A Group Buy Protocol based on Coalition Formation for Agent-mediated E-Commerce

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Abstract

Electronic commerce is becoming an increasingly important channel for retail commerce. There are a large number of e-commerce sites on the Internet. Intelligent agents have been studied very widely in the field of artificial intelligence and multi-agent systems. There have been several researches on agent-mediated electronic commerce. In particular, we focus on volume discount mechanism based on agent-mediated electronic commerce. In this paper, we propose a new group buy scheme for agent-mediated electronic markets. In this scheme, we introduce the concept of sequential decision-making for seller agents and buyer agents. Further, we propose a cooperation mechanism among seller agents based on exchange items in stock. We implemented an agent-mediated electronic markets based on the group buy scheme. The result shows that the new group buy scheme is effective in supporting electronic commerce based on volume discount.

Keywords
Agent-mediated Electonic Commerce, Multi-agent Systems, Electronic Markets, Group Buy, and Negotiation based Exchanging.

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1. Introduction

Electronic commerce is becoming an increasingly important channel for retail commerce. There are a large number of e-commerce sites on the Internet (e.g. Amazon.com[1], eBay.com[6], etc.). These e-commerce sites have proposed new business models for effective and efficient commerce activity. Intelligent agents have been studied very widely in the field of artificial intelligence and multi-agent systems[17]. For purpose of this paper, an agent can act autonomously and collaboratively in a network environment on behalf of its users. It is difficult for people to effectively and efficiently monitor, buy, and sell at multiple e-commerce sites. If we introduce agent technologies into e-commerce systems, we can expect to further enhance the intelligence of their support.

There have been several researches on agent-mediated electronic commerce [8]. We can classify these researches into two categories. One is agent-based electronic markets (Kasbah [5], Tete-a-Tete [9],etc.). The other is shopping information gathering agents (*BiddingBot* [11] [12], ShopBot [13], etc.). Related works are present in Section 5. We focus on the former category, agent-based electronic markets. In agent-based electronic markets, an electronic market is prepared. In general, an electronic market is a server computer. On an electronic market, there exist several agents. Agents try to sell or buy goods on behalf of their user. There are two types of agents, seller agents and buyer agents.

While a seller agent tries to sell goods at higher price, a buyer agent tries to buy good at lower price. The main advantage of agent-based electronic markets is that agents can reduce user's work load for electronic commerce. Suppose an user wants to sell a Palm Pilot. If this user employs a seller agent on an electronic market, he does not need to find several buyers, select one buyer, and negotiate with that buyer. His agent can automatically find several buyer agents, select the best buyer agent, and negotiate with the best buyer agent on behalf of him.

There have been a lot of e-commerce sites based on volume discount (e.g. Volumebuy.com[18]). In these sites, buyers can advantageously negotiate with sellers and purchase goods at volume discount prices by forming a buyer

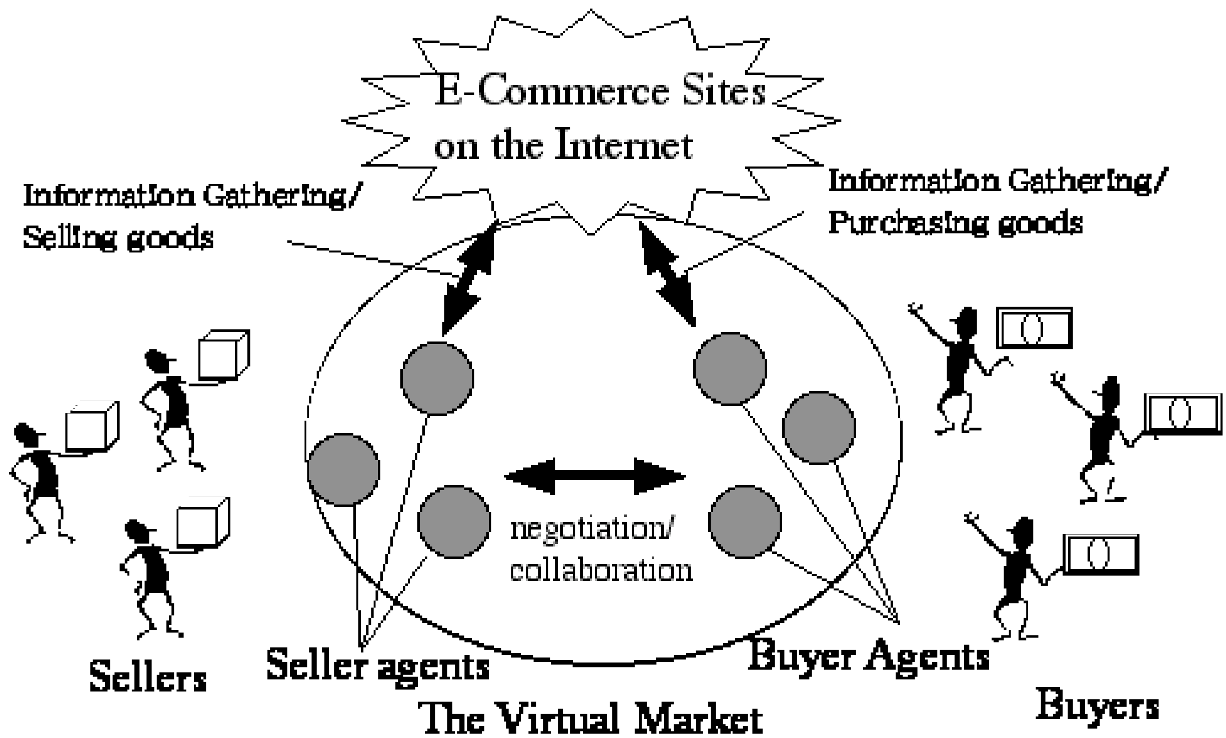


Figure 1 Outline of an agent-based electronic market system

coalition. In this paper, we propose a new agent-mediated electronic commerce scheme based on volume discount. In this scheme, we introduce the concept of sequential decision making for agents. In the real world, sellers/buyers sequentially enter into a market, and they sequentially make a decision to sell/buy items. Yamamoto and Sycara[20] has also proposed a volume discount scheme (called the GroupBuyAuction scheme) for coalition formation among buyer agents on an agent-based electronic markets. They do not consider the concept of sequential decision making.

Furthermore, if a seller agent does not have enough items in his stock, he tries to find another seller agent that has extra items in its stock. Then, they try to exchange so that they can sell enough items for buyers. In our electronic market system, we propose a cooperation mechanism among seller agents based on exchanging items in their stock. We have proposed an exchanging protocol among agents [10]. In the previous work [10], we applied the exchanging protocol to a meeting scheduling problem. In this paper, we introduce the exchanging protocol as a cooperation mechanism among seller agents on our electronic market

2. An agent-mediated electronic market system based on group buy.

2.1. Outline of an agent-based electronic market system

Figure. 1 shows the outline of our electronic market system. In the system, there exist one electronic market that is a computer on which agents act cooperatively and autonomously. A seller (human) can create a seller agent that can automatically find buyer agents and negotiate with buyer agents. A buyer (human) can create a buyer agent that can automatically find seller agents and negotiate with seller agents. These agents can also access World Wide Web sites and sell/purchase goods on the Internet. In our electronic market, a seller agent can sell multiple items. Each item has a price table, a deadline, and the number of the same items in stock. A price table represents item's discount rate for the number of buyers. Figure. 2 shows an example of a price table. According to this example, if buyer agents purchase 5 items, the unit price becomes 45,000 yen. A deadline represents the date at which the item must be sold.

Buyer agents arrive at the electronic market sequentially. Figure 3 shows an example of deadline of multiple items and sequential buyer agents arrival. The starting times and the deadlines to sell items could be different from each other.

2.2. Agent's utility

The utility of an item to a buyer can depend on what other items he buys. We can say that there exists complementar-

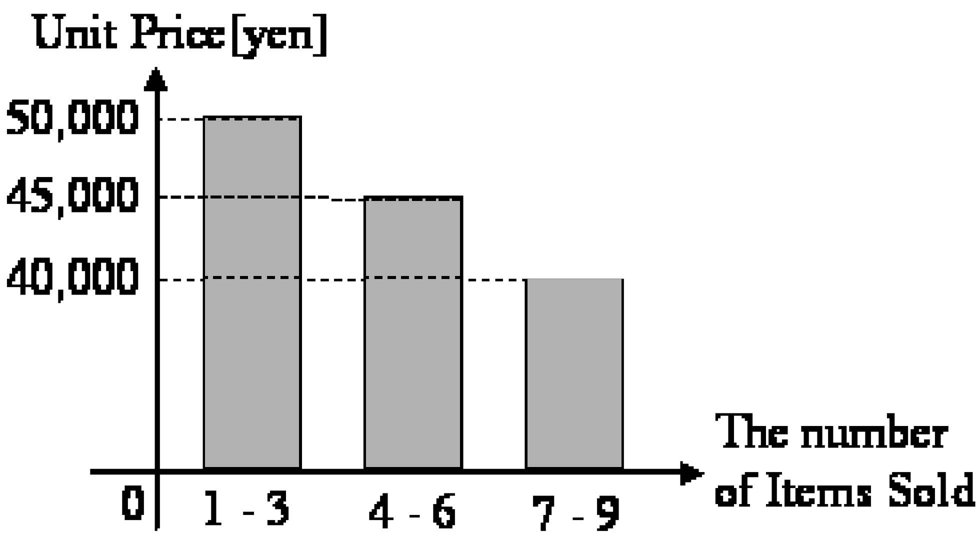


Figure 2 An example of a price table

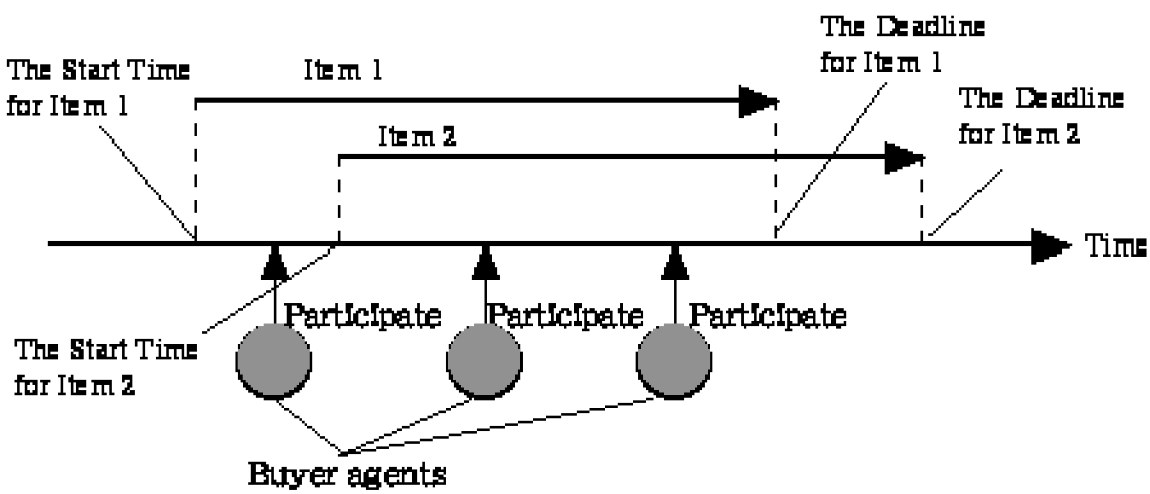


Figure. 3 Deadlines of items and sequential arrivals of buyer agents

ity between items g and h to buyer b if $u_b(\{g,h\}) < u_b(\{g\}) + u_b(\{h\})$, where $u_b(G)$ is the utility to b of acquiring the set of items G. It is also common for bidders to desire a second item less if they have already bought a first item. We can say that there exists substitutability between goods g and h to buyer b when $u_b(\{g,h\}) < u_b(\{g\}) + u_b(\{h\})$. A common example of substitutability is for a bidder to be indifferent between several items but not to want more than one. In our electronic market, we assume substitutability for user's preference.

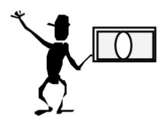
We define agent b's utility for the item g, $u_b(\{g\})$, as the following equation (1):

$$u_b(\{g\}) = (P_{desired}(\{g\}) - P(\{g\})) \times N_{desired}(\{g\}) \quad (1)$$

where $P_{desired}(\{g\})$ is the desired price for the item g. $P(\{g\})$ is the price for the item g. $N_{desired}(\{g\})$ is the number of the item g.

Figure 4 shows an example of agent's utility. Suppose there exist two items, *item a* and *item b*. There is substitutability between *item a* and *item b*. The buyer's preference is like "In the case of *item a*, I prefer one item at 9,000 yen. In the case of *item b*, I prefer two items at 4,000 yen." If he can buy *item a* and the number of items sold is five, the unit price of *item a* becomes 9,500 yen. In this case, his utility $u_b(\{item\ a\})$ becomes less than 0. We ignore the utility less than 0. If he can buy *item a* and the number of items sold is ten, the unit price of *item a* becomes 8,000 yen. In this case, his utility becomes 2,000(= (9,000 - 8,000) x 2). This means that if he can form a group and the group buys ten items, his utility becomes 2,000.

"In the case of the item a, I prefer 1 item at 9,000 yen.
In the case of the item b, I prefer 2 items at 4,000 yen."



Item a ← substitutability → Item b

Item a

The Number of Items Sold	Unit Price	Utility
1 - 3	10,000 yen	-
4 - 6	9,500 yen	-
7 - 9	9,000 yen	0
10 - 12	8,000 yen	1,000

Item b

The Number of Items Sold	Unit Price	Utility
1 - 2	5,000 yen	-
3 - 4	4,000 yen	0
5 - 8	3,500 yen	500
9 - 12	3,000 yen	1,000

Figure 4 Agent's utility

3. A group buy protocol among agents

3.1. Definition of terms

In this section, we propose a group buy protocol among agents. In this protocol, buyer agents try to form coalitions, and seller agents try to select a coalition to sell larger number of items.

Firstly we define terms and notations as follows.

Buyer agents: $B = \{b_1, b_2, \ldots, b_l\}$ represents a set of buyer agents.

Seller agents: $S = \{s_1, s_2, \ldots, s_m\}$ represents a set of seller agents.

Items: $G = \{g_1, g_2, \ldots, g_n\}$ is a set of items.

Price Schedules: s_j's price schedule of g_i is represented as a function $p_{ji} : N \to R$; $p_{ji}(n)$ is a unit price when n of g_i are sold together.

Deadline: d_{ji} denotes seller agent s_j's deadline for selling g_i.

Stock: $stock\_num_{s_j}(g_i)$ denotes the number of g_i in stock.

Reservation Price: r_{ki} represents buyer agent b_k's reservation price for g_i.

Desired Number of Items: num_{ki} represents buyer agents b_k's desired number of g_i.

Coalition: $C_i \subseteq B$ denotes a buyer coalition to purchase g_i.

Buyer Utility: When buyer agent b_k bought g_i from s_j, his utility can be defined as $u_{b_k}(g_i) = r_{ki} \times num_{ki} - p_{ji}(num_{ki})$.

Coalition Utility: Coalition C_i's utility can be defined as $u_{C_i}(g_i) = \sum_{b_k \in C_i} r_{ki} \times \left(\sum_{b_k \in C_i} num_{ki}\right) - p_{ji}\left(\sum_{b_k \in C_i} num_{ki}\right)$.

3.2. Coalition formation among agents

In the electronic market, seller agents show the information on their item. When a buyer agent arrives at this electronic market, he declares his preferences according to seller's information. The preference of buyer agent b_k consists of his reservation price r_{ki}, and his desired number of items num_{ki}. This information on buyer's preference, (r_{ki}, num_{ki}), is stored into the shared memory on the electronic market. Based on these declared buyers' preferences, when a seller agent reaches the deadline of his item, he negotiates with the buyer coalitions based on the following steps.

Step 1 : When the item g_i reaches its deadline, a seller agent s_j selects a coalition of buyer agents C_i.

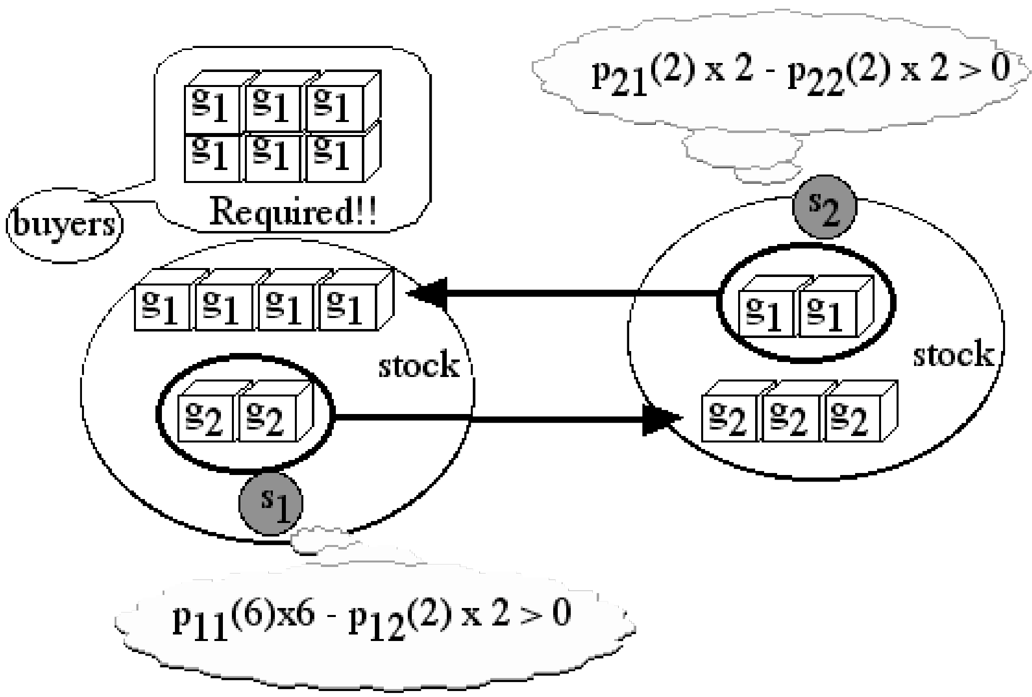


Figure. 5 An exchanging mechanism between seller agents

(1.1) if $\sum_{b_k \in C_i} num_{ki} \leq stock\_num_{s_j}(g_i)$, then go to **Step 2**.

(1.2) else if there is another seller agent that has extra number of item g_i, then s_j tries to cooperate based on the exchanging mechanism. The details of the exchanging mechanism are described in the next section. If the exchanging mechanism succeeds, go back to (1.1). If not, go to (1.3).

(1.3) else $C_i \leftarrow C' \subset C_i$. C' has maximum $\sum_{b_k \in C_i} num_{ki}$.

Step 2 : The seller agent s_j informs $p_{ji}\left(\sum_{b_k \in C_i} num_{ki}\right)$ to all buyer agents in the coalition C_i. Then, the seller agent s_j asks the all buyer agents whether they purchase the item g_i or not.

Step3: A buyer agent $b_k \in C_i$ decides to quit to purchase the item g_i if the following conditions are satisfied:

- $r_{ik} < p_{ji}\left(\sum_{b_k \in C_{buy}} num_{ki}\right)$
- $u_{b_k}(g_i) < u_{b_k}(g_i')$, $g_{i'}$ is the same item of g_i which is on sale by another seller agent.

Step 4:

- if $Nobuy_i$ is empty, then the group C_i purchases the items.
- else $C_i' := C_i \setminus Nobuy_i$.
  - if C'_i is empty then the seller agent finishes selling the item g_i.
  - else go to **Step 1**.

  Here, $Nobuy_i$ denotes a set of the buyer agents that decided to quit to purchase.

3.3. A cooperation mechanism among seller agents based on exchanging items in stock

In the Step 1.1, if a seller agent does not have enough items in his stock, he tries to find another seller agent that has extra items in its stock. Then, if they can exchange their

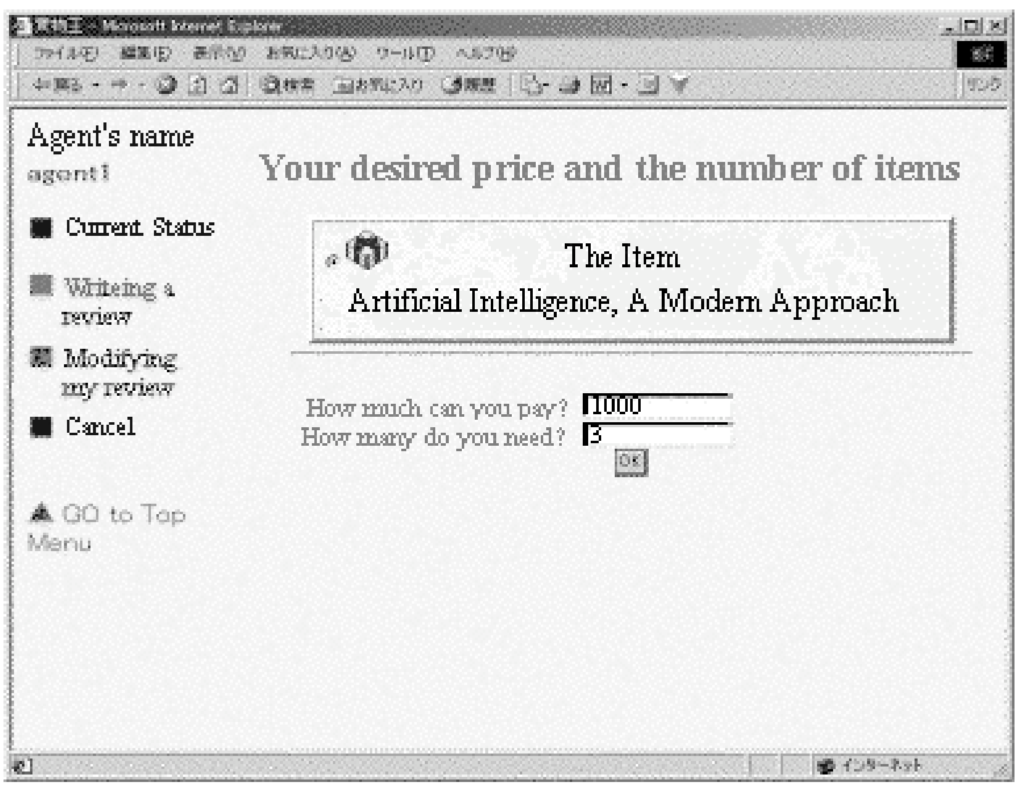


Figure 6 Inputting user's preferences

items in their stock so that they can sell enough items for buyers, both of seller agents and buyer agents can get more revenue. Therefore, we propose a cooperation mechanism among seller agents based on exchanging their items in their stock.

Figure 5 shows an example of exchanging items. There exist two seller agents, s_1 and s_2. The seller agent s_1 has four item g_1s and two item g_2s in stock. The seller agent s_2 has two item g_1s and four item g_2s in stock. Suppose that a buyer group tries to purchase six item g_1s to the seller agent s_1. Since the seller agent s_1 does not have enough items, he tries to negotiate with the seller agent s_2. Firstly, the seller agent s_1 proposes that he gives two item g_2s to the seller agent s_2 instead of that s_2 gives him four item g_1s.

Here, if $p_{11}(6) \square 6 \square p_{12}(2) \square 2 > 0$ for s_1, and $p_{21}(2) \square 2 \square p_{22}(2) \square 2 > 0$ for s_2, we define that both of the seller agents, s_1 and s_2, can agree this proposal. Since both of the seller agents can make profit, they can exchange items.

4. Discussion

4.1. An example of user interface

Figure 6 and Figure 7 show the user interfaces of the electronic market system. The system has been implemented by using MiLog (**M**obile **i**ntelligent agents using **Log**ic programming)[14]. MiLog has been implemented by using Pure Java. To realize an efficient mobile agent development environment, Milog provides a hybrid programming environment in which a mobile agent can be designed by logic programming and Java programming. In MiLog, we can create mobile agents that have an anytime migration mechanism, web-service/access functions. Anytime migration enables agents to infer during migration from one computer to another. A MiLog agent can behave as a CGI program and can access to other web servers via HTTP. Further, MiLog provides user interface development tools, iML and MiPage. Using iML, users can create MiLog agents that have Java-based user interfaces. MiPage en-

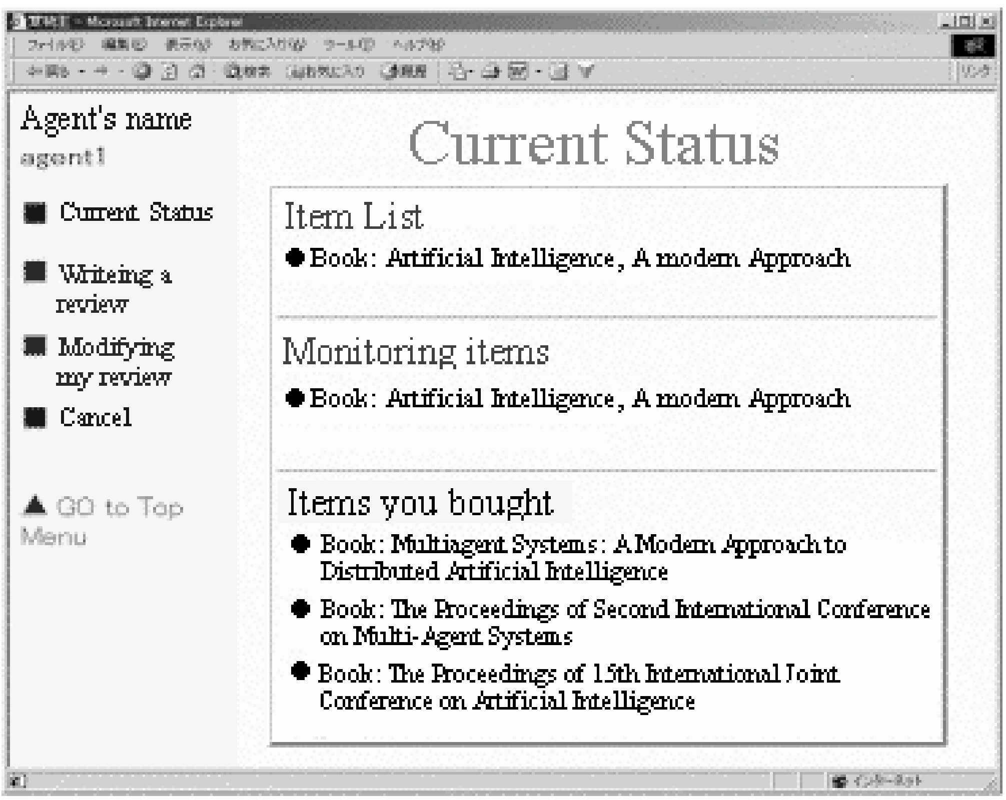


Figure. 7 Presenting the current status

ables users to create web-based user interface for MiLog agents.

The window in Figure 6 shows an user interface for putting user's preferences. A user can access his agent via a web browser. A MiLog's agent has a function to behave as a web server. We utilize this function to allow users to access to their agent. A user can input his desired item and desired price in the text box in the middle of the interface. In Figure 6, user's desired item is a book, "Artificial Intelligence, A Modern Approach". Also, a user inputted that his reservation price is 1,000 yen and he needs three books.

The window in Figure 7 presents a user interface for showing a current status. Users can know which item is now monitored, which item is now on sale, which item is purchased via this user interface. In Figure 7, a book "Artificial Intelligence: A Modern Approach" is monitored.

4.2. Features of our electronic market based on the group buy protocol

The followings are the main features of the electronic market based on the group buy protocol:

1. **Buyer agents and seller agents can sequentially make a decision**
   In the real world, sellers/buyers can sequentially enter into a market, and sequentially make decisions. Therefore, in this scheme, we introduce the concept of sequential decision making for agents. For example, in the real world, each seller has different deadlines to sell his items. Also, buyers can enter into a market anytime. In GroupBuyAuction[20], agents try to make a deal by one-shot style. They do not consider sequential deals. In this sense, we can say that our group buy model can reflect real world sequential deals more effectively.
2. **Sellers can cooperatively exchange items**
   In our electronic market, seller agents can cooperate to make profit. Existing agent-mediated electronic markets do not handle cooperation among seller agents. By employing an exchanging mechanism, seller agents can effectively exchange their items in stock. Subsequently, they can sell more items as a group.

5. Related work

In this section, we present related work on our study.
We can classify related work into the following two categories: *agent-based electronic markets and shopping information gathering agents*.

Agent-based electronic markets: AuctionBot, eMediator, Kasbah, FishMarket, and Tete-A-Tete can be classified into this category. AuctionBot[19] is an auction server. Users can create auctions to sell their item. In the auctions, agents can bid according to the pre-defined protocol. AuctionBot provides API for users to create agents.

Kasbah[5] provides a market place on the Web. Users can create agents that can buy and sell in the market place. In Kasbah, deals between agents are conducted based on a simple protocol.

FishMarket[15] provides an electronic auction site. Users can encode several bidding strategies to their agents. Although FishMarket is an experimental system, virtual tournaments have been conducted several times.

Tete-A-Tete[9]provide an electronic market. In Tete-A-Tete, agents cooperatively negotiate with each other based on arguments.

eMediator[16] is an electronic commerce server and consists mainly of eAuctionHouse and eCommitter. eAuctionHouse is a configurable auction place that supports many auction types. eCommitter is a leveled commitment contract optimizer which can solve the Nash equilibrium thresholds.

GroupBuyAuction[20] is an agent-based electronic market on which agents automatically negotiate with each other on behalf of their users. In particular, in the GroupBuyAuction, buyer agents can form coalitions in order to buy goods at volume discount price. The difference between out approach and this approach is the concept of sequential decision making to sell/buy items and exchanging items among seller agents.

Shopping information gathering agents: Sherlock 2, AuctionWatch, BargainFinder, ShopBot, Jango can be classified into this category. Apple's[2] Sherlock 2 is a meta-search engine which can access several search engines on the Internet. Additionally, Sherlock 2 can search a desired item on online auction sites.

AuctionWatch[3] is a search engine for items in several auction sites. Users can search their desirable items by providing some keywords.

BargainFinder[4] is a shopping agent for on-line price comparisons. Given a specific item, BargainFinder requests its price from the pre-specific merchant Web sites.

ShopBot[13] evolved from BargainFinder. ShopBot can automatically determine how to represent information and queries in the online merchant sites.

Jango[7] is an advanced ShopBot, and helps a user decide what to buy and where to buy it.
BiddingBot[11] is one of the shopping support agents that can actually attend, monitor, and bid in real auction sites. For the *BiddingBot* we have proposed several cooperative bidding mechanisms among agents [12].

6. Conclusion and future work

In this paper, we proposed a new group buy scheme for agent-mediated electronic markets. In the real world, sellers/buyers can sequentially enter into a market, and sequentially make decisions. Therefore, in this scheme, we introduce the concept of sequential decision making for agents. Furthermore, we proposed a cooperation mechanism among seller agents based on exchanging items in stock. By using this mechanism, seller agents can effectively cooperate to sell their goods. We implemented an agent-mediated electronic markets based on the group buy scheme. The result shows that the new group buy scheme is effective in supporting electronic commerce based on volume discount.

Current implementation employs one central server on which several seller agents and buyer agents can negotiate with each other. In the future work, we will employ a Peer to (P2P) Peer connection method. By using a P2P method, people do not need to do find the central server. If a seller wants to sell something, he just put items on his own computer. Also, a buyer just put information on their desired item into his agent on his own computer. Then, a P2P connection mechanism tries to match such seller agents and buyer agents. Thus, the system can be a free market system on the Internet.

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Biography

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