A concept for collaborative supply chain planning


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Abstract—The main challenge for many manufacturers is the increased complexity of the supply chain, and as supply chains get more complicated enterprises require better tools for supply chain planning and execution. Many vendors offer systems to plan and control in-house operations, whereas mainly large vendors such as Oracle, SAP and I2 offer supply chain planning systems. This limits the ability for SMEs to exploit the supply chain planning options. This paper is part of a research project carried out to develop a new supply chain add-on for Microsoft AX, a very common system for SMEs. The paper discusses current supply chain planning solutions and presents a more simple and adaptive concept to be used in both SMEs and larger enterprises.

I. INTRODUCTION

An increasing demand for high flexibility, short and precise leadtimes, high quality and low costs represents a significant challenge for companies to manage operations in networks. This involves both changes from customers and suppliers as well as internal changes caused by lack of materials or resources, changed priorities etc. If decisions are made without having an overview of options and consequences this might lead to high inventories, long lead times, low customer satisfaction or low resource utilisation.

Although these challenges will apply to companies of all sizes, they are particularly true for SMEs as they have limited resources available to invest in Advanced Planning Systems as well as limited staff available for specialist roles in planning and decision making. Besides this, most SMEs belong to a large number of supply networks simultaneously leading to a very complex planning situation without any kind of information visibility or ICT communication between network partners. Thus network effects of individual decisions are often not possible to neither intercept nor predict.

All together this implies that planning and control at any network partner is currently executed with incomplete information about status among the other network partners and therefore without considering the possible consequences of the decisions being made. This challenges existing planning and control approaches, methodologies, tools and knowledge.

The paper briefly discusses current challenges and tools supporting collaboration, planning and control of supply chains. After this an alternative approach to support supply chain planning is presented, to be used in both SMEs and larger enterprises.

II. SUPPLY CHAIN COLLABORATION

Most SMEs have limitations in capacity and flexibility, and depends on their suppliers and customers to compete in the market place. They often operate in multiple supply chains or non-hierarchical networks, where each member is more or less equal in status. There is no dominant actor that dictates plans or imposes a centralised planning perspective on others [1,2]. Coordination and collaboration between the companies is vital in such networks using cooperative efforts in order to meet mutual goals, exchanging information, developing improvement in partnership [3,4]. A manufacturing network is fully coordinated when all decisions are aligned to accomplish global system objectives [5]. Joint planning and control and the exchange of updated demand information and forecasts are important in such networks. Cooperative efforts are used in order to meet mutual goals and the quality and reliability of the plans are improved. The collaboration will compensate for the limitations of each actor in the network.

Several collaborative models for coordination network activities have been developed such as collaborative planning, forecasting and replenishment (CPFR), vendor managed inventory (VMI) and automated replenishment programs (ARP). The aim of these models is to achieve seamless inter-organisational interfaces of materials and information flow by specifying control principles and operational models [6,7].

Companies in non-hierarchical networks face challenges that make collaboration difficult. Each network is dynamic and hard to define and network members frequently face situations with conflicting interests, trust issues and trade-off situations. Lack of information about the current state of the network processes complicate finding near-optimal situations for each network member. This is even worse when customers request changes to orders that are already in production, as a real time overview of possible options and associated consequences is not possible without sharing information. Secondly, products are becoming more and more sophisticated and intelligent, with service and value added elements embedded in the products themselves.

Managing operations in the networks represents a significant challenge with the growing demands for high quality, low costs, short and precise delivery times, increased customisation and high flexibility. These challenges are discussed in the following.
III. SUPPLY CHAIN PLANNING AND CONTROL

Planning in supply chains face the main challenge that no coordination system fully shares all relevant information among the companies involved [8]. All relevant information from the involved companies need to be integrated and up to date and accessible in real time from anywhere in the network. Each company should ideally be able to see the real-time situation in the network, downstream as well as upstream [9]. Although information visibility and system integration are regarded as keys for enabling collaboration, very few networks have successfully achieved this [10].

Currently, the dominating planning systems in industry, ERP (Enterprise Resource Planning) and MES (Manufacturing Execution Systems) have a single-company focus and mainly support centralized production planning and control [8] and does not support network planning with customers and suppliers. In the following, a more advanced type of planning systems titled APS (Advanced Planning and Scheduling) will be discussed.

IV. ADVANCED PLANNING AND SCHEDULING

Advanced planning and scheduling (APS) systems are based on the principles of hierarchical planning and make extensive use of solution approaches known as mathematical programming and meta-heuristics. There are several commercial APS software packages available, e.g. from SAP, Oracle, i2, Lawson, Manugistics, and JDA, that support different planning processes related to procurement, production, transport, distribution as well as sales. APS systems are defined as "any computer program that uses advanced mathematical algorithms or logic to perform optimization and/or simulation on finite capacity scheduling, sourcing, capital planning, resource planning, forecasting demand management and others" [11]. APS systems consider finite capacity constraints (i.e., they assume a finite capacity of resource materials and work centres as they schedule operations by optimizing constraints to meet delivery schedules). The main focus is on supporting the material flow across a supply chain and related business functions: procurement, production, transport and distribution as well as sales [12].

APS provides planning functionality that supplement existing ERP systems. The ERP system handles the basic activities and transactions such as customer orders and accounting whereas the APS system focus on the operational activities related to decision-making, planning, scheduling and control of a supply chain and related management activities, which are not explicitly well covered in ERP systems. Unlike ERP, APS tries to feasible, near optimal plans across the supply chain, while taking potential bottlenecks into consideration. APS has the capability to simulate different scenarios for decision support, to plan and to schedule on-line as well as off-line.

Planning and scheduling is by nature a proactive process, which can initiate an event in another area of the business or at partners based on the workflow control.

APS is the most comprehensive system for supply chain planning and control today. Although APS aims at automating and computerizing the planning processes by use of simulation and optimization, the decision-making is still made by planners with insight in the particular supply chain and know how on the system constraints but likewise important: a feeling for feasibility of created plans. Thus, APS aim to bridge the gap between the supply chain complexity and the day-to-day operative decisions. This requires, however, that planners are able to model and setup decision rules for the planning and optimization.

APS models easily become quite large and complex [12], and APS systems are best suited to manage complexity associated with product variety, volumes and global operations, while companies with simple products or narrow product lines may find negative returns from APS systems due to the additional effort required to manage them [13]. There are several problems involved in implement and using APS software [14]. APS systems have a high entry level and require that decisions makers have a general understanding of optimisation and how data is structured. Often external consultants are required to set up and implement the system. The planning requires very high data quality, and discipline by users in the supply chain who have to update data and parameters. Complex models make it difficult to interpret the results and detect errors, and plans generated by the APS system might contain errors or is not considered feasible by the planners. In addition, the APS systems are not very user-friendly, which lead to a limited use of the system functionality and use of parallel systems [14]. According to [15], APS systems may yield significant benefits if they are used properly, e.g. improved decisions support, reduced overall planning time, cost savings, reduced inventory levels, and increased customer satisfaction. A study by [16] however, showed that only 20% of the APS installations investigated were successful (based on a threshold of achieving 70% of projected gain to become a success).

There are very few documented cases showing how APS supply chain planning has been successful used [15], and in spite of the supply chain functionality, most APS implementations are limited to a single organization or a single manufacturing site. Whilst the planning and optimisation procedure used in Advanced Planning and Scheduling systems is the current state-of-the-art for a single company or a hierarchical supply chain/network, planning among individual companies belonging to several non-hierarchical networks require other solutions. The reason for this is quite simple: an APS system need to have a joint goal and clear constraints for the planning engine to work, and this is not obtainable when dealing with several non-hierarchical networks. Furthermore, the hierarchical demand planning approach is based on the premise of aggregation and disaggregation which is reflected in the master demand schedule as well as the structures for capacity and material, the bill-of-resources and bill-of-materials structure. Today’s APS systems planning and control capability depends on the ability to aggregate and disaggregate plans and the data they are based on. This makes the structure of the planning foundation critical, unfortunately a simple linear disaggregation of information is not always possible due to the nature of the planning foundation and the multiple usage purposes of the information contained herein.
V. THE COLLABORATIVE SUPPLY CHAIN ORDER PLANNING CONCEPT

We propose a relative simple solution based on individual ERP or APS plans in the respective companies followed by improvements in between partners. It is assumed that requests from customers (customer orders) have been accepted as far as possible by the ERP/APS system, possibly based on customer priorities (see below) in case of resource or materials shortage. However, such a plan is normally based on standard customer lead-times to allow the individual ERP-plans to create realistic plans at the first attempt. The option of optimising the joint plan is therefore primarily based on the difference in between standard customer lead-time and actual lead-times in the company.

A promising technique for more advanced supply chain collaboration is the Seiban approach which is used in Asian supply chains. Seiban (meaning a manufacturing number in Japanese) is a technique for managing orders in the supply chain which is an alternative to the traditional MRP logic. A Seiban is a number associated with a specific sales order or customer requirement. All manufacturing activities, including planning and control, are identified by the Seiban [17]. Using the logic of Seiban in the whole supply chain means that all materials and activities related to a customer requirement are visible throughout the supply chain for a decisions maker. The materials and supply activities have an assigned purpose, and cannot be used to satisfy a different customer requirement.

Seiban functionality with hard links between supply and demand is naturally related to the logic of pegging which is the ability to trace requirements through an MRP plan and also the process of identifying the requirements that generated a lower-level activity. An item’s attribute can be set to different pegging levels, allocating supply for a customer order in accordance with the reservation level set in the plan level options [18]. For a soft pegged demand, excess supply (or common supply) is always available for another customer’s demand. No project references are made to planned orders issued to soft pegged items. For hard pegged items, excess common supply from one customer order can only be shared among customer orders in the same planning group. Customer references are attached to planned orders for hard pegged items. Another benefit of Seiban is that orders can easily be planned, re-planned, and managed using the identifying number. A schedule change can be made to an item, and subsequently a system can adjust the schedule of all related activities by the same amount. When all orders are linked, the status of the series of orders can easily be retrieved by using the Seiban.

A simple solution is to use pegging functionality and allow partners to (manually) view the (production) plan of an order, and based on this utilise/request the available “free space”. This will support the option of adjusting plans in between a customer and a supplier to enable a mutual (optimal) solution. A more far-reaching solution would be to allow customers to also move low priority jobs in order to create extra “free space” and thereby make way for more orders. This solution requires that jobs and customers are segmented and assigned a given priority such as illustrated in table 1.

Assigning customer priority is a manual task. Job priorities need to be assigned automatically to allow the system to work without consuming extra resources. High priority jobs are typically related to bottleneck resources or customer orders with little or no slack. Low priority jobs could either be related to customer orders with slack or it could be stock orders. Cancellation or reduction of stock orders (jobs) might lead to higher costs depending on the details (in case of high setup costs the ERP-system might generate a stock order in connection with a customer order to reduce the total costs).

<table>
<thead>
<tr>
<th>Jobs: Customers</th>
<th>High priority</th>
<th>Medium priority</th>
<th>Low priority</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orders are unlikely to be moved (customer requests change)</td>
<td>Orders might be moved (customer requests change)</td>
<td>Orders can be moved (customer initiate change)</td>
<td></td>
</tr>
<tr>
<td>Orders can’t be moved</td>
<td>Orders are unlikely to be moved (customer requests change)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low priority</td>
<td>No access to view plans</td>
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</tbody>
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An initial prototype that incorporates the proposed functionality in a collaborative supply chain order management application for Microsoft AX has been developed. The prototype was developed at NTNU in collaboration with Logica (see Figure 1).

As a supply chain partner log into the proposed supply chain order management application, they are presented with a list of active orders currently in the system. If the list of orders is large the user can type in a known supply chain order number to retrieve that particular order, or orders can be selected from the list and exploded by clicking on a plus sign on the left side of the order. The orders are sorted so late orders are displayed first.

Figure 1: Overview of active supply chain orders [19].
Figure 1 shows how an order might look like if the user explodes the order to view the linked underlying reference orders.

First the different line items of the sales order are shown. In this case the top-level sales order contains two sales order lines, one of which is late. The late line item marked in red can be expanded further by clicking on the plus sign next to it. As this item generated a linked production order this is the next level of the linked orders. The production order in turn generated two reference orders, a purchase order and a transfer order, needed to fulfill the production order. The purchase order is marked in red, as the purchased parts have not arrived in time, causing order to be late. In this case the line exists to the next tier company, which has entered the sales order they received from the first company (Site A) into their system.

The information about the supply chain status for the second company can be further expanded, but is not shown in Figure 1. To provide decision support the user in the first company can evaluate alternatives to meeting their demand when the purchase order is late. This is displayed in Figure 1 as the dropdown menu on the late purchase order. If the user chooses “Vendor Info” the system pulls up information from the ERP system about that particular vendor, which the user can use to contact them to find a solution. If the user chooses “Alternative Sourcing” the system pulls up the item information from the ERP system about which alternatives are defined for the item, e.g. substitute parts, alternative vendors, or different warehouse locations than the default.

VI. CONCLUSIONS

In the highly competitive market that most companies find themselves in it is vital to organise the manufacturing and supply chain operations in the best possible way. The first step in this development process is to organise the internal operations in an appropriate and fruitful way, but for most companies there are similar improvements to be made by involving supply chain partners in the planning process. Information access and visibility, new planning and control principles, collaborative mechanisms and new information tools have to be developed in order to meet the particular challenges of SMEs in non-hierarchical networks. The paper discusses the current state of the art applications and outlines a new approach titled "Collaborative supply chain order planning concept" to further improve the planning with special focus on non-hierarchical networks. Especially a simple approach to align production plans, and get an exploded overview of all material orders is presented.

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REFERENCES


