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INTELLIGENT AGENTS FOR NEGOTIATION AND RECOMMENDATION IN MASS CUSTOMIZATION

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Abstract

Mass customization, as a means to meet individual consumer's need on a large scale, has recently attracted the attention of both researchers and practitioners. However, as customers and their needs grow increasingly diverse, meeting every consumer's need has become a surefire way to add unnecessary cost and complexity to operations. Furthermore, consumers are not all really ready for mass customization. They have to face inconveniences such as expensive price, delay delivery and they have to spend time "designing" their product. In order to solve this problem, we proposed a way of intelligent agent assisted negotiation and recommendation. The recommendation is a preference elicitation process, while the negotiation is a communication process based on the situation of manufacturer, such as the inventory level, production cost and lead time. With the aid of intelligent agent of negotiation and recommendation, a good balance between efficiency and customer satisfactions of mass customization can be reached.

Keywords: Intelligent Agent, Ontology, Recommendation, Negotiation, Mass Customization, Build-to-Order Supply Chain.

1 INTRODUCTION

Today's market environment is characterized by diverse customer tastes and preferences. People are no longer willing to sacrifice their preferences but are looking for exactly what they want and need (Pine 1993). Many companies today recognize the importance of providing outstanding service to customers, and replace "mass production" with "mass customization" to gain a significant competitive advantage. Mass customization refers to the capability to offer individually tailored products or services on a large scale (Bardakci and Whitelock 2003).

As customers and their needs grow increasingly diverse, many managers have discovered that mass customization itself can produce unnecessary cost and complexity (Gilmore and Pine 1997). How to find a good balance between efficiency and customer satisfactions becomes one of the main challenges for mass customization manufacturing (Heikkila 2002). Gilmore and Pine (1997) claim that mass customization should avoid pitfalls of unnecessary cost and complexity, and provide unique value to their customers in an efficient manner. Producers should strike a balance between utility and complexity when designing their mass customization configurations (Dellaert and Stremersch 2005).

As far as the marketing concept is concerned, the driver for implementing mass-customization should come from the market, rather than from the production capabilities of the firm. Researchers have explored the effectiveness of mass customization strategies from a consumer perspective (Huffman and Kahn 1998). In fact, the inconveniences consumers faced do not always focus on the content of configurations. Bardakci and Whitelock (2004; 2003) find that consumers are not all ready for mass customization because the inconveniences such as a mass-customized product cannot be delivered to the customer at the time of purchase. Generally customers could only get an ambiguous delivery time guarantee such as 1-2 weeks, with the noting "your order's estimated lead time is dependent upon the current availability of the system and component parts you order." It has been found that some customers are unwilling to wait for a specific product variant to be available (Salvador et al. 2004). Their buying decisions are based mostly on product availability and the lead time.

Lead time reduction is one of the key issues in mass customization. However, a manufacturer should not pursue the supply lead time reduction at any cost because other objectives such as low cost and high quality could be violated. Unfortunately, multi-criteria optimization of cost and lead time is difficult and often involves judgmental decisions. Mass customization is not "free", and companies pursuing a mass customization strategy tend to experience operational problems such as higher inventories, higher manufacturing costs, and longer delivery times. Trade-offs remains between customization and manufacturing costs and delivery lead times (Squire et al. 2006).

To lessen the inconveniences caused by long lead time and help producers to keep efficiency, we proposed to persuade customer who is not willingness to wait a long lead time to choose the available components based on the inventory situation. We proposed a way of intelligent agent assisted negotiation and recommendation. The recommendation is a preference elicitation process, while the negotiation is a communication process based on the situation of manufacturer, such as the inventory level, production cost and lead time. With the aid of intelligent agent of negotiation and recommendation, a good balance between efficiency and customer satisfactions of mass customization can be reached.

The rest of the paper is organized as follows. Based on the background analysis of mass customization, section 2 describes the ontology of build-to-order supply chain for recommendation and negotiation. The conceptual model of a multi-agent system for negotiation and recommendation is developed in Section 3. We conclude in the last section with contributions.

2 ONTOLOGY OF BUILD-TO-ORDER SUPPLY CHAIN

To implement mass customization, build-to-order supply chain (BOSC) is developed by firms to be flexible and responsive (Gunasekaran and Ngai, 2005). The objective of a BOSC is to meet the requirements of individual customers by leveraging the advantages of outsourcing and information technology. BOSC does not allow inventories of finished goods in the system as it pulls the materials through the value chain based on customer orders. BOSC can be utilized to manufacture a low volume of products of a pre-determined high variety using a cluster of components. Therefore, compare with Traditional Supply Chain Management, BOSC requires more time to fill an order. The process includes configuring the product, obtaining materials from global suppliers, assembling and then delivering the product. The logistics involved in co-coordinating the material flow along the global BOSC is complicated and therefore leads to several optimization variables.

The ontology of the build-to-order supply chain is a computational representation of the structure, activities, processes, information, resources, people, behavior, goals and constraints of the supply chain for mass customization. The development of this ontology has drawn on results from AI, such as knowledge representation (KR) and KR languages. In order to segregate the service feature of negotiation and recommendation from modeling the BOSC domain, we build the ontology from a perspective of alignment of service-dominant logic and service-oriented architecture.

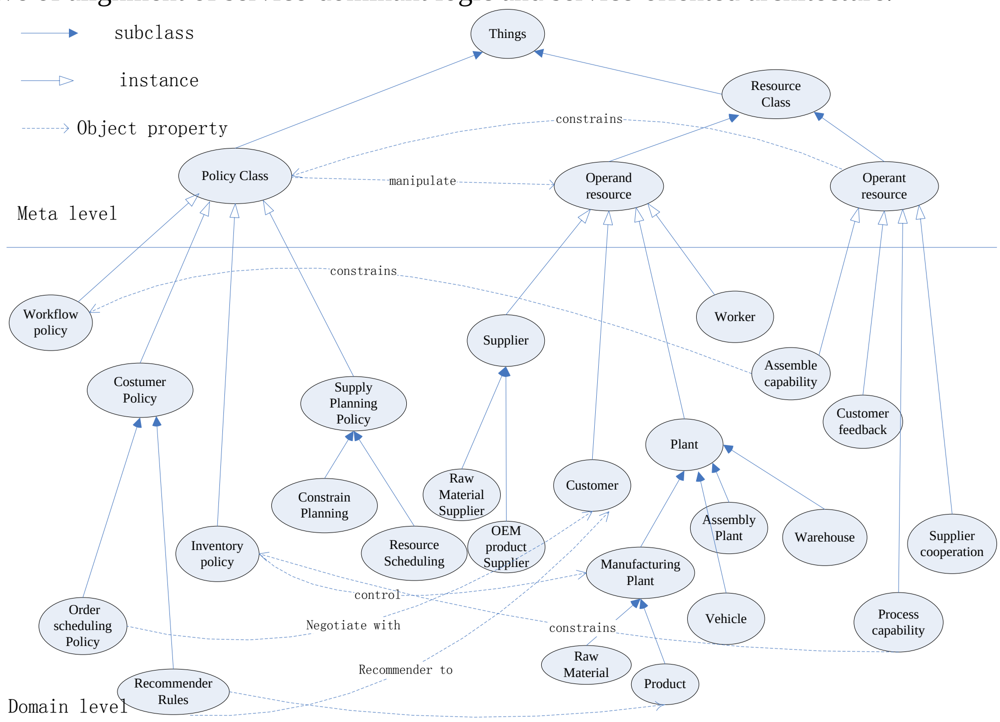

Figure 1. Ontology of BOSC

As shown in the meta-class level of Figure 1, we separate the policy class from resource class to facilitate the modeling of negotiation service and recommendation service. The resource class is classified into operant resource and operand resource. Operand resources refer to resources on which an operation or act is performed to produce an effect, while operant resource are employed to act on operand resources (and other operant resources) (Vargo and Lusch, 2004). In other word, the intangible skills or capabilities of manufacturer (operant resource) are separated from the production material or goods (operand resource). The classification facilitates the separate consideration of resource factor and capability factor, based on which the negotiation service and recommendation service can be model as the manipulation and resource acquisition of operand resource with the servicing constraints of operant resource (Lusch, et al., 2008).

Figure 1 shows a partial semantic schema of BOSC. The ontology is produced in three levels, namely, MetaClass, DomainClass and Token levels. The entities at the Token level correspond to domain BOSC instances, which are not shown in the figure. All classifications of token level objects are presented in the DomainClass level. The subset of the overall BOSC is sufficient to demonstrate the ontology of BOSC. It was with the complexity of the figure in mind that many links and several entities have been omitted.

3 MULTI-AGENT SYSTEM FOR NEGOTIATION AND RECOMMENDATION

In an agent based system for negotiation and recommendation, the agent should be equipped with the capability of information exchange, information updating, and argument generation. Based on the ontology presented in last section, the agents have a share understanding of the BOSC domain. In this section, we present a multi-agent architecture for the negotiation and recommendation.

According to the decision making theory of Simon, we developed three kinds of intelligent agents work together autonomously and co-operate with each other to perform different tasks. Intelligent Agents assists in information retrieval, information filtering, or information searching. Design Agents help to optimize the inventory management, plant scheduling, order arrangement, and the recommendation to customers. The Choice Agents communicate with the consumer by negotiation and the preference elicitation. The multi-agent collaboration is shown in Figure 2.

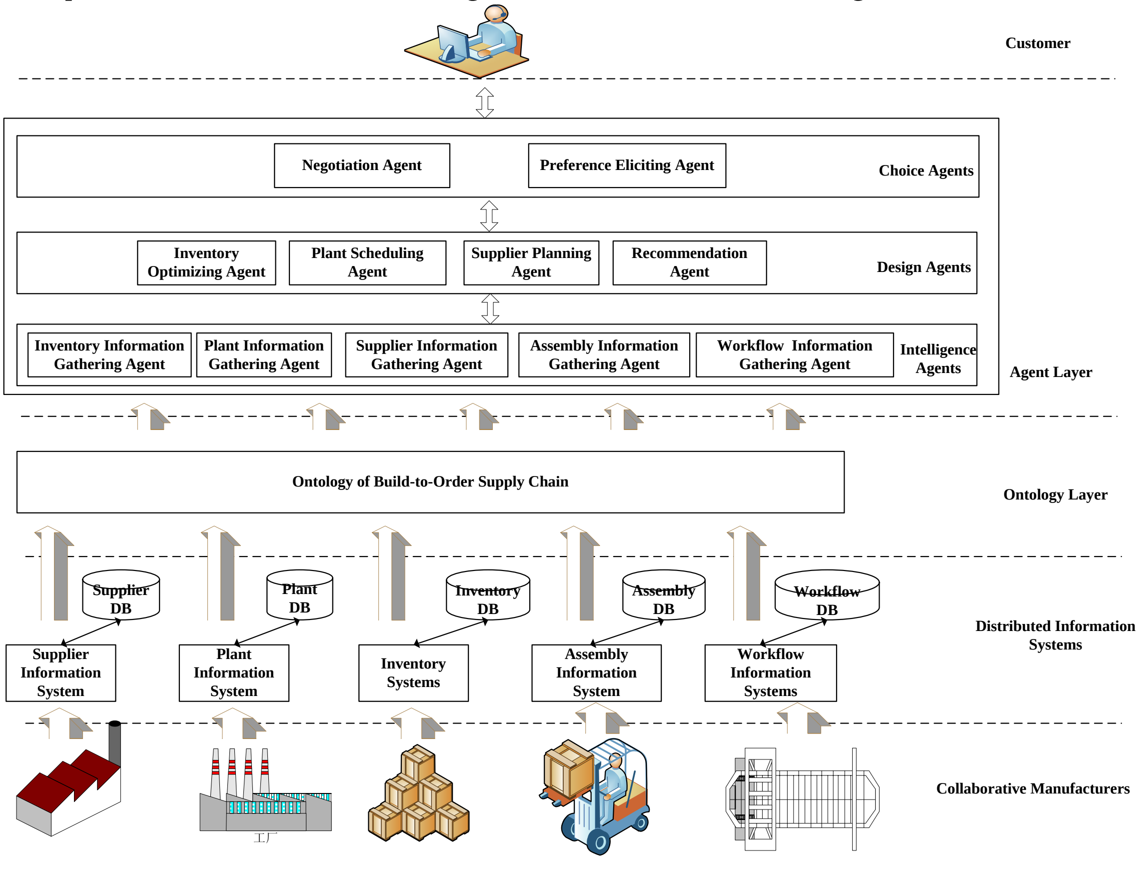

Figure 2: Multi-agent collaboration.

The implementation architecture for negotiation and recommendation is shown in Figure 3, which is derived directly from the design architecture. In this architecture, the intelligent agents are wrapped as Web-services, communicating and interacting with each other in an open environment. Each agent focuses on its particular task without interventions from outside, although there may be one or more agents involved in a particular service. Agents with different tasks cooperatively provide the specific service.

In order to illustrate our concepts and techniques, we will demonstrate a workflow taken place in e-Commerce marketplace of mass customization. The e-Commerce marketplace is equipped with negotiation and preference elicitation service, which is an interactive interface with consumer.

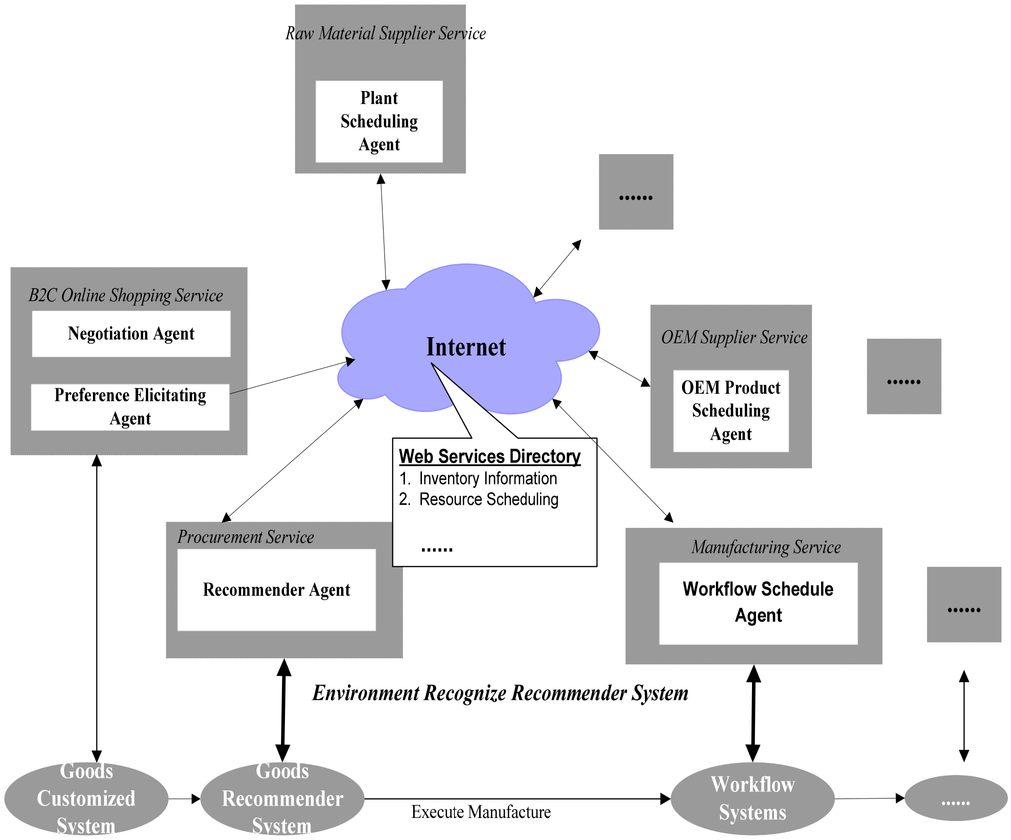

Figure 3: Implementation Architecture.

As shown in Figure 4, when the consumer interact with the online shopping server, the goods and customer's information are transmitted to supply chain resource service. In the supply chain resource service, the agents in charge of plant scheduling, inventory management, supplier planning act autonomously to get a material and time schedule report. If the report shows the available of enough material and schedule, the recommendation agent will suggest consumers within a category of the entire products. If the report tells insufficient resources, the supply chain resource server will communicate with workflow and assemble scheduling agents, OEM product agents, and raw material supplier agents. These agents will share their available information with supply chain resource server to produce an available resource report. Finally, the recommendation agent will recommend the product based on the new resource report. If the consumer is not satisfied with the recommendation, the new loop will start again to transmit information from buyer HCI agent.

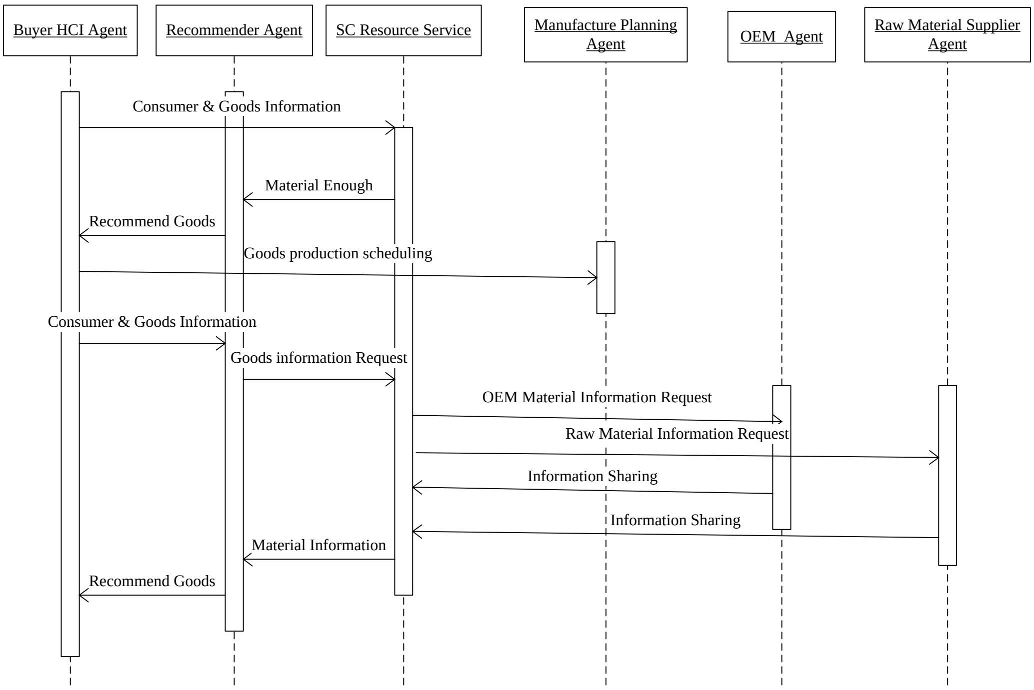

Figure 4: Time Sequence of Negotiation and Recommendation

4 CONCLUSIONS

Tradeoff between efficiency and customer satisfactions becomes one of the main challenges for mass customization. In this paper, we propose an agent based approach of negotiation and recommendation with consumer. The ontology analysis and multi-agent system architecture are proposed in this paper. This system provides a communication platform for customer and manufacture to develop a good balance of efficiency and satisfactions, and is the foundation of Win-Win strategy between manufacturer and consumers.

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