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# Issues in automated negotiation: protocol and ontology

Liu Kexing Feng Yuqiang

(School of Management, Harbin Institute of Technology, Harbin 150001, China)

**Abstract:** In the environment of e-commerce, agents in automated negotiation should share common concept of what they are bargaining and a rule of how to bargain. State of the art overviews of automated negotiation is given. The main barriers to automated negotiation such as protocol and ontology are discussed. Then, a model of automated negotiation is presented with the ontologies of roles and goods described by web ontology language (OWL), the proposal strategies based on the information sets, and a set of rules for agent interaction. In this model, agents coming from different organizations can negotiate automatically based on common ontologies defined by OWL and formal protocol. This makes it possible for the automated negotiation to be performed in an open environment such as Internet, not merely in a closed system.

**Key words:** e-commerce; automated negotiation; negotiation protocol; ontology

Electronic commerce is having a revolutionary effect on business. It is changing the way businesses interact with consumers, as well as the way they interact with each other[1]. No matter whether it is a case of B to B purchase or a case of online shopping, it becomes more and more important to make the traditional negotiation price mechanism automated and intelligent. Negotiation has for decades been a central subject of study in disciplines such as economy, game theory, and management. It can be seen as a process by which two or more agents communicate with one another to try to come to a mutually acceptable agreement on some matter[2]. The negotiations in business have a special character; they are mostly concerned with bargaining between a buyer and a vender. Bargaining is a process in which the participants want to come to an agreement about prices or other issues. Abstractly, a negotiation can be expressed as $G = \{I, P, (S_i)_{i\in I}, (H_i)_{i\in I}\}$, $I = \{A, B\}$ is the set of participants; $P$ is the negotiation protocol that the participants should obey; $S_i$ is a set of strategies of part $I$, under the rule of $P$; $H_i$ means the economic profits when a strategy is decided upon.

An important research in the field of negotiation is the negotiation support system (NSS). The NSS is a tool for the negotiators to analyze and solve problems by way of interact between human beings and computers. It emphasizes the assistant function through human-computer interactions. Essentially, with the NSS, the bargaining is performed between human beings. While the NSS possesses quite powerful tools, and it can often support negotiations which are more productive than would be possible without them, it is far from able to support automated negotiations on their own.

Automated negotiation can be defined as a kind of system, that applies information technology, communication technology and artificial intelligence into the negotiation area, composed of game theory, operations research and decision theory. The bargaining process can be performed automated between intelligent agents instead of human agents, from the beginning to the end. Simply, automated negotiations take place when the negotiation functions are performed by (networked) computers[3].

Although it can be used in the distributed artificial intelligence (DAI), collaborative design, etc., the automated negotiation is ideally efficient in the environment of e-commerce, and it is becoming increasingly important in this field. One reason for this is the technology push of a growing standardized communication infrastructure—Internet, WWW, XML, KQML, FIPA, Java, etc., ad hoc the advantages of the semantic web—over which separately designed agents belonging to different organizations can interact in an open environment in real-time and carry out transactions safely. However, there are many problems that have to be faced. The reason, briefly, is that negotiations are difficult, and automated negotiation is even more so[3].

## 1 Multi-Agent Based Automated Negotiation in E-Commerce

### 1.1 Multi-agent system in e-commerce

The agents can be defined as[4] ① Situated or

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**Biographies:** Liu Kexing(1967—), male, graduate, Liuxen@163.com; Feng Yuqiang(1961—), female, doctor, professor, Fengyq@hit.edu.cn.

embedded in a particular environment; ② Designed to fulfill specific roles; ③ Clearly identifiable entities with well-defined (and limited) resources and interfaces; ④ Autonomous in the sense that they have control over their behavior; ⑤ Capable of exhibiting flexible behavior which can be reactive, proactive, sociable or persistent. The agents have been successfully used in the DAI, and since it is autonomous, self-interested and limited rationally, agents are more suitable for performing negotiations instead of human. Maes pointed out[5] that one characteristic of a network of artificial intelligence agents is that, even though individual agents may act simplistically, the entire environment can seem to be acting in a sophisticated, intelligent manner.

Multi-agent technology facilitates e-commerce oriented negotiation at the operative decision making level. This automation can save labor time for human negotiators, and other savings are possible because computational agents can be more effective at finding beneficial short-term contracts than humans are in combinatorially and strategically complex settings[6].

However, the study of multi-agent based automated negotiation is the beginning stage now. Many researchers are working hard in this field from different angles, and they have presented some relative model prototypes.

### 1.2 Review on the research of automated negotiation

The famous contract net protocol (CNP)[7] was described by Simith in 1980. First it deals with task allocation problems between agents through communication and negotiation. Then there are some extended CNP, i.e., TRACONET, which provide a formal model for bounded rational (BR) self-interested agents to make announcing, bidding and awarding decisions[7]. However, CNP need a formal formatted contract description, and its fitness for the tasks allocation negotiation is not suitable for automated negotiation in business.

Jennings et al.[8] presented the argumentation-based negotiation. In their model, agents generate and exchange arguments to back up or justify their negotiation stances. The nature and types of the arguments can vary enormously; however, common categories include: threats, rewards and appeals. Arguments have the potential to increase the likelihood and/or the speed of agreements being reached[8]. But, to design and build an agent capable of effective argumentation-based negotiation, there are some key factors which should be solved: ① Mechanisms for passing proposals and their supporting arguments in a way that other agents understand; ② Techniques for generating proposals and for providing the supporting arguments; ③ Techniques for assessing proposals and their associated supporting arguments; ④ Techniques for responding to proposals and their associated supporting arguments.

Huang et al.[9] presented a formal model for automated negotiation on the Internet. In the model the negotiation process is driven by internal beliefs or participating agents. Agents "look" at each other's activities and interpret these activities based on their own' beliefs, and then justify their beliefs, where the beliefs are private information, and decide what to do next. Benameur et al.[4] presented a protocol model of a multi-agent based auction for automated negotiation. Bartolini et al.[10], came from HP, trying to establish a general negotiation protocol framework; Vulkan et al.[11] described a pre-auction protocol that included the processes of initiation, pre-auction, negotiations and insurance; Karp[12] discussed the rules of engagement for automated negotiations; Dastani et al.[13] proposed a way to construct flexible negotiation protocols based on dialogue games. Rahwan et al.[14] presented a one-to-many negotiation protocol model called ITA (intelligence trading agency), and progress form negotiation, and so on.

All the protocols and models mentioned above are presented by way of themselves—a jungle of modeling approaches about the protocol. Up to now, most work on automated negotiation has stayed in the laboratory. There are some difficulties with this that should be overcome for the successful industrial deployment of multi-agent based automated negotiation.

## 2 Difficulties in Automated Negotiation

In an open environment of e-commerce, where autonomous agents come from different organizations and negotiate with each other automatically, some abilities are required: first, they should share common concepts about the objects they are negotiating over; secondly, they should communicate and correctly understand what others say; and thirdly, they should have sufficient intelligence to gain more from a negotiation. So, the ontology, protocol, and strategy are three key points for automated negotiation.

The ontology is a way of categorizing objects such that they are semantically meaningful to a software agent. An ontology is required to ensure that the agents are referring to exactly the same good. With a compact disc, it is relatively easy; but specifying an automobile, or a food product, or a delivery schedule can be very difficult. Moreover, with many give-and-take negotiations, attributes such as delivery time, delivery quantity, and batch quality, and financing terms are up for debate; it is crucial that an agent can evaluate the tradeoffs and implications of all the variables[3].

Negotiation protocols are defined as the set of rules which govern the interaction. Indeed, any negotiation is guided by a protocol, which describes the rules of the dispute, that is, how the parties exchange their offers, and how and when the negotiation can go on or terminate. (As opposed to a protocol, a strategy is a directive for deciding among different actions at a certain stage[13]). In the agent-based negotiation, the protocol is a formal model, often represented by a set of rules that govern software processing and communication tasks and impose restrictions on activities through the specification of permissible inputs.

Another difficulty outlined here is that of negotiation strategy. If one agent's negotiation strategy is known to the other agent, the first agent may be at a significant disadvantage. Suppose that the buyer knows that the seller's strategy is to accept all offers above a certain (unknown) threshold value. The buyer can begin at \$0.00, and repeatedly offer the seller a penny more each time, until the seller's threshold value is reached, at which point the (worst possible, for the seller) deal is made. This is but one example of mechanism design; Varian[15] outlines many more issues with economic mechanism design for computerized agents, including some ways to ensure against losses due to strategy inference[3].

## 3 Automated Negotiation Model for B2C E-Market

We have presented three stages in a negotiation process[16]. They are the registration and matching stage, the exchange proposals and bargaining stage, and the end stage (with an agreement or termination without agreement). However, the issue of ontology is not involved in that model. Now we give a simple model of an automated negotiation protocol with some ontologies by OWL[17], and only focus on the bargaining stage.

### 3.1 E-market background description

This is a wholesale market with the same merchandise, such as computer processors. The issues that should be negotiated include price, quantity and delivery. There are two kinds of agents, the seller (S-agent) and the buyer (B-agent). The sellers, who are always selling, are fixed in the market; and, to simplify, we only focus on one S-agent during whole session. The buyers $B = \{b_1, b_2, \dots, b_N\}$, however, are not fixed. They come into the market stochastically with the principle of first come first served.

### 3.2 Roles in negotiation

We give ontologies of roles in a negotiation with OWL (without NameSpace and ontology header) as follows:

```
〈owl: Class rdf: ID = "Negotiator"〉
〈/owl: Class〉
〈owl: Class rdf: ID = "Buyer"〉
  〈rdfs: subClassOf rdf: resource = "# Negotiator "〉
〈/owl: Class〉
〈owl: Class rdf: ID = "Seller"〉
  〈rdfs: subClassOf rdf: resource = "# Negotiator" 〉
  〈owl: disjointWith rdf: resource = "#Buyer"〉
〈/owl: Class〉
〈Buyer rdf: ID = "B-agent"〉
〈Seller rdf: ID = "S-agent"〉
```

### 3.3 Goods bargained for

The goods, for example, processors, is described as follows:

```
〈owl: Class rdf: ID = "Processor"〉
〈/owl: Class〉
〈owl: Class rdf: ID = "ProcessorDescriptor"〉
〈/owl: Class〉
〈owl: Class rdf: ID = "TypeOfProcessor"〉
  〈rdf: subClassOf rdf: resource = "#ProcessorDescriptor"〉
  〈owl: oneOf rdf: parseType = "Collection"〉
      〈owl: Thing rdf: about = "#PentiumIII"/〉
      〈owl: Thing rdf: about = "#Pentium4"/〉
      〈owl: Thing rdf: about = "#Athlon"/〉
      ⋮
  〈/owl: oneOf〉
〈/owl: Class〉
〈owl: ObjectProperty rdf: ID = "hasProcessorDescripter"〉
  〈rdf: domain rdf: resource = "#Processor"/〉
  〈rdf: range redf: resource = "#ProcessorDescriptor"/〉
〈/owl: ObjectProperty〉
```

### 3.4 Information set

For agent $a \in \{b, s\}$, the information set $I^a = \{P^a_{ini}, P^a, T^a\}$; $P^a_{ini} \in \{P^b_{ini}, P^{ini}\}$ is the initial proposal between buyer and seller; $P^a$ is a reserve price of agent $a$, $P^a \in \{P^b_{max}, P^s_{min}\}$, $P^b_{max} \rangle P^s_{min}$, $P^b_{max}$ is the buyer's price deadline. It means the buyer will not accept a terminal agreement that is higher than $P^b_{max}$; and $P^s_{min}$ is the reserve price of the seller. $T^a \in \{T^b, T^s\}$ are time-deadlines for agent $a$, $a \in \{b, s\}$. It sets a restriction that means that when the negotiations continue beyond the time-deadline the S-agent will cancel the bargain. $I^a$ is private information kept to themselves.

### 3.5 Negotiation strategies

At time $t$, B-agent generates a proposal:

$$p_{\mathrm{b}}^{t}=P_{\mathrm{ini}}^{\mathrm{b}}+(P_{\max}^{\mathrm{b}}-P_{\mathrm{ini}}^{\mathrm{b}})\left(\frac{t}{T^{\mathrm{b}}}\right)^{\varphi^{\mathrm{b}}}$$

$\varphi^{\mathrm{b}}>0$ is a recession factor for B-agent, and when $\varphi^{\mathrm{b}}>1$, it means the buyer will give a small recession at the beginning and make a big recession when $t$ near $T^{\mathrm{b}}$; when $\varphi^{\mathrm{b}}<1$, the buyer proposal with a strategy of bigger recession first smaller recession later. Symmetrically, we can give the function of $p_{\mathrm{s}}^{t}$.

### 3.6 Proposal evaluation

At any time, agent $a$, $a\in\{b, s\}$, will evaluate its utility function $U^{\mathrm{a}}=|P^{\mathrm{a}}-p_{\mathrm{a}}^{t}|$ when he receives a proposal $p_{\mathrm{a}}^{t}$ from the other one, or when he generates a proposal $p_{\mathrm{a}}^{t}$; and then he takes an action following section 3.6.

### 3.7 Actions restriction during process of bargaining

At any time $t$, during the negotiation, one of the agents, for instance the S-agent, receives a proposal $p_{\mathrm{b}}^{t}$ from the others, for instance B-agents, can only perform action $A_{\mathrm{s}}^{t+1}(p_{\mathrm{b}}^{t})$:

```
If t > = T^s then
A_s^{t+1}(p_b^t) = quit
    Else if U^s(p_b^t) ≥ U^s(p_s^{t+1}) then
    A_s^{t+1}(p_b^t) = accept
    Else
      A_s^{t+1}(p_b^t) = Send(p_s^{t+1})
End if
```

### 3.8 Solution

The negotiation will terminate with or without an agreement. If an agreement $p^{*}$ exit, $P_{\min}^{\mathrm{s}}<p^{*}<P_{\max}^{\mathrm{b}}$, depending on strategies they deployed in the process, it must be a Pareto efficiency solution, since the bargain is just a zero-sum game.

## 4 Discussion and Future Work

Ontology, protocol and strategy are the bases of the automated negotiation system. The semantic web can provide powerful support for ontologies and protocol. The proposed protocol is simple but different from others that have been presented. Trastour et al. [1] have developed a life-cycle model of e-commerce interaction, and shown how the semantic web can support a service description language that can be used throughout this life-cycle. The stages are: matchmaking, negotiation, contract formation and contract fulfillment. However, they do not create a specific protocol. Our work only focuses on one of the three stages in the life-cycle and presents a reliable description. Some work should be carried out in the future. First, in the real world, negotiators may learn from history and from each other, and then justify their strategies. In the next step, the S-agent and B-agent should have abilities of memory and learning. The ability of memory will decrease as time goes by. Secondly, in this paper we assume that only one parameter, price, is being negotiated. In the future some other attributes, such as quantity, quality, and delivery, should be considered, so the ability to assess the utility of a given negotiation proposal should be more powerful and the utility function will have a complex structure. Thirdly, when agents negotiate with each other, they should share the same ontologies involved. DAML + OIL and OWL are sufficiently expressive and flexible description languages to be used not only in the bargaining stage, but also throughout the whole lifecycle of E-commerce automated negotiation. We hope more and more ontologies will be presented.

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# 自动谈判中的协议和本体等问题

刘克兴　　冯玉强

(哈尔滨工业大学管理学院,哈尔滨 150001)

**摘要:** 在电子商务环境下,自动谈判中的 Agents 之间必须具有共同的概念和规则来明确谈判的内容和方式. 通过分析自动谈判的最新研究进展,对自动谈判中存在的协议和本体论等主要难点进行了讨论. 提出了一个自动谈判模型,该模型应用 OWL 来表达的谈判角色和谈判商品等本体,具有基于信息集的报价策略和 Agents 的交互规则. 应用本模型,来自不同组织的 Agent 可以基于共同的由 OWL 定义的本体论和规范的协议,自动地进行谈判. 这使得自动谈判可以在开放的因特网的环境下,而不仅是在封闭的系统中实现.

**关键词:** 电子商务;自动谈判;谈判协议;本体

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