Inventory cost optimization in supply chain system through Case-based Reasoning

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***Abstract*— Under the mode of the supply chain management, the inventory is always the biggest obstacle. The inventory not only influences the integrated cost of a single enterprise, but also restricts the performance of the whole supply chain. The past single enterprise inventory management approach already cannot adapt the request of the supply chain management. However, the simulation approach is not an optimization approach and it cannot provide the optimal solution or the satisfactory solution of the problem. So the simulation is combined with the optimization to form the simulation-based optimization (SBO) approach, which can achieve the system optimization in a real sense.**

In this paper, case-based reasoning approach is being applied to optimize the inventory cost in supply chain system. The solutions are stored for future use for this purpose.

***Keywords*— Supply chain, Inventory cost, case-based reasoning, Supply chain process optimization, case retrieval, simulation-based optimization .**

I. INTRODUCTION

Many organizations have been struggling with inaccurate demand forecasts, huge inventory buildup, high material acquisition and logistics costs and customer dissatisfaction. These supply chain issues have a significant effect on the organizations' cash flow and costs and ultimately its competitiveness and profitability. Companies aiming for best-in-class performance should take an end-to-end view to transforming their supply chain processes. This requires addressing all the segments of the supply chain:

- Forecasting and Inventory Planning
- Sourcing and Procurement
- Fulfillment and Logistics
- After-Market Services

Consider a retailer that maintains an inventory of a particular product. Since customer demand changes over time, the retailer can use only historical data to predict demand. The retailer's objective is to decide at what point to reorder a new batch of the product, and how much to order so as to minimize inventory ordering and holding costs. More fundamentally, why should the retailer hold inventory in the first place? Is it due to uncertainty in customer demand, uncertainty in the supply process, or some other reasons? If it is due to uncertainty in customer demand, is there anything that can be done to reduce it? What is the impact of the forecasting tool used to predict customer demand? Should the retailer order more than, less than, or exactly the demand forecast? And, finally, what inventory turnover ratio should be used? Does it change from industry to industry?

Inventory management is a collection of interdisciplinary processes that include a full circle from supply chain management to demand forecasting, through inventory control and including reverse logistics.

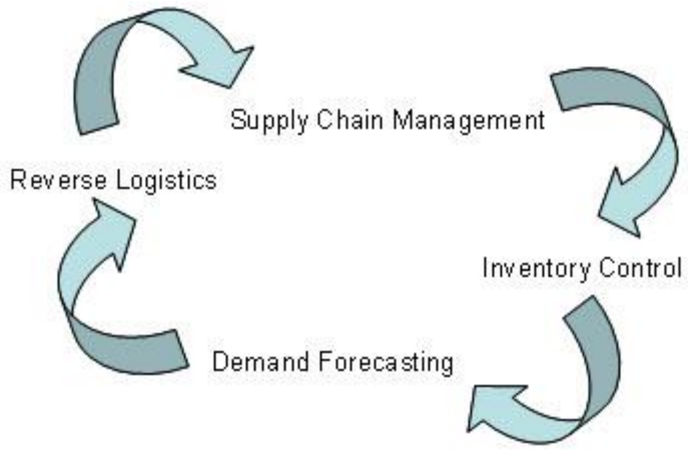

Figure 1: SCM process

Inventory management starts and ends with supply chain management because many of the opportunities to improve efficiencies start with shortening order to receipt time without incurring additional cost. That said, the other stages of the inventory management cycle are no less important in attaining overall efficiency. Given that inventory in all its forms generally represents one of the top three expense lines for nearly all companies, there is a universal need for applying the right discipline to each step in the process. While in the perfect world, all inventory is consumed daily, we must operate businesses in a less than perfect environment. The challenge is: how close can you get to perfect before Just In Time inventory management becomes a little too late.

Inventory management in its most efficient form incorporates many different technical applications of inventory management models. Such concepts as safety stock, economic ordering quantity, cost of goods, inventory turnover, customer managed inventory and a vendor managed inventory, whole spectrum of underlying inventory management tools play a critical role in what is inventory management. Different industries have different needs when asking the question what is inventory management, but many of the concepts are the same.

While the key principles of inventory management remain the same across all industries, the areas which require emphasis vary from sector to sector. Learning to apply the right inventory management tools is part of executing the art and science of what is inventory management.

Effective inventory management depends on understanding all the details of what is inventory management. By applying lean practices to all aspects of the inventory management cycle, businesses can reduce investment in standing inventory, plant rental, shipping costs, reverse logistics while maintaining or improving customer service levels and in-stock metrics on critical inventory. This is the result of having what your need, when you need it, where you thought you had it. That is the core standard by which to measure the results of your businesses inventory management program.

Inventory control elements are an integral part of any supply chain. They control the flow of materials within the supply chain and are mainly of two types—centralized and decentralized control.

- Centralized Control: These elements control the inventory at a particular production element while taking into account the inventory levels in the supply chain as a whole. A typical example is inventory control based on echelon inventory. According to this policy, inventory control is applied while considering the total inventory upstream, also called the echelon inventory. An important requirement for implementing a centralized inventory policy is the ability to access information on inventory levels at other entities in the supply chain.
- Decentralized Control: These elements control inventory at a particular production element by considering inventory levels at that entity in the supply chain. Typical examples of these kinds of policies are: base-stock policy, MRPbased ordering (with no information about inventory status at other agents), and (Q,R) or (s,S) policy. These policies are also used in centralized control, though inventory levels in those cases are calculated based on echelon stock. In a basestock policy, orders are placed as soon as the inventory level reaches below the base-stock level in order to bring it back to that level. In MRP-based ordering, the requirements are based on the MRP explosion (considering the forecasts as exact). In (s,S) [(Q,R)] policy, ordering is done when the inventory levels goes below s [is equal to R] and orders are placed so that inventory is brought up to S [Q + R].

Inventory decisions are often made independently by the SC actors based on the local inventory status and local performance objectives (*local policies*). Local policies are simple to be defined and implemented. Yet they ignore the implications that a decision can have on other stages, so sub-optimizing the whole SC's performance. Also, the lack of a coordinated inventory management policy often causes the *bullwhip effect*, namely an amplification of demand variability that increases toward the upstream stages (Lee *et al*. 1997). The bullwhip effect results in excessive inventory investments, lost revenues, misguided capacity plans, ineffective transportation, missed production schedules, and poor customer service (Lee, Billington, 1992). In addition, it increases the time needed by upstream stages to perceive changes in customer's demand, so making the whole SC less responsive to customers' requirements (Christopher, 1992). These inefficiencies reveal dangerous in both mature markets, i.e. markets where customers value the service as much as (or even more than) the good itself, and innovative ones, such as fashion or computers, where the lack of responsiveness may lead to either lost sales or stock obsolescence (Fisher, 1997).

Uncertainty is another key issue to deal with in order to define effective SC inventory policies. Supply (e.g. lead times), demand, information delays associated with manufacturing and distribution processes as well as inventory and backorder costs are usually uncertain (Verwijmeren *et al.*, 1996; Karwowski, Evans, 1986; Park, 1987). Typically, stochastic techniques have been used to cope with it (e.g. Porteus, 1990). In such cases uncertainty sources are modeled by probabilistic distributions that derive from the analysis of the past cases. Yet, past data are not always available or reliable (e.g. due to market turbulence). Moreover, the resulting integrated inventory policies are often difficult to be implemented, which makes them unattractive even if efficiently computed (Federgruen, 1993). As a result, research has lately been focused on heuristic policies that, though sub-optimal, are easier to be implemented (Chen, Zheng, 1998).

II. RELATED WORK

The first area of research to address supply chain coordination was multi-echelon inventory systems. With customer service requirements constantly increasing, effective management of this part of the supply chain is crucial. Clark and Scarf et al. (1960) presented a recursive decomposition approach to determine optimal policies for serial multi-echelon structures. Silver and Peterson et al. (1985) provided a formulation and discussion of simple two echelon inventory systems.

Muckstadt and Thomas et al. (1980) investigated the applicability of multi-echelon methods in low demand systems. Two approaches were presented for determining stock levels in a two-echelon system, item decomposition and level decomposition. Erkip et al. (1990) presented an approach to determine optimal ordering policies at a depot that distributes to multiple warehouses with correlated demand. Svoronos and Zipkin et al. (1991) evaluated the performance of arborescent inventory/distribution systems with independent Poisson demand at the lowest echelon, assuming stochastic transit times and a one-for-one replenishment policy. The authors developed an approach for using two moments of the transit time to approximate density functions for inventory and back-orders at a single stage, given a base stock level. Ernst and Pyke et al. (1993) studied a two-echelon system composed of a warehouse and retailer, with random demand occurring at the retailer only. Both the retailers and the warehouse operate under a base stock policy.

Pryor (1999) develops models in capturing inventory and transportation simultaneously. The models propose to minimize the total inventory and transportation costs. Lui (1999) investigates inventories from another viewpoint. He tries to control the inventory cost and to consider endcustomer requirements. In this case, a network of inventory queues is developed, where any single queue is defined as a "queuing model that incorporates an inventory replenishment policy for the output store".

Petrovic *et al.* (1999) examine uncertainties in SCs by focusing on "decentralized control of each inventory" and "partial coordination in the inventories control." They simulate and analyze some approaches to promote the SC performance in uncertainty conditions. In their former research Petrovic *et al.* (1998) tried to identify the stock level and order quantities for inventories in an SC, with the consideration of two sources of uncertainty in the SC system: "customer demand" and "external supply of raw material." Türk¸sen and Fazel Zarandi *et al.* (1999) describe the main challenge in fuzzy production planning and scheduling as finding a suitable realization of operations with the intersection of fuzzy constraints for the satisfaction (with a degree) of the overall requirements. Bartholomew *et al.* (2000) developed Advanced Planning and Scheduling (APS) software for the SC in production planning. Olson (*et al.* 1999) demonstrates a new world competition between the SC to the SC rather than organization to organization.

Xia and Wu et al. (2007) used AHP for searching potential suppliers and then used the multi-objective mixed integer programming to determine the number of suppliers to employ and the order quantity allocated to these suppliers. Mendoza and Ventura et al. (2008) also used AHP in the first phase to reduce the number of suppliers. At the second phase they implemented a mixed integer non-linear programming method to determine the optimal order quantities. Demirtas and Ustun et al. (2008) have used analytic network process (ANP) in the first step and for quantity allocation they followed the similar method used. In the studies of O'Brien et al. (2010), fuzzy multi-objective programming models were developed for supplier selection and order quantity allocation. Their later work also considered price discounts.

III. CASE-BASED REASONING

Case-Based Reasoning (CBR) is a problem-solving approach that simulates the human problem-solving behavior. In this approach, the problem is being solved out on basis of past experiences gained from during solving the problem in the past. In case of complex system, it is very difficult to formulate the situations with domain rules. Other drawback is that the rules require more input information than is typically available, because of incomplete problem specifications or because the knowledge needed is simply not available at problem-solving time. But in case of CBR approach, if general knowledge is not sufficient because of too many exceptions, or when new solutions can be derived from old solutions more easily than from scuff, then on basis of past experiences, the problem is being solved.

The case based reasoning involves four phases in the problem solving. Each problem specification & its solution are stored in form of the cases. It maintains the collect of the cases that is known as the case base. In this system, every problem is considered as the new case. In the retrieve phase according the new case, approximate solution case is being searched from the case base & selected. After the selection of the case, that case is adapted with the new case. It generates the solved case. Now the solved case is evaluated in the revise phase & the faults in that case are being repaired. Now modified case is the solution of the problem. This solution is stored in the case with proper index. This action is mandatory for extracting the cases very efficiently & fast access to the cases in future.

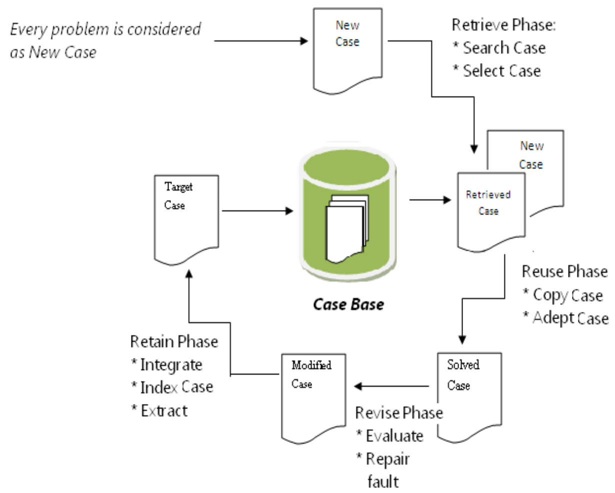

Figure 2: Case Based reasoning Cycle.

Case-Based Reasoning is not restricted to the reuse of experience. Another very important feature of case based reasoning is its coupling to learning. As the human beings learns from the past experience, the case base reasoning supports learning from the past experience. Learning in CBR occurs as a natural by invention of problem solving. When a problem is successfully solved, the experience is retained in order to solve similar problems in the future. When an attempt to solve a problem fails, the reason for the failure is identified and remembered in order to avoid the same mistake in the future.

IV. CASE-BASED REASONING IN INVENTORY COST OPTIMIZATION

Real-world production planning, inventory control and scheduling are usually imprecise. However, managers are to interact in an intelligent way with this environment. Thus they have to reach out for a new kind of reasoning based on imprecise knowledge. The major characteristics of the imprecise knowledge are as follows:

- It contains uncertainties,
- It includes errors,
- It is almost always incomplete.

Moreover, what makes this subject meaningful in SC systems is the need for an integrated approach to the flow of materials and storage of inventories. Here, integration is achieved when the inventory is viewed with other elements of the SC.

The optimization objective is a key component of Supply Chain Process Optimization system. Optimization objective in SCPO system have three key characteristics.

Firstly, the optimization objective is derived from strategic target of organization. The ultimate goal of SCPO is to achieve strategic target of organization. Accordingly, there is the need for a change in the way the SCP and performance measurement information are presented according to the change of the strategic target. From the view of SCPO, for achieving the strategic target of organization, there are mainly three types of optimization objective: minimize cost, shorten circle time, and improve quality of product/service. There are different focus processes and performance measurement metrics for various different SCPO objectives. For example, if the optimization objective is to minimize cost, the supply chain processes which need to expend large cost are taken as the focus processes of SCPO.

Meanwhile, the performance measurement metrics should lay particular stress on measuring the cost of SCP. Secondly, the optimization objective is multiple. That is, it is possible that the optimization objective is the combination of one more types of optimization objective for achieving the strategic target. For example, according to the strategic target, the optimization objective may be to minimize cost as well as to improve quality of product/service. Therefore, there is a trade-off among different types of optimization objective. Thirdly, optimization objective, reflecting managers' immediate preoccupations, may be different in different period. Optimization method is applied to get the optimal solution to SCP improvement. Two types of optimization method can be applied in SCPO system: the CBR-based method and calculating.

In CBR-based method, If there exits unsatisfying performance gaps between the as is model and reference models, new solutions can be generated by retrieving the most relevant industry cases from the knowledge base of industry cases and adapting them to fit the situations. Calculating is to generate the to-be model by some process optimization algorithms directly.

Now let's start the inventory cost optimization process with help of case based reasoning approaches. In case based reasoning, the case contains all information regarding the problem & its solution. In inventory cost optimization decision process, the case contains all information regarding the supply chain components. This approach finds the similar cases to provide the best & optimized inventory cost value.

CONCLUSION

With the effective inventory management, procurement goal can be achieve quickly. The inventory is the joint of the whole supply chain. When optimize the inventory management, upstream activities will run effectively meanwhile downstream activities will go ahead without any stoppage. With efficient Inventory control, the company can adjust the inventory level properly. When calculating the cost, it is better to use unification units. For example, units of material handling and payment cost calculation are trucks. And the unit of material demand is tons. Sometimes it will cause inaccurate of the cost calculation.

REFERENCES

[1] J. Kolodner, "Case Based Reasoning. Morgan Kaufmann," San Francisco, 1993.

[2] S. W. Changchien, M. C. Lin, "Design and implementation of case based reasoning system for marketing plans," Expert Systems with Applications, vol. 28, pp. 43–53, 2005.

[3] J. Sebestyénová, "Case-based Reasoning in Agent-based Decision Support System", *Acta Polytechnica Hungarica*, Vol. 4, No. 1, 2007, pp.127-138.

[4] Aviv, Y.. The effect of forecasting capability on supply chain coordination. Working paper, Washington University, St. Louis, MO, 1998.

[5] Chen, F.. Optimal policies for multi-echelon inventory problems with batch ordering. Working paper, Columbia University, New York 1997.

[6] Haq, A.N., Vrat, P., and Kanda, A., "An integrated production-inventory-distribution model for manufacture of urea: A case", *International Journal of Production Economics* 39 (1991) 39-49.

[7] lshii, K., Takahashi, K., and Muramatsu, R., "Integrated production, inventory and distribution systems", *International Journal of Production Research* 26/3 (1988) 473-482.

[8] Jackson, P.L., Maxwell, W.L., and Muckstadt, J.A., "Determining optimal reorder intervals in capacitated production-distribution systems", *Management Science* 34/8 (1988) 938-958.

[9] Kleutghen, P.P., and McGee, J.C., "Development and implementation of an integrated inventory management program at Pfizer Pharmaceuticals", *Interfaces* 15/1 (1985) 69-87.

[10] Kohli, R., and Park, H., "Coordinating buyer-seller transactions across multiple products", *Management Science* 40/9 (1994) 45-50.

[11] Janne Salmi, ROCE Partners, Improve your profitability through supply chain optimization. April, 1998. Available: http://www.roce.com.

[12] Chris Morgan, Structure, speed and salience: performance measurement in the supply chain, Business Process Management Journal. vol. 10. No. 3. 1987. pp. 259-273.

[13] Lapide Larry, What about measuring supply chain performance?, AMR Research. October 1998.

[14] Benita M. Beamon, Supply Chain Design and Analysis: Models and Methods, International Journal of Production Economics. vol.1. No.2. 1985. pp. 281-294.

[15] David B. Leake, Case-Based Reasoning: Experiences, Lessons, and Future Directions, Menlo Park: AAAI Press/MIT Press, 1996.