AN AUTOMATED NEGOTIATION SYSTEM WITH AUTONOMOUS AGENTS FOR A TRAVEL AGENCY BUSINESS MODEL

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The article develops an automated negotiation environment, in which cognitive agents negotiate on behalf of humans. In order to have an efficient negotiation, the agents employ different bargaining strategies. As more negotiations are taking place, the agents can change their preferences for a certain attribute of the negotiation object. The multi-agent system is applied for a travel agency business model, in which buyer agents represent persons or companies, searching for hotel rooms, and seller agents are used by the travel agency.

Keywords: automated negotiation, multi-agent system, negotiation behavior

1. Introduction

Automated negotiation represents the process, in which intelligent agents communicate between them, for finding a mutually acceptable agreement [1]. An agent negotiates with other entities, by changing its strategy, according to its negotiation behavior [2].

In this paper, the negotiation framework contains a multi-agent system with autonomous agents, applied for a travel agency business model. In the system, there are buyer agents, seller agents, and a facilitator, which is used when a new agent joins the platform, for registering its services. The cognitive agents are designed according to the BDI (Belief-Desire-Intention) model [3]. Each agent has a set of goals, selected from the set of desires. In order to reach their goals, agents develop plans, as a sequence of actions to be performed, or they provide services or ask for services from other agents [4]. In the negotiation process, the agents are able to choose different negotiation strategies.

2. The Negotiation Model

In the automated negotiation process, some bargaining strategies are based on agent profiles, which can define statically or develop dynamically the preferences of the agents for certain attributes of the negotiation object. Using

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these profiles, agents obtain better results than the ones in case of fixed negotiation strategies, that is an increase of the gain from negotiation [5, 6].

The multi-agent system models a heuristic negotiation, in which the agent computes the gain, with respect to its private value for the negotiation object. The agents negotiate using the Iterated Contract Net protocol [7]. The communication primitives used by the agents, from the negotiation framework developed in this paper, are the following:

1) *cfp(A, X, NO, P)* is the communication primitive, which represents a call for proposals from agent *A* to all the partners *X*, regarding a negotiation object *NO*, with an associated price *P*

2) *propose(X, A, NO, P, Round)* is the communication primitive, which represents the response of agent *X* to the *cfp*, with the negotiation object *NO*, price *P* and negotiation round *Round*

3) *accept(X, NO)* shows the acceptance of a proposal from *X*, for the *NO*

4) *reject(X, NO)* indicates the rejection of a proposal from *X*, for the *NO*

5) *counterpropose(A, X, NO_1, P_1, Round)* defines a communication primitive, which represents the counterproposal of agent *A* to the proposal of agent *X*, with the negotiation object NO_1, price P_1 and negotiation round *Round*

Each agent takes into account the private value for any service which is traded. In a buying negotiation, an agent wants to obtain a lower value than its private one, while in a selling negotiation, its goal is to get more than the private value. The negotiation takes place in many rounds. At the end, either an agreement is found or a rejection is concluded. In each negotiation round, based on the preferences specified by the buyer agent for the multiple attributes of the service, the seller agent makes the best possible offer.

The agents have different reasoning capabilities, used to conduct successful negotiation and to reach the goals. Any agent from the system uses a set of behavior rules, which define how the agent fulfills the goals, and a set of strategy rules, which describe the negotiation strategies. During negotiation, the agents gather information about the partner agents and store it in the associated cooperation profiles.

The cooperation profile describes the preferences about the agents with which an agent wants to cooperate. This profile is implemented as a dynamic structure. For each agent with which a negotiation is performed, the knowledge regarding the negotiation result is stored in the cooperation profile. This is updated during the negotiation process, at the end of each negotiation.

The partner agents can be classified into six cooperation classes: unknown, non cooperative, slightly cooperative, cooperative, very cooperative, highly cooperative. The cooperation class is changed, while more negotiations take place. The classification of the cooperation potential of a partner agent is done using the C4.5 learning algorithm, in which a decision tree is a classifier for the cooperation

degree of an agent [8]. During the negotiation rounds, the C4.5 algorithm can classify the partner agent in another cooperation class, if the values of the attributes used in the algorithm are changed.

The approach to achieve a good behavior in a heuristic negotiation is to use utility functions, which enable an agent to generate offers and counteroffers at each round, based on different factors, such as the deadline and the concession behavior of the partner agent [9]. The use of utility functions allows the creation of different strategies, which take into account the deadline of an agent or allow the adaptation to the behavior of the partner agent. The agent behavior is a complex and dynamic process. The agent adjusts dynamically the utilities by exploring and evaluating the options, in order to reach the goal. At each negotiation round, when knowledge increases, the negotiation strategy of the agent could be changed. There are a lot of factors which can influence the results of a negotiation strategy. These factors refer to the strategies of other agents, their constraints and preferences, and other characteristics of the negotiation object.

3. The Negotiation Environment Description

In the travel agency use case scenario, the negotiation process starts when the buyer agent wants to book a hotel room. A request is sent to all sellers. These agents responds to the request with their characteristics for the hotel room. After receiving the initial offers, the buyer evaluates and compares different offers. When an offer is not satisfactory, the buyer agent makes a counterproposal to the corresponding seller agent. This agent has a set of strategies that configure its constraints.

The negotiation strategy is implemented in the form of rules, where each agent has a history of its interactions. If more rules are possible to be applied in a certain situation, then the negotiation strategy decides which rule is ellected from the conflict set. The approach to solve conflicts is to assign priorities between rules [10]. The priority of the rules are dynamically modified, according to the negotiation situation.

Each agent has two prices, the minimum price and the maximum price, between which it accepts offers. The buyer computes its gain as the difference between the maximum price it is willing to pay and the price of the current offer. The seller computes its gain as the difference between the price of the current offer and the minimum price it is willing to accept.

During negotiation, the agent wants to maximize its gain by fulfilling its goals. Also, negotiation criteria refers to the cooperation profile the agent has developed to describe previous interactions with other agents in the system. The cooperation profile is considered as a part of the agent belief about other agents in the system.

Each agent has different reasoning capabilities, described by the behavior rules. These update the beliefs about other agents and describe plans for goal fulfillment. An agent should have information about other agents identity and abilities [11].

After each negotiation round, the mental model of the agent is updated. This refers to beliefs, intentions, goals, and to the cooperation profile of the agents with which it is negotiating. Cognitive aspects associated to negotiation activities are taken into account. When a negotiation ends, an agent evaluates how efficient was the interaction with other agents, by computing the gain associated to the transaction.

4. Experiemental Results

The multi-agent system is tested on different negotiation scenarios, regarding the travel agency business model. The framework is implemented using Java, Jade, Jess, and XML. Jade is used as an infrastructure for building the multi-agent system and Jess as a mechanism to provide the inference engine for the agents that are negotiating. The Jess engine represents the agent's inference engine, which stores the knowledge base of the business domain and also contains the negotiation strategies of the agent, the facts and the concepts of bargaining.

The buyer agent from the travel agency scenario has several criteria, each attribute having a certain priority for the user, upon which the person decides the hotel to choose. These characteristics are encoded in the XML configuration file, associated to the business model. The content of the configuration file is read into the application using the SAX (Simple API for XML) parser. SAX provides a mechanism for reading data from an XML file.

There are several rules defined in Jess, upon which the negotiation is performed. There are different rules defined for each type of the communication primitive. The higher priority is associated to the *accept* rules, the medium priority to the *reject* rules, and the lower priority to the *propose* rules.

In the following one-to-one negotiation scenario, the buyer agent wants to book 36 hotel rooms with 12 different characteristics, 3 rooms of each type. The seller agent has a total of 120 rooms, 10 rooms for each type.

The next diagrams are obtained using the data collected in the statistics file, generated after the negotiation is performed between the agents in the platform. When all the buyers finish their purchases, the negotiation information is recorded in the statistics file. The gains obtained for each cooperation class, with respect to the number of negotiation rounds, for the seller and respectively for the buyer, are represented in Figs. 1 and 2.

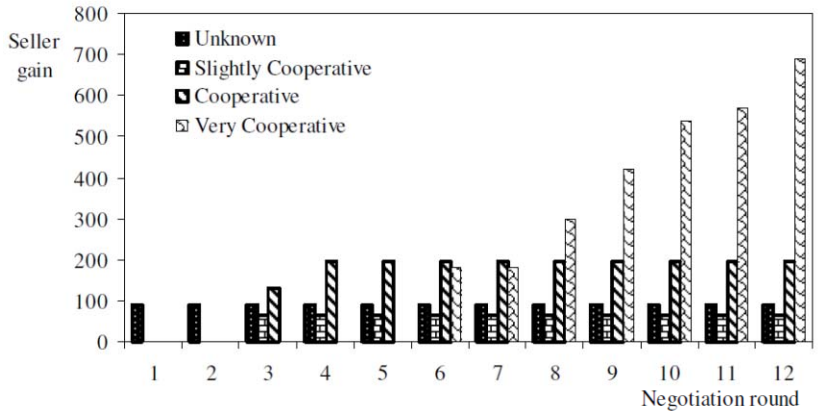

Fig. 1. The seller gain for each cooperation class

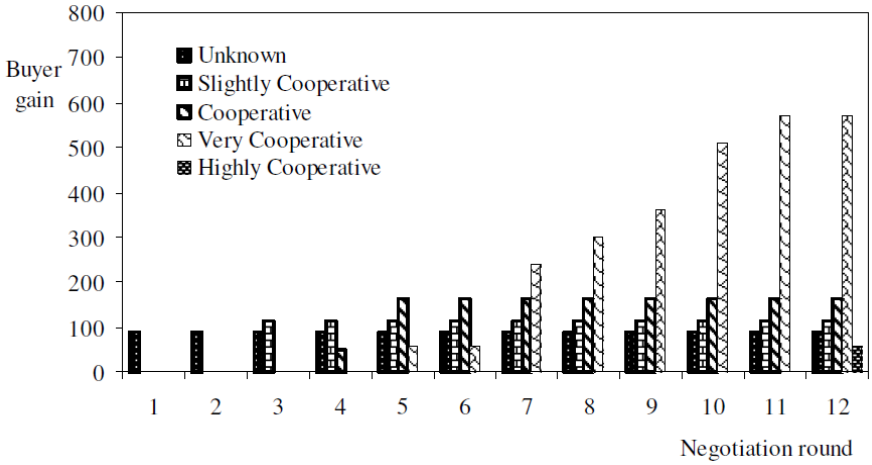

Fig. 2. The buyer gain for each cooperation class

Figs. 1 and 2 show that, during negotiation, the cooperation classes of the agents are dynamically changed, when the negotiation rounds are performed. In the first round, both agents belong to the unknown cooperation class. While they know more about each other, they change the classification of the cooperation potential of the partner agent. The seller agent becomes cooperative from the third negotiation round and the buyer agent from the fourth negotiation round. The buyer agent is very cooperative from the fifth negotiation round and the seller agent from the sixth negotiation round. In the last round, the buyer becomes highly cooperative, while the seller remains very cooperative.

The next scenario involves one seller and a different number of buyers, from 1 to 10. Ten distinct negotiations are done and the number of buyers is gradually increased. The seller has 200 hotels rooms to rent, of 4 types. Each buyer wants to book 20 rooms, 5 rooms of each different type.

A screen capture of the Jade Sniffer Agent for the multi-agent system, showing the messages exchange between agents, during the negotiation between ten buyers and one seller, is represented in Fig. 3.

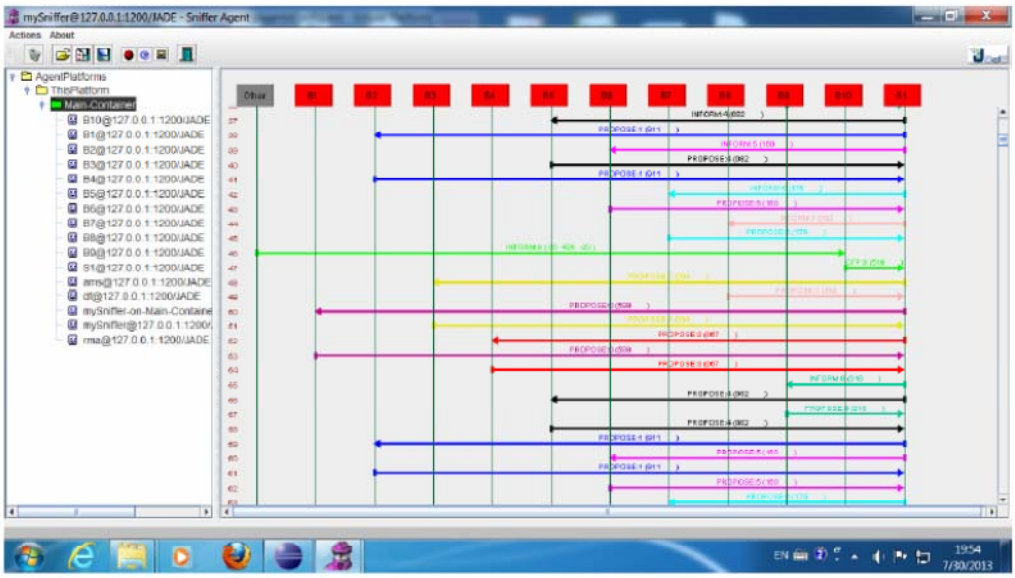

Fig. 3. Screen capture showing the multi-agent system in action

The Fig. 4 displays the seller gain with respect to the number of the buyer agents.

The seller gain is increasing linearly, when there are up to 6 buyer agents. Then, its gain is increasing exponentially, when there are more than 6 buyer agents requiring services from the seller agent.

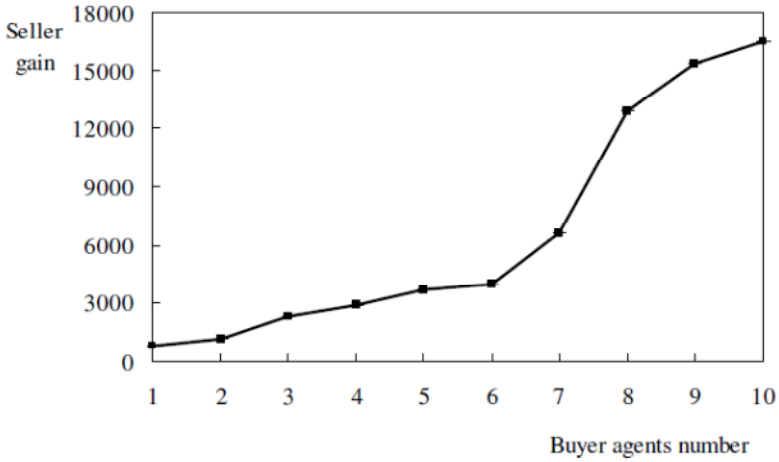

Fig. 4. The seller gain with respect to the number of buyer agents

5. Conclusions

This article approaches some challenging problems concerning bargaining using negotiation profiles and negotiation involving cooperation classes for the agents. A framework for automated negotiation, based on negotiation profiles and rules, which encode the agents negotiation strategy, is presented. If there is not enough information regarding the partner negotiating agent, it is often complex to develop the agent strategies. It is useful to design learning mechanisms for choosing certain strategies for the agents to employ.

A multi-agent system for automated negotiation, applied for a travel agency business model, is described. The gain obtained by agents during negotiation is computed after each negotiation round and is represented graphically. Also, the gain corresponding to each cooperation class of the agents is displayed. Different negotiations are performed, in which the number of buyers is gradually increased.

The set of experiments carried out shows the improvement of the agents' performance in time, with respect to their adaptation capabilities. The negotiation strategy of the agents is enhanced, as more negotiations take place. The agents exchange messages using the Iterated Contract Net protocol, which has the advantage that it can simulate a real-world scenario.

Heuristic negotiation strategies used in this article are based on the exchange of proposals. In case the answer received from the partner agent is a counterproposal, the argumentation-based negotiation extends the negotiation protocol with the possibility to exchange arguments. This information gives

explicitly the opinion of the agent making the argument. Future work will investigate the arguments used by agents for improving the negotiation outcomes.

Also, future work will be directed towards the implementation of more complex agent strategies and knowledge sharing ability between agents.

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