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The Role of Information Technology in Managing Global Supply Chain of 21st Century- CASE AMWAY

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Abstract: *The co-ordination and integration of the supply chain functions are obvious for optimization although difficult to achieve due to the presence of different market and enterprise dynamics resulting inconveniences like non -arrival of materials on time, failure of production facilities, illness of employees. The supply chain of a manufacturing enterprise is a global network of suppliers, manufacturing units, warehouses, distribution centers and retailers that facilitate procurement of raw materials, distribution and delivery of final products to the end customers effectively. Very often deviations from the plans happen due to various controllable factors that lie within the scope of a supply chain function, which may be dealt with locally. The co-ordination of revision of plans across supply chain functions is possible by introducing Integrated Supply Chain Management (ISCM) project that addresses coordination problems at the tactical and operational levels by using Decision Support Systems (DSS) with the help of artificial Intelligence and Enterprise application interface.*

The aim of this paper is to contribute to the efforts of introducing multi -agent systems to the domain of supply chain management in relation to the ISCM project, the first part of which consists of theoretical background which, a) treats important issues of supply chain management, focusing on flexibility, inventory management, and customer service, b) gives an introduction to artificial intelligence, and c) describes the features of the COOrdination Language (COOL), an agent language developed at the Enterprise Integration Laboratories. COOL provides constructs for defining agents and coordination protocols which allow for complex coordinated behavior among agents. The latter part of the paper describes the practical work: the COOL implementation of a simple supply chain model, and the design and implementation of a more extensive (though still simple) multi-echelon supply chain model. . Through simulation on the latter model, several different coordination strategies were tested. The strategies involving more information sharing among agents proved to enhance the reactivity of the supply chain, in this case improving inventory management. Simulating coordination protocols with different levels of information sharing allowed us to produce quantitative estimations of how the absence of information sharing affects the operation of the supply chain.

Keywords: - *Integrated Supply Chain Management, Multi-agent systems, Enterprise Integration Laboratories, Decision Support System, Artificial Intelligence, RFID technology.*

The co-ordination and integration in supply chain management is possible with the facilitation of trading in products or services using computer networks, such as the Internet. E-commerce serves as the best platform for the optimum utilization of supply chain network. Electronic commerce draws on technologies such as mobile commerce, electronic funds transfer, supply chain management, Internet marketing, online transaction processing, electronic data interchange (EDI), inventory management systems, and automated data collection systems. Modern electronic commerce typically uses the World Wide Web for at least one part of the transaction's life cycle, although it may also use other technologies such as e-mail.

E-commerce businesses may employ some or all of the following:

- Online shopping web sites for retail sales direct to consumers
- Providing or participating in online marketplaces, which process third-party business-to-consumer or consumer-to-consumer sales

1

2

- Business-to-business buying and selling
- Gathering and using demographic data through web contacts and social media
- Business-to-business electronic data interchange
- Marketing to prospective and established customers by e-mail or fax (for example, with newsletters)
- Engaging in pretail for launching new products and services

I. Background of the Study

The supply chain is a network of suppliers, factories, warehouses, distribution centers and retailers through which raw materials are acquired, transformed and delivered to the customer. Supply chain management is the decision making that optimizes supply chain performance. In today's competitive business environment industry is recognizing the importance of efficient supply chain management.

HP management has recognized that its performance filling orders will cause it to win or lose the competitive battle. (Lee and Billington)

It has become increasingly apparent that limits in achieving this lie not just in labour or capital, but the availability/accessibility of information and the ability to effectively coordinate both decisions and actions. The role of Information Technology has played a vital role in communication by the introduction of Information and Communication technologies (ICT) namely RFID technology, GPS and GIS technologies.

In a distributed domain such as the supply chain, where any local decision may have widespread effects, a key to meeting the future challenges is the development of next generation information and management systems. These must support coordinated problem solving and decision making in an integrated supply chain. A promising approach is the use of multi-agent systems.

An agent can be seen as a piece of software that is significantly autonomous, goal-oriented and entrusted in performing its functions and that operates globally on networks by relying on application-independent high-level communication and interaction protocols with other "agents". The COOrdination Language (COOL) is developed at the Enterprise Integration Laboratory (EIL) of the University of Toronto. COOL provides constructs for defining agents and protocols for coordination among the agents, so-called conversations. The conversations allow the agents to share information and coordinate their problem solving through message passing based on KQML (the Knowledge Query and Manipulation Language).

This paper will investigate the use of agent technology to improve performance within important aspects of supply chain management, with focus on customer service and inventory management. A supply chain model will be designed and implemented in COOL. Through simulation on different configurations of the model, the impact of information sharing and coordination on supply chain performance will be analyzed.

The Context of the Study

The Study is related to the Integrated Supply Chain Management (ISCM) Project at the Enterprise Integration Laboratory at the University of Toronto.

The EIL research enables businesses to develop, manufacture, sell, deliver and support products and services with unprecedented speed, flexibility, quality and economy. This is achieved through the application of business practices and technologies that create a business infrastructure enabling the dissemination of information, coordination of decisions, and management of actions to and among people and systems within the organization and outside of it. EIL research explores the creation of Enterprise Integration concepts in a bi-directional manner, in that it is simultaneously theory and application driven; an underlying philosophy to this research is that solving real problems leads to breakthrough research. The theories that are being explored include: coordination theory, common sense enterprise modeling and agent-based enterprise information architectures. Applications include enterprise design, concurrent engineering and integrated supply chain management.

Objective of the Study

The objective of the paper is to: Analyze, describe and design information and work-flows for managing effective supply chain. The objective is divided into two main issues.

The first main issue is to study and evaluate the information flow in a supply chain demonstrator. This is interpreted to mean to study and evaluate the need for, and use of, information sharing in a supply chain model.

The second main issue is to extend supply chain agent functionalities and/or typologies to provide for improved information and work flow requirements. The term improved as used here, is interpreted to mean

more consistent with a real life supply chain. As a whole, the second main issue of the thesis objective is interpreted to be: Extend the functionalities and/or typologies of the agents which are used in the current supply chain demonstrator to provide for information and work flow requirements that are more consistent with those of a real life supply chain.

Through the work with the thesis it has become evident the second main issue will precede the first. First the Perfect Minicomputer Corporation (PMC Model) is designed and implemented; next the effects of different strategies for information sharing and coordination are studied and evaluated in this context.

The theoretical background starts with a presentation of supply chain management. The Section presents some important issues within supply chain management, focusing on customer service , handling customer responsiveness on real time basis and maintaining safety stock which follows normal distribution, and how these are related to flexibility. It also presents opportunities for present and future improvements, focusing on integration and coordination. Finally the notions of modeling and simulation are presented.

The Coordination Language, which is the agent language used in the practical work, is described**.** The Section describes the features of the language: agents, conversation classes, conversation rules, continuation rules, and conversation managers, as well as the graphical user interface it provides.

The two sides of theoretical background, supply chain management and agents, lead up to the first of the two Section s describing the practical work. Dedicated to a first of two models implemented using COOL, the Simple Model. The Simple Model was implemented for the author to be familiarized with the tools provided by COOL, as well as the behavior of a simple supply chain model. Many of the solutions used for the Simple Model are in principle reused for the PMC Model. It may therefore be useful for the reader to look through the Section , though higher priority should be given to the next Section .

Presents the PMC Model, first independently of COOL, then as it was implemented. Further, some results of the simulations that were run on the model are described and analyzed. The conclusion section of the Section will, among others, compare the experience and results obtained, with the statements made in the motivation section.

II. CASE AMWAY

Amway Michigan-based Amway has a big global presence, offering products, business opportunities, and manufacturing and logistics services in more than 80 countries and territories. The company has more than 13,000 employees, and more than 3 million Amway individual business owners sell the company's many nutrition, wellness, beauty and home care products. And thanks to VMware technology, Amway's IT infrastructure mirrors the company's profile: lean, yet with a vast global reach. Amway began using VMware Infrastructure in the datacenter at its Ada, MI, headquarters in the fall of 2004. "The company was growing significantly and datacenter capacity was a concern, so the initial focus was on server consolidation," explains System Support Advisor Tom Van Harn. "We started with development and test workloads to get familiar with VMware technology and see how it would function in our environment. Once we saw the stability of the technology—and the availability and manageability benefits it brought us —we began running production workloads on VMware Infrastructure. By the end 2005 we were implementing a virtualization-first policy. Anything new would go to VMware. And that's still the case today—the only exceptions are the rare cases when we have hardware requirements like a physical modem or a T1 card." VMware technology also comes into play at the company's remote datacenters, which are spread all around the globe. "Most of them are around 60 percent virtualized, though we have more than 20 smaller sites throughout Europe that are 100 percent virtualized," Van Harn says. The hardware consolidation made possible by VMware virtualization technology helps Amway set up remote sites efficiently. "There is significant cost savings from an equipment purchase standpoint, because we don't need to buy physical server hardware, we set up a virtual infrastructure to handle the workloads instead," Van Harn points out. "For instance, our smaller offices of less than 20 users need local file services, print services, a local mail server and maybe one or two other application servers. But instead of buying rack infrastructure and three to six physical servers, we can consolidate all that on one VMware host server."

At those smaller offices, that single HP ProLiant server would be a standalone host, without shared storage. Amway outfits the next tier up, sites that have up to 200 users, with a two-host cluster and a small SAN. "That way we have the benefits of VMware High Availability, VMotion and Distributed Resource Scheduler to balance workloads between the two physical hosts," Van Harn explains. "It's still a considerably smaller footprint than if we were running a strictly physical environment—and it's far more cost effective." He adds that Amway's virtualized infrastructure is far more flexible than a conventional setup. "If we need to move virtual

machines around on VMware Infrastructure, say if we're relocating from one city to another, it's very easy to move them," he says. "That lets our IT infrastructure respond dynamically to changes in our business."

"Besides server consolidation, I think the biggest advantage we get from VMware technology is in the area of disaster recovery. About two years ago we made a strategic decision to virtualize everything on our disaster-recovery source list, for instance, Tier 1 applications like EMC Documentum. We've identified virtualization as the key enabler to protect our most important applications."

Tom Van Harn, Systems Support Advisor, Amway

III. REAL CHALLENGE

Save money through hardware consolidation while expanding and strengthening a global IT Network Solution Use VMware Infrastructure to consolidate hosts while improving the reliability and manageability of Amway's technology infrastructure, both at its headquarters and remote offices worldwide. The platform mobility VMware technology brings to Amway's datacenter is also invaluable for disaster recovery. "Besides server consolidation, I think the biggest advantage we get from VMware technology is in the area of disaster recovery," Van Harn says. The VMware tool that he values most when it comes to disaster recovery is Site Recovery Manager (SRM), which ensures that Amway can move virtual machines to other hosts if trouble strikes a particular host or even datacenter. "About two years ago we made a strategic decision to virtualize everything on our disaster-recovery source list, for instance, Tier 1 applications like EMC Documentum Content Server, File Share Services, and Document Transformation Services," he says. "We've identified virtualization as the key enabler to protect our most important applications." Van Harn explains how it works: "SRM offers a cohesive recovery plan for virtualized applications that includes storage replication at a second site. You can literally just click a button to say 'run test' and SRM will make sure your virtual machines and other systems are sequenced properly and that everything can communicate. I'm happy to say we haven't had any disasters, but if one strikes, I'm confident we'll be OK, because SRM lets us see the big picture, including dependent systems that should be included in a recovery plan—ones we might not have identified without SRM. It helps us cover all the bases." Amway is also making good use of two other powerful VMware tools, VMotion and Distributed Resource Scheduler (DRS). "VMotion and DRS are really key to balancing the workloads across the hosts in a cluster so we can get the best performance out of the cluster," Van Harn says. "We also like being able use VMotion to put a host in maintenance mode so we can move all its virtual machines to another host when we're doing memory upgrades and any other hardware troubleshooting. Because maintenance doesn't impact users, we can do it during the day—which is great for us support guys, who prefer not to work on the weekends." As of mid-2009, Amway is in the middle of a successful pilot of VMware View. "We want to realize the benefits we've seen from virtualizing servers in the desktop space," Van Harn says. The plan is to continue the pilot through the rest of the year and begin more aggressive deployment in 2010, focusing on 2,500 U.S. desktops. "We'd like to reduce the amount of desktop hardware we have sitting around various offices and call centers," he explains. "We've done the TCO analysis, and it looks like we'll realize about $4 million savings over three years on things like power, hardware, and desktop deployment costs."

"It's not just the initial cost of hardware," he adds. "It's also that the failure of that hardware takes quite a bit of time to troubleshoot and fix—not to mention the possibility of losing data, say if somebody drops a laptop. With VMware View, we can reduce hardware dependency and store all that data in a protected datacenter. That's good for the user and good for the company, since it will mean we won't have sensitive data wandering around on desktops and laptops and USB keys. And because a virtual desktop is an appliance,

If a device fails, we can swap it out and get the user back up and running very quickly. We can even tie it in with Site Recovery Manager to enable more dynamic recovery, so if we lose a call center in one location, its data is protected and we can start up again in another."

*"*Anybody, everybody should be looking to use virtualization. Companies can make of it what they need. If it's just cost reduction through server consolidation, that's great. With virtualization, you don't have to jump in neck deep to see advantages. But we've taken it to the next level—and so can anyone else—by leveraging VMware disaster recovery solutions like SRM and desktop technology like VMware View and cloud frameworks like vSphere. My advice is to start where you need to, get familiar with VMware technology, and then grow your virtualized infrastructure to suit your business."

Amway India is using state-of-the-art technologies to ensure that all business information is available in real-time and all Amway offices and distributors are connected anytime, all the time.

Efficient information system is the heart of Amway operations. The objective of all our IT initiatives is

to ensure that we have a strong heart to support other organs by providing real time information any time, any place. Amway's long-term IT vision and the deployment of relevant information technology systems to make communication real-time, has enabled it to implement an effective business model

For Amway India the Rs 553 crore subsidiary of US-based $5 billion Amway Corporation, Information Technology has played an integral part in making it one of the biggest success stories in the direct marketing space in the country. With 45 offices and 3.10 lakh active distributors (apart from other distributors), and third-party contract manufacturers spread across the country, contemplating operations without an effective automated system was an unthinkable task for the company's management.

The company's state-of-the-art IT infrastructure has prompted Rajeev Arya, director, information technology & business systems, Amway India Enterprises, to call it a "mini technology company." What makes the company worthy of this title is not just its strategic IT vision, but also its intrinsic technology strength. The fact that Amway has a 25-member IT team, and that almost 60-70 percent of its total capital investment is directed towards funding IT initiatives, is proof that IT is serious business at Amway.

IT Vision

Amway's direct selling business model, warranted the need for in-house expertise. In this, the company was fortunate enough to leverage the technology expertise of its parent company. This gave the company a strong foundation to build upon. Ever since it set up operations in 1988, Amway has stressed on the importance of IT. The early hardware systems and IT processes including the indigenously developed ERP system were part of the package acquired from the parent company. With the initial systems in place Amway went on to fortify it, with one vision in mind "Networked for the 21st century."

According to Arya, the need for a robust IT system was imminent considering the nature of Amway's work processes. Under the direct-selling model, the company has a chain of distributors, vertically as well as horizontally, selling its products. Since one distributor cannot sell all the products, he sponsors another who is below him on the chain. In Amway's distribution system, the chain can go as deep as possible. Furthermore, the benefit of every sale happening down the line goes to each level of the top line, on the basis of a certain formula. These sales have to be tracked on a monthly basis as the points achieved have to be reimbursed by the month-end itself, and cannot be carried over to the next month.

What makes the managing of such a system a Herculean task is the sheer spread of the business operations. With over three lakh active distributors, the chain ripples as low as the 100th and 1000th level in the system, furthermore the person could be based anywhere in the country. "There is a lot of complexity involved in tracking the sales and accounts of each of the distributors at every level of the chain, as the sum due at each level is calculated on the basis of volumes generated by the distributor, as well as all his down lines," explains Arya.

Amway's long- term IT vision and the deployment of relevant information technology systems to make communication real-time, has enabled it to implement an effective business model. According to Arya, "Amway India is using state-of-the-art technologies to ensure that all business information is available in real-time and all Amway offices and distributors are connected anytime, all the time." This, in fact, is the mission statement guiding the choice of IT systems (hardware and software), applications right from ERP, Interactive Voice Response System (IVRS), SMS, disaster recovery management and e-business, VoIP and the advanced communication system.

Amway's IT Deployment

ERP: The ERP system of Amway India was developed in-house. Though generic, the system has been adequately customized to suit Indian conditions. The main modules of the system include order management, inventory management, financial management and bonus calculation, purchase order, HR and payroll systems. According to Arya, some of the modules are also integrated with the global ERP system in order to track the Indian business as part of the global entity.

According to Arya, this system takes care of its distributor accounting, inventory, freight and logistics issues too. Once a distributor acquires a customer, the company has to ship the product to the customer's location, which is tracked by the ERP system. For instance, if the order needs to be delivered in Patna, the system will find out the closest warehouse from which the order can be shipped. The system's inventory management control ensures that stocks are always available.

In the event of a sale, the system does all the tracking and automatically issues and disburses the cheques to the recipients down the supply chain. It even credits the money to their individual accounts, even

though they may be in different banks.

The complete HR process, from recruitment to salaries, is online. The fully automated HR and payroll system, is a browser-friendly solution, which runs on ASP technology. According to Arya, HURIS, the human resource software, is the complete hub of information for the employee. The system facilitates features like online attendance, mid-year appraisals, annual appraisals and leave. The system's e-paymaster, is an intensive payroll system, that facilitates employee-related remuneration. Amway's HR system, and to some extent the payroll system, are currently running on it's intranet. The company soon plans to include the purchase order and travel approval systems, on the Intranet.

From five offices and a reach of 150 location in May 1998, Amway now has 45 offices catering to around 400 cities and towns across the country. By 2002, it plans to increase this number to 47 servicing spread over 450 cities and towns. The sheer magnitude of Amway's operations required an efficient information system. All Amway warehouses, pick-up centres (PUCs) and offices are connected online, so that inventory planners have access to real-time sales and inventory data.

Amway is now focussing on integrating the back-end operations of its supply chain (manufacturing and material planning), into the overall process. The vision is to have a fully integrated and seamless supply chain, whereby a product sale at one end generates an order for raw material at the other end.

Other systems

Complaint Management System (CMS): CMS is another in-house developed Lotus Domino-based package, integrated to the backend. Once the complaint or request is logged, it is assigned to an appropriate assignee. A mail notification with the details of the complaint/request goes to the assignee. Arya says this is a three level escalation process. After the call has been addressed, it goes into the knowledge management database, which generates a report stating the average resolution time taken per call. This system is aimed at analysing performance with regard to customer service in terms of the most frequent mistakes, time taken to resolve a complaint, and reasons for delay. All this ultimately results in improved customer service response, adds Arya.

Interactive Voice Response System (IVRS): This round the clock service provides complete business information such as product information, new launches and promotions, addresses and contact information and most importantly tracks Amway's reward points system. This service is available over the phone to any Amway distributor in India. However, currently only the national capital region can access it as a local call. But the overwhelming response that the company has received, coupled with some regulatory relaxations, has prompted it to soon extend the service to other locations through a service provider. Amway is in talks with various service providers for making IP voice calls.

Short Messaging Service (SMS): Through this service, Amway India is leveraging on SMS to provide critical information to its distributors "anytime, anywhere" on their mobile phones. Amway charges its distributors a minimum amount each month for this service. The business information messages are delivered to the distributors automatically using the push technology. As a result, the top line is always informed of the happenings down the line. In order to provide the service, the company has tied up with CellNext as the application service provider. Elaborating on how the backend works, Arya explains that CellNext has tied up with most of the cellular service providers, which enables it to deliver the service to almost all of Amway's distributors. The software package for this system has been developed in-house.

Disaster Recovery Management: With so much dependence on technology for efficient day-to-day operations, disaster recovery forms an imminent part of the company's IT systems. Currently, all locations connect to the central site at Delhi. In order to deal with the eventuality of any disaster, the company has developed a disaster recovery system. A complete copy of its current production set-up has been housed at its disaster recovery location at Mumbai.

A well-defined standard operating procedure has been put in place to deal with a disaster. These processes are audited and validated from time-to-time. Every quarter, there is a simulation of the disaster and its results are documented. This exercise is also aimed at identifying areas of improvement. The aim of disaster recovery management system is, as Arya puts it, to restore normal business operations within 48 hours of a disaster striking the central site at Delhi.

Heading towards e-business

According to Arya, Amway India has a three-phase approach for foraying into e-commerce. As part of the first phase, it launched its website in January 2001. With that, Amway became the first direct selling

company in India to have its own site. The second phase saw the launch of interactive website a year later, which enabled the distributors to check their business volume and download various business information. The company is currently working on the third phase, with which it plans to commence its e-business operations. The third phase will allow the distributors to conduct their business online.

Taking consideration of the increased security requirements with the introduction of e-commerce, Amway's servers will be in militarised zone, whereby nobody will be able to talk to the iSeries directly. To avoid hacking, only the proxy server will talk to the iSeries server. The implementation of third phase is estimated to be completed by end of 2002 or early 2003.

The company is currently deliberating upon using IBM's Web commerce suite or opting for an in-house software package. Amway wants to leverage the Internet as an additional channel for its distributors, as well as to create synergies in its operations.

Communication Systems: The communication system forms the digital nervous system of the company, as it provides connectivity to all 49 Amway offices and warehouses across the country. It enables users to connect to the iSeries and other services for their day-to-day operations. All locations are connected with the head office through Amway's wide area network (WAN) based on VSATs, leased lines and VPN having an uptime of 99 percent. "With the kind of communication requirements that the company has, it is very critical to have dependable and cost-optimised links. Taking the orders and billing invoices is on a day-to-day basis and we cannot afford any downtime."

The company has evolved a very intelligent communication and networking strategy, which enables both efficiency and cost optimisation. Amway India has established leased line as the primary link, which offers 64 Kbps of bandwidth. VSATs, on the other hand, have been established as the secondary link. As a result, the secondary link takes over if the primary link is down through the implementation of cross-over switch.

On the VSATs front, Amway has judiciously partnered with HCL Comnet and Hughes Escorts Communications. According to Arya, the challenge here lies in managing the large number of communication links and the huge number of users (over 1000), which makes management of the infrastructure a complex task. The company has also got a couple of Virtual Private Networks in place, as they provide for a thicker channel for connectivity.

Voice over Internet Protocol (VoIP): Amway leverages its existing leased line infrastructure to allow users to make toll free long distance telephone calls between Amway offices. At present, it is available at 12 locations. According to Arya, the company has been able to save about $1,600 for a talk time of 9,300 minutes across the 12 locations over a period of two months. To leverage on more cost savings the company will be extending the VoIP facility to additional 35 locations by September 2002.

MIS: The IT team has developed an internal decision support system by using technologies similar to data warehousing and data mining. The MIS tracks various areas like taxation, trend analysis, financial, inventory, stock movement reports, information by regions. For instance, the marketing would like to track down the sales of various categories of products, by business line, regions, periods to analyse and understand the emerging patterns.

Hardware Systems

The hardware systems within Amway comprise around 17 servers and 1,000 workstations connected across 49 locations. The company is using IBM iSeries as the centralised database server. The IBM iSeries system (earlier AS 400) is home to Amway intensive data management. The iSeries is, in fact, the lifeline and most critical system for the company. It serves all locations simultaneously with almost a negligible downtime. A dedicated team works round-the-clock to keep it up and running.

The servers are running largely on the Windows NT and Windows 2000 Operating System except for the iSeries, which runs on OS 400. The choice for NT was also determined by the fact that it is a widely accepted platform and runs on Intel Servers, which are inexpensive. The company is still wary of using Linux as a serious production server.

Though the company feels that it is impossible to pinpoint any tangible benefits derived from IT, it has ensured a business case for all its IT investments. Arya sums up the pivotal of IT initiatives when he says, "Efficient information system is the heart of Amway operations. The objective of all our IT initiatives is to ensure that we have a strong heart to support other organs by providing real time information any time,any place."

IV. Limitations of the research and future scope

It has not been the aim, when designing the model, to find optimal solutions locally, but rather to provide a test-bed for different coordination strategies. The focus has, in other words, been on designing for coordination and information sharing among the entities of the supply chain, rather than to give each entity powerful problem solving tools.

Due to the time constraints, it was important to restrict the focus when designing the PMC Model. The focus has been put on customer satisfaction and inventory values, particularly the raw product inventories (RPI). This is also reflected in the theoretical background.

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