Research paper

Collaborative planning forecasting and replenishment: new solutions needed for mass collaboration

Jan Holmström, Kary Främling, Riikka Kaipia and Juha Saranen

The authors

Jan Holmström is Senior Research Fellow and **Kary Främling, Riikka Kaipia** and **Juha Saranen** are Researchers, all at the Helsinki University of Technology, Espoo, Finland.

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Planning, Forecasting, Management

Abstract

The challenge faced by supplier companies in the grocery supply chain for implementing collaborative planning, forecasting and replenishment (CPFR) is how to get the retailer to forecast, especially when it has not been necessary before. In this paper a solution that would allow collaboration on a wide scale is presented. The forecasting approach is called "rank and share" and uses input from the retailer's existing planning process – the category management process. The benefit of using category management as the basis is that the retailer can scale up collaboration with a large number of suppliers without increasing planning resources. For the supplier the benefit is point of sales forecasts at the time of the assortment decision. To support this collaborative forecasting process there is a need for more robust replenishment solutions, new measures to illustrate benefits, and for a distributed planning architecture and software. Potential solutions for these are also discussed in the paper.

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Introduction

The grocery industry has in the 1990s developed a number of value innovations for the supply chain. Starting from the customer end of the supply chain, the innovation is category management, or systematic merchandizing (Buzzel and Ortmeyer, 1995). At the supplier end the innovation is replenishment, i.e. instead of waiting for the order, the supplier delivers according to consumption.

With category management retailers started to systematically manage the products offered to the consumer. The objective was to maximize the profitability of retail space, while simultaneously improving the value for the customer. In practice this has meant that retailers do not let supplier promotions and new product introductions drive the assortment decision-making process.

The other major innovation is replenishment, i.e. instead of waiting for the order, the supplier delivers according to consumption. The grocery industry realized that the easiest way to improve operational efficiency was to change retailer practices. Procter & Gamble, Campbell Soup and other leading suppliers in the grocery supply chain achieved significant cost reductions by encouraging customers to aggregate demand from many retail locations, and passing this information with minimal delay to the supplier (Fisher, 1997). Here it is important to note that the improvement is just as much a result of reduced ordering delay – that is the delay between consumption at the point of sales and reordering from the supplier – as it is a result of consolidated material flows. The reduction of this delay is important, especially in product categories with much variation and difficulties for the supplier in forecasting demand.

Efficient consumer response (ECR) combines the two innovations on a conceptual level, i.e. efficient replenishment and category management. However, an important link is missing. Retailers, distributors and suppliers plan their operations independently.

Companies in the grocery supply chain have started working on the missing link – collaborative forecasting and planning. In the USA a consortium of retailers and supplier companies published in 1998 (DesMarteau, 1998; VICS Association, 1998) the first

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guidelines for collaborative planning, forecasting and replenishment – abbreviated CPFR and pronounced "CP-far". The importance of identifying exceptions and collaborating on these exceptions is firmly established in the guidelines.

The first collaborative business pilots in the consortium were completed in 1999 (VICS Association, 1999). For example, Nabisco, a manufacturer of sweets and snacks, and Wegman's, a retail chain, reported increased sales and profitability from their collaborative business pilot. Sales in the pilot category increased by 13 per cent at Wegman's, while it declined by 8 per cent in comparable non-collaborative retail chains. The days of supply in the pilot supply chain were reduced by 18 per cent.

However, taking a supply chain planning perspective, the issue of how to keep the collaboration process simple from a retailer perspective is not sufficiently recognized. The co-operation of the retailer is critical for the suppliers, as the retailers have got the best data, because they own the point-of-sales data and they carry out the category management processes that determine which products are on display and where.

The basic issue is that today very few retailers forecast demand for stock-keeping units – the level that is critical for the suppliers. The reason is that forecasting is a laborious process when you have as many as 30,000 different items to manage in a hyper-market. Another reason is that the retailers do not get any benefit from forecasting when supplier service levels are already high. For example, in Finland, the typical grocery supplier has a 95 per cent or higher service level and next day deliveries. This means that one in 20 items cannot be delivered the next day as ordered by the customer, but then the supplier typically can deliver the missing item within a few days. As a consequence none of the retail chains forecast on the stock-keeping units (SKU) level, because they do not need to. The only time that the retail chains forecast at the SKU level is when explicitly asked by the supplier before big promotions or product introductions.

But why is it important that retailers should start forecasting? The reason is that efficient replenishment hinges on it, even though it is extra work for the retailer.

Today, the retailer's distribution operation typically makes its inventory management decisions using a sales forecast that it has made using historical sales data. The new store formats and categories can only be taken into account by going through the SKU, unit for unit in a lengthy collaboration process between the retailer and its distributor. But the biggest source of inefficiency comes from the distributor not extending collaboration to the grocery suppliers. Thus, even in situations where category management changes demand fundamentally, the supplier is forced to make its supply chain plans based on its very own sales forecasts. In the worst case, the supplier is not aware that an SKU has been eliminated from a category, until the distributor returns the last big shipment as obsolescent.

The objective of this paper is to present a forecasting solution for CPFR that involves very little extra work for the retailer in starting to forecast on the SKU level. The solution approach outlined in the paper is under development in the ECOMLOG (www.tuta.hut.fi/ecomlog/) project. The paper first describes the conceptual foundations and the basic structure of the solution approach. Next, results from dry-runs and process verification pilots are presented. Then, the paper moves on to outline what steps a supplier can take to demonstrate the benefits of collaboration to retailers, how to set up a robust replenishment solution based on planning collaboration, and how to design a distributed planning system spanning a large network of supplier and retailer companies. Finally, the architecture of a distributed software solution under development is presented, which is designed to fulfill the requirements outlined for such a system in the previous sections of the paper.

Conceptual foundation: not partnership, but mass collaboration

The collaborative forecasting method must be efficient, unless successful collaboration is to be achieved only with very close partners. Even large retailer and supplier organizations cannot forge close partnerships with very many partners. However, the benefits of planning collaboration are significant only when the collaboration is possible on a larger scale (Hoover *et al.*, 2001). The conclusion is

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that planning collaboration cannot be just a solution between close partners, but needs to be implemented with a large number of different business partners. The goal today must be solutions that enable mass collaboration.

What could be the basis for a solution that enables mass collaboration? The situation today is that an increasing number of retailers do category management, and use chain formats. Category management is basically a periodic review and assortment decision process that is then executed at the store level. Because this process is periodic and at the item level, it makes category management a potential candidate to form the basis for forecasting collaboration on a large scale. For example, in Finland it would be possible for retail customers to provide their suppliers with item level forecasts three times a year using the assortment decision process.

But CPFR is not only forecasting collaboration. There are many more parts that have to be developed together. To succeed, mass collaboration needs new solutions to address three key issues other than the issue of how to improve the efficiency of forecasting at the retailer. The first is how to make replenishment more robust. This issue is followed by how to demonstrate to prospective partners the benefits of an orderless collaborative business relationship. Finally, the question is how to set up the supporting IT systems, so that the planning processes are truly scalable in a business network consisting of independent organizations.

A solution to the first issue, i.e. how the collaborative forecasting and planning process can be made more efficient, is to use the customer's category management as the basis of the collaboration process. The forecasts produced through collaboration then need to be put to good use by the supplier. An area where the forecast is immediately needed is as input to determine pipeline inventory, for example, the buffers for vendor-managed inventory (VMI).

The next issue to be resolved is a solution for replenishment that supports mass collaboration. As with planning, it is not enough if a solution can be found that works with close partners, but replenishment also has to be implemented with many partners to bring the real benefits.

Attention also needs to be put on the subject of performance measurement that is needed to demonstrate collaboration benefits. New performance measures are needed to "sell-in" collaboration to other than close partners. The issue is how do you effectively demonstrate to prospective partners the benefits of orderless delivery processes, when many customers regard purchasing as a core process?

Finally there is the issue of how to develop an architecture for the IT solutions that is scalable for both supplier and retailer. The issue is control. For mass collaboration to become possible each supplier and each retailer need to be able to choose with whom to collaborate independently.

Category forecasting – a lean approach to forecasting for the retailer

Category forecasting using rank and share is an efficient approach requiring very little extra work, if the retailer already has a working category management process. Rank describes the position of the SKU in the category. Share describes how much each rank represents of the total category sales.

The basis for reducing work for the retailers is to work with categories, not individual stock-keeping units when making the forecast. Focusing on changes in the rank order of the stock-keeping units in the category is a practical way to work with the whole category (or subcategory) at the same time.

The idea of streamlining the planning process by focusing on ranking is not new, and has been used successfully, for example, in Volkswagen's spare parts business in the UK. There, ranking was used as the basis for a low cost solution to manage the supply of spare parts according to the local car populations (Simons and Kiff, 1999). The solution was based on periodically publishing national sales ranks, which dealers then could use to tailor local stock profiles. The principle was to focus dealer attention on the parts that rank high locally, but not nationally. Another example is from the electronics industry. Here, the 3C (3C = capacity, commonality, and consumption) approach developed by Lucent in its Spanish Tres Cantos plant (Fernandez-Ranada *et al.*, 1999) links sales planning seamlessly to component suppliers using a collaboration process based on ranking maximum usage rates of individual components.

The first key element of the proposed collaborative methodology is to adopt category management to simplify the planning process for the retailer. To get planning collaboration, drive the supply chain you need to make your new forecasts at the same time as the assortment decisions. In Finland this translates to initiating the retailer-supplier collaboration process three times a year. Through its category management process the retailer determines the role and rank of each item in the category. Then, by estimating the total sales of the category and modeling the category-share of each position an item level forecast is created. This is then used to update safety stocks, initiate materials purchases, and determine re-order levels along the supply chain.

The second key element is to use point-of-sales (PoS) data to improve the accuracy of the forecast. PoS data are used to rank the SKUs within the category and to give the share of sales for each SKU. In the grocery supply chain access to aggregate PoS data enables you to seek out more accurate scaling rules than by using retailers' purchase orders (Gell-Mann, 1994). PoS data can be used to define category shares in the different store formats or chains.

To sum up, the category forecasting approach is intended for retailers or suppliers that are already well-versed in category management. The preconditions are that the retail chain systematically manages categories by store format and type and that assortment decisions are also executed according to these plans. Based on the assortment decision of the retailer either the retailer himself or the suppliers can generate the forecasts. In the best case, both do it and collaborate to arrive at a shared forecast.

The category-forecasting process

Next, the benefits of the category-forecasting approach are described for an example category – with subcategories covering, for example, household cleaning and laundry products. The retail chain has during the last ten years successfully introduced differentiated store formats to serve different customer segments and consumer demand. The supplier is a European multinational.

The benefit of the collaboration for the supplier is best illustrated by comparing the category rank for sales to the consumer and the category rank for sales to the retail chain's distributor. In Figure 1 the variability of weekly rank for sales to the consumer during a three-month period is shown. On the horizontal axis the category rank for the whole quarter is mapped, and on the vertical axis the highest and lowest weekly rank for the three-month period. The analysis illustrates that the role of an individual item is well defined on the point of sales level, since there is little change in rank from one week to the next. However, immediately when going upstream to the supplier and analyzing orders from the retail chain, these clearly defined roles are obscured (Figure 2). During one quarter most stock-keeping units have been both in a high ranking and in a low ranking position.

Figure 1 Period rank and weekly rank variability in PoS

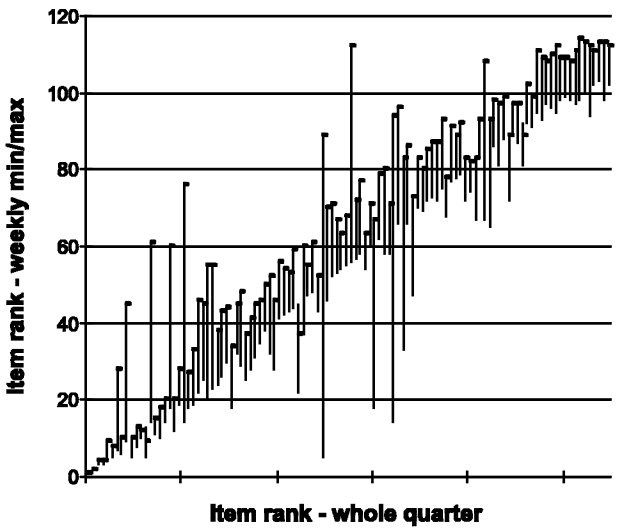
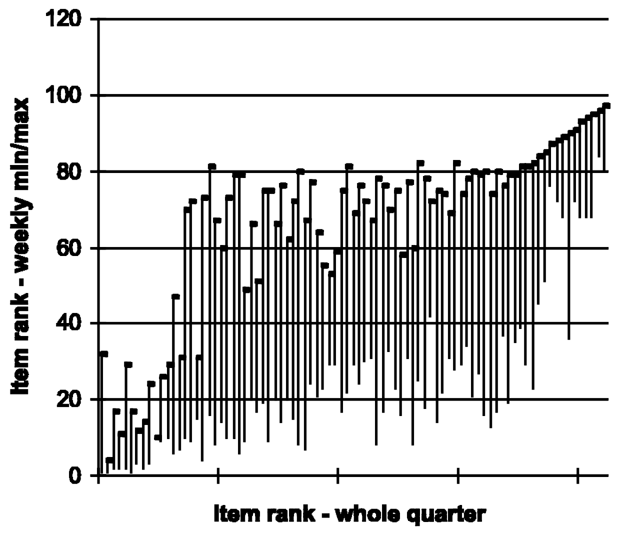


Figure 2 Period rank and weekly rank variability at supplier



Comparing the demand illustrates the importance of focusing the collaborative planning process on the end consumer. In this case supply chain category ranking is difficult on the supplier level, because every SKU is not ordered from the supplier every week but works on the retail chain level, because consumer demand for each SKU is continuous.

The concrete steps in the forecasting process are shown in Figure 3 (see also Holmström, 1998a). A demand forecast in logistical units for the articles of the category is produced based on the assortment decision, promotion and product introduction plans in three basic steps:

(1) rank the products in the category based on the retailer's assortment decision and planned activities of the supplier;
(2) estimate the total category sales; and
(3) estimate the scaling function for relative shares for the items in the category.

The first step is to get input from the category management process. The objective is to determine the rankings of the individual articles in the category. This is done by reviewing historical ranks of the product, promotion and activity plans, and assortment and price changes in the market. Based on the same information, a forecast for the aggregate sales of the category is made. The next, and critical, step is to translate the ranks and the total estimate to individual sales forecasts for all the products in the category. This is done in one step for the whole category by using a scaling function. The sales forecast for a period can then be translated into a logistical demand requirements forecast for the demand period.

Three inputs are used to construct a sales forecast using the category rank and share method. These are the ranks in the category, total category sales, and category share by item. The accuracy of the derived forecast depends on the quality of the inputs. Because demand is continuous, ranking is easy to do on the chain level. Also for the same reason total category sales are much easier to predict.

This is illustrated by the accuracy achieved in the example supply chain. Based on the assortment decision, the category manager of the retail chain was able to provide very accurate total sales and rank inputs (Table I) for five subcategories of the household care products. The mean ranking error was only 1.5 and the subcategory total sales forecast was 92.1 per cent accurate.

The weekly demand forecast accuracy on the SKU level – produced using the rank and share method – was on average 73 per cent, and in the sub-category A 82.5 per cent. The accuracy is measured as the mean absolute percentage error (see, for example, Shearer, 1994). When the results were presented to a leading supplier in the category, they stated that the accuracy of the trial already matches their forecasting performance. This is quite good, considering the amount of work needed – two hours according to the category manager – and the fact that the assortment decision is taken up to three months before taking effect. If the supplier has a VMI system set up with the retail chain, this forecast

Figure 3 The category-forecasting process

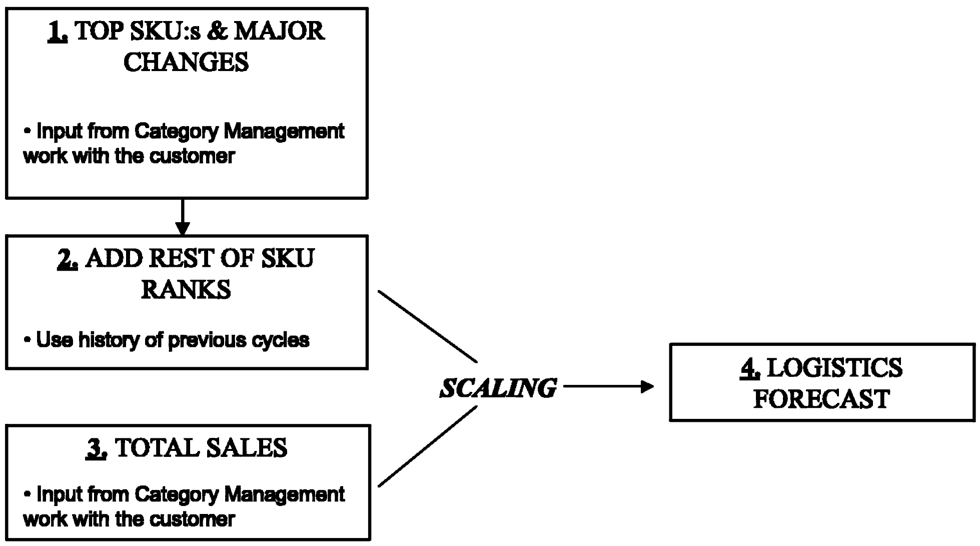


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Table I Forecasting accuracy of rank and share method

	Mean rank error for SKU	Total (sub)-category sales accuracy	Weekly forecast accuracy for SKU	Standard deviation
Sub-category A	1.3	97.5	82.5	19.0
Sub-category B	0.8	96.7	72.0	28.4
Sub-category C	0.7	85.0	79.4	14.7
Sub-category D	1.4	98.2	78.1	24.0
Sub-category E	3.5	83.2	54.7	33.0
Whole category	1.5	92.1	73.3	

accuracy is sufficient to adjust safety stocks and re-order points to meet changes in demand after an assortment decision. Also, this is valuable advance information that can be used to update production and material procurement plans for a proactive response to the new situation.

For the share input a scaling function modeled on the previous period was used. The inaccuracy of the forecast was mainly due to this scaling function. If the category share as a function of rank does not change continuously, the accuracy is able to improve over time. Thus, the issue is how reliably does the approximation model actual sales in each sub-category?

For the well managed sub-categories – A to D – 96 per cent of the ranks selling more than 500 euros weekly stayed within 10 per cent of the period category share. Thus, sales – the share of the total – can be modeled as a function of rank. Also, the same function can be used for both the period and weekly category shares. This similarity of demand on the weekly and period level is a characteristic of demand on the PoS level when assortment decisions are made systematically, based on a category management process.

Robust replenishment solutions needed for mass collaboration

For CPFR, the supplier needs to use the category forecast that is produced based on the periodic assortment decision for adjusting the width of the supply "pipeline". This is the missing link between category management and efficient replenishment.

In replenishment solutions, like VMI, forecasts are very important. This is because the partners need to be able to efficiently react to major changes. The difficulty in doing so has been a major obstacle in the large-scale adoption of the replenishment concept. For example, in VMI the supplier has the responsibility of replenishment; he decides about the timetables and batch sizes (Benfield, 1998); but it is the responsibility of the customer to inform about major changes in advance. By systematically linking assortment changes to efficient replenishment, the category-forecasting process helps the retailer implement replenishment solutions with more suppliers.

However, for mass collaboration the supplier needs to have a solution for replenishment that is easy to implement with a large number of customers. On the retail level it has been difficult to find suppliers prepared to take responsibility for large-scale replenishment. The reason is inaccurate stock levels. Because the inventory situation is calculated based on material movements, even small errors lead to missed replenishments and products being out of stock in the shelves, until a physical inventory count detects the error. When the solution is based on material movements, the same problem also comes up in VMI solutions where the stores still order and the supplier only replenishes a distribution center. The way out is to base replenishment solutions firmly on inventory count, where errors are erased with every cycle.

For example, a supplier solution for replenishing distribution center inventory is simpler to set up and run when the mechanism for sharing information is the stock list, and not orders and material movements (Holmström, 1998b). The reason why inventory count is a simpler and more robust way to share and store info is that errors can be corrected with every new inventory count and replenishment cycle.

When the supplier solution requires that a full inventory management system is implemented for each customer, all material movements with all customers need to be recorded correctly. Since this is often a

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challenge to accomplish even in one operation, the administration task becomes formidable, when it has to be achieved with a number of different organizations.

So why would a supplier need to adopt the more complicated solution of implementing a full-scale inventory management solution for each customer? The reason is consignment. Many customers see replenishment and VMI as a way to move ownership of inventory to the supplier. This is an example of a situation where a contractual agreement requires a more complex solution (Ergengüc *et al.*, 1999). The more complex solution again increases cost to implement (Laughlin, 1999). Today there is even talk of "pay-by-scan" solutions, where the retailer would pay the supplier based on sales to the consumer. In practice this would for accounting reasons require the supplier to have a movement-based inventory management system covering all points of sales. However, for mass collaboration a solution that does not involve consignment is preferable, because the solution requirements and the administrative complexity for the supplier are easier to set up and implement.

In other words, for mass collaboration a robust supplier solution, based on inventory count and without transferring ownership to the supplier, is preferable. This important consideration is often forgotten by customers in a powerful negotiation position, in their efforts to move liabilities to their suppliers. A consignment solution is more difficult and expensive to implement, and thus cannot be adopted by as many suppliers as a more robust replenishment solution.

Implementing the collaborative business model – measures for feedback and sell-in

Why should a supplier bother at all with replenishing? And why should a retailer be prepared to start SKU level forecasting? For collaboration on a larger scale both the supplier and retailer need to quantify the "win-win", and use that to sell-in the new operating model in their own respective organization, and with prospective partners.

The two measures, time-benefit and forecasting accuracy based on the category decision, can when used together demonstrate the benefits of forecasting and replenishment collaboration.

The time benefit measure has been developed explicitly to demonstrate to prospective business partners the benefit of information sharing. Time benefit shows what is the additional response time that a customer gives his supplier when replacing purchase ordering with replenishment based on inventory count data.

Then, what is the idea of changing the responsibility of ordering to the supplier? Transparency in the supply chain helps the supplier to act economically. The supplier gets information earlier, and this way he gets more response time. When the supplier can replenish according to his customer's inventory situation, instead of having to wait for orders, he benefits by getting more time to respond to the consumption by the customer.

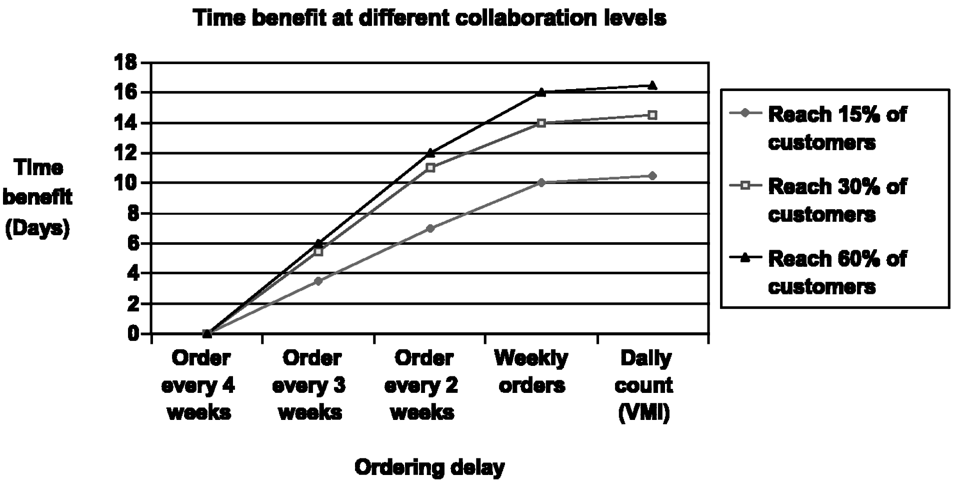
In Figure 4 we can see that the benefit from VMI for the supplier is substantial already with a few customers (Waller *et al.*, 1999). From the Figure we can see how more customers abandoning purchase ordering and adopting VMI give the supplier more time to react. The initial situation is that the average SKU is ordered every four weeks by customers. By moving to a VMI solution the time benefit – or reduction in stock cover – is 16 days with a VMI adoption rate of 60 per cent, 14 days for an adoption rate of 30 per cent, and ten days for an adoption rate of 15 per cent.

Moving to a VMI solution is from a supplier perspective easier than increasing order frequency. Increasing the average order frequency to one week entails reducing the product range, and consolidating orders from the customers. A robust VMI solution – that is without consignment – can often be implemented without reducing the product range or aggregating customer orders. The requirement is only that the customer has an adequate inventory management system, and can share the free stock on a daily basis.

From a supplier perspective, a time benefit of 14 days can be used in many different ways. With local manufacturing capacity it is possible to produce to demand, and with a regional distribution organization it is possible to reduce safety stocks, or improve service levels, or both at the same time.

The above example is based on a simulation model, but the time benefit measure has also been tested on a number of real-life

Figure 4 The benefit of replenishment collaboration



Source: Waller *et al.* (1999)

transaction flows between companies to sell-in VMI solutions. In a perishable goods supply chain, by utilizing the time benefit, the grocery manufacturer was able to reduce the obsolescence from 8 per cent of sales to 2 per cent. At the same time the inventory level in the pipeline declined by over a half and the service level remained the same.

A VMI solution gives the supplier an opportunity to use the time between orders productively, instead of having to buffer for order-induced demand amplification. This additional time to react reduces the need for short-term forecasting, but to deal with medium- and long-term change forecasting collaboration with a strong focus on category management and promotions is needed. The challenge is to focus development efforts where they can bring the most benefit. If the supplier runs into problems with living up to service level goals, it is important to find out how failures are linked to the customer's planning process.

The main requirement for the collaborative planning, forecasting and replenishment process is a performance measure to track accuracy for forecasting the effects of assortment and promotion decisions. These changes are important to communicate, because the retailer cannot respond efficiently without forecasts.

In the example household care product category a 73 per cent weekly forecasting accuracy on the SKU level was achieved eight weeks out from the assortment decision. Presented with the result, the category manager in the retailer-company concluded that with a little bit of practice a forecasting accuracy of 80 per cent three months out should easily be reached using the rank and share method. This is more than sufficient for many planning purposes in the supplier company and is superior to the accuracy of the supplier's own forecasts three months out from the retailer assortment decision.

Architecture to make it work on a large scale

Finally, how to solve the issue of an architecture for forecasting IT solutions that is scalable for both supplier and retailer? The software solution developed in the project is a distributed collaborative Internet-based application. The objective is to enable all parties involved to increase the number of collaborative relationships independently, without increasing system complexity for the individual organizations.

Because a distributed collaborative application does not have a central hub through which the whole network is controlled, the solution is built around a standard data format that is identical for input and output. The standard data format is a virtual "hub" that enables aggregation and drill-down of rank and share plans across organizational boundaries. Through this each party can manage how and when to collaborate with each member in the network and expand the network, without worrying about what database systems, database structure or other information system configuration the other network members use.

The benefit is that the retailer can collaborate with more suppliers, and this way improve availability and reduce lost sales. For the supplier, the benefit is ultimately that it can simplify its own forecasting process, and rely more on the customer processes.

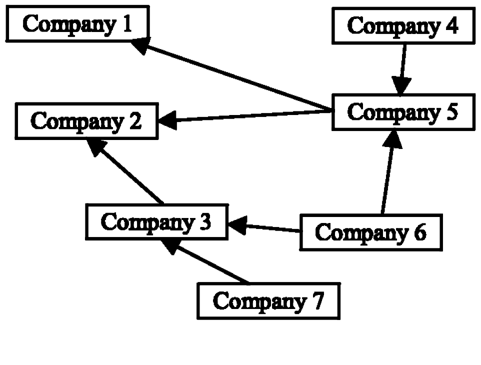
From a software point of view, every node in the supply chain is a potential client and/or provider of the information. This way it is possible to model each member of the supply chain in a uniform way. Basic operations that have to be supported by the system for each node is subscribing to input data (i.e. request by specifying serial and chain), rank and share, and publish results to subscribers.

The intended users of the basic operations are those responsible for category management on the client side, and those responsible for customer relationship on the provider side. The point is that it is the business people, not the logistics people, who are the target users of the system. These are the people who can do the best forecasts and who most need the forecasts of their clients/providers. They are also the people who best know when this information can and should be communicated to the other members of the supply chain.

Since it is not always obvious that all clients/providers should have access to the same information at the same time, the system provides a publishing functionality. After a ranking has been modified for some product assortment, the user may decide to whom it will be published instantly, later or not at all.

Figure 5 illustrates what a real supply chain might look like, where some nodes are just

Figure 5 Supply chain



Note: Arrows indicate product flow, so companies 4, 6 and 7 are only providers, companies 1 and 2 are only clients and companies 5 and 3 are both clients and providers

clients to others, others are just providers, while some are both clients and providers to other members of the supply chain. The actual number of nodes and connections depends on the supply chain concerned, so it cannot be "hard-coded" anywhere in the application. Furthermore, it does not require administration by any third party, since the system is designed in such a way that the members of the collaborative network independently decide to what companies they connect themselves and what companies may access their information. Avoiding a third party is indeed the most essential feature of a distributed business application!

Connections to other companies are to be set up by administrative users who have sufficient knowledge about the program. The needed operations are mainly adding/removing connections to other members of the supply chain and managing security issues.

Each connection is defined at least by the following information:

- name and description of the company;
- network name/address of the computer to contact; and
- public key for authentication purposes.

Since forecasting information is confidential, data and communication security are essential aspects of the system. The system at least has to verify that the computer asking for information is indeed the one that it pretends to be and that nobody can "listen" to the network connection and capture or modify the data being transferred. Public and private key encryption methods are used for authentication and encryption procedures and message digests for ensuring data integrity (NIST, 1999). These techniques are included in the standard Java classes (Campione *et al.*, 1998). Remote method invocation (RMI) (Sun Microsystems, 1998) is the communication protocol that is currently used for implementing the distributed system. RMI is a protocol that is specific for the Java programming language. For implementing the system the Java programming language was selected, because it is the only programming language that makes it possible to run the same executable program on the different computers and operating systems used by various companies. Java also supports uniform communication with various databases used in different companies through Java database connectivity (JDBC).

Current status and next steps

The results presented in the paper have all been from dry-runs and process verification pilots. A larger pilot to test and evaluate the approach for a collaborative business model across several business organizations is the next step. The pilot is being assembled around leading Finnish retail chains with roughly one third of the total grocery market. The grocery manufacturers involved in the project are a leading European multinational with non-perishable packaged consumer goods, and a leading local manufacturer of perishable packaged consumer goods. Both manufacturers have recently implemented a new Web-based VMI solution with the distribution-company of the retail chain. The objective of the pilot project is to create a collaboration process linking category management to replenishment and production planning that can be efficiently expanded to a large number of retailers and suppliers, i.e. to form the basis for mass collaboration.

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