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行政院國家科學委員會專題研究計畫　成果報告

基於 MAUT 之網路商務交談式協商代理人之研究

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基於 MAUT 之網路商務交談式協商代理人之研究
An Interactive Negotiation Agent based on Multi-Attribute Utility Theory over Internet

中文摘要

隨著電子商務的發展，個人的線上交易行為成長快速。在本計劃中我們提出了一個互動式協商代理人系統，可幫助線上購買者，在進行線上交易與網路購物時，做出最佳的決策。我們使用了多重屬性使用理論 (multi-attribute utility theory)來作為系統的決策指標。這個指標標示出買方的購買目標，並平行地與賣方進行協商；由於使用者無法獨自處理複雜的協商程序，我們使用代理程式的技術來作為開發系統主要的機制。

關鍵詞：協商、電子商務、代理程式、多重屬性理論

Abstract

Because of the growth of the Internet commerce, the individual online transactions will grow up rapidly. So in this paper we proposed an interactive negotiation agent system on the Internet to help buyers to make decision. We use multi-attribute utility theory as the basic decision making strategy and the theorem is useful for the decision of multi criteria. We stated the user's goal that can be divided into several independent goals and the sub goals can be negotiated with sellers in parallel. On the other hand the user cannot handle the complex process individually; we take advantage of the agent technology as the major system developed approach.

Keywords: negotiation, multi-attribute utility theory, Internet commerce

1. Introduction

With the growth of the Internet, the on-line transaction would grow rapidly. And the information on the Internet became various and the users could not find the needs completely. In this paper we focus on the negotiation process that is useful for the buyer. We survey the real world transaction firstly. And we found the activities include searching a product, and negotiation with sellers. However, the buyer does not care about only one issue on the product or service. They would consider several issues and set different parameters within these issues. On the other hand their goal can be decomposed into several individual sub goals and search for solution in parallel. So in this paper we focus on the combinational purpose and negotiation mechanism that is based on the multi-attribute utility theory. And we also proposed a negotiation agent system supporting the mechanism.

In order to achieve the design of the system we survey several related work in the past. Negotiation [1,2,3,4,5,6,10,11,12] is an important component in the electronic commerce research area. In [1] Prof. Jennings proposed several research challenge and direction about the automatic negotiation research. They reveal the basic component of negotiation process that includes negotiation protocol negotiation domain and the agent utility function.

Dr. P. Faratin proposed a negotiation approach based on the multi-issues negotiation in [2]. They defined each role in the process and the interaction of these parties that can reach their goals. Their approach is based on the negotiation rules to achieve the negotiation agreement.

Dr. Guttman proposed a negotiation system based o the multi-agent decision technology in [3,4]. They used multi-attribute utility theory and distributed constrain satisfaction as the design discipline. And Dr. Sandholm proposed analysis of distributed cooperative problem of self-interest agent in [6]. They also proposed the analysis approach and simulation result in the paper.

There exists another approach to solve the negotiation problem, that is, game theory. Prof. Soo proposed a negotiation protocol abased on the theory in [5]. They used the third party to ensure the credible problem. They proposed operations in the game theory based multi-agent negotiation protocol with incomplete knowledge.

On the other hand the intelligent software agent[7,8,9,13] is a useful technology in negotiation applications. Several past works have been revealed the opportunities. In [9] the authors presented the concept of the agent-based software architecture. The agent communication language and the agent architecture are two important issues. In order to achieve information and message sharing, the agent communication language is the basic mechanism. In order to build the agent computing environment, the agent architecture is another critical problem.

BASAR is a personalized agent system that keeps the web links based on the user bookmarks[13]. The system is able to support information updating and reduce the number of links by deleting seldom used ones. In [7] a web-based information browsing agent is proposed. The system use the KQML as the agent communication language and reduces networking load. And in order to reduce the complexity of browsing, they use the structure meta information mechanism.

The paper is organized as the following. Section 2 shows the design of the negotiation engine that is the important component in our system. We proposed the Decision Making Machine to make decision in the negotiation processes in Section 3. And we show the design of the interactive negotiation system in Section 4. Last we give a brief conclusion about the contributed in the Section 5.

2. Negotiation Engine

The negotiation engine is the most important issue in the process. All parties in the negotiation process would use the negotiation engine as the computing kernel. In this paper the negotiation engine is the top layer of the design and we describe the basic components and computation strategy in the following subsections.

2.1. The Components of Negotiation

The parties in the negotiation process must achieve their own goals and each party has their private preference. On the other hand we have seen the negotiation states which all parties in the negotiation processes not only interest on one attribute but also several attributes. The negotiation parties would not make a decision with the price only and all interesting attributes will influence the negotiation result. So the buyer would send a request proposal including all the interests he/she like and then the sellers will send the counter proposal with respect to the buyer's proposal. The buyer would offer the initial request about their demands first. The initial request must be translated to the quantitative representation. And then the quantitative request would be sent to several sellers and the request buyer's agent and the seller's agent will begin to negotiate with each other. In the process we stated the

negotiation process as a combination of searching, matching and decision strategy. We state the basic components in the negotiation process as the following :

Searching : The online products or services would be various so that the buyer can not decide the better ones for a short while. So in the negotiation process, we must provide the search function to help buyers to find the interests.

Matching : In the real world a product or service will have several combination within it and with the different combination the result will be various, so we must provide the matching mechanism to fit the needs precisely.

Decision strategy : And the buyer will negotiate with the seller to make the best decision and maximum the buyer's gain. So the negotiation strategy is the most important function in the process. We use the multi-attribute utility theory to achieve the negotiation goal with respect to the buyers' and the sellers' needs.

Ontology : Because of the various of the product's attributes, the knowledge about each product or service should be the same between the buyers and the sellers. The ontology will avoid the ambiguous problem within the buyer's and the seller's knowledge.

Communication : The negotiation between the buyers and the sellers can be treated as the conversation process. We must provide the mechanism including the conversation message format and the communication channel.

2.2. The Computation of Negotiation Strategy

The negotiation processes in the real world include several criterions to negotiate. Each party would have their own preference about these criterions. The preference will be different according to the different domain, for example, the hotel reservation will have the attributes including the price, the air condition and the capacity of the room. So in this paper we use multi-attribute utility theory to model the negotiation problem. First we define a negotiation system as the following :

A negotiation support system $NSS = \{b, S, R, C, U, T\}$

b is the buyer in the negotiation process.

S is a set of all the sellers in the process, $S = \{s_1, s_2, \ldots s_i\}$

R is a set of negotiation attributes, $R = \{r_1, r_2, \ldots, r_j\}$

C is a set of constrains of the buyer and the sellers, each parties in the process have different constrain or preference. The preference includes the maximum and the minimum range of each attribute.

U is set of different utility function with respect to each buyer and seller.

T is a time period of the negotiation life cycle.

So the negotiation process can be model as the following :

$$b \rightarrow S : R \times C_b \times U_b \rightarrow proposal$$

$$S \rightarrow b : R \times C_s \times U_s \rightarrow counter - propossal$$

Each phase of the negotiation process include the buyer send the proposal to the sellers and the sellers send the counter-proposal to the buyer. The process would be continued until the party reach the agreement or the deadline of the negotiation.

The basic idea of the multi-attribute utility theory is a problem that the results come from two or more attributes. Based on the multi-attribute utility and the preference of each party, we can model the negotiation decision of the *Equation(1)*.

$$d(x) = \sum_{i=1}^{n} w_i u_i(x) \qquad (1)$$

$d(x)$ is the total value of the decision function of the party x.

w_i is the weight of the attribute i which comes from the preference of the party x.

$u_i(x)$ is the utility function of attribute i of the party x. And the utility function can be compute with the *Equation(2)*.

$$u_i(x) = \begin{cases} Max - \dfrac{pv - mv}{\max rv - mv} \times rs, if(pv > mv) \\ Max, if(pv = mv) \\ Max - \dfrac{mv - pv}{mv - \min rv} \times ls, if(pv < mv) \end{cases} \qquad (2)$$

Max is the highest utility score of the strategy, we set the score as 5 in general.
pv is the proposal value of the buyer or the counter-proposal value of sellers.
max*rv* is the maximum range value of the attribute according to the preference.
min*rv* is the minimum range value of the attribute according to the preference.
mv is the mean value of the attribute and the value is computed with the *Equation(3)*.

$$mv = \min rv + (\max rv - \min rv) \times w_i \qquad (3)$$

rs is the scale value right to the *mv* and the *ls* is another scale value left to the *mv*. The value of *rs* and *ls* are defined as the *Equation(4)*.

$$\frac{rs}{ls} = \frac{\max rv - mv}{mv - \min rv} \qquad (4)$$

Figure 1 is showed in the following is the logic view of the computation of each attribute.

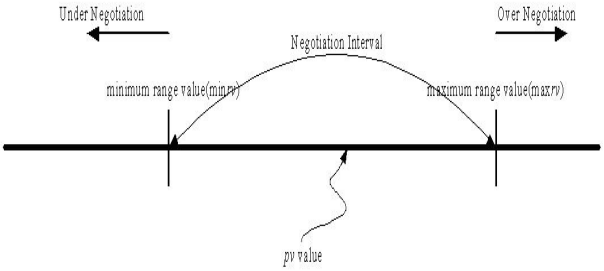


Figure 1 : The Role of the Computation Variables

The *pv* value would be in the negotiation interval if the parties continue to negotiation. Otherwise the *pv* value would be the best case or under the tolerate value and then the *pv* value would be adjust to the better one. The adjustment mechanism will show in the next section.

3. The Proposed Negotiation Process

In this section we proposed the negotiation protocol as the decision making strategy. We proposed the message flow of the negotiation process first and then developed a Decision Making Machine that is an practical approach for the negotiation protocol.

3.1. The Message Flow of the Negotiation

In the negotiation process the second important module is the negotiation protocol. In the figure 2 we show the design of our proposed protocol. The buyer would send the initial requests to the buyer agent and the request includes the buyer's need, the highest and lowest bound of the requested product or service, and the valid time of the negotiation process. The buyer agent would receive the initial request and decompose the request into several individual sub goals. For example, a travel trip would be decomposed into a flight reservation, hotel reservation, and the train tickets reservation. And then the sub goals would be transformed into quantitative value of each goal with respect to the goal's attributes. The searching agent and the matching would search and match these sub goals to fit the buyer's needs. Then the suitable seller agents would get the serial number that is the identification of the negotiation process. Then the buyer agent would receive the proposal request from the seller agent. On the other hand the buyer agent would be cloned to serve the different goal's negotiation. And then the buyer and the seller agent would begin to negotiate with the goal. In the negotiation phrase the buyer agent and seller agent would compute the utility value that proposed by the previous section and generate the proposal and counter-proposal in each negotiation phrase. And the computation flowchart is showed in the figure. Each buyer agent and each seller agent would repeat the negotiation phrase until the end of the valid negotiation time or the agreement appears. The agreement rules can be the one of the following :

- A seller agent would accept the proposal completely, that is, the seller agent can provide the product or service according to the proposal and meet with the proposal description.
- The distance of the vector of the buyer's and seller's goal's attributes is smaller than a threshold which is an experience value of past negotiation process.

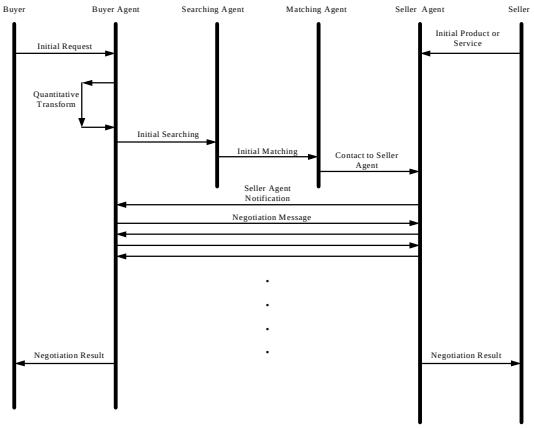


Figure 2 : The Interaction Of the Agents

At last the original buyer agent would received each cloned buyer agent's negotiation results. And then the Buyer Agent would integrate the result into complete result to the buyer.

3.2. The Decision Making Machine

In order to model the decision of the negotiation process, we proposed the Decision Making Machine to inference the decision making. The Decision Making Machine is showed in the figure 3. The *Initial State* is the start point of the negotiation process and the state will trigger by the proposal from the buyer or counter-proposal from the seller. According to the attribute value in the proposal or counter-proposal, the machine would compare the proposal value(*pv*) with the minimum range value(min*rv*) and the maximum range value(max*rv*). If the *pv* value is larger than max*rv* then the state would go to the *Over_Negotiation State*. In this state the machine would got to the *Check State* that would check other attribute's *pv* value. If the other *pv* values are all between the min*rv* and max*rv*, then the proposal or the counter-proposal would be accepted and got to the *Final State*. Otherwise the state would got to *Negotiation State* and adjust the *pv* value to the max*rv*, that is, *pv* = max*rv*. On the contrary if the *pv* value is smaller than the min*rv* then the state would go to the *Under_Negotiation State*. If *pv* value is between the min*rv* and max*rv*, then the state would go to the *Negotiation State* which the buyer and the seller would negotiate with each other and generate the new proposal or counter-proposal. And in the *Negotiation State* if the distance between the proposal and counter-proposal is smaller than a threshold then the negotiation would reach the agreement and go to the *Final State*. The *Final State* is the agreement of the negotiation process.
In the following we conclude the different cases in the Decision Making Machine.
Case 1 : One of *pv* value in the proposal is smaller than minimum range value(min*rv*) of this attribute. The *pv* value would be adjust to the minimum range value(min*rv*) and continue to next state.
Case 2 : One of *pv* value in the proposal is larger than maximum range value(max*rv*) of the attribute. The machine would check other attributes' *pv* value in the proposal whether the value is between the minimum range value(min*rv*) and maximum range value(max*rv*) of each attributes or not. If all other *pv* value are in the interval then the proposal would be accepted by the buyer agent. On the contrary the original *pv* value would not change and continue to next state.
Case 3 : All of *pv* value are smaller than the minimum range value(min*rv*). These *pv* value would adjust to the minimum range value(min*rv*) as the new *pv* value. And the new proposal or counter-proposal would be generate with respect to the *pv* value.
Case 4 : All of *pv* value are larger than the maximum range value(max*rv*). The situation is the best case for the buyer agent so the agent would accept the counter-proposal directly.
Case 5 : All of the *pv* value are between the minimum range value(min*rv*) and maximum range value(max*rv*) of each attribute. This is the negotiation condition that buyer agent and seller agents would negotiate with each other until the end of the valid negotiation time.

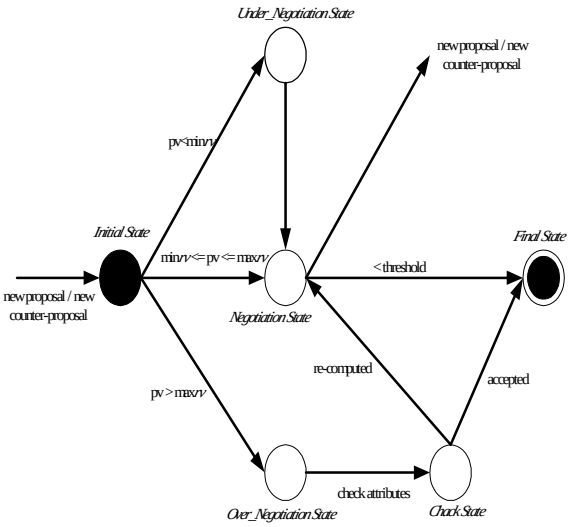


Figure 3 : Decision Making Machine

4. System Architecture

In order to support the run-time environment for the negotiation agent, we proposed the negotiation agent system software architecture to meet the requirement. In the Figure 4 we showed the basic software architecture design. The architecture includes the agent generation component, agent manager component, ontology, agent databases, buyer agents, and seller agents. The agent generation would initialize an agent for the buyer. In the generating process the system would find the suitable seller agents and established the connection between the buyer agent and these seller agents. And then the agent can negotiate with each other. When the agent initialized, the agent manager would control the life cycle and the interaction between these agents. Since the agents would negotiate with common knowledge, so the ontology would store the specification of the product or the service, this would insure the consistent knowledge between agents. And the agent database would store the status of these agents in the system.

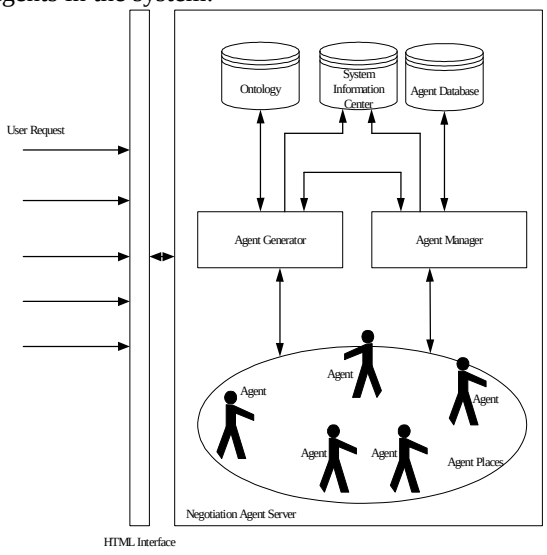
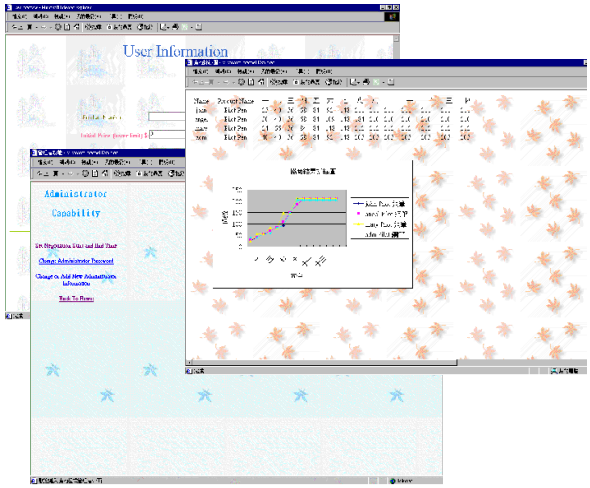


Figure 4 : Negotiation Agent System Architecture

The Buyer agent or Seller Agent software architecture is showed in the Figure 5. The buyer agent or seller agent would include the preference and the constrain requirement as the basic initial parameter. The Decision Making Component is responsible to make new proposal decision or counter-proposal decision with respect to the preference and constrains. The component would include the Decision Making Machine. The Behavior Controller would control the agent behavior that includes the proposal

generation or the message flow in the context of the agent in the negotiation process. The Negotiation History would hold the negotiation records including proposal and counter-proposal of each negotiation phrase. The last package is the communication package that is responsible to the communication mechanism to the buyer or seller agent. The information exchange mechanism used the XML as the basic message format protocol, that is, each proposal or counter-proposal would be encapsulated in the XML based document. The message would include the header, the negotiation



parameters and the signature of the agent on the message. The header would include the message delivery time, or the sender's identification of the message etc.. And the negotiation parameter would include the negotiation attributes' name and value in the proposal. The signature would insure the message security in the negotiation process. Only the valid agent can view the proposal and reply the proposal.

Our system is based on the windows platform, including the IIS web server and ASP language and we use the SQL server as the backend data center. Some user interfaces are showed in the Figure 6 that include user specified request, the negotiation illustrated result etc..

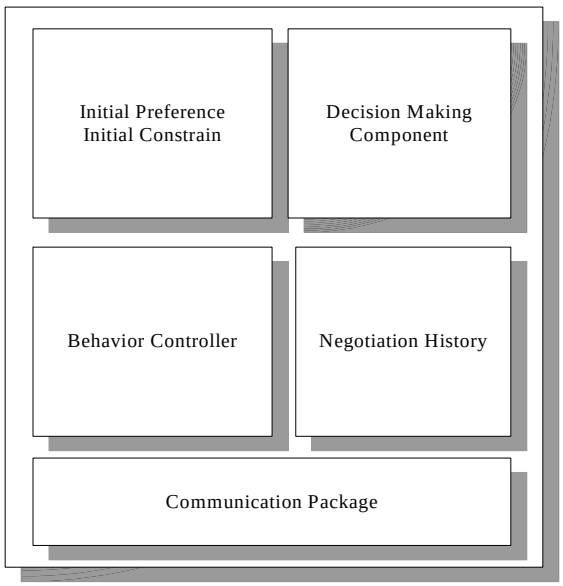


Figure 5 : Buyer/Seller Agent Software Architecture

5. Conclusion

In this paper we proposed an interactive negotiation agent system on the Web. We proposed a decision selection mechanism based on the multi-attribute utility theory to make decision in the negotiation

processes. We design the Decision Making Machine to obtain the mechanism also. Our main contribution is that providing the computer-mediated mechanism to help user to make decision easily. On the other hand the negotiation is a time-consuming work for humans, so the proposed system would solve such problem on the World Wide Web. However, the user privacy is an important issue of the Web application too. For this reason we will add the robust security mechanism to protect the user information in the future.

Figure 6 : Examples of User Interface

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