

Multiagent Framework for Purchasing and Manufacturing Under Distributed and Global Environment

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<Contents>

I. Introduction
II. A Framework for Agent-based Purchasing System
III. Multiagent System based on Distributed Objects
IV. Implementation Using A Prototype
V. Conclusions
References
국문초록

I. Introduction

For the sharing of business information, maintaining business relationships, and conducting business transactions by means of telecommunications networks, e-commerce is adopted. It includes not only buying and selling goods, but also various processes within individual organizations that support that goal. Thus, it involves using network communications technology to engage in a wide range of activities up and down the value-added chain both within and outside the organization. It can be classified as customer-to-business, business-to-business, and intraorganizational (Riggins and Rhee, 1998). As the increase of the internet-based business and e-commerce (Zwass, 1996), agent has been adopted to perform tedious and routine tasks instead of the user or principal. We mean agent as a software program which performs a given function automatically or semi-automatically by communicating with other computer agent, program or human agent (O'Leary et. Al., 1997). Agents are programs that act on behalf of their human users to perform laborious tasks such as information locating, accessing, filtering, integrating, adapting and resolving inconsistencies. The external communication protocol takes HTML format, internal message handling requires SGML for document exchange. Agent has the capability to acquire information, to optimize the utilization of resources, to perform a difficult task by reacting independently and promptly for the changing environment.

With the growing number of information sources available all around the world, the

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problem of how to combine distributed, heterogeneous information sources becomes more important. The available information sources include knowledge bases, human expert's knowledge, databases, internet-based data, programs, etc. The concept of cooperative problem solving as the cooperative solution of problems by a decentralized, loosely coupled information sources is described. Information sources cooperate in the sense that no one of them has sufficient knowledge to solve the whole problem. Decentralized means that both data and resources are logically and geographically distributed. The whole process can be divided into four phases: problem decomposition, sub-problem distribution, sub-problem solution, and synthesis of solution. A major motivation of the cooperative problem solving lies in the potential it offers for making available more problems solving power through a collection of distributed knowledge and information.

One problem is that when there are more than one active agent in the system, there is the possibility that their actions are in some fashion mutually interfering rather than mutually supportive. The conflict can happen in many ways. We may have conflict over resources, one agent may unknowingly undo the results of another, and the same actions may be carried out redundantly. Thus, the collection of agents may somehow fail to act as a well-coordinated, purposeful team. This problem is due to difficulty of obtaining coordinated behavior when each agent has only limited, and local knowledge. For these reasons, any distribution of problem solving effort appears to imply incomplete, local knowledge. It is not obvious how we can guarantee overall coordination from aggregations of actions based on local views with incomplete information.

The central element in a cooperative problem solving is the concept of negotiation. Negotiation means a discussion in which the interested parties exchange information and come to an agreement. The process is as follows: first there is a two-way exchange of information. Second, each party evaluates the information from their point of view. Third, the contractor submits a proposal and finally both sides agree with the condition and final decision is drawn. The negotiation process between a buyer and suppliers is shown in Figure 1. A familiar metaphor for a problem solver through a software agent is a group of human experts trying to complete a large task. The way how human experts solve a complicated problem is: (a) they interact to solve the overall problem, (b) the manner in which the task is distributed among them, and (c) how to synthesize the results. Thus, any one expert can not solve or control the whole problem.

Multiagent systems are the best alternative to characterize or design distributed problem solving. Agents communicate in order to achieve better goals. Communication can enable the agents to coordinate their actions and behaviors, resulting in systems that are more coherent. Coordination is a property of a system of agents performing some activities in a shared environment. Cooperation is coordination among friendly agents, while negotiation is coordination among competitive or simply self-interested agents. The issue in a multiagent system is how it can maintain global coherence (Huhns and Stephens, 1999).

This study proposes a multiagent-based framework for the order and supply management to be implemented in the global purchasing and manufacturing environment. Section 2 suggests a framework for internet-based purchasing mechanism and methodology. Section 3 discusses the multiagent system based on the distributed object. Section 4 shows a prototype of the system to be applied in a shoe making company. Section 5 discusses conclusions.

II. A Framework For Agent-Based Purchasing System

As mentioned in the previous section, the purchasing mechanism is reviewed as the process of solving a complex problem in a distributed environment. Purchasing is well positioned to help firms reduce cost and add more competition against their competitors. Global sourcing or worldwide sourcing is commonly used for improvement in cost and quality, gaining exposure to worldwide product and process technology, increasing the number of available sources, satisfying offset requirements and establishing a presence in foreign markets (Fawcett and Scully, 1998). In other point of view, the above mentioned problem is named as supply chain. The supply chain is defined as a world-wide network of suppliers, factories, warehouses, distribution centers and retailers through which raw materials are acquired, transformed into products, delivered to customers, serviced and enhanced. It should work in a tightly coordinated manner. However in real world, market situation works differently. Customers change or cancel orders, materials are delayed, machine breaks, production plan changes, or other situation changes. These events can not be handled locally meaning a single supply chain agent can not solve all the problems, rather requiring several related agents to coordinate and cooperate to cope with the complex problems. The purchasing and manufacturing activities follow a similar pattern with the manufacturing resource planning system. Production plan is related to the bill of material, and the material requirement planning. It generates an order and a procurement plan. An order-supply agent is proposed and implemented to automate the process of ordering and supplying goods in a shoe industry from the internet environment.

The main elements which guarantee competitiveness in the global sourcing are know-how, method, operating capability to control a series of supply chain. The needs for global sourcing are recognized as: (a) information technology to support part information and data for the global environment. (b) continuous cost reduction and reduction of product cycle due to the new product from competitors. (c) emphasis on the material cost as a managerial factor. (d) development of high quality part suitable for the quality management situation. (e) higher need for the national industry standard and the forming of economic block. (f) need for technology information for the multi item with small quantity (Bae et. al., 1998). The task required for the procurement stage in the global situations is summarized as Table 1.

Recently, most commercial internet applications focus on using the Web to direct a company's marketing message to end customers. More companies have started implementing internet technology that might dramatically change relationships with their business partners. The business-to-business applications of internet technology are called extranets. This implies that intranet data are shared with those outside the organization, mainly suppliers, subcontractors or interested groups. A global purchasing system is composed of internet, intranet and extranet environment. In the intranet environment, all data and information is shared among the group members through the common database. Purchasing agent announces the list and specification of the items to be ordered through the internet to the global market. This information is shared among the employees in the company through intranet. Potential suppliers can receive the order schedule and prepare for the proposal using internet. The supplier agent can automate this process. Extranet is constructed between buyer and suppliers for regular business works. They send and receive data and information for the previous order. The system described above is shown in Figure 2.

KQML (Knowledge Query and Manipulation Language) is a language that is designed to support interactions among intelligent software agents (Finin and Weber, 1993). It was developed by the ARPA supported Knowledge Sharing Effort (KSE) and separately implemented by several research groups. The message protocol to interchange messages among agents is composed of three layers. The top level is the agent communication language layer, which specifies the basic parameters and format for the KQML. The middle is the message layer, which identifies the message protocol. The bottom layer is the content or product specification layer. The detail specification of the product and other conditions are described in this layer. The structure of message communication for purchasing agent is shown in Figure 3. The purchasing agent proposed in this study is composed of a problem solver, a message controller, an address manager, a message gate and supplier agents. The problem solver creates new message and finds solutions for the proposed problem. After creating new messages by interfacing with external database and knowledge, it communicates with the message controller. The message controller validates the correctness of the message based on KQML performative, revises and communicates with the address manager. The address manager finds and responds the address of uniform resource locator from the supplier's database. In the message gate, the message is transformed into communication protocol, then transferred into supplier agent. The supplier agent replies information which satisfies the requirement to the message gate. The retrieved information is evaluated in the message controller and the process is repeated until no more incoming information is available. The whole process is shown in Figure 4.

III. Multiagent System based on Distributed Objects

In order to communicate between distributed objects, the corresponding node should be unique and the implementation object within the node should be identified. Thus, the existing agent system requires fixed internet protocol address or on-line network. In reality, as the small-to-medium sized companies do not possess their own internet protocol address, it's not easy to transfer the message in the server into the client side. This problem can be solved using naming service which supports combined name and object reference from the Common Object Request Broker Architecture (CORBA). Figure 5 shows the relationship between composite name and object reference. The OLE automation server is utilized to transfer the internet protocol data into the server side agent. The OLE automation server transmits necessary information to the server side just after the invocation from the client system. Server side agent communicates with the client system based on the information from the OLE automation server replacing the naming service of CORBA. In addition, the OLE automation server motivates the client agent automatically if needed.

In the proposed system, the client system (the OLE automation server) transfers message to the server component. The received message is stored in the database which overcome the instability of the network. Figure 6 shows the multiagent architecture using OLE server and object request broker (ORB). Six agents are defined with the following functions. OLE automation server connects client and server agent by transmitting internet protocol address into the server and replies the status of the server. It receives messages from the server and notifies client users. Storage agent stores client data in the database. Monitor agent checks a meaningful change in the system, then transmit the message to the OLE automation server. Selection agent chooses suppliers. Negotiation agent controls and negotiates conditions when proposal is not satisfied. User agent helps the user to communicate with the other agent through the user interface. Figure 6 depicts the architecture of multiagent system using OLE server and ORB.

IV. Implementation Using A Prototype

The proposed system is implemented using a real world problem in a shoe making industry. The business process model for agent-based procurement in the company is described as: (a) the company designs and makes prototype for a new season item. (b) the company gets purchasing orders from overseas buyers. (c) bill of material is generated for each product. (d) part procurement plan is generated. (e) procurement list is generated, then it is posted in the internet. (f) potential suppliers review the procurement list, then submit proposal. (g) the purchasing agent evaluates the proposals based on the given condition. (h) supplier is selected and the result is posted through the internet. The system architecture developed following the above mentioned procedure is shown in Figure 7. KQML is used as a software vehicle. For the database manipulation to read files from the server computer, Active Server Page (ASP) is adopted as a server side script.

The developed prototype is implemented for the global purchasing system in a shoe company. As the system is similar to the supply chain that acquires parts from the global open market, the interested parties need to register in advance. A description for a specific item to order is provided in separate format. All information required for supply is provided including due date, payment method, and decision criteria. When the information for potential suppliers are acquired through supplier agent, the result is updated automatically showing the number of registered companies for the given order number. Based on the decision criteria such as tolerance, supply price, quality standard, and failure rate, a company with highest total score is chosen finally. This procedure is similar with the multiple criteria decision making process.

The implementation test has been performed for selecting suppliers for the selected item in the following stage.

Stage 1. When the company plans a new production schedule, it transmits messages to the vendors using OLE automation server. The vendors receive specific conditions such as due date, suggested price, specification via user interface (UI) agent. This process is shown in Figure 8.

Stage 2. The outside suppliers or vendors considers whether they will attend the bidding. When decided for bidding, the items in the Figure 9 are filled and returned to the server.

Stage 3. When a specific company is not selected, the negotiation agent is activated. Then, a negotiation is activated by modifying the given condition. Figure 10 shows the UI agent which is applied to the negotiation process.

Stage 4. After a company with the best condition is selected, production order is transmitted to the company. When the part is produced, the result is transferred to the database through ORB. In order to reduce errors in the database, the business rule is attached between storage agent and database. The production order agent is given in Figure 11.

V. Conclusions

A multiagent framework for an order and supply management is proposed in the global purchasing and manufacturing environment. The order and supply process include a series of activity which occurs during the whole business process starting from purchasing a raw material to a finished product. The proposed system is implemented using ASP, KQML and CORBA for a shoe making company which is focused on global purchasing and overseas manufacturing. The test result shows a potential of cooperating agents that can be applied to the real-world supply chain management process. The expected benefits will be: reduced cost of real-time information exchange, realization of global manufacturing environment, the maximum utilization of internet for the enterprise data exchange, and the possibility of real world utilization of intelligent agent.

References

- Bae, S., J. Choi, and H. Park, "A Strategy for building a WEB-EDI based global sourcing system," *Proceedings on the Korean Institute of Industrial Engineers and Korean Society of Operations Research*, Session D15.3, Pusan, Korea, April 1998, pp1-6.
- Fawcett, S.E. and Scully , J.I., "Worldwide Sourcing: Facilitating Continued Success," *Production and Inventory Management Journal*, First quarter 1998, pp. 1-9.
- Finin, T. and Weber, J., "Specification of the KQML; Agent-Communication Language," DARPA Knowledge Sharing Initiative, External Interfaces Working Group, 1993.
- Huhns, M.N, and Stephens, L. M., Mutiagent systems and societies of agents, *Multiagent Systems: A modern approach to distributed artificial intelligence*, edited by Gerhard Weiss, The MIT press, 1999.
- O'Leary, D. E. D. and Plant, R., "Artificial Intelligence and Virtual Organizations," *Communications of the ACM*, Vol. 40, No. 1, January 1997, pp.52-59.
- Riggins, F.J. and Rhee. H., "Toward a unified view of electronic commerce," *Communications of the ACM*, Vol. 41, No. 10, October 1998, pp.88-95.
- Zwass, V., "Electronic Commerce: structures and issues," *International Journal of Electronic Commerce*. Vol. 1, No. 1, Fall 1996, pp.3-23.

Table 1. Main task for each procurement stages

Procurement stage	Main task
Suppliers sourcing	<ul style="list-style-type: none"> ● Database sharing of part suppliers between headquarters, international purchasing agent, and manufacturers ● Promptness of sourcing information ● Selection and control of suppliers
Request for quotation	<ul style="list-style-type: none"> ● Procurement cost control between suppliers ● Control of request proposal ● Control of proposed price
Negotiation	<ul style="list-style-type: none"> ● Combined procurement ● Reduction of processing cycle ● Bargain power
Ordering	<ul style="list-style-type: none"> ● Reduction of lead time ● Reduction of of paper work ● Productivity improvement
Delivery	<ul style="list-style-type: none"> ● Delivery route ● Freight charge ● Delivery time

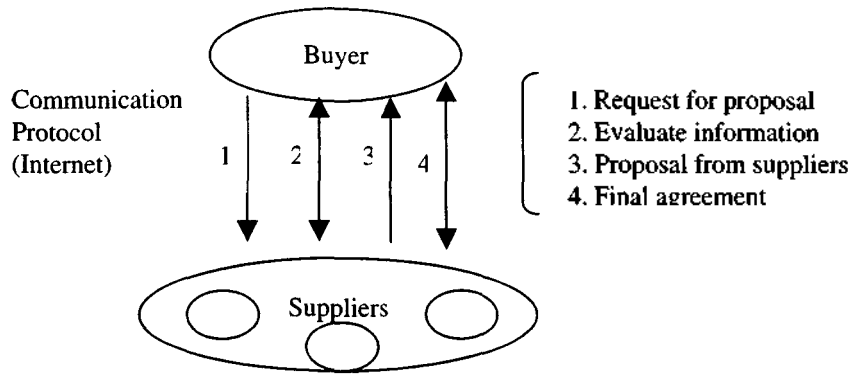


Figure 1. Negotiation process between a buyer and suppliers

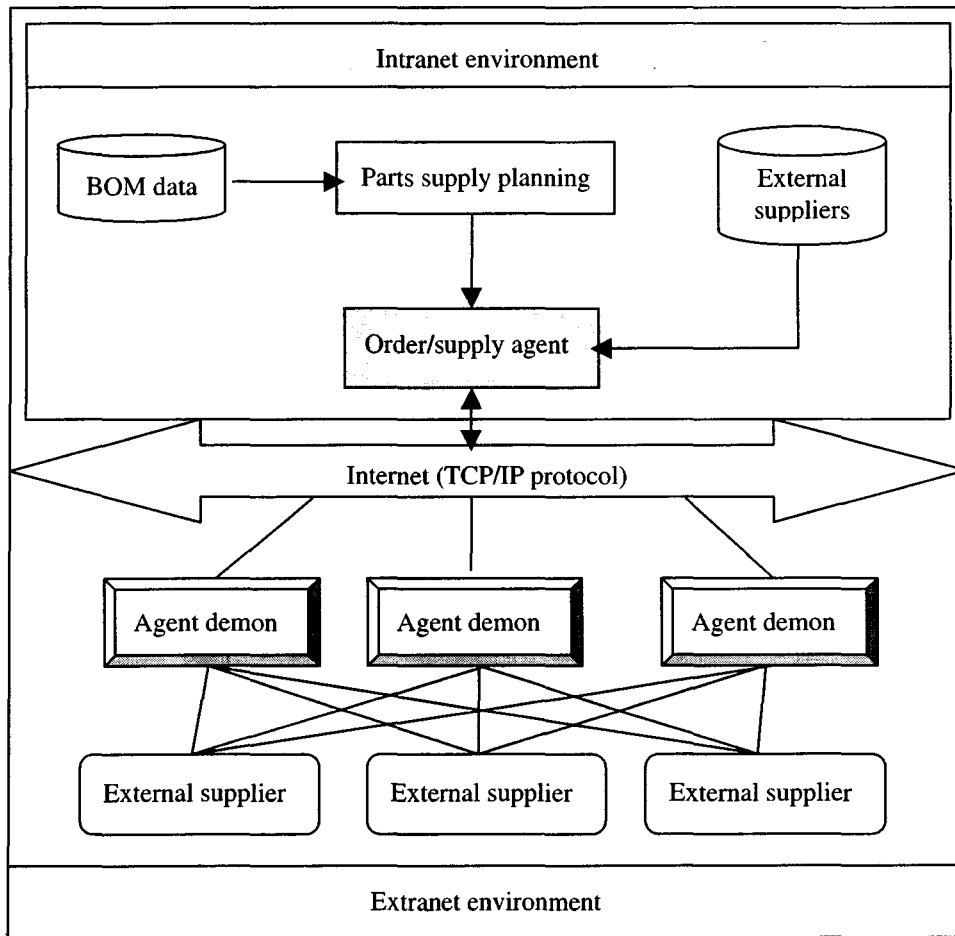


Figure 2. Order/supply agent under intranet/internet/extranet environment

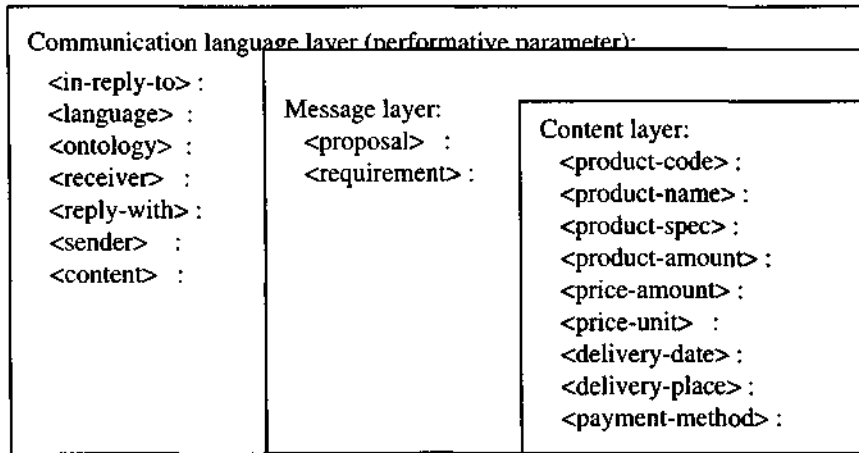


Figure 3. Hierarchy for agent message communication

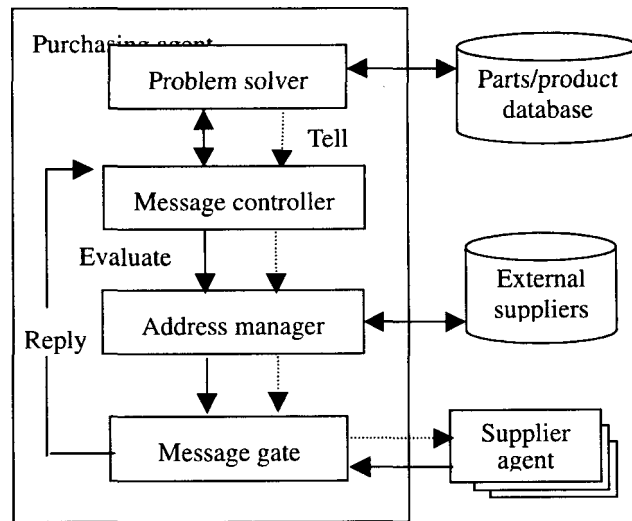


Figure 4. The Structure of purchasing agent

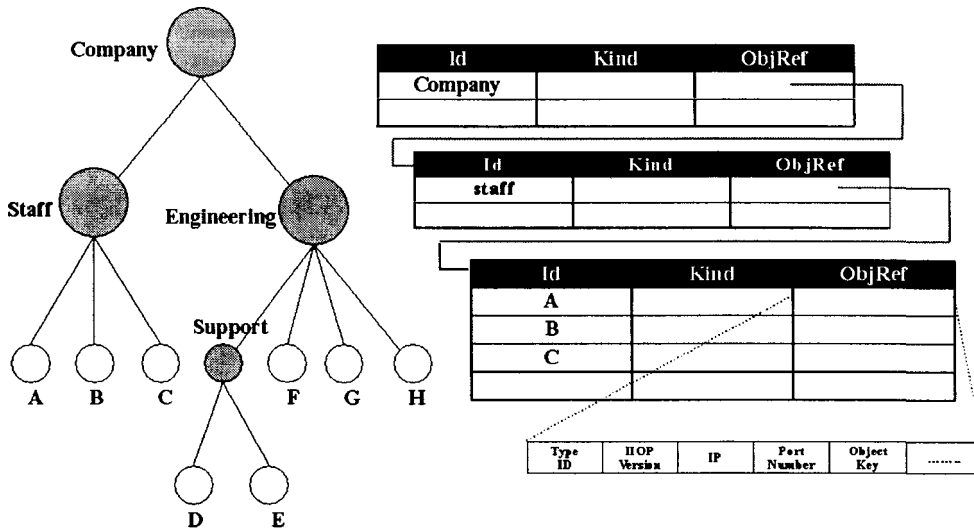


Figure 5. Composite name and object reference

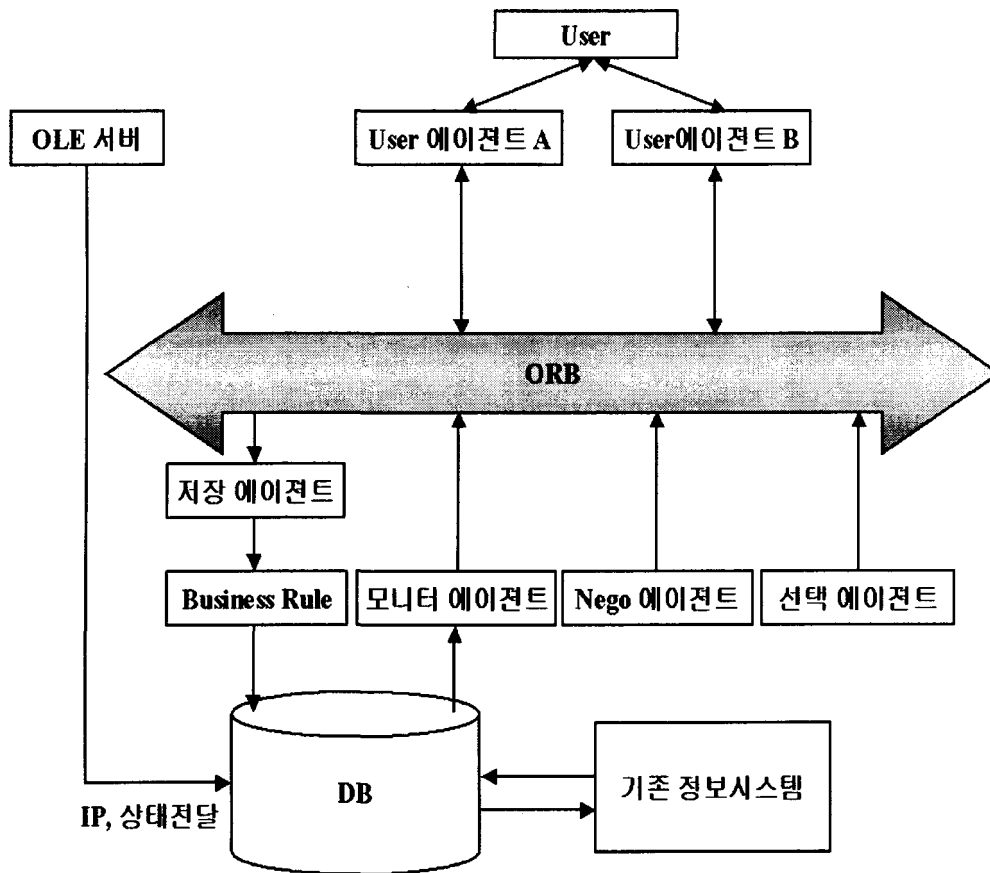


Figure 6. Architecture of multiagent system using OLE server and ORB

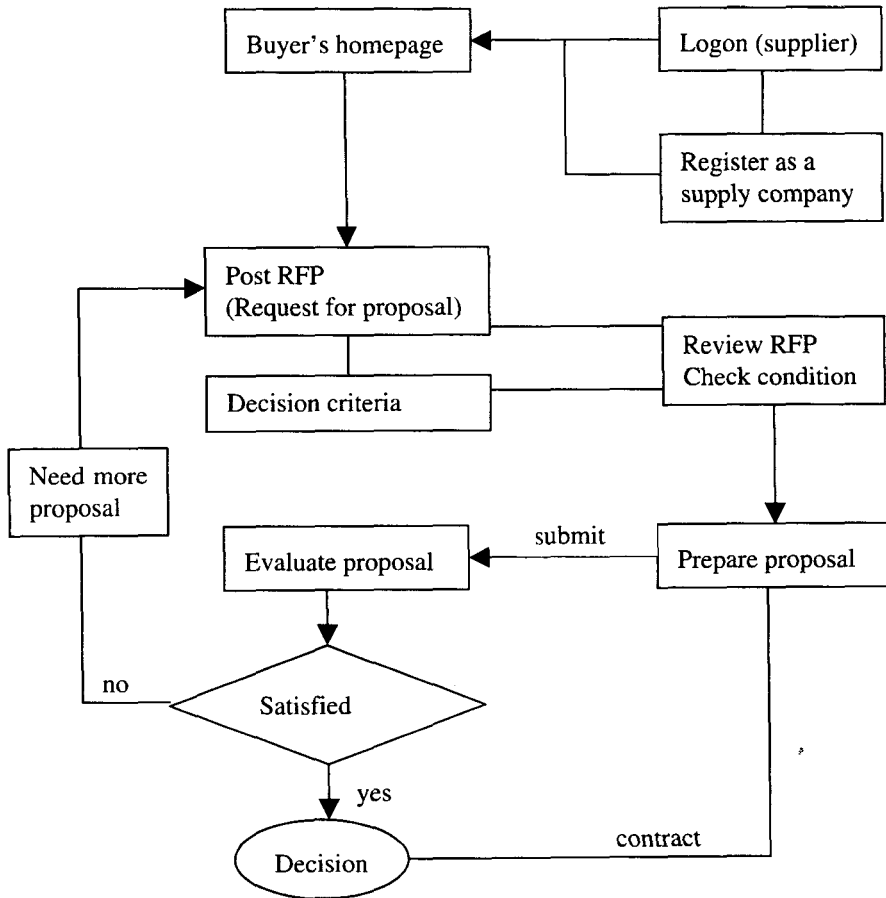


figure 7. Internet-based framework for the procurement activity

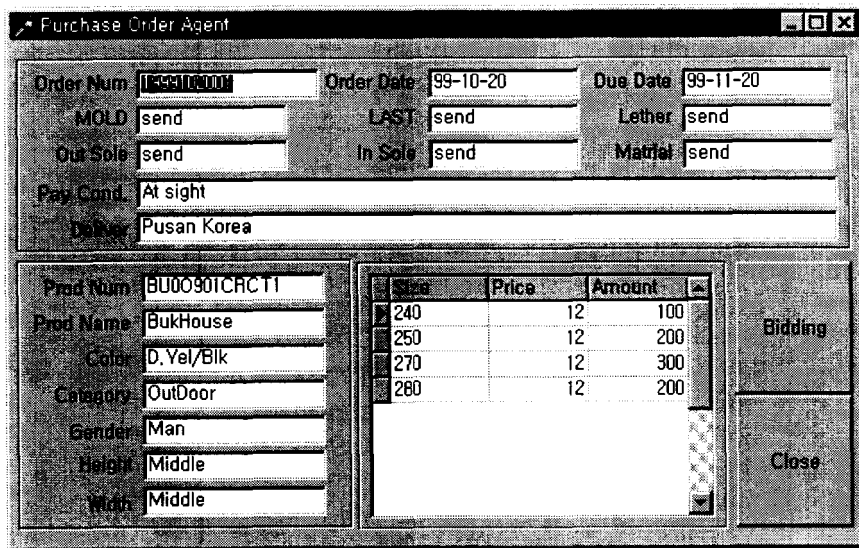


Figure 8. UI agent showing purchase order

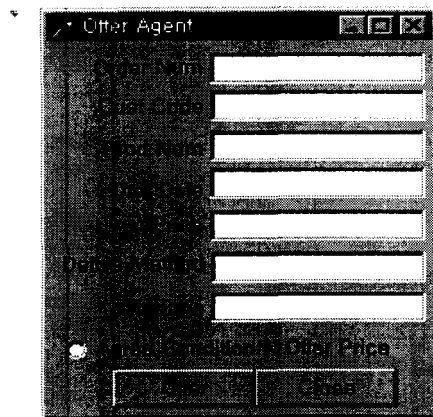


Figure 9. UI agent showing the conditions of the bidding companies

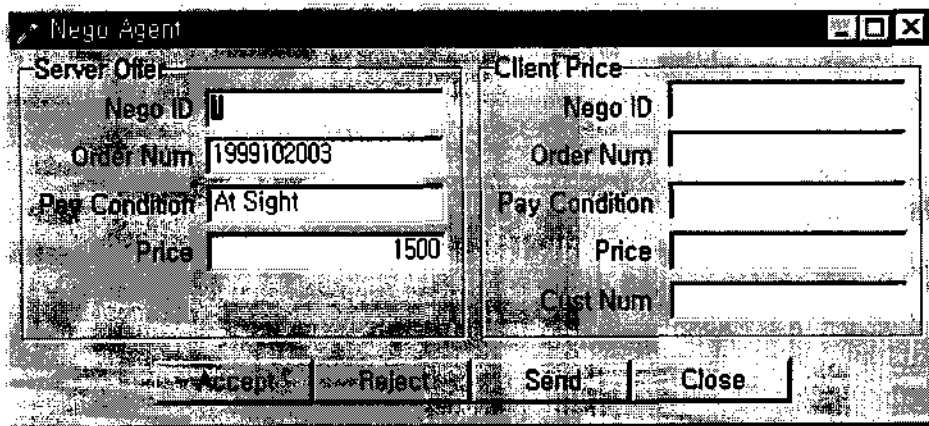


Figure 10. Nego agent used for negotiate with the suppliers to rediscuss the condition.

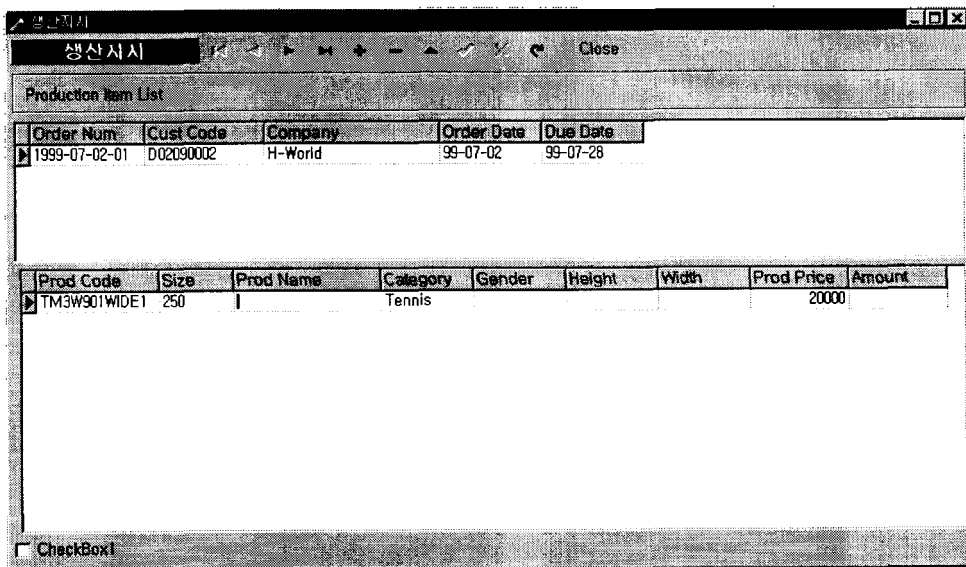


Figure 11. Agent used for production order

<국문초록>

분산 및 글로벌한 환경에서 구매 및 제조용 멀티에이전트 설계

김 태운

본 연구는 글로벌하고 분산된 환경하에서 다중 에이전트에 기반한 공급업자 선정과 이를 통한 글로벌 제조를 위한 프레임 워크를 구축하고자 하였다. 에이전트 시스템을 위해서는 KQML 에 기반을 둔 메시지 전달 시스템에 근거하여 에이전트 통신 계층, 메시지 계층 및 내용서술계층으로 구분하였다. 또한 분산된 객체간에 클라이언트간의 통신을 위해서는 고정된 인터넷 프로토콜의 주소를 없어도 통신이 가능하도록 OLE automation 서버와 ORB (Object Request Broker)를 이용하여 시스템을 구축하였다. 시스템 구현을 위해서는 스포츠용 신발을 주로 수출하는 중소기업의 업무를 대상으로 하여 정해진 생산계획에 대하여 관련 부품을 생산 납품할 수 있는 외부 공급자를 선정하는 업무에 대하여 프로토타입을 만들어서 시험하였다. 네트워크 시설이 열악한 동남아 등지에 협력업체를 많이 보유하고 있는 한국의 섬유분야나 신발산업 같은 분야에 있어서 본 시스템의 활용 가능성이 기대된다.