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The agent-based negotiation process for B2C e-commerce

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ABSTRACT

B2C e-commerce is becoming more widespread as more people come to recognize its convenience and its ability to rapidly respond to requests and as more products and services become available. However, many electronic marketplaces, especially in the business-to-consumer, are in essence some kind of search engine where buyers look for the best product in a database of products offered by sellers. Usually, such e-marketplaces do not use agent technology at all although agents could significantly improve the services provided both for the buyers and the sellers. Further, negotiation capabilities are essential for B2C e-commerce systems. In an automated negotiation, intelligent agents engage in broadly similar processes to achieve the same end. In more detail, the agents prepare bids for and evaluate offers on behalf of the parties they represent with the aim of obtaining the maximum benefit for their users. Nevertheless, in the current situation, price is the only criterion by which agents are created. This factor is easy to measure and automate. However, the criteria for advanced transactions need to be elaborated, for example, details of giveback and dividend. In this paper, we present a multiple-attributes negotiation model for B2C e-commerce, which deploys intelligent agents to facilitate autonomous and automatic on-line buying and selling by intelligent agents while quickly responding to consumers. These include a 4-phase model, information collection, search, negotiation, and evaluation. We also apply fuzzy theory and analytical hierarchy process to develop the system interface to facilitate the user inputs. Finally, an example of the notebook purchasing process is illustrated.

1. Introduction

The internet has fundamentally changed the environment of business, because it offers sellers and buyers a powerful communication channel and makes it possible for the two parties to come together in the e-marketplaces. B2C e-commerce is becoming more widespread as more people come to recognize its convenience and its ability to offer a quick response to requests and as more products or services become available. Electronic commerce is a business practice associated with e buying and selling information, products, and services on the Internet. Electronic commerce is increasingly popular in today's businesses (Du, Li, & Chou, 2005). There are more and more organizations paying attention to the advantage of this new tendency. So, e-commerce is now playing a more and more important role in our daily life (Anumba & Ruikar, 2002). Business-to-consumer is similar in concept to the traditional method of retailing, the main difference being the medium used to carry out business by the internet. Such a method of carrying out business transactions assumes the consumer has access to the WWW. By selling direct to customers or reducing the number of intermediaries, companies can achieve higher profits while charging lower prices (Laudon & Laudon, 2000).

The internet offers consumers greater benefits from increased information and lower transaction costs, which includes search costs. There are more choices than in the traditional economic environment. At present, B2C e-commerce offers functions focusing on catalogue browsing, term screening and search. Customers have to spend much time searching and scanning to find products which achieve their demands. It can see although users can get a lot of information, it will take much time to filter useful information. In addition, more information does not mean higher efficiency. Although people can buy goods at home, they cannot avoid spending much time reviewing products on Internet.

Negotiation in B2C commerce is also a time-consuming process because all parties desire to maximize their own payoff while they may have opposing goals. If some of the parties do not concede, it could take forever to reach an agreement (Choi, Liu, & Chen, 2001). Negotiation is an inseparable component of many e-commerce activities, such as auctions, scheduling, contracting, and so on, and is one area that can greatly benefit from automation (Sergievskaia, Al-Sakran, & Atoum, 2006). Negotiation is a very extensive subject spanning from pre-negotiation to post-negotiation analysis, both at the local and social level. Thus, a considerable

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amount of work on negotiation is available in the literature from different domains, such as operational research, economics, and decision theory (Wanyama & Far, 2007).

Software agent technology is a new approach in e-negotiations. Use of software agents to represent the negotiating parties could greatly decrease efforts and the time needed to complete negotiations. Intelligent agent software is the action of human decision-making behavior in the form of a computer program. Intelligent agent software can help users to perform some actions involving search, negotiation, trade off and so on to improve effectiveness. It also improves the consumer's bargaining position with the opposition from the internet and traditional channels. A negotiation support system (NSS) refers to a specialized group support system designed to help negotiators achieve optimal settlements (Zhu, Guan, Wang, Zhou, & Liao, 2005). Morge and Beanue (2004) present an agent-based negotiation support system having the following functionalities: Information sharing among stakeholders, Auto-negotiation between agents, and Modeling of group decision-making. Faratin, Sierra, and Jennings (2002) proposed an agent negotiation protocol which depends on utility, similar to the analytic approaches. Much effort has been spent on designing agents for automated negotiation (Li, Giampapa, & Sycara, 2003). However, traditional e-marketplaces do not use agent technology even though agents could significantly improve the services provided both for the buyers and the sellers. Moreover, prior research only focused on how to achieve maximum profit. The criteria for advanced transactions needs to elaborated, for example, details of giveback and dividend. Therefore, this paper proposes a multiple-attributes negotiation model for B2C e-commerce.

2. A solution approach of intelligent agent to negotiation

2.1. Intelligent agent

Sycara, Paolucci, Ankolekar, and Srinivasan (2003) precisely defined intelligent software agents as programs acting on behalf of their human users to perform laborious information-gathering tasks. Other scholars consider agent architecture linking aspects of perception, interpretation of natural language, learning and decision-making is provided (Schleiffer, 2005). There is no universally accepted agreement for a definition of the concept of an agent, probably because each definition grew directly out of the application area the definer had in mind. For an analysis of such definitions (Schleiffer, 2002) it is illustrated most of these definitions are built around human-level descriptions of agent activities, regarding software agents as some form of an artificial secretary, or as "the electronic counterpart of their real-world namesakes" (Schleiffer, 2005).

For B2C e-commerce applications, many types of choice to the consumers have also introduced the problem of information overload. Meanwhile, there are so many e-shops and products available to consumers that it has become too time-consuming to find the best deal (Wang, Tan, & Ren, 2004). As electronic commerce becomes more popular, the role of automated negotiation systems is expected to increase. For example, when a virtual shopping mall receives product orders from a customer, it is necessary to make the delivery orders automatically without human intervention, generate a request for proposal (RFP) and announce it to multiple delivery companies. Then, the mall and delivery companies will negotiate over the price and quality (for example, delivery date) of a specific delivery service (Lee, Chang, & Lee, 2000). Thus, there is a need for IA to assist in the negotiation process for B2C e-commerce.

According to automated negotiation, Beam and Segev (1997) defined negotiation in electronic commerce as the process by which two or more parties multilaterally bargain resources for mutual intended gain, using the tools and techniques of electronic commerce. Negotiation is critical in resolving conflicts of multi-agent systems in distributed artificial intelligence (Wang & Chou, 2003). Given the ubiquity and importance of negotiations in various contexts, research into negotiation theories and techniques has attracted attention from multiple disciplines such as distributed artificial intelligence (DAI), social psychology, game theory, operational research, and more recently in agent-mediated electronic commerce (Lau, 2007). The different methods of negotiation can result in different effects on the process and result. The main objective of negotiation is to improve the negotiation efficiency and maximize the benefit.

B2C e-commerce is becoming more widespread as more people come to recognize its convenience and its ability to offer a quick response to requests as more products and services become available. As this adoption spreads, the impetus for employing software agents increases to enhance and improve the trading experience (He, Jennings, & Leung, 2003). As discussed above, the main purposes of this paper are to develop a multiple-attributes negotiation model for B2C e-commerce and provide more benefits and a quicker response.

2.2. Intelligent negotiation agent architecture

In this section, an agent-based architecture called an intelligent negotiation agent (INA) architecture is designed to enhance the existing B2C e-commerce process rather than to modify it, although the process may be modified before such a system is built. The INA researches both the technology and the methods needed to improve the way information is gathered, managed, distributed and utilized to decision-makers in key business functions and operations. Several researches have studied agent architecture. Nguyen and Jennings (2005) proposed a model for the buyer agent consisting of three main components: a coordinator, several negotiation threads and a commitment manager. And some researchers claimed three key processes are needed to make the agent work effectively and simulate the real world buying experience: Identifying a proper set of criteria on which to transact, Identifying agents with whom to transact, Negotiation (Sarkis & Sundarraj, 2002). The Kasbah e-marketplace is one of the early attempts at exploiting agent technology for automated negotiations in e-commerce (Maes, Guttman, & Moukas, 1999). Buyer agents and seller agents proactively seek out potential buyers or sellers and negotiate with one another on behalf of their owners. The objective of each agent is to complete an acceptable deal based on the user-specified constraints such as initial asking (or bidding) price, a reservation price, a date by which to complete the transaction, and restrictions on which parties to negotiate with and how to change the price over time (Lau, 2007).

In this paper, INA architecture which includes buyer agents and seller agents is proposed. Buyer agents can search products, and negotiate and access negotiation records. The seller agents negotiate with the buyer agent and access products and a consumer database. The architecture characteristics:

- Intelligent: The agent automatically customizes itself to the preferences of its customer (or client), based on previous experience and imprecise information from interaction with customers. The agent also automatically adapts to changes in its environment.
- Autonomous: An agent is able to take the initiative and exercise a non-trivial degree of control over its own actions through service agreements.
- Cooperation: An agent does not blindly obey commands, but makes suggestions to modify requests or asks clarification questions. It also cooperates with other agents to query the modules needed.

In the INA system, each INA is able to perform one or more services (Fig. 1). A service corresponds to some problem solving activities of negotiation. Service requirements are issued either from the other department, for example, the purchase department through an Intranet, or from external customers through the Internet. Services are associated with one or more agents responsible for managing and executing those services. Each service is managed by one agent, although executing its sub-services may involve several other agents. The activities of the INA agents involve:

- Selecting products to satisfy the requirements of customers
- Evaluating and Negotiating the products into an integrated service
- Coordinating and scheduling the processes intelligently.

All INAs have the same basic architecture. This involves an *agent body* responsible for managing the agent's activities and interacting with peers and an *agency* representing the solution resources for the problems of product negotiation processes. The body has several functional components responsible for each of its main activities-for example, the buyer agent, interfacing with users, searching for desired products, negotiating with sellers and managing the tasks; the seller agent, interfacing with users, negotiating with buyers and managing the tasks.

2.3. Agent negotiation workflow

The INA plays four roles in the design processes:

1. A *Negotiator* is an agent optimizing the product utility based on the requirements from customers' requirements and constraints.
2. A *Manager* is an agent delivering the status messages of active services between the *Negotiator* and the clients, between an agent and its agency, and between peer agents.
3. A *Searcher* is an agent searching the products located in other distributed databases and performing the role of managing, querying or collating product information from many distributed sources.
4. *Agent Interface* is an agent communicating between the customer and other agents.

Agent negotiation is a method presenting object and exchanges to each other to obtain benefit. In negotiation processes, buyers want to buy at lower prices, contrarily, sellers want to sell at as higher prices as possible. Therefore, in the negotiation process, agents not only consider price, but also consider the after service, preference, present and so on. The INA involved in the negotiation process is illustrated in Fig. 2. The detailed operations will be explained in a later section.

3. Negotiation model

According to the negotiation structure and flow discussed above, we develop the following negotiation model. The negotiation model includes negotiating a decision function and uses fuzzy theory and analytical hierarchy process to obtain the product utility. After that, apply the product utility to negotiate for the following purposes: First, decrease the time of filter product information. Second, decrease the negotiation time. Third, meet buyer's preference and maximize the user's utility.

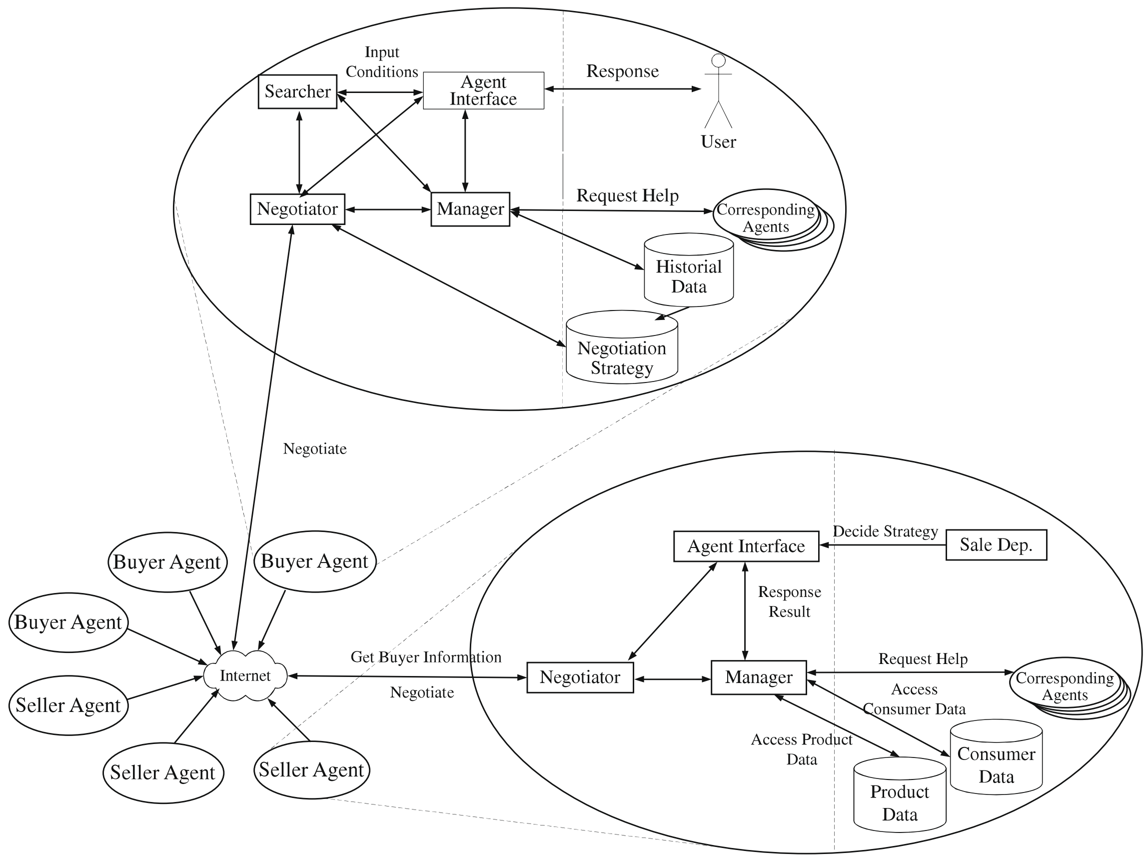


Fig. 1. Intelligent negotiation agent (INA) architecture.

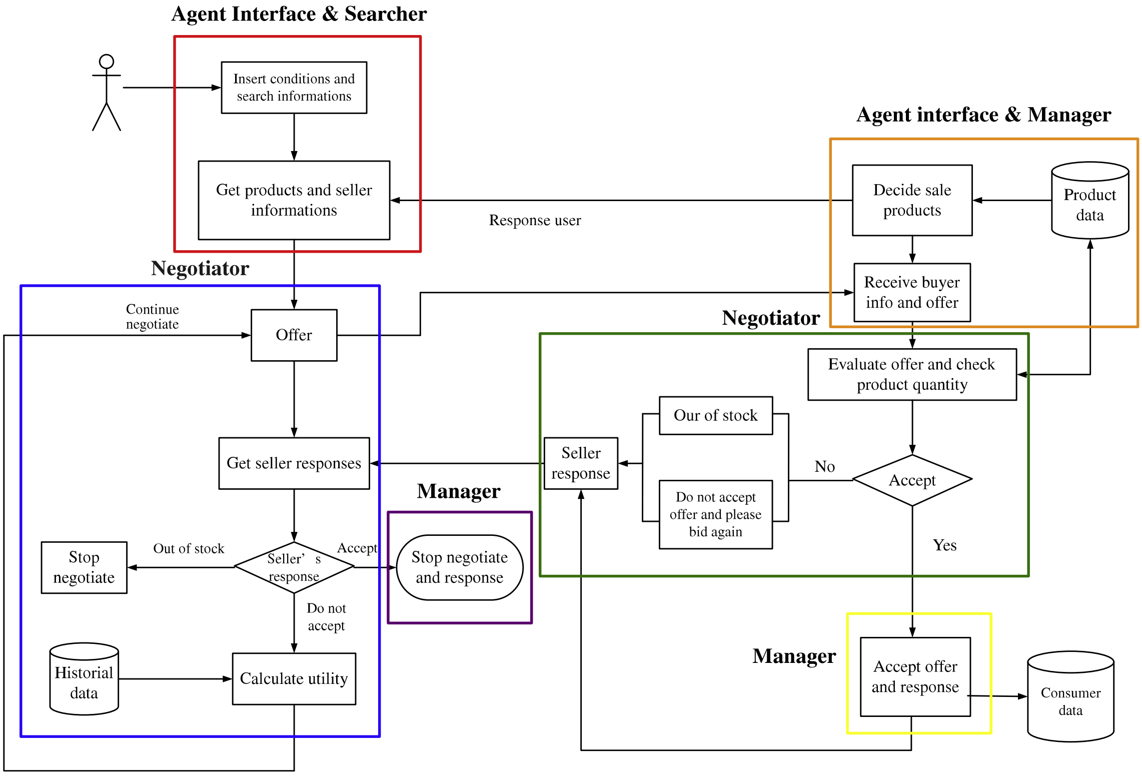


Fig. 2. Negotiation workflow.

3.1. Utility function

Faratin, Sierra, and Jennings (1998) presented the negotiation decision function (NDF) using the negotiation criterion. The NDF allows agents to negotiate with multi-attributes such as price and quantity. The NDF function is shown as follows:

$$U = \frac{\sum w_i \times V^i}{\sum w_i}; \quad 0 \leqslant U \leqslant 1; \quad 0 \leqslant V^i \leqslant 1; \quad 0 \leqslant w_i \leqslant 1 \qquad (1)$$

U refers to the utility and V^i to the utility of issue i. W_i is the weight of issue i. In this paper, we extend the NDF function and join the concept of threshold value of utility to calculate satisfaction. If the total utility of a product is lower than the threshold value, it is eliminated from the list of negotiation objects. This method decreases negotiation time and the number of negotiating objects. The extension NDF function is as follows:

$$U = \frac{\sum w_i \times V^i}{\sum w_i}; \quad 0 \leqslant U \leqslant 1; \quad 0 \leqslant V^i \leqslant 1; \quad 0 \leqslant w_i \leqslant 1$$
$$U \geqslant \overline{u}_i$$
$\overline{u}_i$ refers to the average utility of success negotiation records. (2)

3.2. Analytic hierarchy process

The analytic hierarchy process (AHP) is a mathematical decision-making technique considering both the qualitative and quantitative aspects of decisions. The AHP method uses human ability to compare the single properties of alternatives. It not only helps decision-makers choose the best alternative, but also provides a clear rationale for the choice. The process was developed in 1980 by Saaty (1980). The evaluation criterion of AHP method is weighted. It is targeted at experts in this field and its purpose is to make complicated problems systematized and present decision problems based on hierarchical method and comparison. In the simplest form, AHP structure comprises a goal, criteria and alternative level. The goal is the problem we want to solve; the criteria are the set of elements we should consider during the decision process; and alternatives conform to decision objects. In recent years, the AHP has already been studied extensively. Gu and Zhu (2006) made the decision method of many attributes according to the vector quantity of the characteristic. Osman and Cengiz (2005) also proposed fuzzy multi-attribute selection among transportation companies using axiomatic design and the analytic hierarchy process.

This paper adopts AHP to calculate product weights for initializing the product's attributes. In the initial step, the user compares each possible pair in each matrix to calculate their attention degree. After getting the weight of product attributes, calculate the total utility of product with utility function.

3.3. Fuzzy theory

Fuzzy logic is a superset of conventional logic extended to handle the concept of partial truth values between "completely true" and "completely false". It was introduced by Zadeh (1965) as a means to model the uncertainty of natural language. It contains extensive range, including fuzzy sets, fuzzy relation, fuzzy logic, fuzzy control, fuzzy measure, and so on. The fuzzy theory is currently being intensively researched. For example, Fahim, Dave, and Zakaria (2005) use a fuzzy logic-based system for assessing the level of business-to-consumer (B2C) trust in electronic commerce. Cheng, Chan, and Lin (2006) applied the intelligent agent to the electronic market and trade negotiation occurred by the fuzzy inference system. In this paper, we apply the theory of the fuzzy set and define the attributes membership function to obtain the attributes margin utility value.

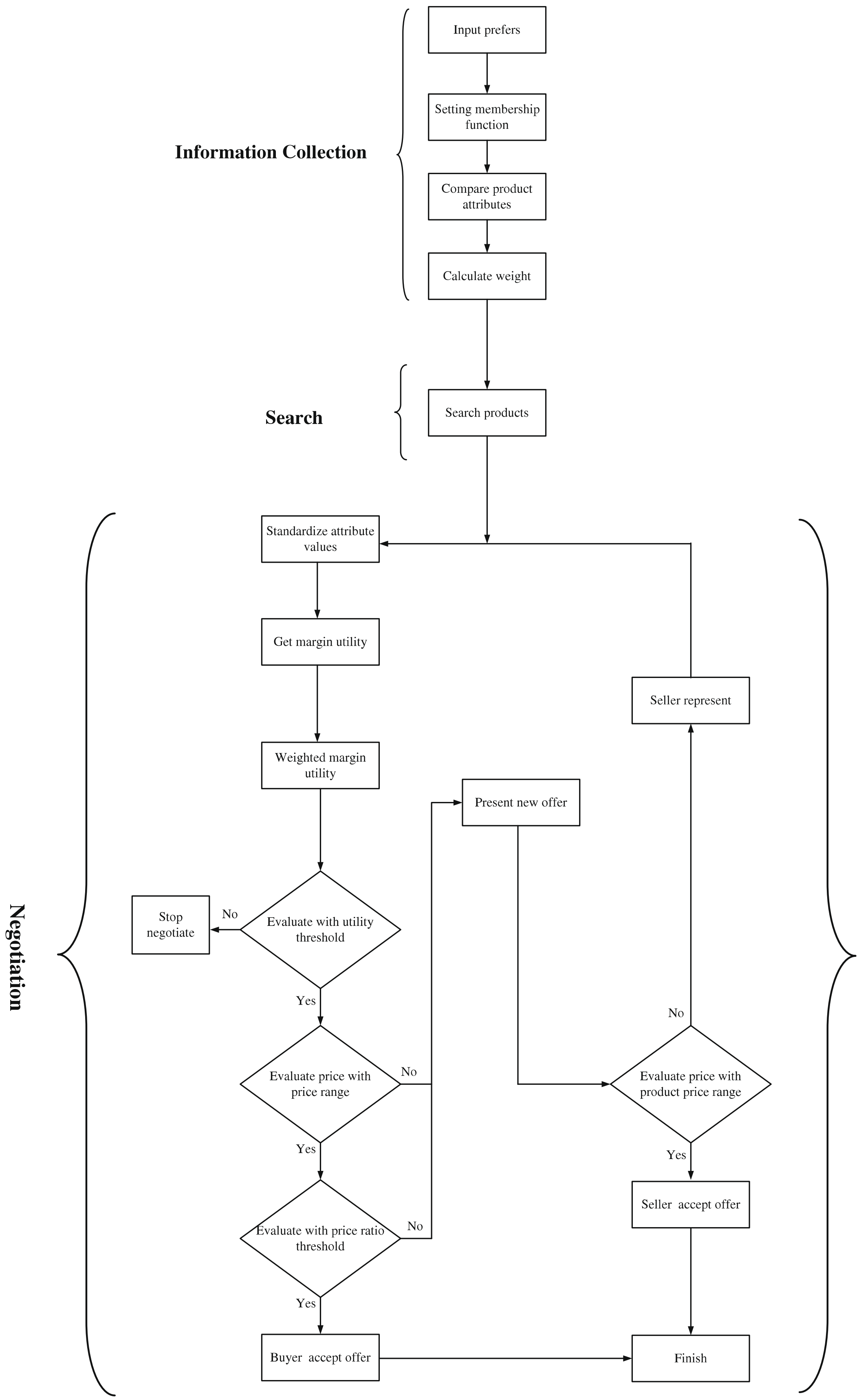


Fig. 3. Negotiation processes.

This paper applies the concept of fuzzy sets to calculate the utilities of each attribute. A fuzzy set is a class of objects with a continuum of grades of membership. Such a set is characterized by a membership (characteristic) function which assigns to each object a grade of membership ranging from zero and one (Zadeh, 1965). In the initial negotiation step, an INA agent asks the user to set up the membership function of each product attribute. Next, an INA agent normalizes these different product attributes according to the membership function. After educing margin utility with membership function, an INA agent computes the utility of the product attributes and finally calculates total utility with utility function combined with weight.

3.4. Negotiation strategy

In this paper, both buyer agents and seller agents own their negotiation strategy. We discuss this as follows: Buyer strategy refers to the offer method of buyer agents and the stop conditions. The New offer is calculated according to the total utility of products and the offering function (Wang et al., 2004). The new offering function is defined as follows:

$$Offer_{new} = utility \times 100 * u + Offer_{old} \quad (3)$$

where $Offer_{new}$ refers to new price, utility to product utility, u to the unit increase value, $Offer_{old}$ to the last offer.

Besides the current offer, the buyer agent must know when to stop the negotiation. In this paper, we present two conditions where both of them must be reached and then agents can decide to trade or not. The first condition is the product price which the seller agent presents must be within the buyer offer range. The second condition is the ratio of buyer offer and seller offer must be larger than a threshold defined by the buyer in the initial negotiation stage.

Seller strategy decides the seller agent current offer and the stop condition. This paper calculates the next offer as follows (Fernando, Nuno, Novais, & Helder, 2000):

$$x[i]_{new} = x[i]_{old} + (-1)^{w} F|RV_i - x[i]_{old}| \quad (4)$$

$x[i]_{new}$ is the new offer and $x[i]_{old}$ is the last offer. F is the factor which between 0 and 1, w is the factor to control the increase or decrease. RV refers to the max or min limit value, setting value or buyer offer. For a seller agent, the condition to stop negotiating is when the buyer offer is at the seller's acceptable price.

3.5. Negotiation process

The negotiation process can be divided into four stages, which includes information collecting, searching, negotiating, and evaluating. Fig. 3 shows the negotiation processes workflow. The first stage includes inserting product search and negotiation conditions, setting the product attribute membership function, comparing product attributes and applying AHP to calculate attribute weights. The second stage works according to search conditions the user inserts. And then an INA agent searches for products from the Internet and gets the sellers' information response to the user. Third, an INA agent starts negotiation by the search result and calculates product utility and determines whether to receive the product or not. Finally, the negotiation evaluation state is the final state of negotiation which the buyer agent and seller agent determine when to finish.

4. Example illustration

In this paper, an example of instance notebook sales is illustrated. The sellers provide the information about the products on an e-commerce platform through the seller agent. The buyer also filtrates, searches and negotiates with the seller through the buyer agent. The four negotiation stages presented above will be described and shown below.

4.1. Information collection stage

4.1.1. Input preferences

Before negotiating, a buyer agent asks the user to login to the system and input preferences; related settings include the price ratio, price range, product specifications, giveback and dividend (Table 1).

4.1.2. Setting membership function

The membership function of the product setting allows users to set all product attributes to carry on the follow-up negotiation by the agent. The membership function of the price set by the user is shown in Fig. 4. After setting the membership function of the products, we can obtain margin utility value which includes the left value, middle value and right value (Table 2).

4.1.3. Compare product attributes

The purpose of establishing a pair-wise comparison matrix is to derive the degree of relative importance among the elements. A nominal scale is used to achieve a concise pair-wise comparison evaluation. The AHP uses a scale with values from 1 to 9 to measure the different weights. In this step, the user compares the attribute pair-wise and obtains the comparison matrix (Table 3).

4.1.4. Calculate weight

In the AHP analysis, the pair-wise comparison procedure is used to determine the priorities for each of the attributes. Determining

Table 1
User demanded preference.

Preference	Details
Product	Notebook
Price range	Lower bound: 15,000 Upper bound: 25,000
Spec.	CPU: 1.5G above HD: 80G above Memory: 512 MB above ROM:DVD+-R(W)
Dividend	Yes
Giveback	Yes
Increase unit	20
Threshold	0.95

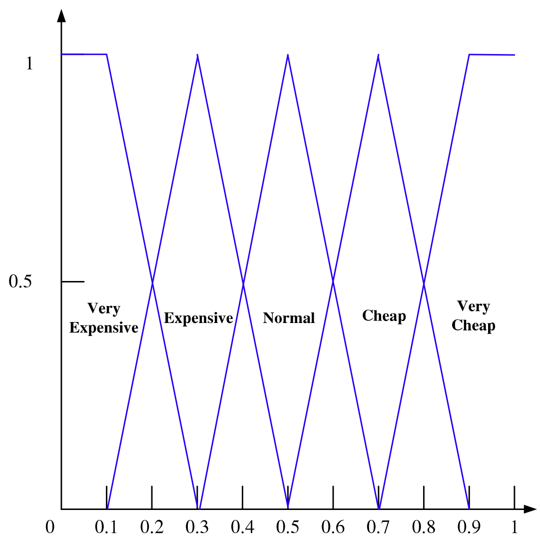


Fig. 4. Membership function (Price).

Table 2
Margin utility (Price).

Membership function	Left value	Middle value	Right value
Very expensive	0	0.1	0.3
Expensive	0.2	0.3	0.4
Normal	0.3	0.5	0.7
Cheap	0.6	0.75	0.9
Very cheap	0.7	0.9	1

Table 3
Pair-wise comparison matrix.

	Price	Spec.	Dividend	Giveback
Price	1	3	5	9
Spec.	1/3	1	5	5
Dividend	1/5	1/5	1	1
Giveback	1/9	1/5	1	1

Table 4
The overall weights.

	Price	Spec.	Dividend	Giveback	**Weight**
Price	0.61	0.68	0.42	0.56	**0.57**
Spec.	0.2	0.23	0.42	0.31	**0.29**
Dividend	0.12	0.05	0.08	0.06	**0.08**
Giveback	0.07	0.04	0.08	0.06	**0.06**

these priorities requires users to express pair-wise comparison preferences for the alternatives using one element at a time. The eigenvector is then derived to indicate the degree of relative importance among the alternatives. Then, by multiplying the eigenvector of relative importance among the alternatives and transposing of the eigenvector of relative importance among the elements, the overall weights can be obtained (Table 4). In this stage, consistency index (CI) is used to judge the degree of consistency. If the consistency index (CI) <=0.1, it means the consistency level is satisfactory. In this case, CI is obtained as follows:

$$CI = \frac{4.116 - 4}{4 - 1} = 0.039$$

Since the consistency index (CI) <=0.1, it indicates the consistency level is satisfactory.

4.2. Search stage

After a buyer inputs the search conditions and defines the membership functions, an agent goes to the next stage and searches products from the e-commerce platform. The search result is shown in Table 5. The range of product prices is set by the user, and the other items such as product specification are retrieved from the database. The data in the database could be updated through the Internet so we could be sure when the product's market price changes, the price could be updated constantly and the data are the latest available.

4.3. Negotiation stage

In the step, according to the search result, the buyer agent calculates product utility in two steps. First, the buyer agent calculates attributes utility. Second, the utility function and attribute weight are applied to get the product utility.

4.3.1. Standardize attribute values

Before calculating the product utility of each attribute, we have to normalize the attributes. For example, Product No. 1's price normalization = 1-[(20410-16588)/(24643-16588)] = 0.52, Product No. 2's = 0.52, Product No. 3's = 0.76, Product No. 4's = 0, and Product No. 5's = 1. The dividend is normalized based on market price and the giveback is normalized according to the discount of market price and favorable price. Particularly, the item of product specification includes other sub-items. Therefore, we normalize the sub-items first (Table 6). After calculating, the sub-item utility of each product is in turn No. 1 = 0.358, No. 2 = 0.358, No. 3 = 0.358, No. 4 = 0.592, and No. 5 = 0.583.

4.3.2. Get margin utility

After calculating the normalizations of each attribute, we check the membership function region of each attribute to find margin utility (Table 7).

Table 5
Search results.

Product No.	Product Spec.		Dividend	Giveback	Price
1	Item	Price	USB: 512 MB	RAM:1G	20410
	Pentium-D-805/2.66G	3000			
	SATAII 160G	1800			
	DDRII 667 1G	1500			
	DVD burner	1500	Market price: 800	Market price: 1300 Favorable price: 1040	
2	Intel Pentium-D 915 (2.8 GHz)	3200	RAM: 512 MB	HP printer	20456
	SATAII 250G	2100			
	DDRII667 1G	1250			
	DVD burner	1350	Market price: 650	Market price: 2000 Favorable price: 1800	
3	Intel Pentium-D 915 (2.8 GHz)	3200	RAM: 512 MB	EPSON printer	18545
	SATAII 250G	2500			
	DDRII 667 512 MB	850			
	DVD burner	1400	Market price: 920	Market price: 2500 Favorable price: 1625	
4	P4-935 3.2G	3500	RAM:1G	iPod 1G (white)	24634
	SATAII 160G	1600			
	DDRII667 1G	1500			
	External DVD burner	1500	Market price: 1100	Market price: 4800 Favorable price: 4320	
5	Core 2 Duo E4300/1.8G	3300	USB: 512 MB	RAM:1G MB	16588
	80G IDE	1450			
	DDRII 667 1G	1500			
	DVD 16X burner	3000	Market price: 650	Market price: 1500 Favorable price: 750	

Table 6
Sub-items margin utility.

Product No.	Product spec.		Margin utility		
	Item	Standardization	Left value	Middle value	Right value
1	Pentium-D-805/2.66G	0	0	0.1	0.3
	SATAII 160G	0.33	0.2	0.4	0.6
	DDRII 667 1G	1	0.7	0.9	1
	DVD burner	0.09	0	0.1	0.3
2	Intel Pentium-D 915 (2.8 GHz)	0.4	0.2	0.4	0.6
	SATAII 250G	0.62	0.4	0.6	0.8
	DDRII667 1G	0.62	0.4	0.6	0.8
	DVD burner	0	0	0.1	0.3
3	Intel Pentium-D 915 (2.8 GHz)	0.4	0.2	0.4	0.6
	SATAII 250G	1	0.7	0.9	1
	DDRII 667 512 MB	0	0	0.1	0.3
	DVD burner	0.03	0	0.1	0.3
4	P4-935 3.2G	1	0.7	0.9	1
	SATAII 160G	0.14	0.05	0.2	0.4
	DDRII667 1G	1	0.7	0.9	1
	External DVD burner	0.09	0	0.1	0.3
5	Core 2 Duo E4300/1.8G	0.6	0.4	0.6	0.8
	80G IDE	0	0	0.1	0.3
	DDRII 667 1G	1	0.7	0.9	1
	DVD 16X burner	1	0.7	0.9	1

4.3.3. Weighted margin utility

Margin utility (Table 7) then can be multiplied by attribute weight (Table 4). Finally, average left value, middle value and right value and get the final result is product A' total utility. Therefore, No. 1 = 0.45, No. 2 = 0.43, No. 3 = 0.81, No. 4 = 0.17, and No. 5 = 0.19.

As described above, product's total utility must be greater than a threshold value in the negotiation process and the utility threshold value is presented by historical total utility. We assume the threshold value would be 0.4. In this negotiation, Product Nos. 1's, 2's, and 3's utility threshold are all greater than threshold value so the buyer agent negotiates only with Product Nos. 1, 2 and 3.

4.4. Evaluation stage

4.4.1. Iteration 1 (Buyer side)

Since only Product Nos. 1, 2 and 3 are greater than the utility threshold, the buyer agent negotiates only with these. Then, the buyer agent evaluates the price ratio threshold. In this range, the price ratio the threshold buyer sets is 0.95. The ratio of Product No. 1 = 15000/20410=0.735, Product No. 2 = 0.73, and Product No. 3 = 0.81. The ratios are all smaller than the threshold so the buyer agent does not accept the seller's offer. Therefore, the buyer agent calculates the new offer and presents to the seller agent according to formula 3. The next offer of product No. 1 = $0.45 \times 100 \times 20 + 15000 = 15880$, Product No. 2 = 15820, and Product No. 3 = 16620.

4.4.2. Iteration 1 (Seller side)

After receiving the buyer agent offers, the seller agent first checks if the offers are larger than the lower limit of the price range (Table 8). In this stage, no one meets the constraints. Therefore, the seller agent offers again according to formula 4 ($w = 0$, $F = 0.3$, $R = 1$). The next offer of Product No. 1 = 19051, Product No. 2 = 19076, and Product No. 3 = 17967.

Table 7
Margin utility of each product's attribute.

Product No.	Product spec.	Left value	Middle value	Right value
1	Price	0.3	0.5	0.7
	Spec.	0.2	0.4	0.6
	Dividend	0.05	0.2	0.4
	Giveback	0.05	0.2	0.4
2	Price	0.3	0.5	0.7
	Spec.	0.2	0.4	0.6
	Dividend	0	0.1	0.3
	Giveback	0	0.1	0.3
3	Price	0.65	0.825	0.95
	Spec.	0.2	0.4	0.6
	Dividend	0.4	0.6	0.8
	Giveback	0.4	0.6	0.8
4	Price	0	0.1	0.3
	Spec.	0.4	0.6	0.8
	Dividend	0	0.1	0.3
	Giveback	0	0.1	0.3
5	Price	0.7	0.9	1
	Spec.	0.4	0.6	0.8
	Dividend	0.7	0.9	1
	Giveback	0.7	0.9	1

Table 8
Seller products' price interval.

Product No.	Price interval
1	20410-19051
2	20456-19142
3	18545-17378
4	24643-23031
5	16588-15603

4.4.3. Iteration 2 (Buyer side)

After receiving the seller agent's new offer, the buyer agent again calculates utility threshold D product No. 1 = 0.24, Product No. 2 = 0.27, and Product No. 3 = 0.83. We eliminate Product Nos. 1 and 2 because their utility is too low (less than 0.4). Then, the buyer agent evaluates Product No. 3's price ratio threshold D16620/17967 = 0.93. Since Product No. 3's price ratio does not meet the threshold, the buyer agent offers again. The buyer agent calculates the new offer according to formula 3 to obtain Product No. 3 = 18220. However, this new offer is greater than the seller agent's last offer (17967). To ensure buyer's benefit, the buyer agent accepts the seller agent's last offer (18220/17967 > 0.95) and replies to accept Product No. 3. The negotiation ends.

5. Prototyping system

In this paper, an open e-commerce platform is developed to validate the proposed negotiation model. We adopt JBuilder2005 as software development tools and MySQL as database system. The source of data are collected from the market. Agents used in the prototyping system are divided into two sets of buyer agents and seller agents. The sellers provide the information about the products on e-commerce platform through the seller agent. The buyer also filtrates, searches and negotiates with the seller through the buyer agent. The four negotiation stages presented above are described and shown below.

5.1. Information collection stage

Before negotiating, a buyer agent asks the user to login to the system and input preference, related settings which include price

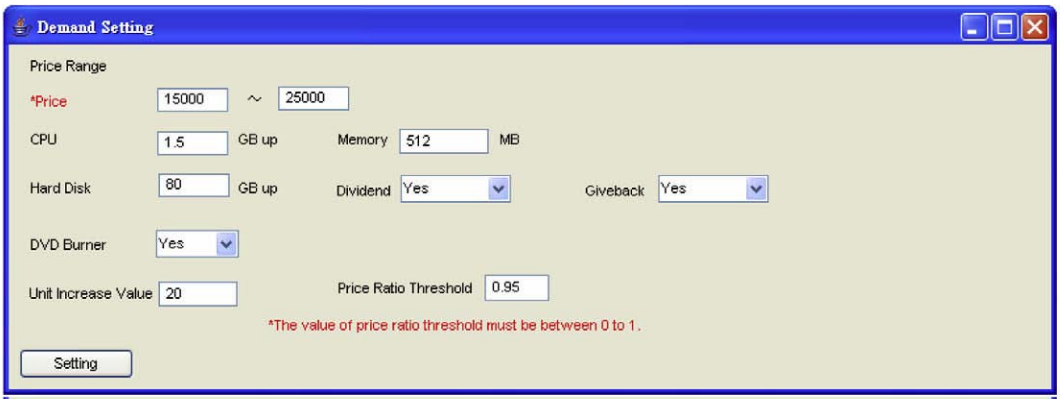


Fig. 5. Buyer demand setting.

Fig. 6. Membership function setting.

ratio, price range, product specifications, giveaway and preference (Fig. 5). The membership function of the product setting is to let the user to set all product attributes to carry on the follow-up negotiation by the agent. After setting the membership function of the products, we can obtain the attribute margin utility value and divide the parameters into the left value, middle value and right value according to the membership function (Figs. 6 and 7). The system then asks the user to compare the product attribute. The system calculates the product attribute weight by the AHP (Fig. 8).

5.2. Search stage

After the buyer inputs the search conditions and defines the membership functions, the agent goes to the next stage and searches for products from the e-commerce platform (Fig. 9).

5.3. Negotiation stage

First, the buyer agent calculates the attribute utility. Second, apply a utility function and attribute weight to obtain the product

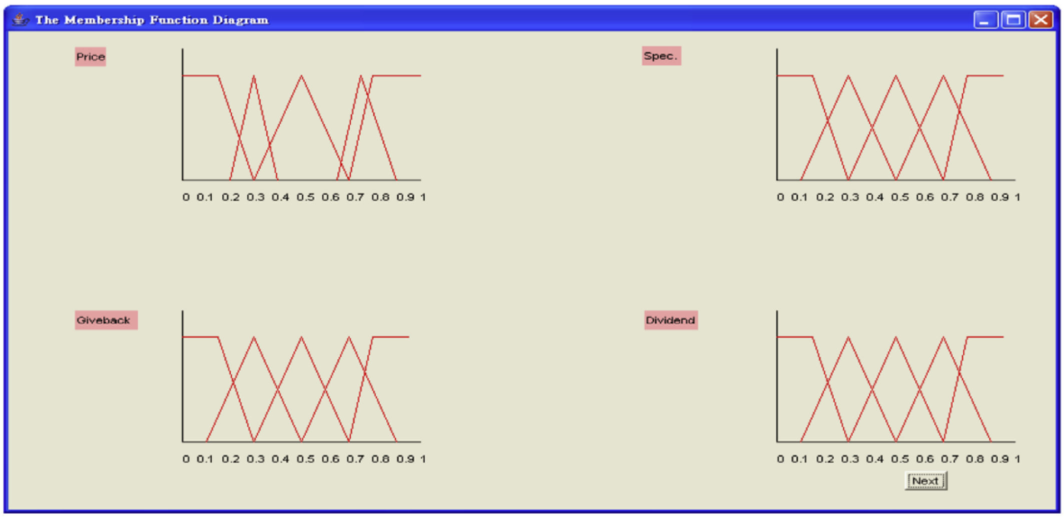
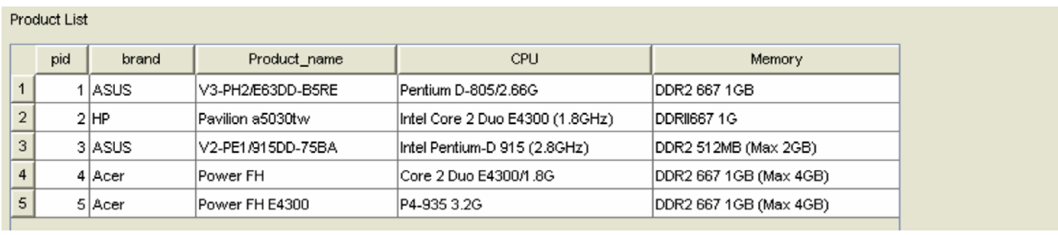


Fig. 7. The graph of the membership function setting.

Fig. 8. The weight calculation by the AHP.



Product List

	pid	brand	Product_name	CPU	Memory
1	1	ASUS	V3-PH2/E63DD-B5RE	Pentium D-805/2.66G	DDR2 667 1GB
2	2	HP	Pavilion a5030tw	Intel Core 2 Duo E4300 (1.8GHz)	DDRII667 1G
3	3	ASUS	V2-PE1/915DD-75BA	Intel Pentium-D 915 (2.8GHz)	DDR2 512MB (Max 2GB)
4	4	Acer	Power FH	Core 2 Duo E4300/1.8G	DDR2 667 1GB (Max 4GB)
5	5	Acer	Power FH E4300	P4-935 3.2G	DDR2 667 1GB (Max 4GB)

Fig. 9. Product search.

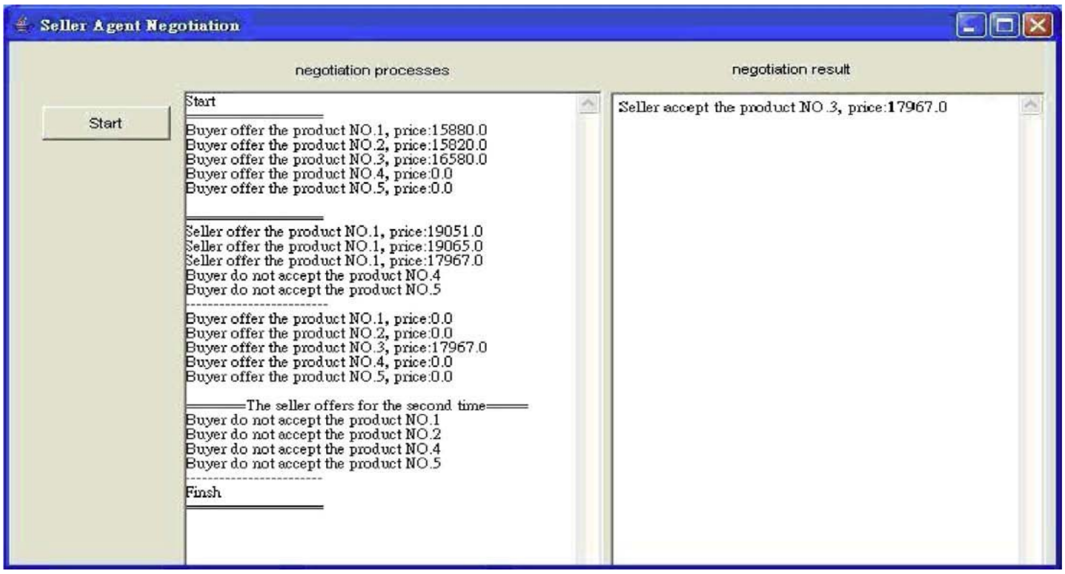


Fig. 10. The seller negotiation process.

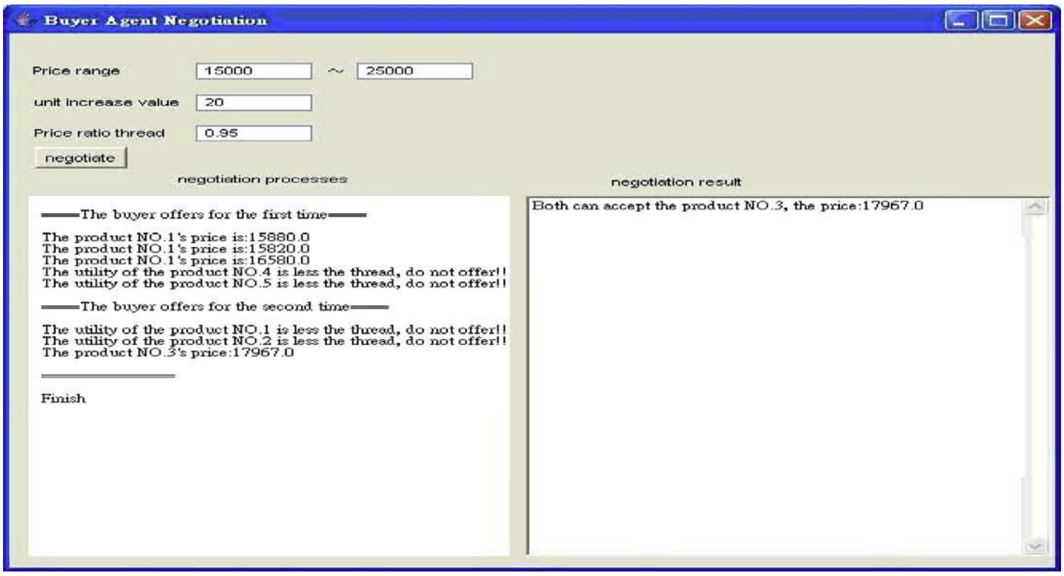


Fig. 11. The buyer negotiation process.

utility. In this system, the seller agent has two columns in negotiation. The left column shows the information of the offer from both sides. The right column shows the trade processes including the products and prices. In the buyer agent negotiation, the right column shows the negotiation processes containing the buyer's offer and seller's offer. Finally, when the negotiation ends, it shows the products and prices both sides can accept (Figs. 10 and 11).

5.4. Evaluation stage

When the buyer agent receives offer from the seller agent, the buyer agent first compares the offer with the buyer price range. The price which the seller agent presents must be lower than the upper limit. After that, the buyer agent also evaluates the product utility which must larger than utility threshold. On the other hand, if the buyer agent does not receive seller agent prices, then the buyer agent calculates new prices and presents them to the seller agent. After receiving the buyer agent prices, the seller agent checks the prices which must be larger than the lower limit of the price range.

6. Conclusion

In this paper, we present a multiple-attribute negotiation model for B2C e-commerce deploying intelligent agents to facilitate autonomous and automatic on-line buying and selling while providing a fast response to consumers. The negotiation model includes a 4-phase model, information collection, search, negotiation, and evaluation. We also apply fuzzy theory and analytical hierarchy process to develop the system interface to facilitate the user inputs. In the end, an example of the notebook buying process is illustrated. The approach to enhancing this negotiation model needs to be explored in the future. One method is to improve the search procedure to make the model more effective and precise. Another possibility is to implement it in the real world and evaluate the results. Undoubtedly, the future of the agent-based negotiation process for B2C application holds great promise and potential.

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References

Anumba, C. J., & Ruikar, K. (2002). Electronic commerce in construction-trends and prospects. *Automation in Construction, 11*(3), 265–275.

Beam, C., & Segev, A. (1997). Automated negotiations: A survey of the state of the art. *Wirtschaftsinformatik, 39*(3), 263–268.

Cheng, C. B., Chan, C. C. H., & Lin, K. C. (2006). Intelligent agents for e-marketplace: Negotiation with issue trade-offs by fuzzy inference systems. *Decision Support Systems, 42*(2), 626–638.

Choi, S. P. M., Liu, J., & Chen, S. P. (2001). A genetic agent-based negotiation system. *Computer Networks, 37*, 195–204.

Du, T. C., Li, E. Y., & Chou, D. (2005). Dynamic vehicle routing for online B2C delivery. *Omega, 3*(1), 33–45.

Fahim, A., Dave, H., & Zakaria, M. (2005). A fuzzy logic-based system for assessing the level of business-to-consumer (B2C) trust in electronic commerce. *Expert Systems With Applications, 28*(4), 623–628.

Faratin, P., Sierra, C., & Jennings, N. R. (1998). Negotiation decision functions for autonomous agents. *Robotics and Autonomous Systems, 24*, 159–182.

Faratin, P., Sierra, C., & Jennings, N. R. (2002). Using similarity criteria to make issue tradeoffs in automated negotiations. *Artificial Intelligence, 142*, 205–237.

Fernando, L., Nuno, M., Novais, A. Q., & Helder, C. (2000). Towards a generic negotiation model for intentional agents. *International Workshop on Database and Expert Systems Applications*, 433–439.

Gu, X., & Zhu, Q. (2006). Fuzzy multi-attribute decision-making method based on eigenvector of fuzzy attribute evaluation space. *Decision Support Systems, 41*, 400–410.

He, M., Jennings, N. R., & Leung, H. F. (2003). On agent-mediated electronic commerce. *IEEE Transactions on Knowledge and Data Engineering, 15*(4), 985–1003.

Lau, R. Y. K. (2007). Towards a web services and an intelligent agent-based negotiation system for B2B e-commerce. *Electronic Commerce Research and Applications, 6*, 260–273.

Laudon, K. C., & Laudon, J. P. (2000). *Management information systems* (6th ed.). London: Prentice-Hall.

Lee, K. J., Chang, Y. S., & Lee, J. K. (2000). Time-bound negotiation framework for electronic commerce agents. *Decision Support Systems, 28*, 319–331.

Li, C., Giampapa, J. A., & Sycara, K. (2003). A review of research literature on bilateral negotiations. Technical Report CMU-RI-TR-03-41. Pittsburgh, PA: Robotics Institute, Carnegie Mellon University.

Maes, P., Guttman, R. H., & Moukas, A. (1999). Agents that buy and sell. *Communications of the ACM, 42*(3), 81–91.

Morge, M., & Beanue, P. (2004). A negotiation support system based on a multi-agent-specificity and preference relations on arguments. In *Proceeding of ACM symposium on applied computing Nicosa Cyprusv SAC 2004* (pp. 474–478).

Nguyen, T. D., & Jennings, N. R. (2005). Managing commitments in multiple concurrent negotiations. *Electronic Commerce Research and Applications, 4*(4), 362–376.

Osman, K., & Cengiz, K. (2005). Fuzzy multi-attribute selection among transportation companies using axiomatic design and analytic hierarchy process. *Information Sciences, 170*, 191–210.

Saaty, T. L. (1980). *The analytic hierarchy process*. New York: McGraw-Hill.

Sarkis, J., & Sundarraj, R. P. (2002). Evolution of brokering paradigms in e-commerce enabled manufacturing. *International Journal of Production Economics, 75*, 21–31.

Schleiffer, R. (2002). A generalized intelligent agent model and its application in the domain of transportation research. Ph.D. thesis, Aachen, Germany.

Schleiffer, R. (2005). An intelligent agent model. *European Journal of Operational Research, 166*(3), 666–693.

Serguievskaia, I., Al-Sakran, H., & Atoum, J. O. (2006). A multi-agent experience based e-negotiation system. Information and Communication Technologies. ICTTA '06. 2nd ed., (Vol. 1(24–28), pp. 286–291).

Sycara, K., Paolucci, M., Ankolekar, A., & Srinivasan, N. (2003). Automated discovery, interaction and composition of semantic web services. *Web Semantics: Science Services and Agents on the World Wide Web, 1*(1), 27–46.

Wang, K. J., & Chou, C. H. (2003). Evaluating NDF-based negotiation mechanism within an agent-based environment. *Robotics and Autonomous Systems, 43*(1), 1–27.

Wang, Y., Tan, K. L., & Ren, J. (2004). PumaMart: A parallel and autonomous agents based internet marketplace. *Electronic Commerce Research and Applications, 3*(3), 294–310.

Wanyama, T., & Far, B. H. (2007). A protocol for multi-agent negotiation in a group-choice decision making process. *Journal of Network and Computer Applications, 30*, 1173–1195.

Zadeh, L. A. (1965). Fuzzy sets. *Information and Control, 8*, 338–353.

Zhu, F., Guan, J., Wang, Y., Zhou, J., & Liao, B. (2005). An automatic negotiation method based on CBR and agent reasoning. Computer and Information Technology, 2005. CIT 2005. The Fifth International Conference (pp. 1019–1023).