Supply Chain Management Simulation Model

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Abstract

This paper discusses the major classes of software that help to manage the Supply Chain. It describes where, how and what exactly each of the so-called silo software operates.This paper intends to discuss the use of simulation for evaluating the supply chain to gain performance improvements for their operations. It focuses on the benefits of using simulation as an effective tool to manage and understand your supply chain. It also discusses the reasons why one would want to use computer simulation as the analysis methodology to evaluate supply chains, its advantages and disadvantages against other analysis methodologies where simulation can find cost reductions that other methodologies would miss. The evolution of SCM software over a period of time and its need for integration is explained in this paper. The paper briefly discusses about the SCM software vendors and its selection procedure.

Introduction

Simulation (discrete-event) can be defined as creating a computer model of a real or proposed system and conducting experiments on the model to describe observed behavior and/or predict future behavior before investing any time or money. Supply Chain Management has been defined by logistics professionals as the managing of the flow of materials and products from the source to the user. Depending on the scope of the problem in the supply chain, there are typical core methodologies – known as "solver technologies" – which include heuristics, constraint management, linear programming, mixed-integer programming, and network programming that provide the results or outputs of the APS tools. Conversely, simulation is not a "solver technology" rather it is a methodology to evaluate detailed solutions and alternatives in the supply chain. [1]

Variability in Supply Chain

The key to understanding supply chain performance is to understand the variability in the system. Following are some of the sources of variability in a typical supply chain:

Manufacturing:
- Stock out situations
- Parts not arriving on time for subassembly operations
- Machines breaking and disrupting production
- Labor problems
- Machine set up/retoolings
- New product line introductions

Warehousing/Distribution:
- Automated material handling systems broken
- Trucking/Shipping/Air/Rail systems deliver late
- Labor problems
- Spacing constraints

Information Technology:
- Changing business processes due to mergers/acquisitions
- Constantly changing business computer systems

Market Conditions:
- Customer changing demand
- Economic conditions
- Currency conditions

All those items mentioned above clearly affect supply chain efficiency and effectiveness.

Other techniques and Simulation

The traditional approach has been to use a linear programming whose objective was to minimize cost or maximize profit. In some problems, we may have used dynamic programming because the problem had stochastic demand. For mutli-period, multi-product, multi-facility, multi-resource nature of problem, which is usually the case, mixed-integer programming is used. But these optimization techniques fail to take into consideration variance, which is a key driver in Supply Chain. Consider a case where we have a demand variance or a forecast error. What does the supply chain do in response? It starts moving material. If the demand forecast is up, the chain tries to produce more products in order to fill inventories up to their proper levels. This can mean overtime expenses, expediting charges, and other charges. If the demand forecast is down, then manufacturing sites go idle, materials already in inventory go obsolete, and costs already in the chain have to be absorbed. Optimization has no way of handling this problem. The reason is that the plan that an optimization gives you may be a good one, but it is wrong. The assumptions that go into the model will not play themselves out over time. The demand will be different, the cost of materials will be different, the supply of key material will be different, and everything will be different. In essence, you have optimized a problem that will never exist in reality. And because of the nature of optimization, the optimal answer can change dramatically if there is a slight change in the inputs. [2]

How Best To Use Simulation for Supply Chain Analysis

There are three areas where optimization and simulation compete – scheduling, tactical planning, and strategic planning. These three areas have different advantages and disadvantages when it comes to using simulation [2].

Scheduling is typically a short time horizon with a limited scope, possibly one plant, at part number level. Resources are typically known and fixed. The demand either fixed, or known to an extent that it could be considered "firm". Variance, though critical, can usually be dealt with on an exception basis. For scheduling applications that can be modeled with optimization techniques, optimization is clearly the better choice. In this case, simulation should be used when optimization cannot be used.

In tactical planning, time horizons are longer, perhaps up to several months in length. The scope is at least regional, and perhaps corporate-wide. The tactical plan is either developed at the part number level or an aggregate level, such as a family of products. Some resources, such as the location of manufacturing facilities, are fixed. Others, including what products are produced in which facilities, could be changed, but that would happen toward the end of the tactical planning horizon. Some capital could be bought and deployed toward the end of the tactical planning horizon. Most other resources are open to adjustment. Certainly, most materials have short enough lead times so that they are ordered during the tactical planning horizon. Labor can be hired, transportation can be procured, etc. But depending on your industry, the demand forecast could be simply a best guess. If the demand forecast is a guess, and you want to be sure that the supply chain will meet the demand without risking high amounts of obsolescence, then simulation is the best choice. If the demand forecast is firm in this time horizon, perhaps an optimization would be the best.

In strategic planning, time horizons are even longer, up to several years in length. The scope corporate-wide. The strategic plan is developed at an aggregate level, perhaps at the level of product divisions or product families. Basically, there are no fixed resources. Manufacturing sites can be opened or closed, any capital can be procured, product deployments are completely open, etc. The demand forecast is certainly a guess at this point. However, decisions with some of the largest costs to a manufacturing operation must be addressed in this time horizon. Primary among these decisions is manufacturing and inventory site locations, which includes the size of the facility, and the basic logistics infrastructure (if it is not already in place). Based on site location, future costs such as labor, taxes and tariffs are set. This is a point where optimization and simulation can both play a role. Because of the level of abstraction at the strategic level, an optimization can be used to help decide the location of new facilities and the closing of others. Based on the output of the optimization, a supply chain simulation can then be used to be sure the supply chain deliver product as expected. The simulation would help set inventory policies based on demand variability and demand risk. The simulation can also give a more realistic capital purchase plan, labor requirement, and a better overall cost estimate.

Case Study

The illustration of how Simulation can be applied to Supply Chain Management practices is developed from the case study -Hypothetical organization called Global Food Manufacturing (GFM) [3]. This case study presented is designed to analyze the manufacturing, distribution, transportation, and retail aspects of the supply chain in which GFM operates. A simulation tool [4] (The IBM Supply Chain Analyzer) is then used to quantify the effects of making changes throughout the supply chain and the impact of those changes to their competitive performance in the marketplace.

The DNA of SCM Simulation Model

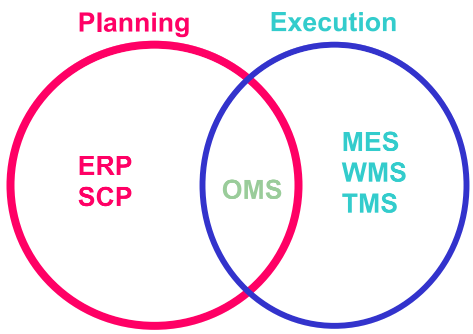
The six primary components of future supply chain management (SCM) software packages perform two primary functions[5]. One is planning (forecasts and schedules) and the other is execution (dynamic management of activities) based on a plan. Enterprise resource planning (ERP) and Supply Chain Planning (SCP) fit into the former category while Order management systems (MES), Warehouse management systems (WMS), and Transportation management systems (TMS) are on the execution side. Order management systems (OMS) fits somewhere in between because it is both the last step in planning and the first step in execution.

Enterprise resource planning (ERP)

This high-level backbone has traditionally focused on enterprise-wide integration of a company's financials, human resources, purchasing, payroll, order placement, and related administrative functions. Many packages also include modules that address manufacturing. In fact, ERP is generally considered to be the evolutionary next step from age-old materials requirements planning (MRP) and manufacturing resource planning (MRP II) packages. More recently, ERP offerings have added warehouse control as well as some order and transportation management capabilities.

For all of this breadth, the generally recognized strength of ERP has been forecasting and management of corporate financials. And that is likely to be to ERP's advantage in the future. To be proficient on the financial side inevitably requires extensive databases, including costs, revenue, assets such as warehousing and manufacturing facilities, and liabilities including inventory.

Those databases provide the information needed to analyze and evaluate orders and what it will take to fill them at the highest level. ERP can project costs to fill an order, determine sourcing options, and figure order profitability. When these and related factors for one order are evaluated against the same parameters for other orders, the ERP system ultimately forecasts the impact on the bottom line.



Supply chain planning (SCP)

These packages are analytical tools that start with order demand and determine how and when that demand can be satisfied. They plan at an enterprise level or at a facility level. To make those determinations, some of the information will inevitably come from either an ERP system or some other form of centralized database.

Of late, supply chain planning, as a stand-alone software package, has evolved into many new forms. Originally, SCP was focused on the shop floor and known as advanced planning and scheduling (APS). It is made up of multiple modules including inventory planning, supply chain network design, manufacturing planning, demand planning, and available-to-promise, to name a few.

As APS has expanded into the warehousing and distribution realm, new modules have come along. These include supply chain inventory visibility, collaborative planning, forecasting, and replenishment, as well as others.

Order management systems (OMS)

Sitting between planning software and execution software is OMS. An order management system takes orders and determines inventory availability on an enterprise wide basis to complete the planning side of the equation. The software then does some execution-type tasks such as prioritizing and optimizing orders for hand off to the MES, WMS, and TMS. Links to the customer service department are also common because OMS can develop expected shipment and delivery dates based on availability of items.

An OMS is probably the perfect example of the need for integration between planning and execution software. If it doesn't have access to database information upstream, it can't make many decisions. And if it isn't connected to the execution software downstream, its decisions don't go anywhere that they can do some good.

Manufacturing execution systems (MES)

To fill orders, an MES manages all resources (equipment, inventory, and labor) needed to create a finished product in time for when it is needed by the customer. Capabilities include allocating, reserving, scheduling, and dispatching those resources as needed.

Making this happen requires dynamic control using real-time data. This allows MES to deal with changing conditions unlike its predecessors, MRP and MRP II. For instance, the software is able to compensate for machine downtime by re-routing work pieces and resetting priorities. Similarly, inventory availability can be factored into the work plan and production goals adjusted to reflect reality, a critical step when trying to balance sometimes conflicting customer requests for finished goods.

Warehouse management systems (WMS)

Much like an MES, a warehouse management system provides real-time control over resources needed to fill orders. It manages inventory, people, and equipment from receiving to shipping.
That means inventory is put away at a particular location because the WMS selected that spot. Orders are picked in a particular sequence by specific individuals using selected lift trucks or other equipment because the WMS determined that was the most efficient way. And in the shipping department, the WMS manages detail down to the level of matching carton size to an order for maximum cost efficiency including cartons and carrier charges.

Benefits of a WMS include shorter order turnaround times, higher inventory accuracy, increased order fill rates, and improved shipment accuracies.

Transportation management systems (TMS)

Beyond operational efficiencies, the real potential of TMS use is considerable cost savings. It is generally estimated that more than 70% of a company's logistics costs are transportation related. With a TMS, shipment inefficiencies, unnecessary costs, and excess labor are minimized on a regular basis for the typical shipment.
This happens because the software automates the shipping and carrier selection process. Functionality includes load planning as well as carrier selection, rating, and pick-up scheduling. Other capabilities are shipment consolidation, freight payment, and claims management.

A new element is also introduced by a TMS-flexibility. With it, companies can make adjustments on the fly in the shipping department as priorities and carrier costs shift.

The evolution of supply chain software

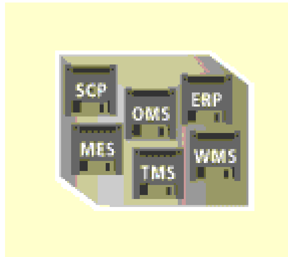
PRE-1998

Until 1998, there were six major types of stand-alone planning and execution software. The six are enterprise resource planning (ERP), supply chain planning (SCP), order management systems (OMS), warehouse management systems (WMS), manufacturing execution systems (MES), and transportation management systems (TMS). Each deals with the supply chain from its own silo with few if any links to other types.

1998-2001

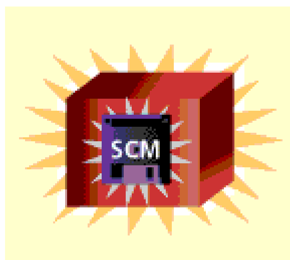
Current development efforts are focused on linking and integrating each of the six software types. The intent is to create packages that deal with the supply chain as a continuum rather than in individual stages. For instance, last year there was considerable focus on connecting WMS with TMS packages. The next phase is building links between OMS and WMS. Additional integration is underway too. Despite these efforts, each of the six is maintaining its pre-existing identity.

2001-2004



Once all six of the current software types have been initially integrated, their names are likely to still be in use. In part, this will be a reflection of the level of integration actually achieved. It will also be a result of the relative strengths of various packages. In any regard, it will only be a short term phenomenon.

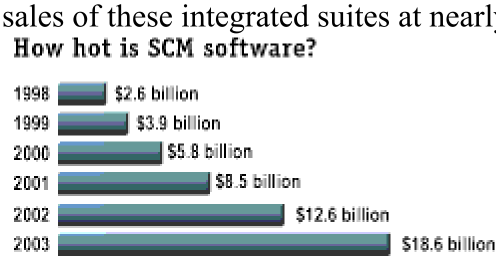
BEYOND 2004



The ultimate goal is to create fully integrated supply chain management software packages. They will perform all key planning and execution functions needed to take time, cost, and labor out of the supply chain. As such, they will be complex and costly, some even think as challenging to install as ERP is today. Nevertheless, leading companies will likely find them to be essential to maintaining or improving their market position.

How hot is SCM software

According to the market research firm AMR Research, there will be a 48% compound annual growth rate for supply chain management software between now and 2003. That will put annual sales of these integrated suites at nearly $19 billion. [5]



SCM Vendors

Some of the SCM Vendors for the various components are as follows:

- Enterprise resource planning (ERP) - Baan, Oracle, PeopleSoft, SAP
- Supply chain planning (SCP) - IMI, American Software, Optum
- Order management systems (OMS) - Kewill, McHugh Software
- Manufacturing execution systems (MES) - AutoSoft Corp, SynQuest, Cube Tech
- Warehouse management systems (WMS) - HK Systems, J.D Edwards, Cambar Software
- Transportation management systems (TMS) - Intentia, EXE, C T Logistics

Leading Vendors: Manugistics & I2

Manugistics [6] offers the following software products, all of which are SCM products:

- Demand Planning
- Supply Planning
- Manufacturing Scheduling
- Transportation Management
- Supply Chain Navigator
- NetWORKS

The first four of these are typical SCM products. Supply Chain Navigator is a graphical SCM modeling tool that allows the user to simulate supply chain changes, including cost analysis, and to view the current status of all elements in the supply chain. After assessing alternatives, changes to the supply chain can be made using drag-and-drop graphical tools.
I2 has a product line similar to Manugistics. Offered as the Rhythm product suite [6], it includes:

- Demand Planning
- Distribution Planning
- Manufacturing Planning
- Transportation Planning
- Advanced Scheduling

Summary and Conclusion

Selecting software for supply chain management presents a daunting task in a large, multifaceted organization - but also for a small, single process business. Typically, the software experts lack supply chain expertise and the supply chain experts often possess limited understanding of information technology. Furthermore, systems alone rarely provide the solution to supply chain problems; instead, most system implementation efforts require process reengineering and occasionally major organizational upheaval [7].

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