Overview of Information Technology tools for Supply Chain Management

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ABSTRACT

Information Technology (IT) and its use in organizations and across the supply chain has become a determinant of competitive advantage for many corporations. This paper focuses the usage of IT tools for Supply Chain Management (SCM). It also highlights the contribution of IT in helping to restructure the entire distribution set up to achieve higher service levels and lower inventory and lower supply chain costs.

An overview and tangible benefits of the existing IT tools that are widely deployed is also provided with focus on existing configurations considerations, available applications. The role of existing communication technologies in making IT an enabler of SCM is highlighted by addressing a range of different point and enterprise solutions in a variety of supply chain settings.

Critical IT demonstrations and implementations in SCM are discussed. Fundamental changes have occurred in today's economy. These changes alter the relationship we have with our customers, our suppliers, our business partners and our colleagues. Reflection on the evolving and emerging Information Technology trends like Software Agents, RFID, Web Services, Virtual Supply Chains, Electronic Commerce and Decision Support Systems further highlights the importance of IT in the context of increasingly global competition. The rapid adoption of the Internet for communication with all stake-holders seems to reflect the potential of the new-age communication media.

KEY WORDS

Agent, Bar coding, Communication Technologies, Demand, Decision Support Systems**,** Distribution, EDI, E-Auction, E-Procurement, E-Supply Chain, E-Tailing, Electronic Commerce, Electronic point of sale, Enterprise system, ERP, Extended Enterprise, FIPA, Forecasting, Information, Information Systems, Information Technology, India, Integrated Supply Chain, Inventory Management, IT tools, Logistics, Material Requirements Planning, Planning, Retail, RFID, RF Tags, Strategy, Software Agents, Supply Chain Management, Transportation Management System, Universal Description, Discovery And Integration, Virtual Supply Chains, Warehouse Management System, Web Services, XML

1. INTRODUCTION TO SUPPLY CHAIN MANAGEMENT

Supply chain management (SCM) is the management of a network of interconnected businesses involved in the ultimate provision of product and service packages required by end customers (Harland, 1996). The term was coined by Keith Oliver, a Booz Allen Hamilton executive in 1982.

Supply Chain Management spans all movement and storage of raw materials, work-in-process inventory, and finished goods from point-of-origin to point-of-consumption (supply chain). Supply Chain Management encompasses the planning and management of all activities involved in sourcing, procurement, conversion, and logistics management activities. Importantly, it also includes coordination and collaboration with channel partners, which can be suppliers, intermediaries, third-party service providers, and customers. In essence, Supply Chain Management integrates supply and demand management within and across companies. More recently, the loosely coupled, self-organizing network of businesses that cooperates to provide product and service offerings has been called the Extended Enterprise (Ross 2006).

Supply chain management must address the following problems:

- Distribution Network Configuration: Number, location and network missions of suppliers, production facilities, distribution centers, warehouses, cross-docks and customers.

- Distribution Strategy: Including questions of operating control (centralized, decentralized or shared); delivery scheme (e.g., direct shipment, pool point shipping, Cross docking, Direct Store Delivery (DSD), closed loop shipping; mode of transportation (e.g., motor carrier, including truckload, parcel; railroad; ocean freight; airfreight); replenishment strategy (e.g., pull, push or hybrid); and transportation control (e.g., owner-operated, private carrier, common carrier, contract carrier, or third party logistics (3PL)).

Supply chain execution is managing and coordinating the movement of materials, information and funds across the supply chain. The flow is bi-directional. The elements are:

- Information: Integration of and other processes through the supply chain to share valuable information, including demand signals, forecasts, inventory, transportation, and potential collaboration etc.
- Inventory Management: Quantity and location of inventory including raw materials, work-in-progress (WIP) and finished goods.
- Cash-Flow: Arranging the payment terms and the methodologies for exchanging funds across entities within the supply chain.

Recent development in technologies enables the organization to avail information easily in their premises. These technologies are helpful to coordinates the activities to manage the supply chain. The cost of information is decreased due to the increasing rate of technologies. In the integrated supply chain model (Fig.1.1) bi-directional arrow reflect the accommodation of reverse materials and information feedback flows. Manager needs to understand that information technology is more than just computers. Except computer data recognition equipment, communication technologies, factory automation and other hardware and services are included.

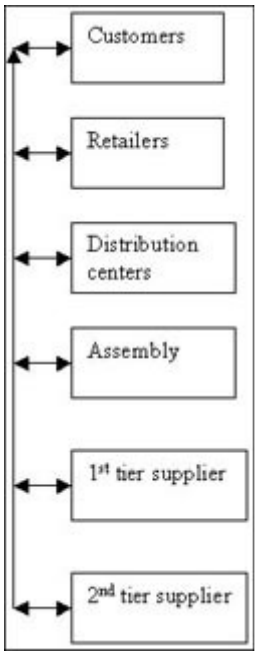

Fig 1 - Integrated supply chain model

2. INFORMATION TECHNOLOGY AS AN ENABLER OF SUPPLY CHAIN MANAGEMENT

Prior to 1980s the information flow between functional areas within an organization and between supply chain member partners were paper-based. The paper-based transaction and communication is slow. During this period, information was often overlooked as a critical competitive resource because its value to supply chain members was not clearly understood. IT infrastructure capabilities provide a competitive positioning of business initiatives like cycle time reduction, implementation, implementing redesigned cross-functional processes.

Three factors have strongly impacted this change in the importance of information. First, satisfying in fact pleasing customer has become something of a corporate obsession. Serving the customer in the best, most efficient and effective manner has become critical. Second information is a crucial factor in the managers' abilities to reduce inventory and human resource requirement to a competitive level. Information flows plays a crucial role in strategic planning.

Information sharing between partners in the supply chain is also crucial and these integration attempts are accompanied by IT initiatives. Such IT initiatives include:

- Use of bar-coding in logistics systems
- Use of EDI to communicate between branches
- Use of Material Requirements Planning
- Enterprise Solutions like ERP
- Internet and Web Services for communication between partners

Early studies on the impact of Electronic Data Interchange (EDI) on Just-in-Time (JIT) shipments in the automobile industry showed significant earnings with lowered shipment errors (Srinivasan et al, 1994).

In the seven principles of SCM, Anderson et al (1996) pointed out that it is necessary to develop a supply chain-wide technology strategy that supports multiple levels of decision making and gives a clear view of the flow of products, services, and information. For this an IT system, that integrates capabilities of three essential kinds.

For the short term, the system must be able to handle day-to-day transactions and electronic commerce across the supply chain and thus help align supply and demand by sharing information on orders and daily scheduling. From a mid-term perspective, the system must facilitate planning and decision making, supporting the demand and shipment planning and master production scheduling needed to allocate resources efficiently. To add long-term value, the system must enable strategic analysis by providing tools, such as an integrated network model, that synthesize data for use in high-level "what-if" scenario planning to help managers evaluate plants, distribution centres, suppliers, and third-party service alternatives.

The functional roles of IT in SCM have been outlined as follows (Auramo et al 2005):

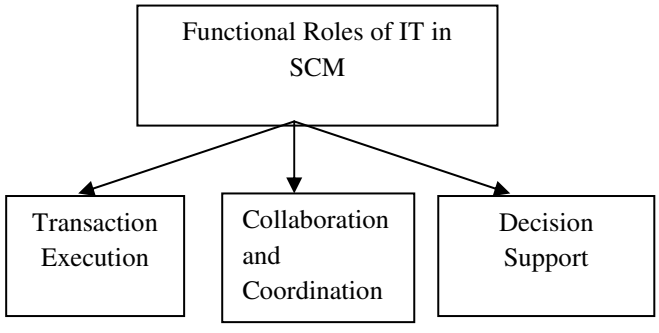

Fig. 2 – Functional Roles of IT in SCM

3. OBJECTIVES AND BENEFITS OF INFORMATION TECHNOLOGY IN SUPPLY CHAIN MANAGEMENT

The objectives of IT in SCM are (Simchi-Levi, 2003):

- providing information availability and visibility;
- enabling a single point of contact for data;
- allowing decisions based on total supply chain information; and
- enabling collaboration with partners

IT in SCM enables great opportunities, ranging from direct operational benefits to the creation of strategic advantage. It changes industry structures and even the rules of competition. IT is key in supporting companies creating strategic advantage by enabling centralized strategic-planning with day-to-day centralized operations. Infact supply chain become more market-oriented because of IT usage.

Cisco reported savings of $500 million by restructuring its internal operations and integrating processes with suppliers and customers with the help of web-based tools (Berger, 2000). The Wal-Mart & P&G experiences demonstrate how information sharing can be utilized for mutual advantage. Through sound information technologies, Wal-Mart shares point of sale information from its many retail outlet directly with P&G and other major suppliers Anderson et al (1996).

Celestica, one of the world's largest electronic manufacturing services companies, has applied a web-based IT tool to regulate its global supply base (Shore, 2001). IT has helped Celestica to improve its responsiveness to customers, thus helping its customer, Dell to maintain its delivery promise to end-users.

4. CHALLENGES IN IMPLEMENTING INFORMATION TECHNOLOGY IN SUPPLY CHAIN MANAGEMENT

Any company that has undertaken the mission of implementing an integrated supply chain management strategy with the use of IT tools knows that one of the greatest challenges it faces is the significant change in internal culture that is required to make the supply chain redesign successful. It is not an easy thing, to re-condition people to accept change, especially in organizations where a certain mindset has prevailed for many years. However difficult it may be to accomplish, change can be implemented successfully when directed by a strong and knowledgeable leader, who understands the tools available for achieving positive change, as well as their role in initiating and sustaining these changes.

Integrating new applications with existing and legacy systems could also pose problems. Incompatible systems at buyer and vendor facilities are another management challenge to tackle. Data sharing with diverse stakeholders like suppliers and customers, filtering and mining data generated and finding "business" value of the data are other issues.

Disconnected enterprise systems create data redundancy, errors and can lead to costly business inefficiencies. Poor coordination between enterprise systems leads to flawed production plans, increased supply chain pressure and poor customer service. Lack of visibility of orders, schedules and shipments can lead to costly administrative decision making processes.

According to Macleod (1994), supply chain managers increasingly want to automate all of the supply chain, from forecasting to distribution, and to link every element of the chain. More and more companies want an integrated solution to enable them to see the entire supply chain at once. For instance, they want to know that if they drill down to forecast, they can see the demand history, which is a combination of data which have come from sales order processing, inventory management and the warehousing system.

Van Oldenborgh (1994) says that the ability to reduce human intervention yet oversee minutely the flow of parts and products along the entire length of the supply chain can help dramatically in cutting logistics costs and boosting customer satisfaction. Unfortunately for many midsize companies in these times of economic recession, such clarity in global distribution remains largely restricted to major multinationals with deep pockets and volumes large enough to justify the hefty initial investment in IT that can run into millions of dollars.

Towill (1997) sums up "To survive, let alone win, a company must be part of one or more supply chains producing world class performance". Hence companies need to work together and optimize the complete pipeline by establishing a seamless supply chain to maximize their market share. Only with this support of the holistic chain concept can further significant and radical improvements in individual business performance be realized. Process manufacturers and IT system vendors are working to develop a filter to sift through the barrage of data from process control systems to move important information to higher level IT systems.

5. EXISTING INFORMATION TECHNOLOGY TOOLS AND APPLICATIONS IN SUPPLY CHAIN MANAGEMENT

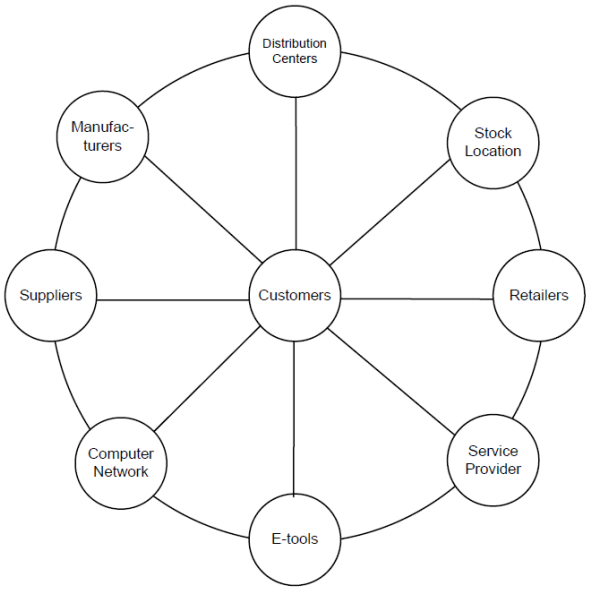

Fig 3 – IT tools in SCM

5.1 Electronic Data Interchange (EDI)

Introduced in the 1970s and popularized in the 1980s, Electronic Data Interchange (EDI) technology has been widely used by firms in supply chains to facilitate transactions and information exchanges. EDI is defined as computer to computer exchange of structured data for automatic processing. EDI is used by supply chain partners to exchange essential information necessary for the effective running of their businesses. These structural links are usually set up between organizations that have a long-term trading relationship.

For example, some multiple retailers will supply electronic point of sale (EPOS) data directly to suppliers, which in turn triggers replenishment of the item sold. Therefore, the consequence of this type of strong link those suppliers will be able to build a historical sales pattern that will assist their own demand forecasting activities. Because there is no need for employees to collate the information manually, EDI has many benefits, for examples, it is providing timely information about its customers' sales as well as highly accurate and very efficient. Moreover, it is utilized for sending invoices, bills of lading, confirmation of dispatch, shipping details and any information that the linked organizations choose to exchange (Rushton et al., 2000).

The main advantages of using EDI are to enter only informative needs on the computer system once, and then it is able to speed of transaction and to reduce cost and error rates. Other benefits of EDI are Quick process to information, Better customer service, reduced paper work, increased productivity, improved tracing and expediting, Cost efficiency and improved billing. Through the use of EDI supply chain partners can overcome the distortions and exaggeration in supply and demand information by improving technologies to facilitate real time sharing of actual demand and supply information.

Although companies gain a lot of benefits from EDI, it is often the mismatch between EDI's expectations and the company's activities undertaken to achieve the desired performance. Also larger organizations are major adopters of EDI, whereas Small and Medium Enterprises (SME) often do not use EDI.

5.2 Bar coding and Scanner

Bar Codes are the representation of a number or code in a form suitable for reading by machines (Rushton et al., 2000). Bar codes are widely used throughout the supply chain to identify and track goods at all stages in the process. Bar codes are a series of different width lines that may be presented in a horizontal order, called ladder orientation, or a vertical order, called picket fence orientation. For example, goods received in a warehouse may be identified by the warehouse management system and added to stock held in the warehouse. When put away, the bar code is used to associate the storage location with the bar-coded stock, and on dispatch the stock record is amended. The use of bar codes can speed up operations significantly. On the other hand, the problems can occur if bar codes are defaced or the labels fall off in transit. The maintenance management must be applied for extending the long-life period of this equipment.

Bar code scanners are most visible in the check out counter of super markets and hyper markets. This code specifies name of product and its manufacturer. Other applications are tracking the moving items such as components in PC assembly operations, automobiles in assembly plants.

In 1983, with barcodes printed on most goods, Wal-Mart introduced checkout scanners in all its stores. They updated inventory numbers for individual items at point of sale and enabled headquarters to easily aggregate sales and inventory data at its centralized IT department. Later in 1987, a satellite communications network installation linked all the stores with the headquarters with real-time inventory data.

5.3 Enterprise Resource Planning (ERP) Systems

Enterprise Resource Planning (ERP) Systems are Enterprise-wide Information Systems used for automating all activities and functions of a business. These are transaction-based information systems that are integrated across the whole business. Basically, they allow for data capture for the whole business into a single computer package which's give a single source for all the key business information activities, such as customer orders, inventory and financials.

Many companies now view ERP systems from vendors like Baan, SAP and People soft as the core of their IT infrastructure. ERP systems have become enterprise-wide transaction processing tools which capture the data and reduce the manual activities and task associated with processing financial, inventory and customer order information. ERP system achieve a high level of

integration by utilizing a single data model, developing a common understanding of what the shared data represents and establishing a set of rules for accessing data.

In addition to the huge costs that are involved in procuring an ERP application, installation of such systems will entail widespread change within the organization. It will have implications in terms of Business Process Reengineering (BPR), changes in organizational structure, people and change management. Many companies have benefited from using this system whilst some have experienced severe problems with their application. Generally, they also require a lot of customization and training for each user.

5.4 Warehouse Management Systems

Warehouse management systems are systems that control all the traditional activities of warehouse operations. Areas covered usually include receipt of goods, allocation or recording of storage locations, replenishment of picking locations, production of picking instructions or lists, order picking, order assembly and stock rotation. Some systems are used in conjunction with radio frequency (RF) communication equipment. This equipment can be mounted on fork-lift trucks. The warehouse management system communicates with the RF system and directs the activities of the warehouse staff (Thongchattu et al, 2007). For example, when picking that it will provide the tasks for the operative to carry out. Once the task is complete the operative updates the system and is directed to the next task. This has the advantage of updating the stock holding in real time.

There are highly sophisticated systems that control the operations of fully automated warehouses. This may include automated storage and retrieval systems (AS/RS), automated guided vehicles (AGVs), and the many other devices that are relatively common in today's modern warehouse such as, conveyors, carousels, sortation systems, etc. A number of computer models have now been developed to assist in the planning of warehouse design and configuration. These are generally very sophisticated 3D simulation models that provide a graphic, moving illustration on the computer screen of the layout of the warehouse.

5.5 Transportation Management Systems

Transportation Management Systems provide more visibility into shipments and orders. Scheduling issues are also addressed on time. Multiple transportation options can be explored as a result of earlier visibility into the supply chain. Timely communication and status reports can also be obtained. By having control on its supply chain, businesses can make efficient routing decisions.

An example of such a system is developed by Target Corporation and NTE. Initially Target was making transportation requests manually for inbound shipments. There was limited visibility for shipments and as a result of this; there were more number of less-than-truckloads, which was not cost-effective. Implementation of the new system resulted in target vendors submitting the relevant freight information electronically with increased speed and efficiency. The new system resulted in improved cost controls, better labour planning and reduced administrative overheads.

5.6 Inventory Management Systems

During the mid to late 1990s, retailers began implementing modern inventory management systems, made possible in large part by advances in computer and software technology. The systems work in a circular process, from purchase tracking to inventory monitoring to re-ordering and back around again.

Retailers such as Target, Lowe's and Best Buy stock tens of thousands of items from all over the world. Wal-Mart alone stocks items made in more than 70 countries, according to its corporate Web site. It is estimated that at any given time, the Arkansas-based retailer manages an average of $32 billion in inventory. With those kinds of numbers, having an effective, efficient inventory control system, or inventory management system, is imperative. Wal-Mart's system helps it maintain its signature "everyday low prices" by telling store managers which products are selling and which are taking up shelf and warehouse space.

Inventory management systems are the rule for such enterprises, but smaller businesses and vendors use them, too. The systems ensure customers always have enough of what they want and balance that goal against a retailer's financial need to maintain as little stock as possible. Mismanaged inventory means disappointed customers, too much cash tied up in warehouses and slower sales. Factors such as quicker production cycles, a proliferation of products, multi-national production contracts and the nature of the big-box store make them a necessity.

Modern inventory management systems must have the ability to track sales and available inventory, communicate with suppliers in near real-time and receive and incorporate other data, such as seasonal demand. They also must be flexible, allowing for a merchant's intuition. And, they must tell a storeowner when it's time to reorder and how much to purchase.

6. EMERGING AND NEW INFORMATION TECHNOLOGY SOLUTIONS FOR SUPPLY CHAIN MANAGEMENT

6.1 Radio Frequency Identification (RFID)

The bar code was intended to improve efficiencies in the retail space, but the bar code cannot uniquely identify the specific object such as when items are produced, the lot of the items was made and when will the items expire. RFID was able to take care of these issues.

Both RFID and Bar codes are indeed, quite similar, both being auto-ID technologies, which are intended to provide item identification. The primary difference is the reading

data from the items. In bar coding, the reading device scans a printed label with optical laser or imaging technology and in RFID; the reading device scans a tag by using radio frequency signals

The need to minimise operating costs and employed assets has resulted in the adoption of radio frequency technology to track inventories within a supply chain down to the item level, thus reducing channel volume and enhancing forecasting and planning capabilities (D'Avanzo et al., 2004). RFID is a type of automatic identification system. The purpose of an RFID system is to enable data to be transmitted by a portable device, called a tag, which is read by an RFID reader and processed according to the needs of a particular application. The data transmitted by the tag may provide identification or location information, or specifics about the product tagged, such as price, colour, date of purchase, etc. (EPIC, 2002).

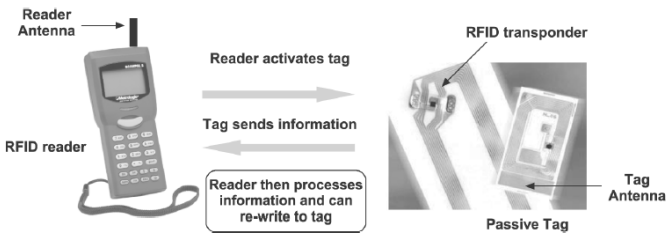

Figure 4 - RFID reader and tag communication flow diagram.

The tag is a microchip connected to a small antenna. The chip can capture a certain amount of data. The radio waves via which the tag and the reader communicate with each other can vary from low frequency (125 KHz) to microwave frequency (6 GHz). In the view of De Wachter and Pleysier (2004) the impact of RFID from a supply chain perspective includes: supply chain inversion, pressure on inventory, increased regulation and legislation, cost control, connectivity and visibility. Supply chain inversion concerns shifting from a push system to a pull system. Pressure on inventory is related to the use of RFID to reduce lead times of information through faster and more reliable registration and increased visibility in the supply chain. In terms of increased regulation and legislation, government regulation has led to more product information and safety requirements. RFID has been used for traceability and visibility of products. In terms of cost cutting, RFID is used to reduce labour costs. Other practical applications of RFID include authentication (Coronado et al 2004) and shrink prevention. In terms of authentication, the use of electronic sealing through RF-tags can warrant the authenticity and origin of a product. RF tags can be used to prevent non-malicious and malicious shrinks. Non-malicious shrink is associated with product handling. Malicious shrink is usually associated with theft and fraud. RFID systems have permitted the tracking of work-in-progress in automotive manufacturing and computer hardware manufacturing. Tags are re-used on other components or products or they may remain permanently fixed to the product to provide a secure serial number (Schneider, 2003). Original equipment manufacturers (OEM's), retailers and suppliers benefit equally from tracking inventories. In the view of Schneider (2003), retailers are very interested in turning the supply chain management industry into an RFID-dependent business as long as it is cost efficient. The drinks sector has been using RFID to track and manage its inventory to decrease product losses and increase revenues. For example, Scottish Courage Brewing Ltd, which owns 45 per cent of the UK draught beer market, has invested approximately $14 million (USD) in RFID to track 2 million kegs and 736 vehicles (Schneider, 2003). RFID has helped the brewing company enjoy significant reductions in keg losses and a more efficient delivery process. Since, the company deployed its RFID systems four years ago they have improved cycle times by four days.

Reno GmbH, one of Europe's largest shoe companies, operating more than 700 stores in 15 countries, plans to embed wireless RFID chips in shoes sold at stores across the continent. Reno has been using RFID technology to track product shipments from its factories to its stores for several years but has not yet used the technology to track individual products inside each store. These wafer-thin RFID chips are designed especially for shoes from its Asian production facilities. By having the RFID tags integrated into its shoes, Reno aims to curb theft for boxed products, those on display, and the shoes customers try on inside the stores.

Schiff Nutrition International, a midsize company based in Salt Lake City, maker of vitamins and nutritional supplements, is in the process of a deployment of the RFID technology in order to continue doing business with Wal-Mart. In 2003, Wal-Mart began setting deadlines for suppliers to start using RFID tags on their shipments.

6.2 Sofware Agents

Artificial Intelligence emerged into the paradigm of software agents with the application area of multi-agent systems. A software agent is a software system, which has attributes of intelligence, autonomy, perception or acting on behalf of a user. Agents can behave autonomously or proactively. The intelligence of an agent refers to its ability of performing tasks or actions using relevant information gathered as part of different problem-solving techniques such as influencing, reasoning and application specific knowledge. Java has been the most common tool for building such intelligent agents which are increasingly becoming mobile. Most of the agent platforms available today like AgentBuilder, Aglets, Voyager, JADE, ZEUS and FIPA are implemented using this language.

One classification of agents given by Haag (2006) suggests that there are only four essential types of intelligent software agents:

- Buyer agents or shopping bots - Buyer agents travel around network (i.e. the internet) retrieving information about goods and services. These agents, also known as 'shopping bots', work very efficiently for commodity products such as CDs,

books, electronic components, and other one-size-fits-all products. Amazon.com is a good example of a shopping bot. The website will offer you a list of books that you might like to buy on the basis of what you're buying now and what you have bought in the past.

- Monitoring and Surveillance Agents are used to observe and report on equipment, usually computer systems. The agents may keep track of company inventory levels, observe competitors' prices and relay them back to the company, watch stock manipulation by insider trading and rumors, etc.
- User agents (personal agents) - User agents, or personal agents, are intelligent agents that take action on your behalf. In this category belong those intelligent agents that perform tasks like checking your e-mail and sorting it according to the user's order of preference, and alert you when important emails arrive; Play computer games as your opponent or patrol game areas for you; Assemble customized news reports for you. There are several versions of these, including newshub and CNN.
- Data mining agents - This agent uses information technology to find trends and patterns in an abundance of information from many different sources. The user can sort through this information in order to find whatever information they are seeking. Classification is one of the most common types of data mining, which finds patterns in information and categorizes them into different classes.

Monitoring and Surveillance agents and Data mining agents are being considered for applications in SCM. For example, NASA's Jet Propulsion Laboratory has an agent that monitors inventory, planning, and scheduling equipment ordering to keep costs down, as well as food storage facilities. These agents usually monitor complex computer networks that can keep track of the configuration of each computer connected to the network.

Agent-based solutions are being introduced for SCM. Air Liquide America LP, a producer of liquefied industrial gages, reduced its production and distribution costs using agents. Merck and Co, a leading research-driven pharmaceutical company used agents to help it find more efficient ways to distribute anti-HIV drugs. Proctor and Gamble used agents to transform its supply chain network into a network of software agents whose behaviors are programmed through rules.

6.3 Decision Support Systems

Decision Support Systems (DSS) are a specific class of computerized information systems that supports business and organizational decision-making activities. A properly-designed DSS is an interactive software-based system intended to help decision makers compile useful information from raw data, documents, personal knowledge, and/or business models to identify and solve problems and make decisions.

Typical information that a decision support application might gather and present would be:

- an inventory of all of your current information assets (including legacy and relational data sources, cubes, data warehouses, and data marts),
- comparative sales figures between one week and the next,
- projected revenue figures based on new product sales assumptions;
- the consequences of different decision alternatives, given past experience in a context that is described

In SCM, there is always a likelihood of having disagreements among parties for a certain decision making process. This phenomenon gets worse, when the business environment becomes more competitive and turbulent. Accordingly Decision Support Systems (DSS) have been integrating in various areas like logistics, inventory management, facility design, sales analysis etc.

Baan, a leading ERP vendor unveiled an application, Baan Enterprise Decision Manager for aiding corporate decision-making. Major retailers like Walmart, Sara Lee, Roebuck have increasingly started using Collaborative Forecasting and Replenishment (CFAR) which uses DSS for jointly developing forecasts. GAF Materials Corp, the largest manufacturer of asphalt-based roofing materials in the US, uses a freight-management DSS (Lee et al, 1999).

6.4 Web Services

Web services are application interfaces accessible via Internet standards that use XML and that employ at least one of the following standards: Simple Object Access Protocol (SOAP), Web Services Description Language (WSDL) or Universal Description, Discovery and Integration (UDDI). These standards, and the next-generation standards that are being built on them, are defining the way that forward-thinking enterprises manage lightweight integration tasks.

In the view of Sun Microsystems (2004), web services interoperability for supply chain management is being used to support business-to-customer models. The computing giant provided an example where retailers offer electronic goods to consumers. To fulfil orders, the retailer has to manage stock levels in warehouses (Coronado et al 2004). A typical business-to-business model is used when an item in stock falls below a certain threshold. In that case the retailer must restock the item from the relevant manufacturer’s inventory. In order to fulfil a retailer’s request, a manufacturer may have to execute a production run to build the finished goods. In reality, a manufacturer would have to order the component parts from its suppliers

and that may be a manual process which is supported through the use of fax.

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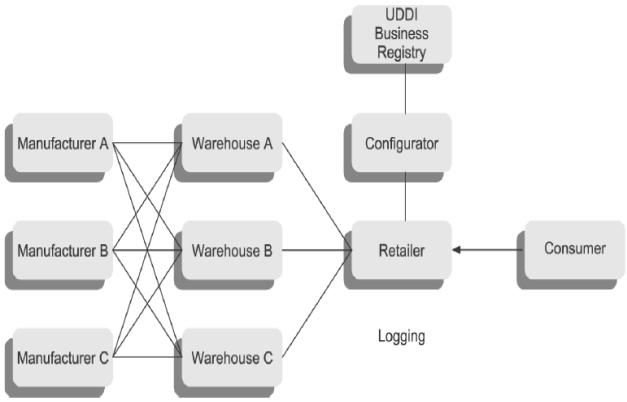

Fig 5 – Web Services Architecture

For the example shown in Figure 5 there is one retailer, one logging facility, three warehouses, three manufacturers and one configurator, and thus a total of nine web services. The Universal Description, Discovery And Integration (UDDI) protocol is one of the major building blocks required for successful web services. UDDI creates a standard interoperable platform that enables companies and applications to quickly, easily, and dynamically find and use web services over the internet (UDDI, 2004). UDDI also allows operational registries to be maintained for different purposes in different contexts. UDDI is a cross-industry effort driven by major platform and software providers, as well as marketplace operators and e-business leaders.

The Web Services Interoperability Organisation (WS-I) (Sun Microsystems, 2004) is an organisation committed to promoting interoperability among web services based on common, industry-accepted definitions and related extendible mark-up language standards support. Towards this end, the WS-I organisation is producing a set of deliverables that is intended to assist developers in creating and deploying interoperable web services.

6.5 Electronic Commerce

Electronic commerce refers to the wide range of tools and techniques utilized to conduct business in a paperless environment. Electronic commerce therefore includes electronic data interchange, e-mail, electronic fund transfers, electronic publishing, image processing, electronic bulletin boards, shared databases and magnetic/optical data capture. Companies are able to automate the process of moving documents electronically between suppliers and customers. This system provides access to customers all over the world and thus eliminates geographical limitations.

Some of the E-commerce applications with applications in B2C (Business to Consumer) and B2B (Business to Business) space, which are changing the dynamics of Supply Chain Management include:

E-tailing: using the Internet for selling goods over the internet. The archetypal e-tailing application is that of a bookseller such as Amazon. This company is renowned for the fact that it only sells books over the internet and doesn't even take telephone orders.

Customers of Amazon interact with its website and carry out a number of functions including:

- browsing readers' reviews of books;
- reading feature articles about books and authors similar to those found in magazines and newspapers;
- searching for details of a book based on information such as the author's name or the title of the book;
- browsing the books which are the Amazon bestsellers;
- ordering books using credit cards or some other similar payment method;
- tracking the progress of an order.

e- Procurement: The term procurement is used to describe the purchase of goods and services which are not directly used in the main business of a company. For example, a car manufacturer will procure stationery for its employees or procure training courses for them to attend in order to improve their skills. An e-procurement system which would automatically take the form produced by the person making the procurement, check that it satisfies all the company rules for procuring the item that is required, carry out authorisation if it is below a certain limit or send the form to someone who can carry out authorisation and then log the purchaser into the site of the supplier. He or she is then able to use this site to make the purchase, quoting an automatically generated procurement requisition number.

E-Auctions: These are sites on the web which run conventional auctions. There are two types of auction: those that are carried out in real time, where participants log in to an auction site using a browser at a specified time and bid for an article until the highest price is reached and no other bids are forthcoming. The other type of site – and the most common – is where an item is offered for sale and a date advertised after which no more bids are accepted. Such sites make a profit from two sources: first they usually charge a commission on the items that are sold and, second, they display adverts which are viewed by visitors to the site. The auction site will then receive some fee for displaying the advert, a further fee if a visitor clicks on an advert and it takes them to the advertiser's website and another fee if they purchase something from this site. Again, this is just an online analogue of a conventional business

6.6 Electronic Supply Chains

Electronic Supply Chains (ESC) refers to those supply chains that are electronically facilitated between or among participating firms. Also called Virtual Supply Chains, these are realized in two forms, EDI-based or Internet-based. EDI generally connects firms through proprietary Value Added Networks (VAN), whereas the Internet generally connects firms through open networks which use standard protocols. The ESC links trading partners to allow them to buy, sell and move products, services and cash

Due to the low implementation costs, the introduction of the Internet has brought about opportunities that allow firms to transact with other enterprises electronically. Amazon is one such example. New types of intermediaries have been created as a result of virtual supply chains. The e-supply chain also envisages use of internet-based applications to transact and exchange information like product and inventory information with their downstream or upstream trading partners. Supply Chain initiatives like Collaborative Planning, Forecasting and Replenishment (CPFR), Vendor Managed Inventory (VMI), Efficient Customer Response (ECR) and Quick Response have been increasingly facilitated in the new e-supply chain paradigm. Information sharing among suppliers, manufacturers, distributors and retailers are greatly improved. American-On-Line and lastminute.com have achieved innovative results using ESCs (Gunasekharan et al, 2004).

Over the past few years, Intel has been building e-business capabilities to conduct business with customers and suppliers. Intel's ultimate goal is to become a "100 per cent e-corporation" by marrying internet technologies and critical business systems to increase productivity and competitiveness in the marketplace. Intel's E-Business Group is
ultimately responsible for delivering this goal for the corporation.

In the mid-1990s (Sammon et al, 2007), Intel began to recognise the power of the internet as a corporate communication channel by using the internet as "brochureware", to share technical information and market the Pentium processors. In 1995, Intel formed the Internet Marketing and E-Commerce Group (IM&E) to centralise online marketing efforts. In 1998, Intel launched a global online ordering system that reached a record US$1bn in product orders in the first month of operation. Today, Intel generates over 85 per cent of revenue from online orders and virtually all Intel customers are transacting business with Intel over the internet. In its pursuit of becoming a "100 per cent e-corporation", Intel is aggressively moving towards paperless purchase orders, shipment notification and deployment processes. In trying to achieve this, Intel now offers its suppliers two options, as follows:

1 a web based solution known as Intel Web Suite; and
2 a system-to-system/business-to-business (B2B) "e-solution" known as Rosetta Net XML standards.

7. CONCLUSION

Industry trends like globalization, outsourcing, customization, time to market and pricing pressure have compelled enterprises to adopt efficient and effective supply chain management technologies, practices, and policies. Customers' expectations are also increasing and companies are prone to more and more uncertain environments in the face of increasing competition. To survive, companies will find that their conventional supply chain integration will have to be expanded beyond their boundaries so as to integrate all stakeholders. Adoption of Information Technology tools is vital for such efforts.

This paper discusses the role of IT as an enabler in Supply Chain Management and also highlights the vast benefits to companies with a comprehensive IT strategy. An overview and deployment of the present alignments of widely deployed IT tools like EDI, ERP, bar codes, inventory management, transportation management and warehouse management systems is provided. Several successful IT implementations in SCM like Walmart, Target, NASA, Best Buy, Intel etc are described.

The basic elements of emerging and new-age tools like RFID, software agents, decision support systems, web services, e-commerce, electronic supply chains etc are also reviewed. Internet technology, World Wide Web, electronic commerce etc. will change the way a company is required to do business. These companies must realize that they must harness the power of technology to collaborate with their business partners. More comprehensive and comparative case studies of successful implementation and the role played by IT in these implementations would be helpful to those who are still struggling. Future studies need to examine how organizations not only carry out GSCM, but how they actually deal with failures.

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