AN E-COMMERCE PRODUCTION MODEL FOR MASS CUSTOMIZED MARKET

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ABSTRACT

Popularity of the Internet has enabled consumers to have access to a larger variety of products. Online accessibility to information about products has allowed consumers to specify and demand customized products directly from manufacturers. Supporting this shift requires a production model that caters to mass customized markets. We define characteristics of mass customization and describe an infrastructure based on intelligent agents and distributed computing to support a production model that satisfies specific needs of these markets. A software system that meets these requirements is also presented.

Keywords: Mass Customization, Intelligent Agents, Synchronized Supply Chain

INTRODUCTION

Consumers today have easy access to information and products, can reach suppliers anywhere in the world, are vastly better educated about their purchases, demand quality products at competitive prices, and expect responsiveness and expediency in the entire transaction process, from product selection, ordering, delivery all the way to after sales support. This revelation is changing the consumer-supplier relationship. According to [14], sales conducted via the Internet were just a novelty in 1994, and grew to approximately $500 million in 1996, and $7 billion in 2000. The Forester Research recently predicted that the worldwide Internet economy would reach US $6.9 trillion in 2004. Companies across the world are maintaining online presence and offer their products and services to any buyer worldwide. Obviously this has increased consumer choices. One consequence of these advancements has been a change in consumer behavior. Before the Internet, suppliers offered products through their distribution channels and consumers had to select from whatever they found in the retail shops. Today, consumers are demanding custom products, and are asking suppliers to meet their demand at competitive prices. We discuss how this shift to customization will effect manufacturing operations and how to respond to this new production paradigm.

Traditional production models used information about past consumption to forecast future production levels. This policy, referred to as production to stock, and is a "*push*" system. It uses a centrally planned and scheduled production system that is linear and static in nature. To improve production efficiency, Material Requirements Planning (MRP) systems were introduced. In its basic form, an MRP system is a computer program that determines the quantity of each item and when it is needed to complete a specified number of units in a specific time period. MRP systems have grown to become fully integrated, interactive systems capable of multi-site global applications. An effective manufacturing system still needs to further integrate MRP systems with the firm's other software systems. These additional needs resulted in a new generation of software systems known as enterprise resource planning (ERP) systems, which form the information backbone of most modern enterprises. These enterprise-level software systems enable large operations to consolidate their activities by using a single software system. Although these packages offer company-wide solutions to operation-centered activities, they are still vendor specific and observe corporate boundaries.

Traditional manufacturing paradigm has used a centralized decision making approach. These systems have been very effective for developing long-term strategic plans. The centralized approached is used to gather information from the supply chain and integrates it into a production planning system for the entire enterprise. These systems, however, fail to respond quickly to a changing customer demands and are not suitable to support the new production paradigm of mass customized markets. Although production system is inherently a distributed process, most existing systems are centralized and are production centric. The new paradigm of mass customization requires a "*customer centric*" approach that can support centralized strategic planning, but allows for a decentralized execution and decision-making in support of tactical and operational activities.

MASS CUSTOMIZED PRODUCTION SYSTEMS

In today's information-based economy, manufacturing processes are moving from mass production, where producers decide what products to offer, to mass customization, where the consumers decide what is produced. Inclusion of the customer in the production cycle has resulted in a steady and rapid progression toward a "mass customization" business model, where products such as PCs, clothing, music, and even cars are created, marketed, and sold not by forecasts of demand, but on a make-to-order basis. Some even claim that "mass customization will be as important to business in the twenty-first century as mass production was in the twentieth," [7]. Businesses are moving toward customization because *"pleasing the customer isn't just about producing more stuff. It's about producing the right stuff"* [4].

Obviously, the relationship among the supply chain members of a manufacturing firm also must be altered to support this new business paradigm. Transitioning from mass production to mass customization is a complex, enterprise wide process which effects external supply chain members, which are not typically controlled by the core company. In this context, the mass customization of products implies the existence of a production infrastructure and process that can quickly change to produce customized products. This type of production infrastructure will be component-based and may involve many business partners. This new paradigm requires a significantly greater degree of synchronization of the entire supply chain. In particular, the order, reorder, replenishment of inventory cycle under this model will be more frequent, involve smaller lot sizes, and require shorter delivery schedules.

A most important part of product customization is the actual customer. Early forms of mass customization produced co-operatives and membership based clubs. Some would even define multiple product variations as a form of customization; although they were supplier defined. Manufacturing of these products still followed the mass produced model. Advances in the Internet technology and WWW allowed consumer to directly become part of production process. In some cases, such as PCs, companies like Dell employed a production system that is totally demand driven. Customers define and configure their own PC online, place their order and only then the company produces the product. Similarly, a music buyer can use Internet to select a dozen cuts from over 10,000 titles from *CDuctive* (A New York based company) collection to order his/her own CD. Another form of consumer-based customization includes grouping of "*like-minded*" buyers. Buyers in this group can act collectively over the Internet to engage suppliers to produce custom products, even in large quantities. The insurance industry is an example of this category.

Regardless of the source of customization, demand driven production models offer new challenges to the manufacturers. [4] estimates that, in the case of the Dell computers, the number of possible product configurations that consumers can choose is about 16 million choices. Managing an inventory of parts to satisfy orders is a very complex task. Similarly, when trying to define product specification for collaborative buyers, reaching consensus in a timely fashion becomes a formidable challenge. Finally, buyers in this arena demand custom products at commodity prices with no switching costs whereas suppliers, on the other hand, would like to sell mass-produced products at custom prices with prohibitive switching costs [5].

The traditional manufacturing models with their linear, static supply chain processes are not suitable for such markets. The production paradigm for mass customization needs to allow a synchronized production process that will necessitate greater cooperation among the participating members-from the manufacturer to the first and secondary suppliers [1]. Truly successful members of such a manufacturing environment must have stronger alliances and be willing to significantly improve their inter-firm communications. In addition, this infrastructure should reduce time-to-market for product development, enhancement, and customization; directly tie order-entry and manufacturing planning systems to speed the availability; intelligently and selectively communicate with a manufacturer's trading partners; and provide flexibility in a manufacturer's component supply. Implementing such a model requires strong business partnerships among the participants. A manufacturing firm needs to coordinate and share its customer demand data with its supply chain partners; these partners, in turn, must be more agile and have the ability to respond quickly to a change in demand. Collaborative manufacturing planning is the result of order and market information flowing upstream continuously from the point of sale, while information on product availability and inventory levels flows downstream. The most highly synchronized order fulfillment approach uses data on customer demand to directly drive orders rather than basing orders on forecasts. A manufacturing system that satisfies these requirements must expand individual company's boundaries to form a virtual manufacturing enterprise (VME) [3]. The physical reality of manufacturing imposes requirements that demand a VME to manipulate both matters and information. Globalization of the business adds another dimension to this challenge. We next present the enabling technologies to address these challenges.

TECHNOLOGY INFRASTRUCTURE FOR MASS CUSTOMIZED MARKETS

The technology infrastructure to support mass customized markets must account for the entire system - the customer, manufacturers, the entire supply chain and the supporting market structure. An effective infrastructure for such a vast domain requires an interoperable open system. Popularity of the object-oriented methodology and Java technology offers a venue that fosters open systems and allows for interoperability among heterogeneous computer environments. The web-centric nature of Java technology is taking full advantage of the Internet and is rapidly becoming the platform of choice for new initiatives. Efforts utilizing these technologies are providing connectivity across the entire trading spectrum.

These technical advances have allowed development of intelligent agent technology that can address many of the concerns of the mass customized markets. In particular the intelligent agent technology has become an effective approach to study customer behavior, manufacturing alternatives and trading markets.

Software agents are defined as atomic computer programs that can accomplish a task or activity on behalf of the user and without constant human intervention [11]. Software agents were first used to filter information, match people with similar interests, and automate repetitive behavior. Integration of software agents with the Internet has been used to represent consumer preferences in product definition. Authors in [3] describe a system that uses such technology for "*collaborative filtering*." They suggest using collaborative filtering along with other techniques such as studying bookmarks of web pages, content analysis of web pages browsed, and cluster analysis based on text messages to study groups with similar tastes and/or preferences. They further suggest using this infrastructure to build an "*interactive bargaining*" environment in which the group can negotiate with manufacturers to produce customized products. Consumers are using specialized intelligent agents to gather information about products on their behalf. [8] refers to these agents as "*infomediaries*." These agents are eliminating or at least reducing the need for middleman in finding or defining customized products

Intelligent agents are also used to monitor a process or react to a set of sensors and take appropriate action. For example, an intelligent agent can monitor basic office supplies for an organizational unit and shop for replenishments as the inventory falls below a threshold. Amazon.com uses an intelligent agent, called Eyes, to send notifications to customers based on events of interest to them [12]. Other applications support customer-to-customer (Kasbah), price shopping (BargainFinder), or auction activities (AuctionBot) [12]. These software tools are used as mediators that act on behalf of their users. Specifically, these agents perform repetitive and predictable actions, and they can run continuously and without human intervention.

Agent technology has also been applied to manufacturing and production systems. The manufacturing domain uses both information and material in a distributed manner. Intelligent agents are used to efficiently reconfigure available productive resources. [3] have developed an infrastructure, called AARIA, to support this hybrid "*info-mechanical*" domain. This architecture supports the VME by introducing intelligent agents that can manage production resources, can perform negotiations, and can monitor and manage processes. These agents can tie together resources, parts and process knowledge, in a single or multiple locations, to create an agile production system. The system can be utilized in an interactive mode to react to job streams with customized orders. Scheduling algorithms are used to balance "time" vs. "price" trade-off by examining the relations between manufacturers and its suppliers and subcontractors. Other researchers have used multi-agent technology to schedule, control and monitor manufacturing activities and facilitate real-time collaboration among design teams [9]. Agents in this environment can provide information about the product development process, availability of resources, commitments to deliver tasks, and knowledge of expected product completion in a distributed platform. Yet others have used agent technology to support "*adaptive virtual* *enterprises*" [13]. They have used mobile agents to extend across organizational boundaries. In their model, these agents extract knowledge from resources in order to reconfigure, coordinate, and collaborate with other agents in solving enterprise problems. The agents can interface with a customer, a manufacturing resource, a database, or another agent anywhere in the network.

Software agents are being used in trading markets as well. Agents are used for business-to-consumer (B2C) and business-to-business (B2B) transactions. These phenomena are referred to as electronic marketplaces, B2B exchanges, and e-hubs. These marketplaces are similar to existing trading centers, such as stock markets or spot markets. These B2B operations, however, are highly computerized and Web-centric. And like all exchanges, their objective is to enhance market liquidity and lower transaction costs by aggregating buyers and sellers in a single medium [2]. In general, electronic marketplaces use market-making mechanisms to mediate any-to-any transactions by efficiently distributing market information.

The agent technology can be applied to the entire supply chain problem. Java's interoperability and the power of intelligent agents can be used to create mobile software agents to support a distributed decision-making process. A mobile agent, unlike a stationary agent, is not bound to one execution environment. A mobile agent can transport itself and its supporting data to other execution environments. It can then begin execution or use data from both sites to perform its tasks. The mobility also allows the agent to interact with other agents or traditional software systems on the new site. Mobile agents introduce a new paradigm to distributed computing. In this paradigm, any host computer in the network can benefit from the "*know-how*", resources, and processors throughout the network. There are many mobile agent systems that provide a platform for agent applications; most of these systems are Java-based. Some examples include "Aglets" from IBM, "Concordia" from Mitsubishi, and "Voyager" from ObjectSpace [10].

IMPLEMENTING A SYNCHRONIZED SUPPLY CHAIN MANAGEMENT SYSTEM

Both mobile intelligent agents and e-marketplaces can be used as components of a new approach to support the SSCM system. In this section, we present an SSCM model that uses object technology, brokers, e-marketplaces, and intelligent agents.

In a mass customization environment, an open trading market replaces the traditional forecasting and linear supply chain interactions. The manufacturer probably focuses on supporting a limited group of strategic suppliers-those essential to the customer-driven business effort. To coordinate among members of this limited group, we introduce the concept of a broker as the mediator. The organization and form of this broker can vary with the type and scope of the businesses involved.
In its simplest form, a broker can organizationally belong to the manufacturing firm and work with several suppliers or members of the trading market to decide which suppliers can best meet a manufacturer's needs. All members of the trading market need a Web-centric software solution capable of tracking transactions and sharing information in real-time.

Saltare.com offers such a system, called LEAP [15]. This SSCM system can be placed on all supply chain partners' systems and can provide real-time information to all participants. Additionally, LEAP can send to each participant in the trading market only the information it needs. By eliminating extraneous information, each participant becomes as efficient as possible.

This solution is Java based and employs intelligent agents that can make repetitive decisions automatically. The availability of this system enables all participants to monitor, detect, predict, and intelligently resolve supply chain problems in real-time. Participants can obtain up-to-date, customized visibility into other members of the marketplace and can measure historical supply chain performance activities. This information can lead to a manufacturing operation that supports a make-to-order strategy and avoids inventory bloat. In mature implementation, the supply chain operation can be transformed into a "*demand chain*" operation, in which inventory is reduced to its minimal level throughout the entire system.

In such a system, suppliers view information that was not previously available to them. For instance, suppliers have access to the manufacturer's demand information and can see in real-time what customers are ordering. This knowledge helps the suppliers respond quickly to changes in demand and presents a win-win situation not only to manufacturers, but also to suppliers, and ultimately, to customers. By providing a common communication infrastructure along with intelligent agents and optimization algorithms, LEAP transforms static supply chains into dynamic, Web-centric trading markets that are closely integrated with the manufacturer's systems. To enable this level of access, LEAP interfaces with the manufacturer's existing ERP and logistics packages. And because a Web browser is used to access LEAP, the software is accessible anytime, anywhere.

The mobile agent technology employed in LEAP uses a combination of rules- and constraint-based approaches [6]. It uses optimization algorithms to solve capacity allocation, material shortage, and inventory management problems. These algorithms use actual consumption to forecast values that help to determine dynamic replenishment points. The agent technology also is used to perform automatic negotiation using both English and Dutch auctioning methods. These auctions are used to procure material; adjust, reallocate, or resequence orders; purchase inventory shortfalls; or sell excess inventory in the e-marketplaces [6].

In addition, LEAP is implemented as a flexible and modular suite of distributed Java applications, so it also can scale easily as enterprises join the trading market. Suppliers in the trading market are not required to install any new components-the client-side applets can connect directly and securely across firewalls to the LEAP server.

This software system can fully support an SSCM system. It obtains its input from ordering and configuration systems that may be part of existing ERP systems; provides recommended manufacturing levels to MRP systems, and provides the two-way manufacturer-supplier communications software that underpins a dynamic trading market. LEAP's intelligent agents guide the manufacturer in optimally rescheduling production as changes in demand occur. The intelligent agents can schedule production in real-time for optimal throughput and lowest costs.

Connectivity of the entire customer-order-to-production system, the information system infrastructure, and real-time capabilities of the system described give all participants access to demand, supply, and production information in real-time. The participants include the manufacturer, its suppliers, subcontractors, distributors, delivery channels, and shippers. This information availability and the assistance from the intelligent agents allow all parties to synchronize and coordinate their activities. By using this process, the production system can support the "mass customized" business model.

CONCLUSIONS

To support mass customization, manufacturers need an agile production system that offers online visibility to the entire supply chain participants. We described a system that uses intelligent agents and distributed computing technologies to allow decentralized decision making in real-time. The system supports synchronized production and can manage the digital and physical interaction among trading partners.

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