Mobile Agents in Supply Chain Management

Anurag Gupta, Larry Whitman and Vikram Ketkar
Department of Industrial and Manufacturing Engineering
Wichita State University
Wichita, KS 67208, USA

Ramesh K. Agarwal
National Institute for Aviation Research
Wichita State University
Wichita, KS 67208, USA

Abstract

Mobile agents are autonomous computer programs that can migrate from one network to another by resuming their same state of execution. This refers to the attribute values of the agent that helps it to determine what to do when it resumes execution at the remote host. At each host a process can be spawned which will provide a "black-box" view into that host's information. This technology introduces a way to integrate and optimize global production and distribution in a supply chain. This paper will discuss the purpose of mobile agents and their use in designing and managing the supply chain.

Keywords
Supply chain, Mobile agents, Intelligent agents

1. Introduction
“A supply chain is a network of facilities and distribution options that performs the functions of procurement of materials, transformation of these materials into intermediate and finished products, and the distribution of these finished products to customers” [1]. The supply chain forms the backbone of any manufacturing industry or a service industry. In this paper we introduce mobile agent technology and list down its applications and advantages in the context of supply chain management.

2. Competition between Supply Chains
Global competition forces enterprises today to come up with better products and services, at better rates and delivery schedules. They have to introduce these new products or services in the market at regular intervals and thus have to be agile in their manufacturing and marketing. It is imperative that the entire chain is optimized as in the existing industry most of the product is manufactured outside the enterprise. This outsourcing determines the order lead-time, the quality, delivery schedules and the cost of the final product. To keep up with the changing and demanding customer requirements the whole value chain of the enterprise has to improve co-operation and synchronization between partners to unprecedented levels. The channels of communication within the supply chain should be must be dynamic and intelligent. The supply chain must operate in real time. A combination of net and information technology can make this possible. Companies can use latest tools like data warehousing, data mining, wireless applications and online data retrieval systems for better utilization of this real time data in order to enhance efficiency in the supply chain.

3. Mobile Agents
“The importance of agent technology is not hard to predict, since shock waves are already being felt throughout the computer industry. A steadily increasing number of research projects, prototypes and even products containing, or claiming to contain, agent technology are being announced almost daily, and autonomous mobile agents are beginning to appear on the Internet” [2].
Mobile agents are the independent programs or mobile codes that can travel from one network to another while performing different kinds of operations. Mobile agents have the inherent capacity to pack a conversation and dispatch it to a destination system, where the interactions can take place locally. The main idea is to simply move computations to the data rather than the data to the computations. For designing agent-based systems for supply chain management, network intelligence to handle networking issues of security, reliability, authenticity, integrity and management of information has to be developed [2].

Information can also be accessed globally by using different types of devices like mobile phones, personal digital assistants, digital diaries, laptops, and workstations. In this rapidly changing world, adaptability and flexibility are the major requirements for the distributed system. In traditional information systems like the client/server model for distributed systems, various preprogrammed interfaces define the communication system. All the interfaces are preprogrammed to use the resources at each system intelligently, to control the data flow and to decide on the data and information that can be shared by using protocol properties like windowing and resource reservation [2].

However, the new distributed systems that are based on mobile agents can easily setup direct access between client and server. The mobile codes that carry the communication link and other required information with them can migrate anywhere in the system maintaining their same state of execution [2]. The same state of execution means that if the code is executed fifty percent on one system then it can go to some other system and resume its execution from where it left off at the previous system.

4. Mobile Agents in Supply Chain
Supply chain decisions are improved with access to global information. However, supply chain partners are frequently hesitant to provide full access to all information within a single enterprise. A mechanism to make a decision based on global information without complete access to the information will create an ideal supply chain decision-making environment.

Mobile agents are programs that can be initiated on a single host and then migrate from host to host over a network. Rules can be established to determine the migration path wherein the mobile agent determines its own next host. At each host a process can be spawned, similar to some decision support system. They will provide a "black-box" view into that host’s information. Since only the result of the query is needed by the mobile agent, complete information viewing is not necessary. The process views the required information and returns only the results. This provides access to the necessary information, while maintaining privacy for company sensitive information.

“Mobile agents can act as local representatives for remote services, provide interactive access to data they accompany, and carry out tasks for users temporarily disconnected from the network” [3]. For example the mobile agents can be programmed to buy shares on behalf of its user. If somebody wants to buy 100 shares of company ‘X’ at a price rate of ‘B’ and the current rate is ‘A’ then a mobile agent can be programmed and sent to the destinations server. It will wait there until the price drops to ‘B’ and as soon as the price drops to the desired amount, it will buy the 100 shares on behalf of its user and return to its home server.

4.1 Electronic Marketplace
Recently, an IBM team has developed electronic marketplace framework for conducting global business more safely and efficiently. An electronic marketplace is a system that consists of multiple agents, which interact with each other in order to buy or sell something on behalf of their users.

The architecture is mainly designed considering the advantages of conventional business systems that involve marketplace owners, shop owners and consumers. Marketplace owners maintain the overall infrastructure. Shop owners are the agents that want to sell something on behalf of their users and consumers are the agents those indulging in the buying activities as shown in figure 1.

The shop agents go to a market (Marketplace server) from the shop owner’s computer to buy the required product. The customer agents keep roaming around various marketplaces to get more information. Lastly, market advertiser agents go to other markets to advertise about their market and to invite customer agents. In a marketplace the shop agent and consumer agent can negotiate with each other in terms of cost, quality and service just like a normal business. “Since the agents can be developed independently, the agent system is made flexible in the sense that
adding a new agent or updating an existing agent can easily modify its behavior. For example, one should be able to replace a shop or a customer agent with an updated agent as long as the new agent behaves in accordance with the defined interaction protocol” [4].

Mobile agents have wide applications in distributed information systems. In modern business, mobile agents are the main building blocks for integrating the business and the enterprise information systems. In today’s competitive business world, agent technology is considered as an important approach for developing industrial distributed systems. A number of researchers have attempted to apply agent technology to manufacturing enterprise integration, supply chain management, manufacturing planning, scheduling and material handling. Companies outsource instead of producing themselves due to the faster change in market conditions and lower lead times. The next generation manufacturing systems put more stress on integrating the process chains between customers and vendors in order to form distributed virtual factories [5].

4.2 Virtual Factory
“A virtual factory is defined as a community of dozens of factories each focused on what it does best, all linked by an electronic network that would enable them to operate as one – flexibly and inexpensively regardless of their location” [5]. A virtual factory is basically used in a distributed kind of environment to enhance distributed decision making and planning. Mobile agent technology is one of the available tools, that are used to enhance communication and coordination in a distributed kind of system, to ensure efficient decision-making, and distributed job planning.

This technology is used in several European textile-manufacturing firms to integrate their production control and marketing activities. The woolen industry, where the fashion and style change quite frequently, requires tight scheduling and shorter delivery periods. “The market requirement is therefore for an interconnecting network where product data coupled with a strongly integrated scheduling of the production between retailers, the garment producer and its suppliers, commission transformers and customers, reduces the time between securing an order and delivering the product to a minimum” [5].

Some specific properties of the distributed system should be kept in mind while designing the framework for the factory’s information model. The framework should be heterogeneous in terms of design so that it can accommodate
various languages and operating systems. It should be scalable so that it can be easily updated at various stages without affecting the other components. It should also be re-configurable so that it can modify itself according to the market dynamics. Apart from this it should also be secure and easily accessible in order to protect the system from hackers and other competitors [5].

An agent-based framework is categorized into three levels. It includes supply chain level, factory level and user level. At the supply chain level, only static agents play a role in managing the product and information model to integrate it with factory’s Enterprise Resource Planning (ERP) system. It also provides assistance for mobile agent usage on the factories computer computing system. The other level, which is also called factory level, includes the hierarchical control modules at every level. At user level interface, the mobile agents assist the user in retrieving information through the supply chain with the help of a web browser. They act like interfaces between the user and factory agents [5].

Agents are also used in implementing real time supply chain optimization systems. Broadly, the information system is divided into two parts, one is the static information model and other is the dynamic information model. The static information model involves making requests, processing the requests and delivering responses. On the other hand in the dynamic information model real time data is taken into account. In the age of global interconnectivity a huge amount of data is available on the web. Through the effective use of electronic data interchange a factory can track the amount of inventory in its warehouses, retailers and distributors very easily. Based on that inventory, effective forecasting regarding the sales and production can be done [2].

To monitor various systems and processes several types of mobile agents can be utilized. For example in a manufacturing facility continuous monitoring of inventory and WIP levels is necessary for maintaining production. Mobile agents can be used to keep track of these levels. Whenever these quantities fall below a certain level the inventory agent gets activated. It can then, on its own, send an electronic procurement request to the vendor for the required material and send an alert message to the concerned procurement manager at the same time. Thus agent-based systems offer many more advantages for manufacturing facilities and entire supply chains. It helps in increasing the responsiveness of the enterprise to the market requirements and ensures involvement of customer responses in supply chain optimization [2].

4.3 Agents in Manufacturing
Agents have also revolutionized the manufacturing systems. In distributed intelligent manufacturing systems, the main function of the agents is to integrate manufacturing enterprise activities such as designing, planning, execution, simulation, distribution, forecasting between suppliers, customers and partners via net. They are also used to represent various manufacturing entities like products, parts and operations to facilitate different manufacturing activities.

The agent based manufacturing systems can be classified according to their system architecture: the Hierarchical approach, the Federation approach and the Autonomous agent approach. A combination of Hierarchical and semi-autonomous agents is mostly used in typical modern manufacturing enterprises. In the Facilitator approach, several related agents are combined into a group. An interface called Facilitator helps these agents in communicating with each another. The Facilitator also routes outgoing messages to the correct destinations and translates the incoming messages for consumption by its agents [6].

Real world manufacturing environments are highly dynamic because of diverse and frequently changing situations: bank rates change overnight, political situations change, materials do not arrive on time, power supplies breakdown, production facilities fail, workers absenteeism, new orders arrive and existing orders are changed or canceled. Such changing situations lead to deviations from existing plans and schedules. It is therefore necessary for the system architecture to be able to satisfy such requirements and for the working system to adapt to such dynamic environments [6].

5.0 Conclusion
“The ability to learn faster than your competitors may be the only sustainable competitive advantage” [7]. Dynamic business environments challenge enterprises in many ways. There are compulsions to come up with new products for new markets and new customers. New alliances, mergers and partnerships have to be formed and new
competition has to be faced. These challenges create a great strain on the existing supply chains. There is a dire need for an application technology that can make quick intelligent decisions based on real time information whenever there is such a need. Such technology will prove the competitive edge of one company over another. In any case this technology has to cost less than the value it creates to prove profitable for business.

The supply chain systems developed with software agents capture generic supply chain processes, which speed up modeling and quality decision making of supply chain systems. However, security and compatibility are two major risk factors with mobile agents that need to be resolved for better operation and acceptability. With the advent of mobile agent technology the method to integrate and optimize the global production and distribution supply chain has being revolutionized. The agent technology gives a powerful approach to support supply chain information architecture.

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