Multi-agent Architecture Design for Supply Chain Logistics

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ABSTRACT
Logistics, as defined by the Council of Logistics Management, "is that part of the supply chain process that plans, implements and controls the efficient, effective flow and storage of goods, services and related information from the point of origin to the point of consumption in order to meet customer's requirements." To make this happen, transportation, distribution, warehousing, purchasing and order management organizations must execute together. Traditional approaches used by any environment using old systems stitched together by spreadsheets and manual procedure could not cope with the exploding complexity. They diverge in maturity and scope of coverage. The traditional Logistics tool is very slow in process execution and they lack of automation and decisions. By the use of multi-agent base architecture for Supply chain Logistics, it over comes the limitation of traditional logistics tools. In this paper we will show how Multi-agent Software (MAS) architecture interacts in the integrated Logistics architecture with the help of various intelligent agents to overcome limitations of Traditional approaches. Second aim is to design a flexible architecture that can deal with next generation supply chain problems based on a multi-agent architecture. Here in this article, a multi agent system has been developed to simulate a multi supply chain logistics. Each entity is modeled as one agent and their coordination and negotiation mechanism help an organization to control inventories and minimize the total cost of SC by sharing information and forecasting knowledge.

General Terms
Multi-agent Software (MAS), master production scheduling, Vendor managed inventory

Keywords
Logistics management, material management, supply chain, production planning, warehouse.

1. INTRODUCTION
In the recent world most persistent technologies used in Supply Chain Logistics are software agents. Software Agents are being used in increasingly wide variety of applications, ranging from comparatively small systems such as information management, business management process, health care, email filters to large, Complex mission critical systems such as air traffic control. One of these application domains is the Supply Chain Logistics that has been attractive to agent researchers for several reasons. First of all, Logistics is an important industrial activity. Secondly, Logistics systems are inherently distributed and most dynamic systems showing many changes and disturbances during operations. The software agent technology has triggered the development of new architectures and software for modeling and managing the supply chain Logistics. With this paradigm, activities in Logistics such as material management, sales and distribution, planning, execution tracking, Customer Service etc. are represented by a software agent. Each agent acts based on its internal model of that particular activity and interacts with other agents in the network. In order to execute a particular operation in Logistics, agents not only interact with each other, but they also share information and negotiate and coordinate with each other which leads to improvement in delivery, performance and inventory reduction. This is no small task, especially in an environment that is becoming increasingly demanding, with customers expecting their products to be delivered as quickly as possible and according to their exact specifications Normally use of traditional research tools results in late delivery, wrong product/quantity or sometime not shipped at all etc. are most important issues which are addressed by using multi-agent architecture. Fig. 1 is an example of a typical Abstract Architecture for Intelligent Agents

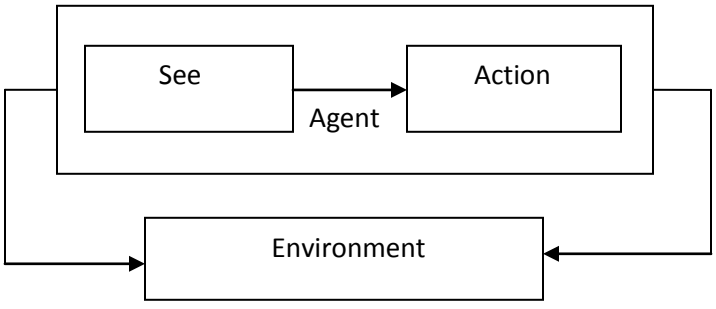

Fig. 1

2. RELATED WORK

In 1997, Hinkkanen proposed a distributed decision support system to support real-time supply chain management [Hinkkanen 1997]. Hinkkanen modeled human decision makers as agents, who are able to adjust behavior according to the changes in the environment. For optimization of resources allocation, an auction market model was used, where resource agents and request agents submit bids and asks simultaneously.
A rule-based multi-agent approach has been proposed by Fox et al. (2000) which concentrates on coordination problem and sharing knowledge at the tactical and operational levels. For [Karimi02] logistics is the glue that holds together the different entities of a SC. Any manufacturing company is a good example of this thought and a good example of possible agent-based SCM, with the objective of reaching efficient results [Julka02].
Venkatadri. M [2010] presented the paper titled as A Novel Business Intelligence System Framework that states Business Intelligence (BI) systems plays a vital role in effective decision making in order to improve the business performance and opportunities by understanding the organization's environments through the systematic process of information. The development of BI systems is limited due to its huge development costs. developing the complex systems with Self Organized. Multi-Agent technology would reduce the building cost without affecting the scalability and reliability of the system. Hence, this paper presented a novel framework based on Self Organized Multi Agent technology for building the low cost BI systems European Journal of Scientific Research shows - Agent design patterns form a new methodology used to improve the development of software agents. Agent design patterns can help by capturing solutions to common problems in agent design. Patterns are applied in different systems such as knowledge management systems, real-time systems, and network management systems. Agent design patterns for business-based systems, aim to support different e-commerce paradigms business-to-business (B2B), business-to-consumer (B2C), and Consumer-to-Business (C2B).

3. SUPPLY CHAIN LOGISTICS MANAGEMENT TOOLS

Logistics tools are used for the management of the flow of goods, information and other resources, including energy and people, between the point of origin and the point of consumption in order to meet the requirements of consumers.

These Logistics tools involve the integration of information, transportation, inventory, warehousing, material-handling, and packaging. Logistics management tools activities typically include inbound and outbound transportation management, fleet management, warehousing, materials handling, order fulfillment, logistics network design, inventory management, supply/demand planning, and management of third party logistics services providers. To varying degrees, the logistics function also includes sourcing and procurement, production planning and scheduling, packaging and assembly, and customer service. An organization should develop and implement a formal logistics strategy in order to identify the impact of imminent changes to ensure service levels are not reduced. In logistics tools, there are four distinct levels of their logistics organization which are highly used while dealing with multi-agent architecture:

3.1 Strategic:

By examining the company's objectives and strategic supply chain decisions, the logistics strategy should review how the logistics organization contributes to those high-level objectives.

3.2 Structural:

The logistics strategy should examine the structural issues of the logistics organization, such as the optimum number of warehouses and distribution centers or what products should be produced at a specific manufacturing plant.

3.3 Functional:

Any strategy should review how each separate function in the logistics organization is to achieve functional excellence.

3.4 Implementation:

The key to developing a successful logistics strategy is how it is to be implemented across the organization. The plan for implementation will include development or configuration of an information system, introduction of new policies and procedures and the development of a change management plan.

Figure 2 is an example of a typical logistics in a manufacturing unit which depicts an abstract structure of supply chain logistics as well it shows flow of information between different entities.

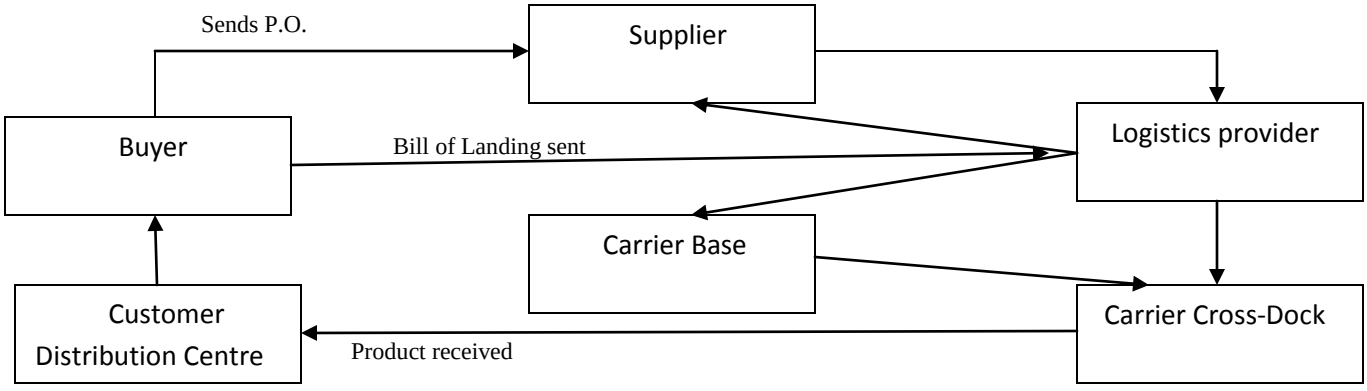

Fig. 2

4. PROBLEM WITH THE TRADITIONAL LOGISTICS TOOLS AND SOLUTIONS

Traditional research tool uses old systems stitched together by spreadsheets and manual procedures could not cope with the exploding complexity. The traditional logistics research tool is very slow in process execution and they have lack of automation and they did not have any concept of artificial intelligence so as to make self decision. Normally use of traditional research tools results in late delivery, wrong product/quantity or sometime not shipped at all etc. are most important issues which are addressed by using multi-agent architecture. . Designing the architecture of Agent based logistics which overcome the limitation of traditional logistics tools and leads to improvement in delivery performance and inventory reduction.

5. AGENT BASED LOGISTICS DESIGN

In today's volatile economic climate, logistics management is becoming more important than ever before. Getting the right amount of goods to the right place at the right time is critical, especially in an age when budgets are tight and customer's demands are unpredictable and unforgiving. Consumer goods manufacturers now recognize that success requires more than just making market-leading products. In today's business, it is not enough just to produce market-leading products, but to predict how much merchandise is available and when it can be distributed makes the difference in staying ahead of other manufacturers. For this one has to build robust agent-based software architecture for a supply chain logistics where logistics activities should be distributed and coordinated across the agents. The following are the agents whose jobs are well defined and also supposed to communicate with other agents which are shown in the model.

1. Material management agent:- the materials management component is the foundation for the logistics functions of a company. The agent includes Purchasing, Accounts Payable, Fixed Assets, and Inventory which are completely integrated within the Materials Management system, as well as with the General Ledger and Budget Control process and the material master file, which contains the information on all materials and services used at a company. The primary goal of the agent is to control inventory and in order to achieve its goal, it communicates and coordinate with sales and distribution agent and production planning agent.
2. Sales and Distribution agent:- the sales and distribution agent incorporates the processes from customer order to the delivery of the product to the customer. The component includes the sales functions, pricing, picking, packing and shipping. It keeps records of sales status, payment status, stock report as well as expense report. It communicates with scheduling agent for the smooth delivery of finished goods to customers. It performs the important task in supply chain by controlling stock by not allowing excess / shortage of stocks. It keeps on communicating to information Monitor agent to ensure that supply chain should not suffer from any market fluctuations.
3. Quality Inspection Agent:- This agent is used to ensure and improve on the quality of your company's products. The functions of this component include the planning and execution of quality inspections of purchased and finished products.
4. Production Planning agent:- It manages a company's production process. The functions of this component include capacity planning of a company's production, master production scheduling (MPS), material requirements planning (MRP) and the shop floor functions of producing a company's finished products. It takes inputs from scheduling agent regarding production and delivery schedule and plan accordingly. It also communicates and coordinates with material management agent for raw material acquisition, storage management and shipment of raw materials and finished products.
5. Warehouse management Agent:- helps companies to accurately manage inventory and maximize storage capacity. This component can reduce time it takes to place and remove items from the warehouse by suggesting the most efficient location to store a material and the most efficient way to place and remove that material from the warehouse.
6. Customer Service Agent:-manages a company's service that it provides to customers for repairs and warranties. Items can be sent back for repair or visits made by staff to customer facilities. If a company makes finished products that are sold with warranties, then the agent will help a company to service and repair those items with maximum efficiency.
7. Reverse Logistic Agent:- It keeps tag of processing returned merchandise due to damage, seasonal inventory, restock, salvage, recalls, and excess inventory. It also includes recycling programs, hazardous material programs, obsolete equipment disposition, and asset recovery. It keeps the record of the returned product depending on whether it is reconditioned, refurbished, remanufactured, resell or recycled.
8. Scheduling Agent:- This agent interacts with monitor agent , production planning agent and sales and distribution agent . It gets requirements from monitor agent and inform production management for planning of production. It also inform the delivery schedule to sales and distribution agent. The goal of the agent is coordinate with production planning agent and sales and distribution agent and ensure that lead time is reduced considerably.
9. Information Monitor Agent:- it is the heart of logistics management system. It communicates and coordinated with all agents in supply chain logistics and eliminates the following inconsistencies:

Eliminates missed shipments/shipment discrepancies
Improve profit margins by providing more accurate and timely data.
Minimize the bull whip effect
Improve customer satisfaction through quality finished goods, improved delivery reliability.
Identify, and preferably, eliminate the cause of customer order reductions or Cancellations. Provide vendor-managed inventory (VMI) services by collaboratively planning inventory needs with the customer to projected end-user demand then, monitor actual demand to fine tune the actual VMI levels.

Fig. 3 depicts Agent based Supply Chain Logistics. Here agents communicate and coordinate with each other through Information monitor agent which is the heart of supply chain logistics management. Communication across agents through Information Monitor agent is depicted using double arrow. Logistics database has raw data which is used by Information Monitor agent to share/provide information to other agents.

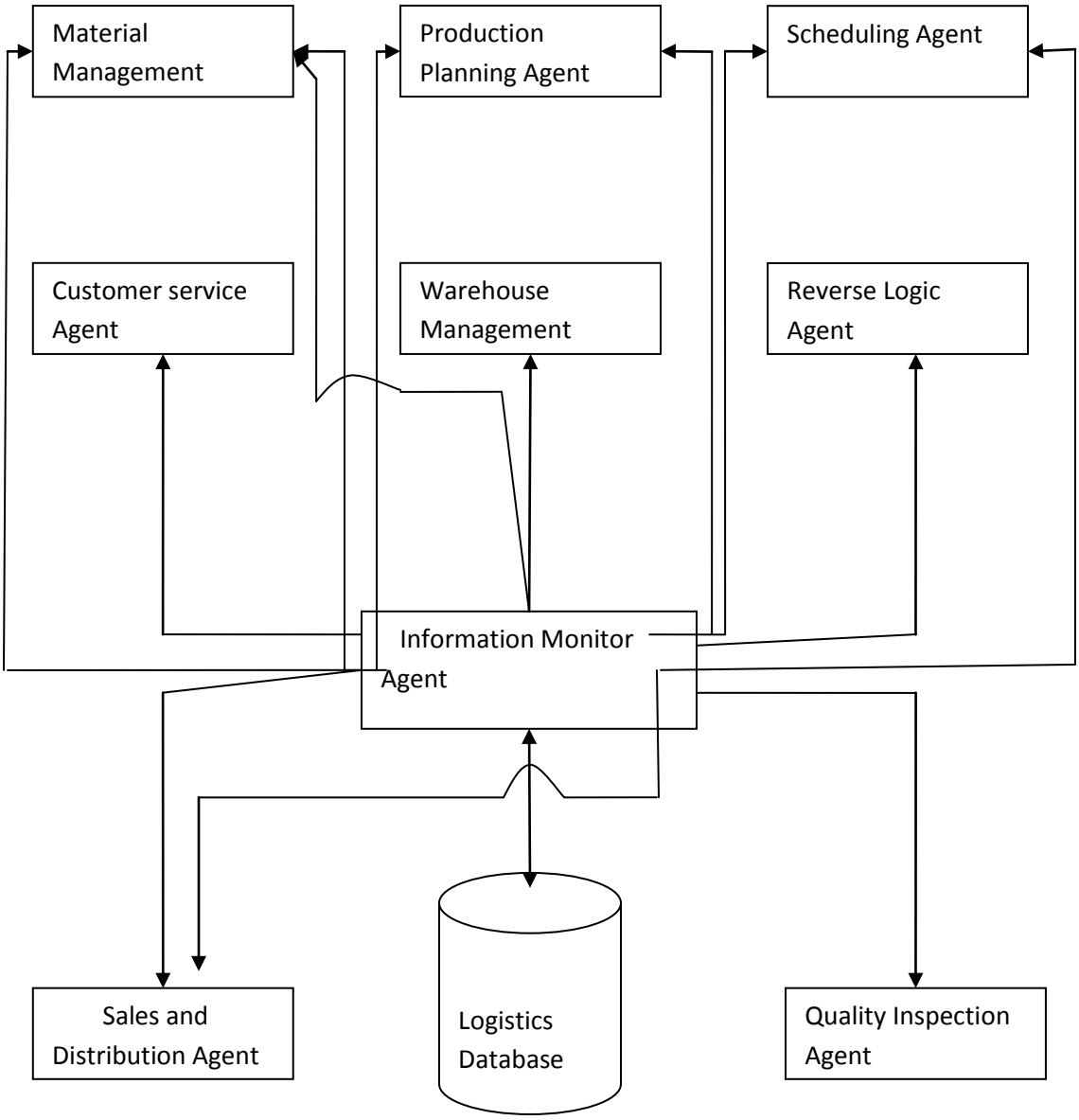

Fig. 3

10. CONCLUSION

Approach of agent oriented technology in designing of supply chain logistics enhance the efficiency and capability of traditional Logistics management system. The traditional logistics tool is very slow in process execution and they have lack of automation and decisions. By Using the Agent base architecture, it over come the limitation of traditional logistics management systems

7. FUTURE SCOPE

By the use of decision support algorithm along with negation techniques, we can improve the efficiency of multi-agent base supply chain logistics

8. REFERENCES

[1] Lee, H.L., and Billington, C., "Managing Supply Chain Inventory: Pitfalls and Opportunities," Sloan Management Review, Spring 1992.

[2] Anderson, D. L., Britt, F. F., and Favre, D. J., "The Seven Principles of Supply Chain Management," Supply Chain Management Review, summer 1996.

[3] Hinkkanen, Kalakota, R., Saengcharoenrat, P., Stallaert, J., and Whinston, A. B., "Distributed Decision Support Systems for Real Time Supply Chain Management using Agent Technologies," Working Paper, 1997

[4] Proceedings of the 32nd Hawaii International Conference on System Sciences – 1999-A New Approach to Solve Supply Chain Management Problem by Integrating Multi-agent Technology and Constraint Network by Stanley K. Yung and Christopher C. Yang

[5] Deugo D., Oppacher F., Kuester J., Vontte I, 1999 "Patterns as Means for Intelligent SoftwareEngineering". Carleton University, KIS5B6, Ottaw, Canda

[6] Cabri G., Leonardi L., Zambonelli F, 2002 "Modeling Role-Based Interactions for Agents". Workshop on Agent-Oriented Methodologies at OOPSLA, USA.

[7] Langley, 2003] B.K. Langley, K. Sycara, J. A. Giampapa and M. Paolucci, "The RETSINA MAS, a Case Study," in Software Engineering for Large-Scale Multi-Agent Systems: Research Issues and Practical Applications, Alessandro Garcia, Carlos Lucena, Franco Zambonelli.

[8] Andrea Omici, Jaelson Castro, ed., Springer-Verlag, Berlin Heidelberg, Vol. LNCS 2603, July 2003, pp. 232—250

[9] Philip E. Agre , Hierarchichy and History in Simon's—Architecture of Complexity — Journal of Learning Science 12(3) , 2003

[10] Roger D H Warburton, An analytical investigation of Bull Whip Effect , NTC SO3-MDI3s , , University of Massachusetts, Dartmouth , Nov , 2004.

[11] Lind J, 2005. "Patterns in Agent-Oriented Software Engineering. GmbH. D-82008, agent Lab, Germany.

[12] C.Martinez-Olvera and D. Shunk (2006), Comprehensive framework for the development of a supply chain strategy, international Journal of Production Research, Vol. 44, No. 21, 1, pp 4511–4528.

[13] Application Application of MultiAgent system & Agent Co-ordination " in a National Conferece on Artificial Intelligence conducted by Delhi University , Sept. , 2008 By Dr. S. Srinivasan

[14] Multi-Agent Conceptualization for Supply chain uitous Computing and Communicating Journal , Korea , Volume 3 , Number 4 , 2008 By Dr. S. Srinivasan

[15] Multi-Agent System Supply Chain Management in Steel Pipe Manufacturing ,IJCSI , Vol 7 , Issue 4 Jul 2010 By Dr. S. Srinivasan

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Ms. Pankaj Rani obtained her MCA from M.D. University, M.Tech from C.D.L.U University and PhD (CE) Pursuing from Suresh Gyan Vihar University She has attended various national seminars, conferences and presented research papers on Artificial Intelligence and Multi-Agent Technology.

Dr S Srinivasan obtained his M.Sc (1971), M.Phil(1973) and PhD (1979) from Madurai University . He served as Lecturer for 7 years in National Institute of Technology in the Computer Applications Department. Again he started his teaching career serving as Professor and Head of the Department of Computer Science, PDM College of Engineering, Haryana, India. He has published several papers on Multi-Agent Technology Systems and its applications. He is member of Computer Society of India. Attended various national and international seminars and conferences and presented papers on Artificial Intelligence and Multi-Agent Technology.