Agent-based e-marketplace system for more fair and efficient transaction

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Abstract

Despite the rapid emergence of Internet-based electronic transactions, many users are still unfamiliar with the system and find it difficult buying and selling products in the cyber marketplace. The agent-based virtual marketplace system, where agents take care of the transactions for individual users, has been suggested to solve this problem. Many of the models proposed for the system can be largely divided into two types. The first type is direct transaction between sellers and buyers, and the second is agent-based transaction. However, the deals between buyers and sellers are not made efficiently or fairly for both sides. To improve such conditions, this paper suggests a broker-based synchronous transaction algorithm that would guarantee a more fair and efficient transaction deal for both sellers and buyers. This algorithm, implemented by Visual C++, showed better performance in every aspect in the experiment for comparison with the current two model types. The number of transactions increased by 21% and the prices were adjusted up to 280% more efficiently in some transaction cases.

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Keywords: Agent; Transaction model; The direct transaction; The agent-based brokered transaction; Broker-based synchronous transaction

1. Introduction

Today, electronic transactions take place actively worldwide and the transaction amount is continuously increasing day by day. Market Business Research Services Forrester Research forecasts that Internet commerce (both B2B and B2C) will make up 5% of the global sales amount estimating up to US$3200 billion by the year 2003. Also, IBM’s CEO Gerstner expects that electronic transactions in the U.S. would increase up to US$5 billion by 2001 from US$240 million in 1998. Though many outlooks on the future e-business market size vary, it is definite that electronic transaction will take an active role in the 21st century [2].

Such forecasts on the increase of electronic transaction are based on the fact that transaction on the Internet is highly efficient and relatively less expensive. Regarding this, and considering the increasing common use of super high-speed communication network and virtual reality in the near future, it is expected that transaction on the Internet will take place across a far more wider range [1].

However, there are some underlying problematic matters. Users who are not computer experts may find electronic transaction rather confusing and awkward. The cyber marketplace is completely different compared to the markets in the real world. For this matter,
the agent-based system is proposed for providing a more user-friendly transaction environment [4].

Agent is the software that automatically carries out the work for the user [3]. The agent-applied systems can be divided into two major types, the geographic information system (GIS) and the transaction agent system. In the GIS, the agent searches for the online shops after receiving requests from the users and notifies the acquired information to the users. On the other hand, in the transaction agent system, the agent registers the product information input by users who want to buy or sell a product, searches for the users’ transaction partner, and settles a deal after bidding the price.

The agent of the latter system type described above sells and buys products in the marketplace. The agent carries out transactions in accordance to the transaction algorithm of a certain market system. The two major transaction algorithms are the direct transaction algorithm (Fig. 1) and the algorithm of transactions done by broker agents (Fig. 2). These transaction algorithms show weakness in providing a fair and profitable deal to both the seller and buyer. The present paper suggests the broker-based synchronous transaction for overcoming such weaknesses.

The present paper is organized in the following order. Section 2 is a description of the transaction algorithms that are currently used through reference of related studies. Section 3 suggests the broker-based synchronous transaction as a solution for disadvantages of the current algorithms, and Section 4 describes the designing/engineering and implementation of the two systems applying the current algorithms and the broker-based synchronous algorithm. Section 5 will deal with the experiment results and analysis, and finally, Section 6 will conclude the study and suggest the direction for future studies.

### 2. Related research

The transaction agent system type has the agent take part in the marketplace. In accordance to the transaction algorithm of a certain marketplace, the agent searches for a certain transaction partner and settles a deal through negotiation. Through practice of such systems, there has been many research on designing a more efficient and consistent transaction algorithm.

As mentioned before, transaction algorithms are classified into types for direct transaction between providers and consumers or brokered transactions between agents [6].
2.1. Direct transaction algorithm

In the case of direct transaction, agents are given permission for transaction by time division. On receiving permission, the agent searches for a transaction partner and settles a deal after the price is adjusted. When an agent has completed a transaction settlement, it is put off the market. Agents that have no settled transaction are allocated with additional processing time within the final negotiation time and goes through the process again.

While this algorithm enables individual negotiations between buyers and sellers, the expenses are high for searching for the right transaction partner and losses may occur for the buyer or seller in some cases since the agents’ transactions are permitted by time division. As with the second matter, agents participating in transactions with the desired prices set most recently lose the most because the agents transact with the prices set at different points of time[5]. Kasbah is one of the systems that use this type of transaction model.

2.2. Algorithm for transactions through broker agents

In transactions carried out by broker agents, the agent receives permission for transacting in a certain marketplace, informs the broker agent the desired price. Then the broker agent searches for the most appropriate transaction partner. When a deal is settled for transaction, the agent is put off the market list. On the other hand, if no transaction deals are settled yet, the agent goes through the same process after being allowed to transact within the final negotiation time.

Though this algorithm cuts the costs for searching for the right partner, unfair transaction still occurs because the transactions are made based on prices set at different points of time due to the time division. Also, the deals are not always settled on the best conditions for both the buyer and seller [5]. Systems such as Magma use this transaction model.

3. Broker-based synchronous transaction algorithm

The broker-based synchronous transaction algorithm that this paper suggests is based on transactions carried out by broker agents. It is purported for more efficiency in making transactions and more fairness in prices offered by agents at different points of time so that both buyers and sellers can profit the most in the transactions. The main concerns on designing the algorithm are as follows.

3.1. Fair transaction

Fair transaction implies that the seller and buyer should transact based on the price set at the same point of time. In the case of direct transaction, the processing time is allocated to the agent by time division before the agent carries out transaction. The agent sets the desired price after receiving the allocated processing time. However, when agent A starts searching for a partner after setting the desired price first and agent B takes the leading role in the transaction process after receiving allocated processing time, agent B tends to be more disadvantageous in getting a transaction settlement. This is because agent A would have applied the price information they had acquired in the past, that is before agent B receives allocated processing time, in setting the desired price. Due to this, the agent starting transactions after receiving allocated processing time would adjust the desired price if a transaction is not settled. When a transaction is settled in such cases, the agents with allocated processing time have more advantage because the agent is transacting with the price set at a point of time earlier than the other party. Such cases occur also in transactions by broker agents.

In a broker-based synchronous transaction, standard time has been applied to solve such problems as mentioned above. The standard time is a point of time among the physical market time that provides a standard for all the agents to refer to in setting their desired price. When agents set their desired price based on the standard time, all the desired prices offered in a transaction will be from the same certain point of time. Thus, more fair transaction between agents.

3.2. Matching the best deal

The best deal should guarantee the seller the highest price and the buyer the lowest price [6]. The best deal is matched by comparing the differences between the selling price and the purchase price set by the agents. When selling agent X sets the desired selling
price as 3000, and buying agents A and B set their desired prices as 1000 and 2000, respectively, no deal is made. This is because the selling agent’s desired price is higher than both desired prices of the buying agents.

However, when selling agent X sets the desired price at 1000, and buying agents A and B set their desired prices at 1500 and 2000, respectively, a deal can be made between X and A or between X and B. The difference between the selling and purchase prices are 500 in the deal between X and A, and 1000 in the deal between X and B. In this case, the deal made between selling agent X and buying agent B is the best match.

The difference between the selling price and purchase price varies according to which selling agent is matched with which buying agent. Table 1 is a sample list of selling agents and buying agents in a marketplace.

In the above sample, the best deals are made between C and X and also A and Z. The average difference between the selling and purchase prices is US$20. In the case of direct transaction, the best deals are not likely to occur so often since the agents start transaction on receiving processing time allocated by time division. Meanwhile, in the case of transaction by broker agents, the best deals are made for those agents that request to the broker agent for transaction. But the results differ according to the circumstances of the requesting agent. While X is found as the best deal match when C requests to the broker agent, it is not so when D requests for transaction.

In the suggested broker-based synchronous transaction, the seller agents are listed starting from the highest price to the lowest price, and the buyer agents are listed starting from the lowest to the highest. And during the transaction process, the seller with the lowest price is matched with the buyer with the highest. This way, only the best deals are made.

### Table 1
Agent in the marketplace and their price

<table>
<thead>
<tr>
<th>Seller agent</th>
<th>Asking price</th>
<th>Buyer agent</th>
<th>Bid</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>US$157</td>
<td>W</td>
<td>US$147</td>
</tr>
<tr>
<td>B</td>
<td>US$176</td>
<td>X</td>
<td>US$185</td>
</tr>
<tr>
<td>C</td>
<td>US$150</td>
<td>Y</td>
<td>US$153</td>
</tr>
<tr>
<td>D</td>
<td>US$183</td>
<td>Z</td>
<td>US$162</td>
</tr>
</tbody>
</table>

### 3.3. Efficiency of the marketplace

A deadline is applied to every agent in the marketplace. The agents that did not make any transactions within the deadline are put off the list. Due to this, it is important to have the agent working continuously until a deal is made. In the direct transaction, overhead occurs when some of the allocated processing time is left over after a deal has been made or when the allocated processing time is up and has to be handed over to the next agent. In the transaction done by broker agents, the broker agent has to search for a transaction partner every time the user agent requests. This means wasting time on carrying out the same process on every request. Both the direct transaction and transaction done by broker agents are expensive in searching process.

However, in the broker-based synchronous transaction, the user agent simply just sets the desired price and does not need to worry about searching for the transaction partner at all. The broker agent takes care of the whole matter by organizing the seller agents and buyer agents in order and matching the best deals. The overlapping workload in the search for transaction partners is reduced compared to the transaction done by broker agents, and the marketplace becomes more efficient.

### 3.4. Broker-based synchronous transaction algorithm

In the broker-based synchronous transaction, the manager agent organizes the user agents within the marketplace (i.e. deleting the agents whose processing time is up and registering new agents applying for transaction). The manager agent also sets the standard time for setting the desired price, notifies the user agents and has them set the price according to their policies. When the desired price is set, the broker agent takes over and matches the deals between sellers and buyers.

Fair deals are made concerning the prices since all the user agents set the desired price based on the standard time. Also, the best deals are made for both sellers and buyers since the broker agent observes and compares the prices of all the agents in the market. And the market is run more efficiently by having the broker agent take care of the rest of the process after the seller and buyer agents simply just set their desired
prices [5]. Table 2 below shows how the broker-based synchronous algorithm operates.

### 4. System design and implementation

The current transaction algorithms and the suggested broker-based synchronous transaction were each applied to the e-commerce system for comparison. And an agent generator was implemented for fair testing.

#### 4.1. Simple Market Place (SMP)

SMP is the transaction system applying the direct transaction algorithm. It is as shown below in Fig. 3.

When a user applies to sell or buy a product on the e-marketplace, the interface agent requests for the information on the product that must be registered into the product database. And based on the information, the interface agent generates the user agent.

The generated user agent carries out the transaction in the e-marketplace for the user. And when a deal is made, the user agent notifies the results to the user. The user agent is classified into the buyer agent and the seller agent. As mentioned above, these agents are generated when a user accesses the marketplace and inputs the information required for generating a user agent. The generated user agent must first wait before entering the market, and then when it is registered by the manager agent, it can start transaction in the marketplace. In the case of direct transaction, the user agent receives permission for transaction by time division, sets the desired price, and also searches for the transaction partner.

The manager agent permits the user agent to transact by time division and removes the agents that have made deals or agents whose negotiation time is over to register new agents into the market.

The product database stores data on products that are transacted in the marketplace.

The whole process of a transaction is divided into two periods. The transaction time and the management time.

During the management time, the agents that are participating in a marketplace are organized. The newly generated user agents are put on the buyer and seller lists and agents who have made a deal are removed from the marketplace lists. Transaction time is the time permitted for the user agents to adjust their desired prices according to their own price adjustment policies and make a deal.

When a user (buyer or seller) accesses the electronic marketplace, the interface agent informs the user on what kinds of items are transacted on the site. Then, when the user selects the item they want to buy or sell, the interface agent refers to the product database for the required information the user must fill out to generate a user agent for selling or buying. After the user has filled out the information, the interface agent generates the user agent. This user agent is then registered at the manager agent and finally participates

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**Table 2**

Broker-based synchronous transaction algorithm

<table>
<thead>
<tr>
<th>Algorithm: Broker-based synchronous transaction</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Input:</strong> List of seller and buyer agents</td>
</tr>
<tr>
<td><strong>Output:</strong> Agents with deals settled</td>
</tr>
<tr>
<td><strong>Step 1:</strong> The manager agent registers the seller and buyer agents that apply to enter the marketplace and puts them on the list.</td>
</tr>
<tr>
<td><strong>Step 2:</strong> The agents with deals settled and agents whose negotiation time is up are removed from the lists.</td>
</tr>
<tr>
<td><strong>Step 3:</strong> The standard time is set and all seller and buyer agents set their desired prices.</td>
</tr>
<tr>
<td><strong>Step 4:</strong> The seller agents are listed starting from the highest price to the lowest and the buyer agents are listed starting from the lowest to the highest.</td>
</tr>
<tr>
<td><strong>Step 5:</strong> The buyer agent with the higher purchase price is matched with the seller agent with the lower selling price according to the order on the lists.</td>
</tr>
<tr>
<td><strong>Step 6:</strong> If there are any agents left in the marketplace or more agents have applied, the process is repeated starting from Step 1. If not, the transaction process is ended.</td>
</tr>
</tbody>
</table>
in the transaction. During the transaction time, the manager agent permits each registered user agent to make a deal by time division. On receiving permission to transact by time division, the user agent searches for the right transaction partner and makes a deal. When a deal is made, the agent notifies the user and sends a message requesting a final acceptance of the transaction. Those agents that have not been able to make a deal reset their desired prices and wait for their next turn. When transaction time is over, it is management time. During this period, the manager agent removes agents who have succeeded in making a deal and those whose final negotiation time is up. Then, the newly generated agents waiting to participate are registered.

4.2. Broker-Based Market Place (BBMP)

BBMP is the transaction system applying transaction through broker agents as the transaction algorithm. It is organized as shown below in Fig. 4.

The interface agent and the product database operate just the same as those in the SMP described previously.

The BBMP user agent’s basic functions are similar to that of the SMP user agent, except for the fact that the BBMP user agent cannot search for the transaction partner itself. Instead, the user agent requests to the broker agent for the right transaction partner. The broker agent searches for the partner that offers the best price to the user agent.

As with the manager agent, the functions are basically the same as the manager agent of SMP. However, in the BBMP system, the manager agent also controls the practices of the user agent and the broker agent.

The whole process of the transaction is the same as in SMP except as mentioned above, the broker agent does the search for a transaction partner on the request of the user agent. When the best partner offering the best price is found and a deal is made, the user agent notifies the user and sends a message for final acceptance. When the transaction time is over like in the SMP system, the manager agent removes agents with deals made or whose final negotiation time is up and then registers newly generated agents onto the marketplace list of sellers and buyers.

4.3. Synchronous Broker-Based Market Place (SBBMP)

SBBMP is the suggested transaction system applying broker-based synchronous transaction as the algorithm. This system is organized the same way as the BBMP, but the functions of user and broker agents are slightly different from those of the BBMP system. Meanwhile, the interface agent, product database, and the manager agent are the same as those in the BBMP system.

The user agent functions basically the same as that in SMP. However, the user agent in SBBMP does nothing else but setting the desired price based on the marketplace standard time. No efforts are made by the user agent to find a transaction partner as in direct transaction or transaction through broker agents.

In the broker-based synchronous transaction, the broker agent takes full charge of matching the best deals by searching for the best transaction partners with the best price offered.

The transaction process up to the point where the generated user agent registers at the manager agent and is permitted to participate in the transaction is the same as in SMP and BBMP. However, when the user agent is permitted to transact, it sets the desired price based on the marketplace standard time. When the price is settled, the broker agent matches the best deal. After the deal is made, the user agent, as in SMP or BBMP, notifies the user and sends a message requesting for a final acceptance. The process during the management time is the same as described for the SMP system.
4.4. Agent generator

To participate in a marketplace, the user must generate an agent. When the agents generated by users during a certain period of time are listed, the list becomes a scenario of agent generation.

In this study, three types of transaction algorithms have been introduced in the previous context. These three types were the direct transaction, transaction through broker agents, and the broker-based synchronous transaction. Each of the algorithms was implemented into the transaction system for comparison of the functional performances. Applying the same agent generation scenario is crucial in terms of fairness of the tests. For this reason, the agent generator has also been implemented. This agent generator generates a certain number of agents during a certain period of time.

Starting from the point it is generated until the point of removal, the seller agent continuously adjusts its desired price. It starts with the highest price, then gradually lowers the price as time passes. This is the same with the buyer agent except that it starts from the lowest price and gradually adjusts the price to a higher level.

The three figures below in Fig. 5 show the three types of price adjustment policies of the seller agent.

5. Experiment and analysis of results

5.1. Experiment

The test was implemented on Windows NT using the language Visual C++. Using the agent generator, five lists of 1000 buyer agents and 1000 seller agents were made respectively. And a period of 1 s was set between the management time and the transaction time.

The agents were generated based on the condition that 10 different items were transacted. The agent generation point of time was to be set within 10 min and the removal time within 20 min. The agents’ starting price was to be set between 20,000 and 40,000. And the closing price was to be set between 50,000 and 100,000. The price adjustment policy was selected from among the three types shown in Fig. 5. The processing time for the SMP system applying the direct transaction algorithm was set as 10 ms.

The main concern of this experiment was comparing the functional performance of the three different transaction systems SMP, BBMP, SBBMP, and measuring the rate of best deals made in each system. The following three factors were observed for comparison. First, the number of transactions achieved which shows how well and frequently transactions are achieved in

![Fig. 5. The asking price change policy of the seller agent.](image)

![Fig. 6. The number of transactions.](image)

![Fig. 7. Mean difference between asking price and a bid.](image)
the system. Second, the average amount of time taken to achieve a transaction which shows how long it takes for an agent to make a deal starting from the point of generation. And third, the average of difference between seller’s asking price and buyer’s price, which shows how effectively the best deals are made (Figs. 6–8). The first two factors are observed for comparing the functional performance of the transaction system, and the third for measuring the degree of satisfaction.

5.2. Analysis of results

Results from five experiments carried out respectively for each of the systems have been averaged to show number of transaction achieved in direct transaction as 773.8, in transaction through broker agents as 853.4, and in broker-based synchronous transaction as 937.6. Transaction through broker agent achieved 10.3% more transactions than direct transaction. And the broker-based synchronous transaction achieved 21.2% more than direct transaction and 9.9% more than transaction through broker agents.

As with the average time taken for an agent to make a deal, agents in direct transaction took 120 s, agents in transaction through broker agents 126 s, and broker-based synchronous transaction 142 s. The agents in transaction through broker agents took 5% more time in making a deal, and agents in the broker-based synchronous transaction took 18% more than agents in direct transaction and 12% more that agents transacting through broker agents.

And lastly, as with the average of difference between starting price and closing price, which shows how effective the best deals are made, direct transaction’s average was US$2209.2, transaction through broker agents’ average was US$2474.2, and broker-based synchronous transaction’s average was US$8395.8. Transaction through broker agents showed 12% improvement compared with direct transaction. And broker-based synchronous transaction showed 280% improvement compared with direct transaction and 239% improvement with transaction through broker agents.

6. Conclusion and future work

In the transaction agent system, the agents participating in a marketplace to sell or buy are controlled by the system’s transaction algorithm. This study has suggested the broker-based synchronous transaction algorithm for fair and satisfying transaction between agents. And the functional performances of the algorithm were compared with those of the current algorithms through experiments.

As shown in the test results above, the agents took more time in making a deal in the broker-based synchronous transaction than in the others. However, broker-based synchronous transaction showed greater performance in terms of number of transactions achieved and rate of best deals made.

It is true that the shorter the time taken in making a deal, the better. The weak point concerning processing time is to be improved in the future work by giving the broker agent intelligence.

References

Further reading


Namo Kang graduated with a BS degree and Master degree from the Department of Computer Science and Engineering at the Chung-Ang University in February 2000. He published some papers. Mr. Kang’s thesis title is “Broker Based Synchronous Transaction Algorithm On Market Place” at the Electronic Commerce and Internet Application Laboratory under the guidance of Sangyong Han. After he finished a Master degree, Mr. Kang worked for Adelinux which produces an embedded system using linux. Now, Mr. Kang prepares for the Doctoral Program in Computer Science and Engineering at the Chung-Ang University.

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