Agent-Based Assistant for e-Negotiations

Simone A. Ludwig

Department of Computer Science, University of Saskatchewan, Saskatoon, Canada
ludwig@cs.usask.ca

Abstract. Knowledge about conflict styles and time pressure during a negotiation are important factors in a negotiation. This knowledge is used to model an agent-based assistant for e-negotiations. The idea of the proposed method is to model a utility concession function depending on the conflict style behaviour of a negotiator. Negotiators, prior to engage in e-negotiations, are asked to fill in a questionnaire designed to measure the conflict mode and specify their reservation levels. The agent-based assistant uses reservation levels and a concession-making model to propose the concession and timing of offers and attributes e.g. in a multi-attribute negotiation. The concession-making model is constructed in the utility space and it is constructed using the Thomas-Kilmann Conflict Mode Instrument and negotiation data from an experiment conducted by human negotiators.

1 Introduction

Negotiation, for decades, has been a central subject of study in disciplines such as economy, game theory and management. When discussing negotiation, it is important to distinguish between *negotiation protocol* and *negotiation strategy*. The protocol determines the flow of communication between the negotiating parties, dictating who can say what and when. It provides the rules by which the negotiating parties must abide if they are to interact. The protocol is necessarily known to all negotiation participants. The strategy, on the other hand, is the way in which a given party acting within the protocol rules makes an effort to get the best outcome from the negotiation. Strategy is used to determine, for example, when and what to concede, and when to hold firm. The strategy of each participant is therefore necessarily private.

Electronic negotiations are business negotiations conducted electronically e.g. via the Internet. The underlying IT infrastructure makes it possible for e-negotiation systems to offer features such as graph support, decision analysis and communication management. The goals of supporting negotiations through information technology are to reduce transaction costs in e-negotiations, to find and suggest an optimal deal, to conduct checks during the negotiation (e.g., that they conform to the accepted protocol), to offer decision support, and to provide argumentation support for human or software agents.

The benefit of e-negotiations is the support of negotiations via information technology offers decision support for human or software agents. To some extent, agent technology can be helpful in automating or assisting the buyer with the need identification stage. Specifically, agents can play an important role for those purchases that are repetitive (e.g. supplies) or predictable (e.g. habits) [1].

A. An et al. (Eds.): ISMIS 2008, LNAI 4994, pp. 514–524, 2008.

Interest in the automation of negotiations through the use of multi-agent systems has been stimulated to a great extent by the vision of software agents negotiating with other software agents to buy and sell goods and services on behalf of their principals in a future Internet-based global marketplace [2]. Until now, research has focused on accounting for particular interactions among agents by developing and improving specifically tailored negotiation protocols and strategies.

In any negotiation involving agents it is important that the agent is able to adequately represent the principals' interests. However, the process by which this knowledge is acquired is normally not taken into consideration [3]. In order to overcome this shortage, a possible approach is presented in this paper taking knowledge into account to model principals' objectives. The approach for the agent-based assistant for e-negotiations consists of a concession-making model which is constructed in the utility space and it is constructed using the Thomas-Kilmann Conflict Mode Instrument and negotiation data from an experiment conducted by human negotiators using the Negotiation platform Invite.

The remainder of this paper is structured as follows. Section 2 summarizes and discusses several related approaches. In Section 3 the research method is proposed including modeling and mapping of the conflict styles and the consideration of the opponent's concession making to a utility concession graph. Section 4 explains the model in more detail using a contract negotiation example. Section 5 concludes this paper by presenting the findings and discussing the shortcomings regarding further work.

2 Related Work

The construction of efficient and effective algorithms enabling software agents to be successful and obtain acceptable outcomes is one of the most active areas in agent-supported and automated negotiations. It is also important that software agents, alike human agents, represent the principal as closely as possible and are able to negotiate on behalf of their principals. For this to be effective, software agents must learn the principals' interests, strategies, preferences and prejudices in a given domain. Without this, software agents cannot execute their task appropriately. The acquisition of such knowledge is, therefore, an essential requirement for applying negotiating agents in practice, in particular:

- Exactly what knowledge an principal needs to impart to their agent in order to achieve high fidelity negotiation behaviour; and
- Ways in which this knowledge can be effectively acquired from the principal.

Guo, Mueller et al. [4] investigate how agents act on behalf of their principals in e-negotiations by eliciting information about the principal's preference structures. Using a multi-attribute utility theoretic model of user preferences, they propose an algorithm which enables the agent to learn the utility function over time. The learning method is based on an evolutionary framework with three-step learning in each generation. It combines population-based evolution with the possibility to apply external knowledge, and with individual learning through simulated annealing for further refinement of the solution.

Luo, Jennings et al. [5] analyze an automated negotiation model whereby user trade-off preferences were found to play a fundamental role in negotiation. With the method proposed user trade-off preferences were captured, modeling the main commonalities of trade-off relations and reflecting users' individualities. The basic idea behind the method is the following. First, the system queries the user about choice features in order to determine which attributes the trade-off relations exist between. Second, in order to determine the shape of the trade-off curve, the system queries the user about the relative importance degree of one attribute against another and about some features of trade-off curves. Finally, the system queries the user about his/her satisfaction degree for each trade-off alternative.

Luo, Jennings et al. [3] devised a default-then-adjust acquisition technique, whereby the system conducts a structured interview with the user to suggest the attributes of the trade-off, and then it asks the user to adjust the default preferences of the trade-off alternatives.

The goal of the described related work is the modeling of user's preferences and trade-off alternatives. The modeling and acquiring of knowledge is done using many different approaches such as learning algorithms and modeling of a range of strategies and tactics to acquire necessary domain knowledge.

The proposed approach makes use of the idea of an interview whereby Luo et al. used a default-then-adjust acquisition technique to extract negotiation knowledge. The proposed approach differs as it uses the Thomas-Kilmann conflict mode instrument designed as a questionnaire to identify the conflict mode, thereby acquiring behavioural knowledge of the negotiator. This behavioural knowledge is then used together with data from a conducted experiment, the Invite experiment, to construct a concession model for the negotiator, in particular to help inexperienced negotiators. The concession model corresponding to a particular conflict style will be modeled in the assistant and the assistant will support the negotiator by suggesting the concession to be made at a particular time during the negotiation.

3 Concession Modeling Approach

The Thomas-Kilmann Conflict Mode Instrument (TKCMI) is a commonly used psychological assessment tool and measures the five different behavioural classifications proposed by the Dual Concern Model: which was introduced by Blake and Mouton [6]. Thomas and Kilmann [7] developed and extensively tested a questionnaire in order to elicit conflict modes posited by Blake and Mouton's model. The questionnaire is a useful tool for probing bargaining styles in consulting. Shell [8] summarized his findings of the usefulness as follows:

- Ease of administration (it takes only about ten minutes to take and score);
- Relative freedom from social desirability biases in the way statements in the instrument are presented;
- Conflict styles that match up with strategy concept widely used in the negotiation literature; and
- Significant congruence between the classifications and their perceptions of their own behaviour across a set of simulations.

Thomas and Kilmann [7] did not develop the measures with bargaining or negotiation in mind. Rather, they were interested in finding a measurement device for probing the validity and independence of the five conflict modes hypothesized by Blake and Mouton. However, the Dual Concern Model had been plagued by problems as the variance in results appeared to be strongly linked to subjects' desire to exhibit socially desirable traits rather than to their actual preferences for one conflict mode. Thomas Kilmann addressed this problem by pairing simple, equally desirable or undesirable phrases representing each conflict attitude and forcing subjects to choose between the statements in each pair.

The five conflict styles are described as:

1. *Competing*: High assertiveness and low cooperativeness. The goal is to win.
2. *Avoiding*: Low assertiveness and low cooperativeness. The goal is to delay.
3. *Compromising*: Moderate assertiveness and moderate cooperativeness. The goal is to find a middle ground.
4. *Collaborating*: High assertiveness and high cooperativeness. The goal is to find a win-win solution.
5. *Accommodating*: Low assertiveness and high cooperativeness. The goal is to yield.

3.1 Invite Platform

The Invite software [9] is a negotiation support system platform mainly developed for the protocol-driven generation of systems. Their purpose is primarily educational: they are used to teach the subject of negotiation. The major features of the Invite platform are:

- Implementation of a negotiation methodology, in particular the process model and its various activities.
- Support for multiple, concurrent negotiation protocols, decision models, and interfaces.
- Provisioning of an intuitive web-based user interface.

The Invite platform allows users to negotiate a case independently of time and place restrictions. The system provides the user with general and private information about a case, allows to rate the issues and options, allows to send messages and offers, and provides a history to view exchanges in a tabular and graphical form.

This platform is under experimental use and different protocols are investigated. The different protocols are distinct from each other by the availability of analytical support and the provision of predetermined preferences. The experiment has three stages: pre-negotiation stage (questionnaire), negotiation stage and post-negotiation stage (questionnaire). The pre-questionnaire stage consists of the TKCMI, quiz, expectations and BATNA (Best Alternative To a Negotiated Agreement), case ratings of issues and options. For the negotiation stage the Invite system is used, and for the post-questionnaire stage questions about system adoption and the user's and opponent's conflict modes are asked. 88 participants successfully negotiated a case of a contract negotiation between a singer and a music agency. Out of these 88 negotiations, 48 reached an agreement. This sample data was used for the model of the proposed method which is described further below.

3.2 Concession Analysis of Negotiation Data

Data was extracted from the database of the Invite system of successful negotiations, in particular the TKCMI questions and negotiation graphs. The five conflict styles were calculated from the TKCMI questions. The negotiation graphs were taken and, where possible, the distribution of the curve categorized into convex, linear and concave distribution. A convex distribution means that large concessions are made first and then at the end only small concessions. A linear distribution means that equal concessions are made each time step, and a concave distribution characterizes small concessions at the beginning with larger concessions made at the end. Additionally, the concession of each timestamp was taken to calculate the relative concession made and the absolute value.

By analysing the data it was found that the conflict style collaborating was not strongly represented and was therefore discarded from the model. The conflict style avoiding was deliberately discarded as this conflict style describes behaviour that is unassertive and uncooperative, which means that this person would not pursue a negotiation in the first place. Hence, the avoiding conflict style was not considered for the model.

For the purpose of this study a grid was used which, for each approach, divides the TKCMI scores into three groups indicating the strength of an approach. The grid was developed by Shell [8] who collected the scores from over 1600 executives participating in negotiation training sessions. Considered are only approaches which have a strong presence as measured by the top 25% of the responses. That is, placing the limitation on the minimum score of:

- 7 or more for competing;
- 9 for compromising; and
- 6 for accommodating.

By applying the above score conditions to the questionnaire data, three types of negotiation profiles were obtained: purely compromising; a mix of competitive and compromising, and purely accommodating. For each profile type three types of functions: concave, convex and linear were fit and the accuracy was checked based on the 88 samples available. Out of the 88 samples, only 48 samples reached an agreement and therefore could be used. Out of these 48 samples 15 samples had concave concession curves, 21 had a convex concession curves and 12 showed a linear distribution. Table 1 presents the three profiles, associated function types and their accuracies based on the top 25%. It shows the summary of TKCMI measures with regard to the curve distribution.

The accuracy for each curve distribution is given in the last column and indicates how many TKCMI/curve distribution pairs match the proposed profiles, e.g., for profile 1, 10 out of 15 matched the proposed model.

Table 1. TKCMI measures and curve distribution

Profile	Compet.	Comprom.	Accommod.	Curve	Accuracy
P1		1		concave	67%
P2	1	1		convex	62%
P3			1	linear	67%

In summary, high values in compromising dictate a concave distribution curve, high values in competing and compromising result in a convex distribution and high values in accommodating result in a linear distribution. The gradient of the curve distribution is determined by the reservation level and the counterpart's first and second offer.

3.3 Utility Concession Modeling

The approach to negotiations is qualitative and indicative in nature. The assignment of shapes of the utility concession function is based on the user's conflict style and reservation values. A precise form of the utility concession graph needs to be determined depending the results given in Table 1. The equation for the utility concession graph can be constructed as follows, assuming the shape of the utility concession function to be exponential:

$$u = \delta_i \cdot u_1 + \delta_j \cdot u_2 + \delta_k \cdot u_3 \tag{1}$$

where:

$$u_1 = u_x - \alpha \cdot e^{\tau} \tag{1a}$$

is the concave distribution of the utility concession curve, and u_x is a constant value;

$$u_2 = u_x - \alpha \cdot \tau \tag{1b}$$

is the linear distribution of the utility concession curve;

$$u_3 = u_x - \alpha \cdot e^{-\tau} \tag{1c}$$

is the convex distribution of the utility concession curve;

$$\delta_{i,j,k} = \begin{cases} 1 & for\ i,j,k = 1 \\ 0 & for\ i,j,k = 0 \end{cases} \tag{1d}$$

whereby i, j, k are the factors for the concave, linear and the convex distribution respectively.

Factor τ is determined by three given points, one is the start point, the other is the end point and the third point is obtained from the analysis of the counterpart activity and normalized by *T*, the overall negotiation time. The constant value c is determined by the normalization of the utility rating, and α is a constant value.

3.4 Utility Concession Flowchart

The concession-making and offer construction of the agent-based assistant during a negotiation is done as follows. The first rule is to wait until the counterpart has made the first offer. As soon as the counterpart sends an offer the assistant checks whether the reservation level is reached. If so, the assistant suggests agreeing to this offer. If not, the assistant constructs the first offer with a utility of 100 and sends it to the counterpart. After this, the assistant waits until the counterpart makes the second offer. Once this offer is received, the assistant checks whether the reservation level is reached; if so the assistant suggests the negotiator to agree to the offer, if not then the concession made by the counterpart is evaluated and a new offer is constructed with an equal concession. Depending on the time line, as given by the constructed utility concession curve, this offer is sent to the counterpart at the calculated time. This process is repeated until an agreement is achieved or until the negotiation time has finished.

4 Agent-Based Assistant Using the Concession Model – An Example

The concession model and its use by the agent-based assistant are illustrated with an example of a contract negotiation between an artist (singer and song writer) and an entertainment promotion agency. There are four issues which the parties need to agree on, these are, number of new songs, royalties for CDs, contract signing bonus and number of promotional concerts.

Table 2. Ratings reflecting both negotiators' preferences

Issue	Option	Agency's option rating	Artist's option rating
Number of promotional concerts (per year)	5	30	0
	6	25	5
	7	5	25
	8	0	30
Number of songs	11	0	0
	12	5	15
	13	30	20
	14	25	15
	15	15	0
Royalties for the CDs (% of revenue)	1.5	20	0
	2.0	10	10
	2.5	5	15
	3.0	0	20
Contract signing bonus ($)	125,000	20	0
	150,000	10	15
	200,000	0	30

The parties negotiate using a NSS (Negotiation Support System) and, in addition, the artist uses an assistant. Prior to the negotiation, the assistant asks the artist to:

1. Fill in the TKCMI questionnaire;
2. Formulate the reservation levels for each of the four issues;
3. Set the time by which the negotiation should be completed; and
4. Engage in the preference elicitation and utility construction scheme.

The assistant uses the questionnaire to determine that the artist is a highly compromising person. This means that the artist's profile is P1 and the concession function is concave. Then the assistant normalizes the utility values to 0-100 and calculates the utility value for the alternative constructed with the four reservation levels; the obtained value is 60. At this point the assistant could engage in interaction with the artist and verify the way the reservation levels should be treated. The assistant needs to learn of the alternatives which yield a higher utility value than 60. For the sake of simplicity we assume here that every alternative which yields utility of 60 and higher is acceptable.

For this example, the issue ratings of both negotiators are assumed as shown in Table 2. Furthermore, Table 3 displays the offers exchanged by both negotiators and the corresponding utility ratings.

Table 3. Offer sequence and the artist's utility values

No	Agency's offer	Utility	Artist's offer	Utility	Utility concession
1	[5,13,1.5,125.000]	20	[8,13,3.0,200.000]	100	-
2	[6,13,1.5,125.000]	25	[7,13,3.0,200.000]	95	5
3	[6,13,2.0,125.000]	35	[7,13,2.0,200.000]	85	10
4	[6,13,2.5,125.000]	40	[7,13,3.0,150.000]	80	5

In Fig. 2, the sequence diagram of this example can be seen. The NSS helps the negotiators in their negotiation by providing a platform for conducting negotiations on the internet.

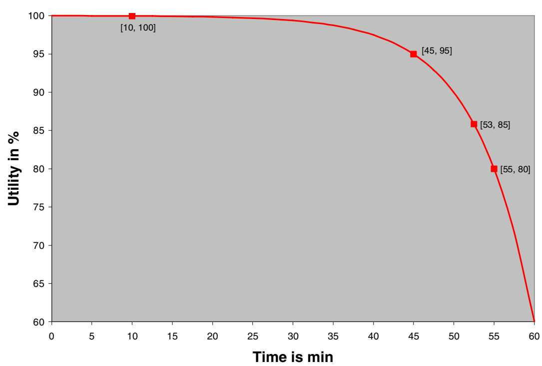

Fig. 1. Utility concession graph of the artist

The artist waits until the counterpart, the agency, makes the first offer. When the agency sends the first offer (see offer package in Table 3) after 5 min., the assistant selects the first offer with utility of 100 (see offer package in Table 3) and sends it back to the counterpart after 10 min. 13 min. later the counterpart sends the second offer (see offer package in Table 3). At this time the curve distribution is determined by three points and the utility concession curve as shown in Fig. 1 is selected and used by the agent. In particular, equation (1b) is used whereby the coefficient α is set to 0.01 (normalization for 100 range; time of negotiation 1h) and τ is defined as time t divided by a factor of 7.325. Please note, that this factor is a constant value which is determined by 3 points as mentioned previously, the starting and end point, and the point of the second offer from the counterpart (determined concession made between the first and second offer and the time the second offer was sent).

The assistant calculates the concession made (utility concession of 5) and selects the next offer with the same concession based on the modeled utility concession graph in Fig. 1 (see offer package in Table 3). Please note that the concession from the counterpart is calculated based on the negotiator's own preference setting. This implies that the negotiator should wait until t = 45 min. before this offer is sent to the counterpart.

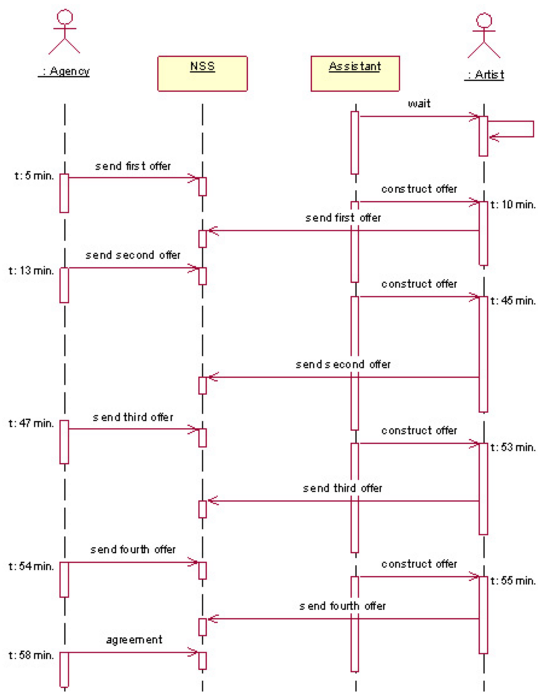

Fig. 2. Sequence diagram of negotiation

The counterpart reacts with a counter offer at 47 min. in the negotiation (see offer package in Table 3). The assistant calculates the concession made which is a utility concession of 10 and selects the next offer (see offer package in Table 3). This offer is sent at 53 min. and followed by a counter offer (see offer package in Table 3) at 54 min. After calculating the concession made by the counterpart the assistant suggests the negotiator the next offer (see offer package in Table 3) which is sent after 55 min. The counterpart agrees to the offer 2 min. before the negotiation terminates.

5 Conclusion

The proposed approach of concession modeling is based on negotiation data taken from the experiments conducted by the Invite system. The concession model is constructed using the Thomas-Kilmann Conflict Mode Instrument and the utility concession graphs. Results showed that people who had high compromising values had a concave utility concession graph, people who had high accommodating values had a linear graph and people who had a high value for competing and compromising had a convex utility concession graph. An agent-based assistant uses this concession model to help inexperienced human users during a negotiation, by suggesting possible offers to send at calculated times depending on the constructed utility concession graph.

This approach is a good first step in assisting inexperienced human negotiators based on the user's conflict behaviour and style in e-negotiations. However, more research is necessary to refine the concession model. For example, one of the problems of capturing the opponent's behaviour is that assumptions based on own preferences are made. This however is a drawback which is eminent in all negotiation scenarios where preferences are not revealed. Instead of only focusing the calculation of the opponent's concession during each offer cycle on the own preferences, a fuzzy approach could allow for a better prediction of the opponent's concession making.

Furthermore, the assistant can only deal with negotiators falling into one of the proposed categories. For example, people with a strong conflict style in collaborating are not accounted for. This clearly needs to be investigated further.

Another issue which needs to be addressed is the sample data. The sample size of 88, available for this investigation, was clearly too small for accurate results as evident from the accuracy values shown in Table 1. It is intended to expand this work as soon as more data from the negotiation experiments, which are currently underway, becomes available.

Acknowledgement

The author would like to thank Gregory Kersten for his helpful discussions and useful suggestions. This research was partially supported by grants from the Initiative for New Economy of the Social Sciences and Humanities Research Council Canada, and the Natural Science and Engineering Research Council Canada.

References

1. Boudriga, N., Obaidat, M.S.: Intelligent Agents on the Web: A Review. Computing in Science and Engineering 06, 35–42 (2004)
2. Tamma, V., Phelps, S., Dickinson, I., Wooldridge, M.: Engineering Applications of Artificial Intelligence 18, 223–236 (2005)
3. Luo, X., Jennings, N.R., Shadbolt, N.: Acquiring User Tradeoff Strategies and Preferences for Negotiating Agents: A Default-Then-Adjust Method. International Journal of Human Computer Studies (2005)

4. Guo, Y., Mueller, J.P., Weinhardt, C.: Learning User Preferences for Multi-attribute Negotiation: An Evolutionary Approach. In: Mařík, V., Müller, J.P., Pěchouček, M. (eds.) CEEMAS 2003. LNCS (LNAI), vol. 2691, pp. 303–313. Springer, Heidelberg (2003)
5. Luo, X., Jennings, N.R., Shadbolt, N.: Knowledge-based acquisition of tradeoff preferences for negotiating agents. In: Proceedings of 5th International Conference on Electronic Commerce, ACM Press, Pittsburgh, Pennsylvania, pp. 138–149. ACM Press, Pittsburgh, Pennsylvania (2003)
6. Blake, R.R., Mouton, J.S.: The managerial Grid. Gulf Publications, Houston (1964)
7. Kilmann, R.H., Thomas, K.W.: Developing a Forced-Choice Measure of Conflict-Handling Behavior: The MODE Instrument. Educational and Psychological Measurement 37, 309–325 (1977)
8. Shell, G.R.: Bargaining Styles and Negotiation: The Thomas-Kilmann Conflict Mode Instrument in Negotiation Training. Negotiation Journal 17, 155–174 (2001)
9. Strecker, S., Kersten, G., Kim, J.-B., Law, K.P.: Electronic Negotiation Systems: The Invite prototype. In: Multikonferenz Wirtschaftsinformatik, Track Collaborative Business, Gesellschaft für Informatik e.V., Passau, Germany (2006)