

Supply Chain Management Systems: Architecture, Design and Vision

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A supply chain is a network of suppliers, factories, warehouses, distribution centers and retailers, through which raw materials are acquired, transformed, produced and delivered to the customer. The supply chain consists all the activities associated with the flow and transformation of goods from the raw material stage, through to the end user, as well as the associated information flows. Supply Chain Management is a set of synchronized decision & activities, utilized to effectively integrate suppliers, manufacturers, transporters, warehouses, retailers & customers so that the right product or service is distributed at the right quantities, to the proper locations & at the appropriate time, in order to minimize system wide costs while satisfying customer service level requirements. Information Technology application has brought enormous opportunities to supply chain management and making it grow at an even faster pace. Role of information is crucial & drives the entire supply chain system. For many companies, it has become clear that a supply chain that flows information and material effectively can be a significant differentiator, the competitive winner. Supply chain management system can be regarded as a type of distributed information management system, of which agent technology provides the ultimate in its development. This paper reviews the state of the art of conventional supply chain applications provided by top manufacturing software vendors. The paper reviews the implemented systems of supply chain management and presents the requirements for the next generation of supply chain management systems.

INTRODUCTION

Supply Chain Management is a major concern in many industries as Companies realize the importance of creating an integrated relationship with their suppliers and customers. According to the *Global Supply Chain Forum (GSFC)*, Supply Chain Management is defined as “the integration of key business processes from end user through original suppliers that provide products, services, and information that add value for customer and other stakeholders.”(Chan & Qi, 2003). We can only talk about Supply Chain Management, if there is a proactive relationship between a buyer and supplier and the integration is across the whole supply chain, not just first tier suppliers.(Cox,2004). The supply chain encompasses all activities associated with the flow and transformation of goods from the raw materials stage, through to

the end user, as well as the associated information flows.(Vollmann & Berry 2005) says Supply chain management (SCM) is the integration of all these activities through improved supply chain relationships, to achieve a sustainable competitive advantage [1]. For many companies, it has become clear that a supply chain that flows information and material best can be a significant differentiator, the competitive winner. The Internet is dramatically affecting the way products are bought and distributed. In Internet business, companies have to solve a major supply chain problem - how to efficiently incorporate, integrate, and utilize the rich inflows of information provided by multiple suppliers. Agents are now being regarded as an important technology to assist in helping to solve the problems of information overload and management [2]. Collaborative information agents will play a major role in the supply chain management. This paper reviews the implemented systems of SCM, and presents the requirements for next generation of SCM system. Finally, in end, multi agent system is thought as a vision of approach to next generation of SCM systems.

OVER VIEW OF SUPPLY CHAIN MANAGEMENT (SCM)

The pressures of the global competition and the need for the extensive inter-organizational, collaboration is forcing industries to streamline their supply chains to make them agile, flexible and responsive. The old way of delivering product was to develop relatively inaccurate projections of demand, then manufacture the product and fill up warehouses with finished goods. Aided by electronic data exchange and worldwide communications, inter-relationships among warehousing, transportation, manufacturing, procurement, and order management functions were discovered. The implemented SCM systems and techniques have substantially increased overall productivity, improved inventory and shipping accuracy rates, improved inventory reduction, improved forecasting accuracy, and reduced lead time and non-value-added activities [3].

Six characteristics define current supply chain management philosophy: -

- Shared Information
- Organizational Relationships
- Inventory Management
- Total Pipeline Coordination
- Readiness to adopt Flexibility
- Costing Issues

Supply Chain Management Applications: -

SCM software applications provide real-time analytical systems that manage the flow of product and information throughout the supply chain network. They are designed to enhance SCM operations - supplier sourcing, production planning, inventory planning, transportation planning, demand planning, and so on. At present, the SCM solutions are fragmented along these functional applications into specific spaces – for example, advanced planning and scheduling for the manufacturing plant, demand planning for the sales group, and transportation planning for the distribution center. Table 1 lists top 10 manufacturing software vendors and their product suites (conducted by Plant-Wide Research Co., North Billerica, MA), where,

- APS: Advanced Planning and Scheduling
- BI: Business Intelligence
- CM: Component Management
- CRM: Customer Response Management
- EAM: Enterprise Asset Management
- EM: Enterprise Resource Planning
- MES: Manufacturing Execution System
- PDM: Product Data Management
- SCE: Supply Chain Execution
- FDM: Forecasting & Demand Management
- SCP: Supply Chain Planning
- SSC: Secure Supervisory Control
- T&L: Transportation & Logistics

- WM: Warehouse Management.

The trend, however, is to consolidate these disparate functions into a comprehensive SCM suite. With the emergence of new telecommunications and information technology, new SCM systems, linking suppliers, manufacturers, distributors, retail outlets, and ultimately, customers seamlessly together, throughout the world, exchanging information almost instantly, are now being developed and studied.

**TABLE 1
TOP 10 MANUFACTURING SOFTWARE VENDORS AND THEIR APPLICATIONS**

Company	Software Categories	Product Suite
SAP America (www.sap.com)	APS, CRM, E-Business, ERP, PDM, PDM, CM, Groupware, SCP	SAP R/3
Oracle Corp. (www.oracle.com)	APS, CRM, E-Business, ERP, FDM, PDM, SCP	Oracle Applications
J.D. Edwards (www.JDEdwards.com)	APS, CRM, E-Business, ERP, FDM, SCP, WM, Groupware,	OneWorld, ActivEra, Genesis, WorldVision,
Baan Company, The (www.ban.com)	APS, CRM, ERP, PDM, CM, Groupware, SCP	Baan ERP
JBA International (www.jbaworld.com)	ERP, WM	System 21
I2 Technologies (www.i2.com)	APS, E-Business, FDM	RHYTHM, Optiflex, Think Demand
InterBiz Supply Chain Group (www.cai.com)	APS, BI, E-Business, ERP, FDM, DM, CM, Groupware, SCE, SCP,	InterBiz Solutions
Foxboro Co., The (www.foxboro.com)	MES, SSL	I/A Series Intelligent Automation
Peoplesoft, Inc (www.peoplesoft.com)	APS, BI, CRM, E-Business, ERP, CM, SCP	Peoplesoft Solutions
Manugistics (www.manugistics.com)	E-Business, SCP	Manugistics6

Enterprise Resource Planning (ERP) Vs. Supply Chain Management (SCM)

ERP is a strategic tool, which helps the company to gain competitive edge by integrating all business processes and optimizing the resources available. It equips the enterprise with the necessary capabilities to integrate and synchronize the isolated functions into streamlined business processes. ERP is being implemented in almost all types of organizations irrespective of its mode and spread of operation. However, ERP is sometimes confused with SCM [4].

(1) An enterprise system (such as ERP) is a system for a single company, attempting to integrate most of the business activities within that company. But a supply chain almost always spans across multiple companies, and involves only a relatively few people and resources within each company. One enterprise may be involved in many supply chains, for different product lines or Different markets for the same product line.

(2) The most distinguishing characteristic of ERP systems is their comprehensiveness. Some ERP systems broadly cover sales and distribution, business planning, production planning, shop floor control, and logistics. On the surface, this would seem to cover anything that SCM claims to provide. However, effective SCM enables to make informed decisions along the entire supply chain. Supply chain should be planned and optimized as a continuous and seamless activity that integrates all planning functions across the supply chain. It goes beyond traditional planning solutions by simultaneously considering demand, capacity and material constraints.

(3) Real-time information throughout the entire supply chain is needed to make correct decisions, and SCM products are designed to gather that real-time information. Traditional ERP systems generally do not gather real-time information from everywhere in the supply chain - on the contrary, they often contain static, dated information only related to subsections of the supply chain. Getting answers from an

overloaded ERP systems may take hours, whereas getting them from a separate, memory resident, always running SCM system may take minutes or seconds.

NEXT GENERATION OF SUPPLY CHAIN MANAGEMENT

Today, virtually all industries and most companies are facing a more dynamic environment - that is, greater uncertainty of demand, shorter product life cycles, greater demand for mass customization, more significant seasonality, higher competitive intensity, fewer warehouses, more third-party service, new cost/service balance, globalization, channel integration, and so on. However, almost all existing supply chain systems are featured in one or more of the following demerits: product availability focus; reactive rather than proactive; long lead times; uncertainty throughout; lack of flexibility in systems; performance measured functionally; poorly defined management process; no real partnerships; product price lead relationship; paper, phone, fax based relationship; performance measures insufficient. In order to overcome all of these shortcomings, next generation of supply chain management systems are required to meet the needs.

Requirements for Next Generation of SCM

The next generation of SCM should possess the following set of characteristics: integrated, customer-centric, distributed; having interoperability, scalability; with open and flexible infrastructure; autonomous, capable of self-organization and reconfiguration, coordination and negotiation; with optimization and learning mechanism so evolve in and adapt to the dynamic marketplaces; synchronized and agile (to handle rapid change); involving production planning and scheduling; capable of making forecasts accurately; both active and proactive; compatible with globalized manufacturing; seamlessly Integratable with E-commerce and M-commerce; and proper performance-measurements. These characteristics are interrelated.

Integration: The keyword that appears throughout the whole new generation of supply chain is integration, because it spells the difference between the old view of logistics as the discrete functions of transportation and distribution, and the new vision of SCM that links all the players and activities involved in converting raw materials into products and delivering those products to consumers at the right time and at the right place in the most efficient manner. Business success will be increasingly dependent on functional integration.

Integrate with E-Commerce and M-Commerce: While e-commerce offers some exciting opportunities to improve SCM effectiveness by lowering costs and increasing the speed of order-to-delivery, it is by no means the first stop on the path to having highly competitive e-supply chain capabilities. E-commerce is digitally connecting the entire world into one big network of supply chains. E-commerce already has, and will continue, to fundamentally change business to- business [B2B], business-to-consumer [B2C], and business-to-employee [B2E] supply chain models. Mutually, E-commerce requires intelligent supply chains that provide instant access to the right data anywhere. With the new development of mobile communication and wireless technology, it will usher in the next wave of electronic commerce - the so-called m-commerce. It allows users to access systems whenever they want without physically being connected to the network.

Engage in collaborative supply chain planning, scheduling and optimization: SCP enables companies to intelligently manage the activities of the supply chain. Collaborative SCP involves improving the coordination and information sharing for all activities, from supplier's supplier to customer's customer. In addition to coordinating activities across the entire product life cycle, SCP involves a comprehensive solution including changes made in alliance strategy, business process, performance measures and technology. The appeal of APS solutions to manufacturers is obvious: companies can optimize their supply chains to reduce costs, improve product margins, lower inventories, and increase manufacturing throughput. Exploiting Internet for collaborative SCP provides a critical link for sharing information, planning & scheduling supply chain activities.

Integration of performance measurement: The performance of a supply chain activity should be measured globally. The most notable measures for customer service include short order lead times and in-stock availability. Such measures also may include order and invoice accuracy, access to information on order status, ability to respond to customer inquiries, and so on.

Customer-centric service: Providing online commitments for orders and schedules is key to enhancing customer service and gaining a competitive advantage. Many companies envision this capability as part of the SCM strategy. Also, dynamic webpage creation capability is needed to a customer-centric system. The next evolutionary stage of SCM solves customer problems by. [5]

- Gathering & analyzing knowledge & personalized data about customers, their problems, and their unmet needs.
- Identifying partners to perform the functions needed in the demand chain.
- Moving the functions that need to be done to the channel member that can perform them most effectively and efficiently.
- Sharing with the other chain members' knowledge about consumers and customers, available technology, and logistics challenges and opportunities.
- Developing products, services and executing the best logistics, transportation, and distribution methods to deliver products and services to consumers in the desired format.

Globalization: SCM is being viewed as a global strategic issue that recognizes the significant cost and service improvements to be gained by viewing the supply chain as a whole encompassing everything from initial supplier to final customer fulfillment. Supply chain globalization is the process of corporate structuring that focuses all supply chain applications on a single, worldwide market, creating growth and profit opportunities through synergies and efficiencies in engineering, sales, purchasing, production and distribution. Globalized supply chain supports multilingual translations.

Synchronization: Next generation of supply chain suites will synchronize supplier planning, production planning, logistics planning, and demand planning. These solutions will provide a comprehensive view of all supply chain activities and enable upper management to make more informed tradeoff decisions. Supply chain synchronization is the secret to improving customer service without increasing inventory investment. A capable supply chain matches the rate of supply with the rate of demand at each node. It synchronizes the product mix that is in production with the product mix that customers order.

Agility: SCM systems must be able to process transactions rapidly and accurately. In today's business environment it is important that a business be agile as well as efficient. Organizations must focus on moving information and products quickly through the entire supply chain, distribution, assembly manufacture and supply.

Inter-enterprise collaboration: Collaboration entails sharing once-distinct proprietary business processes. To illustrate, a manufacturer and retailer may collaborate to determine the best forecast for each product category. Or a supplier and manufacturer may collaborate to create a new product. In fact, SCM rests upon the concept of trading partners and extended partners collaborating for competitive advantage.

Capture and Manage demand: Next generation SCM solutions are designed to enable demand capture for intra- and inter-enterprise constituents through a distributed architecture with web browser access. In this scenario, the demand planner is designed as an integral part of a single data model solution that provides tight integration between demand & supply planning. Once demand has been captured in the system, the demand planner can aggregate & match demand against supply constraints to determine the appropriate commitment for a customer's forecast.

Webification: Web-enabled technologies that speed the flow of information and decision-making across the supply chain offer significant competitive advantage. Internet technology can deliver what the customer wants - timeliness, accuracy and low cost. Customers previously had to call a customer service representative, while now orders can be taken and tracked online, and a customer's credit status can be verified online. This provides a tighter integration between consumers and producers. In B2B marketplace, companies are beginning to shift SCM functions themselves to the web.

Coordination: In order to operate efficiently, supply chain applications must work in a tightly coordinated manner. However, the dynamics of the enterprise and of the world market make this difficult. In many cases, unpredictable events can not be dealt with locally, i.e. within the scope of a single supply chain "agent", requiring several agents to coordinate in order to revise plans, schedules or decisions.

Learning: Supply chain is a complex system - large, open, dynamic, and unpredictable. For such system it is extremely difficult and sometimes even impossible to correctly & completely specify these systems a priori, that is, at the time of their design and priori to their use. Next generation of SCM would deal with the usage of machine learning concepts to treat supply chain activities. It must have the capability to learn

to change, be able to adapt to new ways of doing business as a flexible information system, & have the vision to recognize the need for & the direction of change.

Distributed Information Management System (DIMS)

Next generation of SCM system is a type of DIMS. In I.T. era, the more information that becomes available electronically gives people potentially greater diversity and choice, but means that more time will be expended in sorting the relevant information from the irrelevant. The large number of applications, communication protocols and data formats result in a heterogeneous network information system, and the dynamic nature of information repositories causes the inconsistent and incomplete information distribution on Internet. The aim of DIMS is to develop and provide methods for managing change and evolution, not just discovering or retrieving, in a large, distributed networked environment. Multi agent systems are the best way to characterize or design distributed information management systems. Multi agent environments provide an infrastructure specifying communication and interaction protocols. They are typically open and have no centralized designer. They contain agents that are autonomous & distributed, & may be self-interested or cooperative.

AGENT-BASED SCM: THE VISION

An agent is a computer system that is situated in some environment, and that is capable of autonomous action in this environment in order to meet its design objectives [7]. A generic agent has a set of goals (or intentions), certain capabilities to perform actions, and some knowledge (or beliefs) about its environment. To achieve its goals, an agent needs to reason about its environment (as well as behaviors of other agents), to generate plans and to execute these plans. Intelligent agents - regarded as software entities that exhibit autonomy and environmental awareness enabling their interaction with the environment (e.g. with other agents) to achieve internal goals - have become very popular in the past decade. Agents are needed to coordinate - either through cooperation, competition, or a combination of both. These agent "societies" are called multi agent systems (MAS). Multi agent systems may be regarded as a group of agents, interacting with one another to collectively achieve their goals. By drawing on other agents' knowledge and capabilities, agents can overcome their inherent bounds of intelligence. Many real-world systems are naturally distributed by spatial, functional, or temporal differences, therefore, MAS can easily fit into such distributed environments. There are a wide range of application domains that are making use of agent-based systems: enterprise applications; B2B applications; process control; personal agents; information management tasks (searching for information, information filtering, information monitoring, data source mediation, interface agents/personal assistants); nomadic computing applications [8].

Agents can help transform closed trading partner networks into open markets and extend such applications as production, distribution, and inventory management functions across entire supply chains spanning diverse organizations.

CONCLUSIONS

The review of commercial SCM applications has presented the state of the art in the field of SCM. Some requirements have been proposed for next generation of SCM systems. Agent-based SCM systems provide a single solution for managing the next generation of SCM in a multi-plant, inter-enterprise environment. Future efforts seem to be focused only on the Multi agent-based approaches to integrated and globalized SCM. All achievements in agent-based SCM systems implementation can be extended to develop other distributed information management systems.

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