Automated Negotiation Based on Proactive Information for Agent Community

Xiping Tian
School of software engineering, Anyang normal university, Anyang 455000, Henan, China

Qinxia Wu
School of computer and information engineering, Anyang normal university, Anyang 455000, Henan, China

Abstract
In this paper, we consider the problem of automated negotiation in the Agent community on the internet. Based on characteristics of the Agent community and proactive information, we give proactive information model with feedback, quantify evaluation results between Agents, analyze Frame structure of Agent during negotiations, and propose automated negotiation algorithm based on proactive information. In the end, we develop some experiments based on Java Agent Development Environment, and verify the efficiency and effectiveness of algorithm through experiment and analysis.

Key words: Agent Community; Proactive Information; Automated Negotiation; Utility Function

1. INTRODUCTION
The advantage of E-commerce facilitates more and more completion of transactions on-line (Julie and Mariga, 2003; Turban, Lee and King, 2009). Intelligent Agent technology has been introduced into the E-commerce which makes the possibility of automation and intellectualization in every trade stage. In reality trading behavior affected by various factors, such as, economics, management, sociology, psychology, and so on, so the researchers try to introduce these factors into electronic commerce based on Agent to make it approach the practical.

Automatic negotiation refers to the process by which a group of autonomous Agents mutually coordinate to achieve consistent (Lomuscio, Wooldridge, and Jennings, 2003; Robert, Guttman and Alexandros, 2006; Maia and Rharon, 2013). As a middle part of the transaction, negotiation is the key point to decide whether the transaction is succeed, as well as whether the requirements of buyer and seller are met simultaneously. Nowadays, many researchers try to introduce social relations and value system into the transaction process. Such as, Li and Qiu have proposed negotiation model according to social change (Li and Qiu, 2008), Wang and Li have introduced business networks into associated purchase (Wang and Li, 2007). These existing works form a theoretical foundation for our research.

In this paper, the related definition and influence factors of Agent community are analyzed in the first place. Then we give proactive information model with feedback based on characteristics of the Agent community and proactive information. Thirdly algorithm of automated negotiation is proposed based on proactive information. In the end, the efficiency and effectiveness of algorithm is verified through experiment and analysis.

2. AGENT COMMUNITY
2.1. Factors influencing Agent behavior
Interaction behaviors between groups of Agents are always focusing on in traditional game theory, while the influence of external factors on agent is often ignored. In researches on electronic commerce based on Agent, scholars consider buying behavior of Agent as a purely individual behavior, which form the contrast with the real world, so it is not conducive for them to perform tasks assigned by the human. In fact, the Agent would be affected by the external environment and other Agents. In Agent community, how to let agents provide their information and how to use information to negotiate are hot topics in this paper.

2.2. Virtual communities based on Agent
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Each Agent of Agent community own a value attribute in addition to the basic characteristics, which is calculated by some feedback of community members according to correctness and usefulness of information.

3. INFORMATION EXCHANGE BASED ON PROACTIVE INFORMATION

3.1. Disadvantage of traditional information exchange

In Agent community, key issues include the ways and means of exchange information between Agents so how to exchange information and let to play a role is very important in the negotiation process. These are some disadvantage in the traditional question and answer mode of information exchange.

1) Information needs Agent can not sure whether store knowledge can be used in the current situation. If the validity of knowledge always be verified when using, communication costs will increase at this time.

2) Due to the limitations of demand Agent on stored knowledge, sometimes the Agent can’t know exactly what information you need. In that case, Agent does not fully express their needs on information, so the response information of other Agents is not accurate.

3.2. Proactive information delivery with feedback

Pro-activity means to the ability to take initiatives, make conscious decisions, and take positive actions to achieve chosen goals (Fan, Yen and Volz, 2005). If Agent can initatively participate in other Agent's information needs, and provide proactive information according to oneself inference to the problem. Fan put forward to talking model to express delivering process of proactive information. In this paper, we modify this model. The modified model of delivering information is shown in figure 1.

In Agent community, when Agent i want to some formation, it would send information request to Agent j according to knowledge of itself. If Agent j own related information, it would provide this information to Agent i, and Agent i would give an evaluation to Agent j according to the information provided. If the Agent j has no relevant information, it would send third requests to Agent n in community who maybe know information. In the process of information transmission, Agent m directly takes behavior without Agent i, which is an independent and proactive information transfer process. Information provided by Agent m makes up for knowledge limitations, and share communication consumption of Agent i. Agent m and agent n are volatile variables involved in the process from state 3 to state 7, which refers to several groups of Agent for proactive information transfer at the same time.

3.3. Quantification of evaluating value

Because Agent make decisions using information provided by the other Agent, it is very necessary to evaluate these Agents who provided information. In the negotiation process, Agent a would make evaluation to Agent b if Agent b provided information to Agent a, and the evaluating value can calculated as shown in formula 1.

\[
R_{i, ab} = \frac{1}{n} \sum_{i} \left| \frac{V^i_a - V^i_b}{V^i_e} \right| \tag{1}
\]

In where, n refers to the number of negotiation issues provided by interaction Agent, \( V^i_a \) indicates transaction value of the i-th issue for Agent a, \( V^i_b \) represents reference value provided by Agent b for the i-th issue, and \( V^i_e \) refers to expectations of the i-th issue deduced by Agent a according to information provided by other Agents. \( V^i_e \) can be calculated according to the formula 2.
\[ V'_E = \sum_{j=1}^{m} x^j \cdot P(x^j) \quad (2) \]

Among them, \( j \) refers to the number of all information provided by Agents, \( x^j \) represents the value of the \( i \)-th information, \( P(x^j) \) indicates the probability of \( x^j \).

In whole community, we used trust model proposed by Onker and Treur (1999) to calculate evaluating value of Agent (Jonker and Treur, 1999). At the same time, we simplified this model and re-defined the relevant parameters. The calculation of evaluating value is represented as shown in formula 3.

\[ R(r, R') = (1 - d) \cdot r + d \cdot R' \quad (3) \]

\( R(r, R') \) is a mapping function, which represent that the current evaluating value is \( R' \), the new evaluating value \( R' \) would be calculated after obtaining \( r \).

The parameter \( r \) refers to the resulting evaluation after the Agent provided information.

The parameter \( d \) represents the influence degree of previous credibility degree to calculate the current credibility, and the formula \( 1 - d \) indicates the current negotiations on two Agent credibility degree influence. In our experiments, \( d \) is the random value between 0 and 1, and the bigger it is, the greater influence of current negotiation to total reputation evaluation.

In the community, the higher the value of the Agent, the more reliable of information provided. In the negotiation process, the evaluating value is a key factor to choose information provided in the later negotiation.  

4. AUTOMATED NEGOTIATION BASED ON PROACTIVE INFORMATION

4.1. Frame structure of Agent during negotiations

According to information obtained from Agent community and their own knowledge, Negotiation Agent should solve the following problems:

1. Negotiation Agent should send request and receive proactive information to understand their requirements.
2. Negotiation Agent should form the proposal in the negotiating process by scheme evaluation mechanism and reasoning mechanism, in where the former is used to estimate requirement based on the obtained proactive information and their own knowledge base, and the latter is used to retrieve data from information layer.
3. Negotiation Agent should do evaluation to these Agents provided information according to the evaluation model after negotiation, so that other Agent makes reference to the relevant information.

From what has been discussed above, the whole negotiation is composed of three modules: data layer, network system, internal module of Agent. The logical structure of negotiation Agent is depicted in Figure 2.

\[ \text{Figure 2: The logical structure of negotiation Agent} \]

In where, decision and control module help to realize some important functions. For example, generate new proposal when Agent rejected rival proposal, search information provided by Agent community, send message to reasoning mechanism, and so on. Reasoning mechanism is used to send back reasoning results. There is a set of rules of the weighted score in scheme evaluation module, which is mainly designed for evaluating the received opponent’s proposal. Negotiation interface is used to receive other Agent’s proposal, send their proposal, interact with each other between Agents, and accept the control information, etc.

The whole algorithm process is as follows:

S1: send request to other agents of community;
4.2. Problems of negotiation based on proactive information

In negotiations based on proactive information, Agent proposal is generated according to information provided by the other Agent in community. When the Agent received a new proposal, he calculate firstly utility value of proposal according to evaluation function, then he would accept the proposal if utility value up to the setting threshold, otherwise he would generated new proposal by exchanging information to other Agents in community. Agent send new proposal if negotiation deadline is not come up, otherwise negotiation ended with failure. Do this process until the end of negotiations.

(1) Calculation of threshold function

Threshold is set to aim at negotiations of total utility. In this paper, utility would be calculated according to formula 4.

\[ U'_i = \sum w_i \times V'_i \]  

Among them, \( w_i \) refers to the weight of issues, and the formula \( \sum w_i = 1 \) is established. At the same time, the character \( i \) represents negotiation issues, \( j \) is on behalf of Agent. The symbol \( V'_i \) indicates Agent \( j \) make assessment on the issue \( i \) in the \( t \)-th time. The greater the value \( U'_i \), the higher utility obtained by Agent, and vice versa.

According to the relationship between issue value and utility value, issues can be divided into two types. If the issue value is proportional to the utility, we can calculate \( u_i \) by the formula \( u_i = \frac{X_i - X_{i,\text{min}}}{X_{i,\text{max}} - X_{i,\text{min}}} \). If the issue value is inversely proportional to the utility, we can calculate \( u_i \) by the formula \( u_i = 1 - \frac{X_i - X_{i,\text{min}}}{X_{i,\text{max}} - X_{i,\text{min}}} \).

For discrete issue, such as color, we use the list to choose. At the same time, we specify its utility value for each discrete value. Take a color attribute example; its list value is red, yellow, and blue. User can give the utility value, such as \( u_c = u_c \{\text{red, yellow, blue}\} = \{5, 3, 2\} \). For each attribute values in the list, its utility can be recorded by the formula \( u_i = \frac{X_j}{\sum X_j} \). Among them, \( j \) is the location of attribute value in the list, and \( x_j \) refers to the value of attribute.

(2) Generation of counter-proposal

When Agent received information from other Agents in community, the expectation value of every issue can be calculated using the corresponding formula. A new proposal would be formed after expectation values about all issue are found out.

5. THE TESTING RESEARCH AND ANALYSIS

In order to evaluate effectiveness of the proposed method, we developed some experiments based on Java Agent Development Environment (Multi Agent system platform experiment). JAVA program language was used to develop our system, and MS SQL was choice as a tool to manage data. These are 50 Agents in Agent Community, who own some information about sellers, goods, and so on. Price (P1), time of delivery (D) and payment time (P2) were selected as negotiation issues, then Offers between Agents can be formalized as \( O(P1, D, P2) \).

In experiments, we mainly considered the following two types of negotiations: with proactive information and without proactive information. We analyzed experimental results according to different situations involving in the process of negotiation. The experimental results showed the efficiency and successful rate of negotiation with proactive information is higher than negotiation without proactive information.

In Agent community, the buyer’s average utility obtained from successful negotiation using proactive information is shown in figure 3. As can be seen, along with the increase of the number of transactions, the buyer’s average utility is on the increase and showed a rising trend in negotiation with proactive information, but the value is on the decrease and showed a decreasing trend negotiation without proactive information. In Agent community, the negotiations with proactive information have good stability.
For negotiations with proactive information, the more proactive information we supply, the fewer offers Agents need to perform to complete negotiation, as is shown in figure 4. At the same time, due to information and the limited Agents of community, communication overhead is obviously reduced to save negotiation cost.

6. CONCLUSION

This paper have put forward a negotiation strategy based on proactive information in the Agent community to simplify negotiating process and improve the negotiation efficiency under the condition of the setting utility. Our future work includes two aspects; self-interested Agent would involve into negotiation to simulate the man's behavior in reality, and punitive measures would be explored to avoid Agent to provide false information. In addition, we will be more formally to describe automated negotiations used in the proposed agent and design a formal system to make this model more practical for electronic commerce.

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