of the customer and a purchase order matching the sales order is created automatically. Figure 14.7 summarizes the relationships between a supplier and a customer in an inventory collaboration.

Procurement Collaboration. A procurement collaboration—also called supply-side collaboration (Fu and Piplani 2002)—is similar to a demand collaboration. The customer and the supplier exchange demand and supply information as shown in Fig. 14.6. The main difference is that a procurement collaboration is driven by the customer, whereas a demand collaboration is driven by the supplier.

Medium-term procurement collaborations provide information about constraints on the supplies of materials for master planning (Chap. 8). Short-term procurement collaborations create short-term material supply information which is used to update short-term plans, for example production schedules. It interfaces with purchasing and material requirements planning (Chap. 11).

Intel Corporation is an interesting case for medium-term procurement collaboration (Shirodkar and Kempf 2006). Intels suppliers of substrates—these are advanced materials containing hundreds of precision electrical connections used for chip production—not only collaborate in providing Intel with data regarding capacity availabilities. Suppliers also have collaborated in generating an optimization model (a MIP model to be more precise, see Chap. 30) of their production facilities.

By combining the submodels of its suppliers, Intel now possesses a medium-term substrate planning tool covering a 9-months planning horizon and incorporating potential bottlenecks of the total supply chain. This (central) model enables Intel to find feasible purchase plans and to minimize purchase and transportation costs. Obviously, this approach is only applicable for a very powerful supply chain leader.

14.2.2 Service-Related Collaborations

Capacity Collaboration. The collaborations discussed so far—demand, inventory and procurement collaboration—are related to the exchange of demand and supply information of materials. A capacity collaboration is an example for a service-related collaboration: Supplier and customer exchange information about demand and availability of production services. For instance, a manufacturer (i.e. the customer) collaborates with a subcontractor (i.e. the supplier) on the usage of the subcontractor's production facility based on the manufacturer's master plan. The manufacturer wants to ensure that he gets a reservation for a specific amount of capacity, without knowing for which production order the capacity actually will be used and what product actually will be produced. Similar to procurement collaborations capacity collaborations are usually driven by the customer.

Besides the forecasted capacity, a minimum and maximum capacity level is often negotiated between the two parties:

- The subcontractor (supplier) is interested in defining a minimum capacity to ensure the load of his production facilities.
- The manufacturer (customer) is interested in knowing the maximum capacity that is provided by the subcontractor.

The difference between the forecasted capacity and the maximum capacity is called the *upside flexibility* of the subcontractor. However, if the subcontractor has multiple customers using the same capacity this upside flexibility range might be announced to more than one customer. In this case multiple manufacturers are sharing the flexibility range.

The typical goal of a capacity collaboration is to provide additional upside flexibility for the manufacturer (customer) in case his own capacity is fully loaded. However, in practice it often occurs that the manufacturer has to make sure that the minimum load negotiated with the subcontractor is considered first before loading its own capacity in order to avoid penalties.

An alternative to setting up a capacity collaboration is to invest in additional manufacturing capacity. This decision can be made by the manufacturer based on a long-term plan (see Chap. 6 about Strategic Network Design). Potential issues of a capacity collaboration like the required know how of the subcontractor about the manufacturing processes and availability of the right manufacturing equipment at the subcontractor's site have to be considered for this decision.

Transport Collaboration. Transport planning and vehicle scheduling is one of the operational tasks of purchasing and distribution (Chap. 12). Often, several logistic service providers are involved in the main purchasing and distribution process of an enterprise or a certain part of the supply chain. The transportation services (for inbound and for outbound transportation) are nowadays provided by external transportation and logistics providers.

A transport collaboration is similar to a capacity collaboration: Both are service-related collaborations driven by the customer. While the capacity collaboration is related to production services, the transport collaboration is related to transportation services. In a transport collaboration the customer is typically a manufacturer or retailer, and the supplier is a transportation and logistics provider.

For example, a transport planner of a manufacturer (i.e. the customer) uses a planning tool to assign transport requests to a provider either by hand or through an optimization run. The requests are sent to the chosen provider, e.g. by e-mail, containing a hyperlink to a website or an XML-document. The provider checks the request and accepts or modifies the conditions, e.g. route, pick-up points and delivery dates, or rejects it in a predefined time window. Alerts are generated, if for example the requested transport capacity exceeds the agreed quantities, response is belated or the request has been changed or rejected. For the latter cases the transport planner can accept the change or choose a different provider. With the acceptance of a request a predefined order fulfillment workflow starts.

14.2.3 Material- and Service-Related Collaboration

Demand, inventory and procurement collaborations are material-related collaborations, capacity and transport collaborations are service-related. Besides these "pure" material- or service related collaborations there exist combined material- and service-related collaborations. These collaborations are formed mainly in industries where materials and services have to be synchronized in order to efficiently and reliably fulfill the customer demand.

As an example for a material- and service related collaboration we consider the procurement of computer equipment. Large organizations such as banks, insurance companies, public administration etc. procure large quantities of computer equipment, including computers, servers, printers, network components etc. The procurement process is often organized as a "rollout project" that is managed by a specialized service company (see Fig. 14.8). Hardware suppliers provide products (materials), service providers provide transport, customization and computer installation services. For instance, the computer equipment that is to be installed in one floor of an office building is collected at the customizing center. If it is complete, all servers, workstations, printers and further equipment are customized, software is installed, network addresses are assigned etc. After customization is complete the transportation and logistics provider forwards the equipment to the installation site. Technicians are arriving at the same time on site and install and replace the old equipment by the new one.

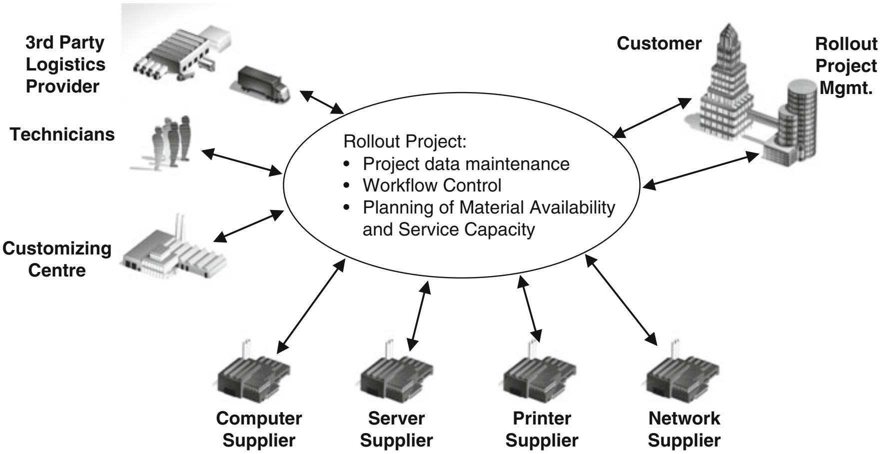


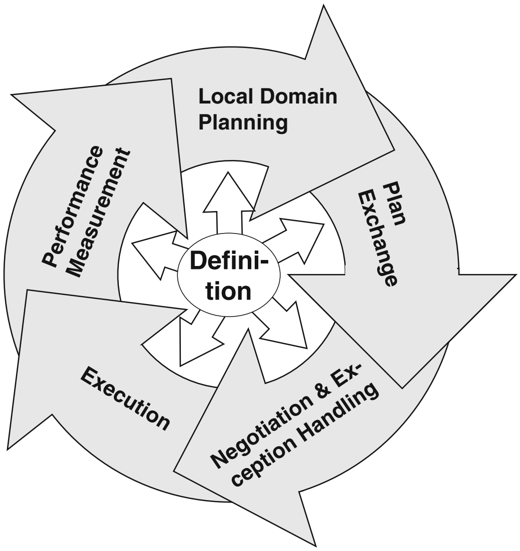
Fig. 14.8 Structure of a rollout project

Traditionally, the availability of materials and service capacity is controlled manually, leading to an insufficient information flow and slow reaction in case of changes. As a consequence, the delivery performance is low and large inventories are stocked at all sites involved to buffer against shortages. In order to better coordinate all parties involved by faster information exchange a material- and service related collaboration is formed. This collaboration is usually driven by the service company coordinating the project. The customer receiving the customized computer equipment has the role of the customer, while the hardware suppliers and service providers act as suppliers.

The material- and service-related collaborations may be supported by collaboration modules of APS, typically in combination with an Internet portal consolidating all information flows and providing role-specific views for all parties involved. As an example, consider a material shortage at the server supplier. Having an APS-based collaboration process installed, the server supplier updates the availability information for the servers that are needed for the rollout project. The remaining hardware suppliers use this information to adjust their production and distribution plans. The service providers update their plans accordingly, and may for instance re-allocate available capacity to other customers or may even reduce capacity in case they employ subcontracted workforces.

The synchronization of services and materials by APS-based collaboration processes gets more and more important as services gain a broader share in many industries. Other examples of industries with a high fraction of services that have to be synchronized with material availability are telecommunications, building and construction industry, and medical technology industry. For further details on collaboration on services and materials refer to Kilger and Holtkamp (2001) and Keinert and Ötschmann (2001).

Fig. 14.9 Phases of a generic collaborative planning process



14.3 A Generic Collaboration and Collaborative Planning Process

A typical generic collaboration process consists of the following six phases (see Fig. 14.9):

1. Definition
2. Local domain planning
3. Plan exchange
4. Negotiation and exception handling
5. Execution
6. Performance measurement

Comparing the above phases with the eight tasks corresponding to the CPFR model VICS (2004) reveals a number of similarities. However, CPFR addresses collaborations among manufacturers and retailers in general, while our focus is on collaborative *planning* issues among arbitrary business partners.

Definition. The definition of a collaborative relationship of business partners incorporates the goal of working together in some mutually defined ways by a formal agreement. Four main issues have to be considered: gives & gets, the collaboration objects, including planning horizons, the time horizon of the collaboration and an agreed dispute resolution mechanism in case of conflicts (along the lines of Anderson and Narus 2009, p. 25):

- "Gives" address the contribution of each partner to the collaboration, e.g. personnel, fixed assets, money, knowledge, commonly used software, whereas "gets" are the specific gains of each partner participating in the collaboration,

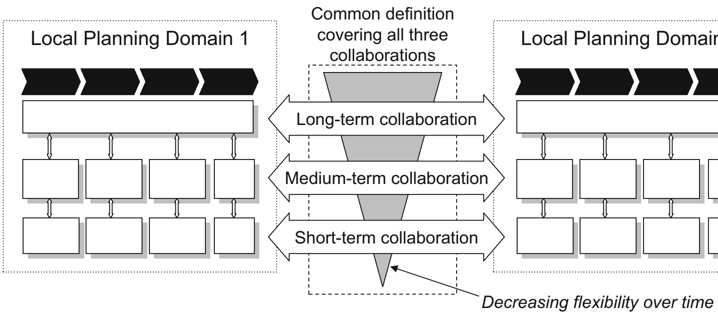


Fig. 14.10 Long-term, medium-term and short-term collaborations

e.g. greater expertise, broader market access and additional earnings. Conflicts often occur if one partner's perception of gives compared to gets received is not balanced. Monitoring gives & gets by success metrics, e.g. KPIs, helps to avoid discrepancies, supports compensations and fosters a continuous improvement process.

- The collaboration objects are materials and/or services to which the collaboration is related. By focusing on main material flows in the supply chain, important items such as bottleneck raw materials, end-products with long lead-times or high-value are potential candidates of a collaboration. Related to the objects are parameters such as a negotiated (demand) levels or minimum demands, exception rules as well as classification of importance for several partners.
- The time horizon determines the duration of the collaboration. It also contains milestones for common aims and review points to analyze the relationship. At the end of the time horizon the partners have to decide whether to continue, expand or curtail the relationship.
- Close relationships include potential disagreements and conflict situations. Thus, an agreed dispute resolution mechanism has to be established. Depending on the severity of the conflict, different mechanisms might be taken into account, e.g. negotiation processes to rearrange agreements, mediation to focus on objective conflict issues by external moderation, or arbitration to accept a third parties' decision as final and binding.

A collaboration addresses a specific *time horizon* relating to a certain level of the Supply Chain Planning Matrix (see Chap. 4). Thus, a supplier and a customer can connect their local domain planning processes to form "seamless" long-term, medium-term or short-term collaborative planning processes. Resulting plans then have to be disaggregated locally (see Fig. 14.10).

The time horizon on a specific planning level is usually structured into multiple time phases, each representing a specific degree of decision flexibility (see also Fig. 14.11). The *history phase* represents actuals of a collaboration, e.g. ordered and supplied quantities, actual inventory levels etc. The actuals are used as a foundation on which the future development of the collaboration is planned. The *frozen phase*

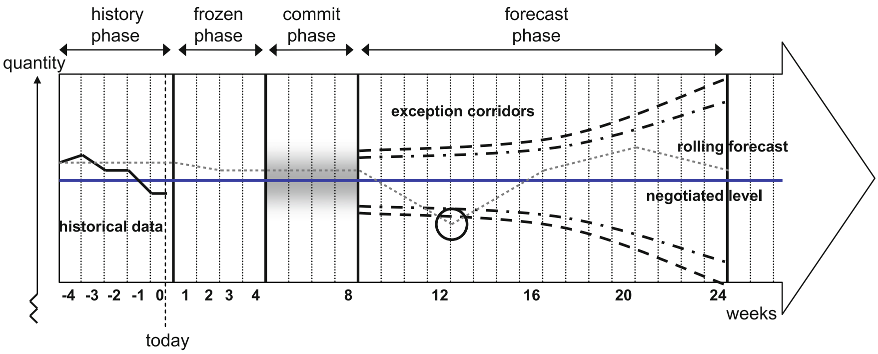


Fig. 14.11 Time phases of a collaboration (example)

covers the next time buckets, e.g. the next 4 weeks. In that time horizon the plan is fixed for execution. During the *commit phase* the plan is being reviewed in detail and approved to become fixed for execution. The length of the commit phase indicates the (maximum) duration of the commitment process. The *forecast phase* covers the remaining time buckets up to the forecast horizon.

Local Domain Planning. A planner organizes his future activities in a local domain plan, that takes into account a certain local planning situation, his individual objective function, current detailed internal information, know-how about process restrictions and assumptions about the environmental development. In particular, assumptions about planned activities of suppliers and customers are uncertain without collaboration. In a decision making process several plans are created, evaluated and ranked by an objective function to identify the best one. Plans having similar objective function values may have very different structures. Thus, alternative plans should not be discarded, but stored in separate versions. This enables the planner to react to changes in the planning environment such as changes in restrictions. In a collaboration the locally created plan will be the basis for communication with partners.

Plan Exchange. Plan exchange is a starting point of negotiations. It is regarded a highly sensitive process. The partners intent is to augment planning quality by exchanging information. In the definition phase of a collaboration objects are defined such as materials on which data might be exchanged. Depending on the content, e.g. inventory of a certain delivered item or inventory of all similar items, the accuracy and the use of data lead to more or less valuable information. The sources of data might be transactional data of suppliers and customers, that are maintained in ERP-systems, or their local domain plans such as forecasted demand, replenishment orders or supply commitments retrieved from an APS.

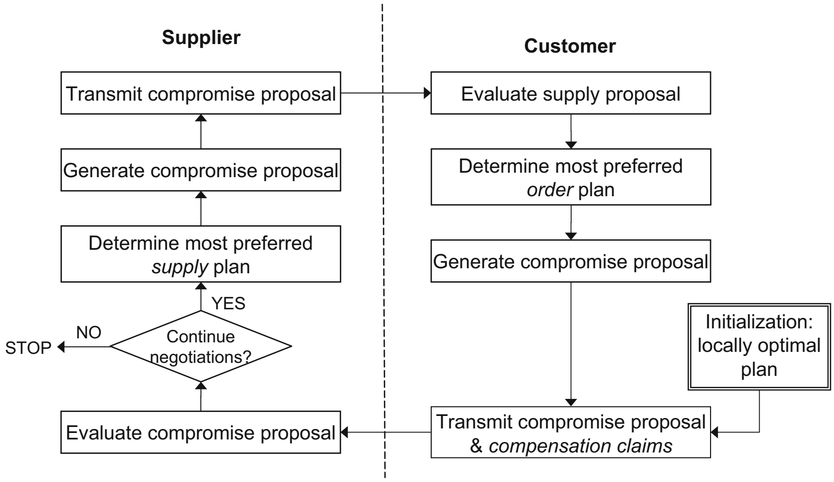


Fig. 14.12 Negotiation-based collaborative planning process (adapted from Dudek 2009)

Negotiation and Exception Handling. The partners exchange information needed for collaborative planning under the terms defined in the collaboration process. This enables partners to gain an overview of the planning situation and identify whether the predefined goals are achieved.

Dudek (2009) describes a negotiation-based collaborative planning process that is based on an iterative improvement process between customer and supplier. The process is depicted in Fig. 14.12. The idea is to only exchange insensitive data, like a purchase plan and a supply plan as well as a compensation request by the customer if a supply plan suggested by the supplier increases his local costs. Note that capacity utilizations and (absolute) cost figures are usually regarded sensitive and will remain local to each party.

The negotiation process starts with upstream planning. In case the purchase plan transmitted by the customer gives rise to further (cost) improvements for the supplier the iterative procedure is continued. If the search for a new compromise solution is continued the supplier generates a new production plan and an associated supply proposal with only minor modifications to the customers purchase plan but large improvements to the suppliers local cost situation. This requires to generate a most "preferred" production and supply plan first. Dudek describes MIP models (Chap. 30) to support these local planning tasks assuming an individual capacitated lot size model for all parties involved.

Once the local steps of the supplier have been completed the new compromise proposal (i.e. the supply plan) is transmitted to the customer for evaluation. Since constraints on the supply side tend to increase the customers local costs he will ask the supplier to compensate for any cost increases resulting from the supply proposal (compared to his initial minimum cost plan). Next, the customer will generate a further compromise proposal by looking for small changes to the suppliers supply plan which result in relatively large cost reductions for the customer. Now the customer is able to transmit to the supplier:

- First, a compensation request associated with the supply plan received
- Second, a new compromise proposal (purchase plan) plus the associated compensation request.

It is up to the supplier to terminate negotiations. This will be the case if the suppliers local costs plus the compensation request from the customer are at a minimum—also representing a minimum for the supply chain as whole! (To be more precise the supplier will not know when the minimum is reached. Hence, Dudek (2009) proposes a Simulated Annealing stopping criterion to control the procedure.) Note, that the customer starting from his locally optimal plan will never lose in the course of negotiations provided compensations are calculated correctly. However, the supplier can and usually will win by these negotiations.

Dudek generalizes the procedure to general two-tier collaborations (with multiple partners on one tier, see Dudek 2009). While Dudek assumed a capacitated lot size model for the local planning domain of each party, Albrecht (2010) even outlines a mechanism which is based on any type of Linear Programming model (and with some limitations also for Mixed Integer Programming models). These models are very well suited for the Master Planning level. If detailed schedules have to be coordinated there is a very nice and practice oriented proposal by Scheckenbach (2009) which is based on an adaptation of the Genetic Algorithm (for details see Chap. 31) utilized as a solver in SAP's Production Planning and Detailed Scheduling (PP/DS) module.

Note that time for coordinating plans is scarce the closer we get to execution. As a result, in mid-term Master Planning personal negotiations supported by a solver for generating alternative solutions are advisable while for collaborative scheduling dealing with short-term events, like a machine breakdown, a fully automated procedure requiring only little CPU-time is required. Comprehensive surveys of computer supported negotiation processes are given by Rebstock (2001) and Stadtler (2009).

Execution. An adjusted plan leads to replenishment-, production- and purchasing orders to fulfill the planned goals and is then executed.

Performance Measurement. The common goals and conditions of the partners are measured by KPIs. Planning results, both for the local domain and collaborative plans, are compared with the real-world data based on the KPIs. Analysis of plan deviations helps in identifying ways in which future plans may be improved. Various data views and aggregation levels of the data to be compared support this analysis. Reactions to deviations from the plan are closely associated with the plan review.

If the partners have decided on a particular threshold value for a given KPI exceeding this value should trigger a process which either pushes the KPI back within its allowed range or allows an exception to occur. The first case strictly disciplines unauthorized actions by partners, initiates a negotiation process to mutually align plans between partners or is used to achieve a desired supply chain behavior (such as less planning “nervousness”). The second case comes into play where structural changes or other exceptional situations occur. Causes for exceptions might be internal, e.g. planning faults or insufficient decision support, or external such as changed economical or competitive situations. Exception handling is triggered by alerts indicating specific planning problems, for example:

- Mismatch between the demand forecast and the supply capability
- Violation of a minimum demand level
- A missing response from the supplier to match a forecasted demand
- An item demand planned by a customer that is not yet released for collaboration by the supplier.

In a rolling schedule environment “as-is/to-be” analysis is used at predefined intervals of time to measure the effects of collaboration. Planning results are more easily accepted by everyone in the case of a win-win situation throughout the entire supply chain. More difficult is the case in which some members lose. Compensation approaches must be developed in this case which lead to reimbursement of the members who agree to “lose” for the benefit of the supply chain as a whole. The deviation from a local domain plan can be used as a measurement.

14.4 Software Support

Planning and coordination within an enterprise are difficult tasks for today’s software, and the addition of collaborations increases this complexity. Challenges for software tools supporting collaborative planning include master data integration, user-specific secure data access and the mutual decision-making process. Systems that enable collaborative planning must support partners during each step of the process.

Definition. The definition-step establishes a framework of collaboration and consists of a management agreement to confidential cooperation as well as the definition of common goals, objects of collaboration, success metrics and incentives/penalties. The selection process of appropriate objects or partners is supported by reporting systems based on Data Warehouses. As the selection process is qualitative and thus not supported by APS, the results of a collaborative planning agreement must be customized in the APS. For example, SAP APO allows the authorization of specific users, the specification of the type of collaboration as well as the definition of exchanged data such as master data and—in case of forecast data—the time series of dedicated key figures. This issue is of critical importance, because an incorrect mapping of master data or time series granularity causes severe planning problems.

Local Domain Planning. The step of local domain planning to generate individual plans by each partner is the main focus of APS. As planning becomes more complex with respect to the consideration of partners’ plans, several “good” plans with different structures or containing changed data-scenarios might be stored in so-called versions. Thus, changes of considered planning restrictions are anticipated and responsiveness is improved.

Plan Exchange. The step of exchanging plans with a partner is related to the data implemented by the customizing of the collaboration. Furthermore, the way in which data are exchanged is defined by workflows. These include entering data using a web-based interface, or exchanging information such as orders or time series in one of several formats: XML-documents, RosettaNet, EDI, Excel spreadsheet or flat file.

SAP ICH (Inventory Collaboration Hub) is a typical example for a web-based exchange platform for demand and supply plans. SAP ICH supports two basic collaboration types on the procurement side. The first one—*Supplier Managed Inventory (SMI)*—supports a traditional min/max-based supplier-driven replenishment and inventory monitoring process. The second method is *Release Processing*. It represents support of buyer-driven replenishment via SAP R/3 delivery schedules, typically derived from buyer-side internal MRP runs. In addition, SAP ICH supports alert monitoring, master data maintenance and processing of advanced shipment notes (ASN).

A main problem facing todays software tools is the lack of considering interdependencies between multiple exchanged items, resulting from the bill of materials or limited machine capacity (e.g. shifting the due date of an order for one item might result in delays for an order for another item).

Negotiation and Exception Handling. To support the step of negotiation and exception handling, rules that trigger information flows indicating specific planning problems have to be defined. The rules are related to collaborative planning objects such as resources indicating capacity overload, materials indicating shortage situations or lateness of an order. Most APS contain some predefined rules (e.g. SAP APO Alert Monitor profiles) or have a programming interface to trigger alerts by deviations from calculated key figures such as exception corridors shown in Fig. 14.11 (e.g. JDA—violation of funnel agreement; SAP APO—MacroBuilder to define user specific alerts). Depending on the severity of deviations from the agreed limit and the ability to influence the plan either negotiation processes are started by defined workflows to align the plan (e.g. splitting an order) or an exception is allowed (e.g. sourcing from a partner's competitor).

Execution. The execution step contains the fulfillment of an aligned plan between the partners. It leads to activities in transactional systems (e.g. SAP R/3) such as entering production or replenishment orders. Shop floor control systems support "track and trace" of orders and material flows, resource loads and staff assignments.

Performance Measurement. In order to evaluate the results of collaboration "Plan vs. as-is" data are analyzed using reporting tools. For example, input of transactional data such as sales are compared to sales forecast data to identify gaps and opportunities for improvement. Inside a single APS it is customary to define KPIs and KPI schemes in order to measure supply chain performance. Special tools (e.g. SAP APO Plan Monitor or SAPBW for reporting) are then used to keep track of the KPI values. KPI schemes throughout the entire collaboration have to be customized in each of the partners' APS. That is, in order to measure collaboration performance, the KPI schemes must be agreed upon by each collaboration partner.

References

Albrecht, M. (2010). *Supply chain coordination mechanisms, new approaches for collaborative planing*. *Lecture Notes in Economics and Mathematical Systems* (Vol. 628). Berlin/Heidelberg: Springer.

Anderson, J. & Narus, J. (2009). *Business market management: Understanding, creating, and delivering value* (3rd ed.). Upper Saddle River: Prentice Hall.

Becker, T. (2001). Collaborative development chain management. *Supply Chain Management, 1*(1), 27–36.

Cachon, G. & Lariviere, M. (2001). Turning the supply chain into a revenue chain. *Harvard Business Review, 79*(3), 20–21.

Cachon, G. & Lariviere, M. (2005). Supply chain coordination with revenue-sharing contracts: strengths and limitations. *Management Science, 51*(1), 30–44.

Dudek, G. (2009). *Collaborative planning in supply chains: A negotiation-based approach* (2nd ed.). *Lecture Notes in Economics and Mathematical Systems* (Vol. 533). Berlin: Springer.

Fu, Y. & Piplani, R. (2002). Supply-side collaboration and its value in supply chains. *European Journal of Logistics, 152*, 281–288.

Graf, H. & Putzlocher, S. (2004). DaimlerChrysler: Integrierte Beschaffungsnetzwerke (2nd ed.). In D. Corsten, & C. Gabriel (Eds.), *Supply Chain Management erfolgreich umsetzen* (pp. 55–71). Heidelberg: Springer.

Holweg, M., Disney, S., Holmström, J., & Småros, J. (2005). Supply chain collaboration: Making sense of the strategy continuum. *European Management Journal, 23*(2), 170–181.

Keinert, W. & Ötschmann, K. (2001). Vom SCM zum e-Service-Chain Management. *Computer@Production*, (3), 68–69.

Kilger, C. & Holtkamp, R. (2001). Koordinierung von Dienstleistungen und Material mit eBusiness- und Supply-Chain-Management-Technologien. In W. Dangelmaier, U. Pape, & M. Rüther (Eds.), *Die Supply Chain im Zeitalter von E-Business und Global Sourcing* (pp. 373–388). Paderborn: Fraunhofer-Anwendungszentrum für Logistikorientierte Betriebswirtschaft and Heinz-Nixdorf-Institut.

Kilger, C. & Stahuber, A. (2002). Integrierte Logistiknetzwerke in der High Tech-Industrie. In H. Baumgarten, H. Stabenau, & J. Weber (Eds.), *Management integrierter logistischer Netzwerke* (pp. 477–506). Bern: Haupt.

Kouvelis, P., Chambers, C., & Wang, H. (2006). Supply chain management research and production and operations management: Review, trends, and opportunities. *Production and Operations Management, 15*, 449–469.

Landeros, R. & Monczka, R. (1989). Cooperative buyer/seller relationships and a firms competitive posture. *Journal of Purchasing and Materials Management, 25*(3), 9–18.

Rebstock, M. (2001). Elektronische Unterstützung und Automatisierung von Verhandlungen. *Wirtschaftsinformatik, 43*(6), 609–617.

Scheckenbach, B. (2009). *Collaborative Planning in Detailed Scheduling*. Ph.D-thesis.

Shirodkar, S. & Kempf, K. (2006). Supply chain collaboration through shared capacity models. *Interfaces, 36*(5), 420–432.

Smaros, J. (2003). Collaborative forecasting: A selection of practical approaches. *International Journal of Logistics, 6*(4), 245–258.

Stadtler, H. (2009). A framework for collaborative planning and state-of-the-art. *OR Spectrum, 31*(1), 5–30.

Tempelmeier, H. (2012). *Bestandsmanagement in Supply Chains* (4th ed.). Norderstedt: Books on Demand.

VICS (2004). Collaborative planning, forecasting and replenishment: an overview. http://www.gs1us.org/DesktopModules/Bring2mind/DMX/Download.aspx?PortalId=0&TabId=56&EntryId=631. Visited on Feb. 28, 2014.