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## Towards a Behavioural Agent-based Assistant for e-Negotiations<sup>♦</sup>

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### Abstract

Software agents typically negotiate on behalf of their owners. For this to be effective the agent must be able to adequately represent the owners' preferences. However, the process by which this knowledge is acquired is normally not taken into consideration. The idea of the proposed method is that a user uses an e-negotiation system and fills in the Thomas-Kilmann questionnaire which is designed to measure the conflict mode. The assisting software agent then uses an implemented model to construct the user's concession graph and suggests the concession for each offer package e.g. in a multi-attribute negotiation. The modeling of the concession graph was designed by comparing negotiation history graphs with the five conflict styles (competing, collaborating, compromising, avoiding and accommodating). Certain patterns were found which allow to model and map the conflict styles to a concession graph. It was found that people who had high compromising styles produced a concave concession graph, people who are highly accommodating generated a linear graph, and people who had a high value for competing and compromising had a convex concession graph.

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## 1. Introduction

Negotiation has been for decades 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 messages between the negotiating parties, (i.e. dictating who can say what and when) and acts as the rules by which the negotiating parties must abide by if they are to interact. The protocol is necessarily public.

The strategy, on the other hand, is the way in which a given party acts within those rules in an effort to get the best outcome in the negotiation. 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 (i.e. via the Internet). Electronic negotiation systems can offer more features such as graph support, decision analysis, communication management, etc., than traditional negotiations due to the underlying IT infrastructure.

Recent technological and economical advances provide the setting for e-negotiation research and require efficient support of electronic negotiations, e.g. in electronic commerce. The goals of supporting negotiations through information technology are to reduce transaction costs in e-negotiations, to find an optimal deal, to conduct checks during the negotiation, to offer decision support or to provide argumentation support for human or software agents.

In electronic negotiations usually a seller and a buyer exchange offers with the objective of achieving a settlement. The goal of supporting negotiations through information technology is to offer 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).

Interest in automated negotiation involving 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 owners in a future Internet-based global marketplace. Until now, research has focused on accounting for particular interactions among agents by developing and improving specifically tailored negotiation protocols and strategies; where the former refers to the rules that the agent has to follow in order to participate in a negotiation, while the latter refers to the rationale for choosing a certain action at a given stage.

Software agents typically negotiate on behalf of their owners. For this to be effective the agent must be able to adequately represent the owners' preferences. However, the process by which this knowledge is acquired is normally not taken into consideration. In order to overcome this shortage, a possible solution is presented by taking knowledge into account to model owners' preferences.

The remainder of this paper is structured as follows. Section 2 gives an introduction to electronic negotiation support systems. In Section 3 related work is listed by summarizing their approaches and shortcomings. Section 4 describes the research method proposed including the modeling and mapping of the conflict styles to a concession graph. Section 5 concludes this paper by presenting the findings and discussing the shortcomings as well as further works.

## 2. Negotiations and Negotiation Support

### 2.1 Negotiation support systems

Negotiation support systems (NSS) are designed to facilitate the various phases of the bargaining process. Because negotiations are considered complex and unstructured, NSS functional requirements have emphasized support capabilities which are very general; as such, these systems neither lend themselves to nor are intended to be fully automated. The tools for support are varied; many emphasize mathematical support tools, such as decision trees, forecasting, and so forth. However, Jelassi and Foughi (Jelassi 1989) have called for tools which address behavioural characteristics and cognitive perspectives of negotiators.

### 2.2 Negotiation stage model

During the process of negotiation, the interaction involves the dynamics of either escalation or de-escalation, pending on the communication and negotiation skills employed by both parties and mediator (Walton 1987).

In literature, a negotiation process is described by a “three stage model” (Graham and al. 1994): antecedent phase, concurrent phase, and consequent phase. In the antecedent phase, negotiators form their bargaining styles before the opening of talks. Since bargaining styles established before the negotiation affect the characteristics of the subsequent interaction, negotiators who are positively oriented behave more cooperatively than those who are negatively oriented” (Rubin and Brown 1975; Graham and Mintu-Wimsat 1997).

In the concurrent phase, negotiators bargain and try to find solutions by exchanging information and offers. In this phase, they may choose to fight or cooperate pending on the situational factors and the progress of the negotiation.

Finally, in the consequence phase, negotiators may either reach an agreement or leave the conflict unresolved, depending on the interaction of both parties in the previous stages.

There are some independent variables reflecting negotiator’s characteristics and situational constraints in each stage (Sawyer and Guetzkow 1965; Rubin and Brown 1975). Generally, the bargaining style and attractiveness (Graham and Mintu-Wimsat 1997) are considered most important in the antecedent phase; the concurrent phase can be described in terms of time spent, information exchanged, offer proposed, degree of cooperation, and concession made (Graham 1985).

Typically, the consequence can be described by objective measures, (e.g. joint outcome, individual outcome, contract balance) or by subjective measures (e.g. satisfaction and relationship).

In the process of negotiation, the ways the negotiators think about and approach to manage conflict are often more important in determining its outcome than the nature of the conflict itself (Hall 1986).

Negotiations involve the interaction between negotiators, including exchanges of their arguments and counterarguments. Through these attempts to justify their positions and persuade others, the negotiators jointly arrive at the outcome. Because of their interdependence, the fact that the outcome can only be determined jointly and through the actions of both parties is the defining characteristic of negotiations (Kersten, Koszegi et al. 2003).

### 3. Related Work

Related research in this area has mostly focused on an efficient and effective algorithm enabling agents to be successful and obtain acceptable outcomes. While this is definitely important, it is only one part of the solution. Agents should represent as closely as possible the owner and negotiate on behalf of their owners. For this to be effective, agents must acquire the owners' interests, strategies, preferences and prejudices in a given domain. Without this, software agents cannot execute their task appropriately. Therefore, the acquisition of such knowledge is an essential requirement for applying negotiating agents in practice. However, not much thought has been given to the problems of determining:

- What exactly knowledge an owner needs to impart to their agent in order to achieve high fidelity negotiation behaviour.
- How such knowledge can be effectively acquired from the owner.

These are clearly serious shortcomings of existing research that need to be addressed if negotiating agents are to be widely used.

Guo et al. (Guo, Mueller et al. 2003) investigate how agents that act on behalf of users in electronic negotiations by eliciting information about their users' preference structures. Based on a multi-attribute utility theoretic model of user preferences, an algorithm is proposed that enables an 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. The learning method reveals good performance in the simulated experiments. It is shown that a substantial improvement of basic learning can be achieved by adding the steps of knowledge integration and local search.

Luo et al. (Luo, Jennings et al. 2003) analyze an automated negotiation model whereby user trade-off preferences were found to play a fundamental role in negotiation. With the method proposed users' trade-off preferences were captured, modeling the main commonalities of trade-off relations and reflecting users' individualities.

The basic idea behind the method has three steps:

1. The system queries the user about choice features in order to determine which attributes the trade-off relations exist between.
2. 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.
3. The system queries the user about his satisfaction degree for each trade-off alternative.

Luo et al. (Luo, Jennings et al. 2005) 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. Their research seeks to start bridging the knowledge acquisition gap between the negotiating agents' owners and the negotiation algorithms that their agents use. Their paper explores how the necessary knowledge about a user's negotiation trade-offs can be acquired. The overall method is described as follows:

1. The system queries the user about choice features in order to determine which attributes to trade-off. The system queries about related attributes that could be used to trade-off.
2. In order to shape the trade-off strategy, the system initially presents a default. Then it pretends that it is a seller and makes a number of concessions on one attribute and asks the user (buyer) for the limit of the other attribute s/he would be willing to worsen to compensate. It reshapes the trade-off strategy according to the user's adjustments. Later on, the user can make more adjustments in this way or can ask the system to set the trade-off strategy back to its default.
3. The system can re-shape the default preference according to the user's adjustment of the parameters, which configure the trade-off preference on the alternatives in the strategy set.

The goal of the described related work is to model the user's preference models 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. Our approach is different as it uses a measurement to identify the conflict mode, thereby acquiring behavioural knowledge.

## 4. Proposed Method

The idea of the proposed method is that a user uses an e-negotiation system and fills in the Thomas-Kilmann questionnaire which is designed to measure the conflict mode. The assisting software agent uses an implemented model to construct the user's concession graph and suggests the concession for each offer and attributes e.g. in a multi-attribute negotiation. The model of the concession graph is designed by comparing utility graphs from a real negotiation experiment with the five conflict styles. Certain patterns are found which allow to model and map the conflict styles to a concession graph.

### 4.1 Thomas-Kilmann Instrument

Many negotiation courses and executive training programs cover the subject of bargaining styles. The Thomas-Kilmann Conflict Mode Instrument is a commonly used psychological assessment tool and measures the five different behavioural classifications proposed by the Dual Concerns Model: which was introduced by Blake and Mouton (Blake and Mouton 1964) in the mid 1960s. These five classifications are competing, collaborating, compromising, accommodating and avoiding.

Thomas and Kilmann (Kilmann and Thomas 1977) developed these five classifications to elicit and test the five conflict model posited by Blake and Mouton's model. It is a useful tool for probing bargaining styles in a classroom setting. Shell (Shell 2001) summarized his finding 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 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 (Blake and Mouton 1964). However, the *dual*

*concerns 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 and 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. It was the simplicity of the statements, their repetition, and the need for subjects to select one against other (i.e. equally compelling or repelling statements minimizes social desirability variance).

The five conflict styles, as shown in Fig. 1, are now described in more detail.

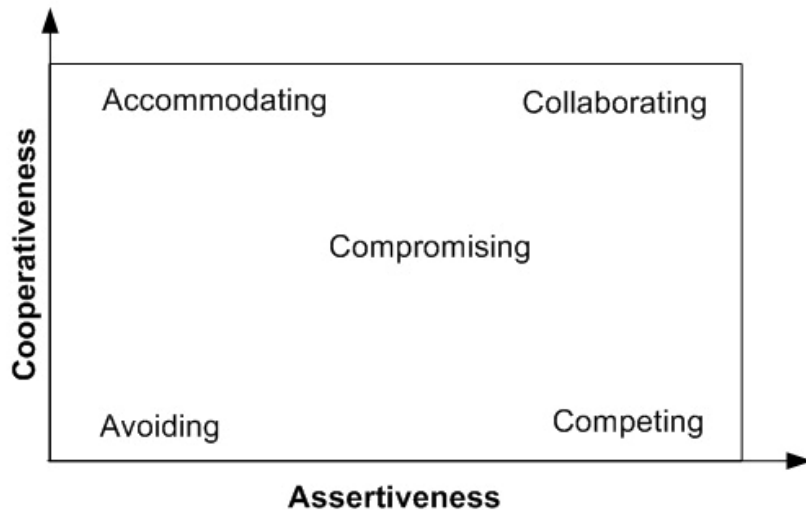


Fig 1. Five styles of Thomas-Kilmann conflict mode

*Cooperativeness* is defined as attempting to satisfy the other party's concern; and *assertiveness* is defined as attempting to satisfy one's own concern. According to the dual concern model, any person's conflict management style is a function of people's concern for self and concern for others. These two dimensions of behaviour can be used to define five kinds of different styles of dealing with conflicts.

*Competing* is defined in negotiations where the stakes are high, time is limited, and bluffing is possible. The competitive style can dominate the bargaining process, meaning competitive people can negatively influence relationships. In addition, competitive negotiators instinctively focus on the issues that are easiest to count in terms of winning and losing, e.g. money. No quantitative issues may be overlooked that can yield substantial value.

*Accommodating* is used to describe behaviour that is both unassertive and cooperative. An individual with accommodating style tends to neglect his or her own concerns to satisfy the concerns of other persons. It means accommodators try to meet the needs of others at the cost of their own interest, which is a self-sacrifice style.

*Avoiding* is used to describe behaviour that is unassertive and uncooperative. An individual with avoiding style tends not to immediately pursue his or her own concerns or those of the others. They usually avoid, postpone or withdraw rather than address the conflict at hand. It is a passive style of conflict resolution.

*Collaborating* is used to describe behaviour that is both assertive and cooperative. An individual with collaborating style tends to work with another person to find a solution that fully satisfies the concerns of both parties. This kind of negotiators follow the problem solving strategy (Kersten, Koszegi et al. 2003). As a “Win-Win” style, it usually involves a process of finding preferences of each party and reaching an agreement by a creative solution. It is an active style seeking mutually beneficial solutions.

*Compromising* is a hybrid of the above four. It is used to describe behaviour that is both intermediate in assertiveness and cooperativeness. In the process of conflict resolution, the object is to find a mutually acceptable solution for both parties. As a result, some degree of concession has to be made by parties involved. Compromising is a style between competing and accommodating; similarly, it is also lies in the middle of avoiding and collaborating.

Research provides fairly strong support for the dual-concern models. Multidimensional plots of interrelationships show that the five conflict styles fit in a two-dimensional space in the manner theorists suggest (Vliert 1990; Vliert and Euwema 1994). In addition, there is no better or worse among these five styles. A style appropriate in one situation might be inappropriate in another conflict context. In the process of conflict resolution, people with different styles tend to exhibit different strengths and weaknesses (Shell 2001).

## 4.2 Invite NSS

The Invite software (Strecker, Kersten et al. 2006) 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:

1. Implementation of a negotiation methodology, in particular the process model and its various activities.
2. Support for multiple, concurrent negotiation protocols, decision models, and interfaces.
3. 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 the case, allows to rate the issues and options, allows to send messages and offers, and provides a history to view exchanges in a graphical form.

This platform is currently under experimental use where different protocols are being 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).

So far, one treatment has been evaluated which consisted in the pre-questionnaire stage of the Thomas-Kilmann questionnaire, quiz, expectations and BATNA (best alternative to a negotiated agreement), case ratings of issues and options.

In the negotiation stage the Invite system was used, and in the post-questionnaire stage questions about system adoption and the user's and opponent's conflict modes were asked. 46 participants successfully negotiated a case of a contract negotiation between a singer and a music agency. Out of these 23 negotiations, 12 reached an agreement. This sample data was used for the proposed method.

### 4.3 Negotiation Data

Data was extracted from the database of the Invite system. It included the Thomas-Kilmann (TK) questionnaire questions which needed to be calculated for the five TK conflict styles. Besides that the negotiation graphs were taken and, where possible, the distribution of the curve categorized into concave, linear and convex distribution.

A concave distribution means that big concessions are made first and then at the end only small concessions are given. A linear distribution means that equal concessions are made each time step, and a convex distribution characterizes small concessions at the beginning with bigger concessions made at the end. Additionally, the concession of each timestamp was taken to calculate the relative concession made and the absolute value.

TABLE I  
TK MEASURES AND DEGREE OF CONCESSION

Curve	Relative Concession Value of	Accuracy
Concave	TK3	62%
Linear	TK1 + TK3	69%
Convex	TK5 / 2	72%

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

Used in the upcoming tables are the following abbreviations:

- TK1 represents competing,
- TK3 represents compromising,
- TK5 represents accommodating.

Table I shows the relative concession made in regard to the TK conflict styles. The relative concession represents the gradient of the distribution. For the concave distribution it was found that TK3 roughly results in the gradient of the curve. For the linear distribution the addition of TK1 and TK3 was found to be representative, and in the case of the convex distribution, 50% of TK5 was found representative. The accuracy of the relative concession value is measured comparing the actual relative concession of the sample data with the value of the proposed formula.

To analyse the data, the Wharton Grid (Shell 2001) was used. The Wharton Grid, shown in Fig. 2, was introduced by Shell in order to adapt the raw scores derived to the bargaining context. TK scores were collected from over 1600 global executives participating in negotiation training sessions. Taken for this investigation were the TK values for the High 25% Wharton Grid as shown in Table II.

TABLE II  
WHARTON-TKI GRID – BORDER HIGH 25%

TK1	TK3	TK5
7	9	6

The result of applying the Wharton Grid High 25% values is shown in Table III. It shows the summary of TK conflict styles in regard to the curve distribution.



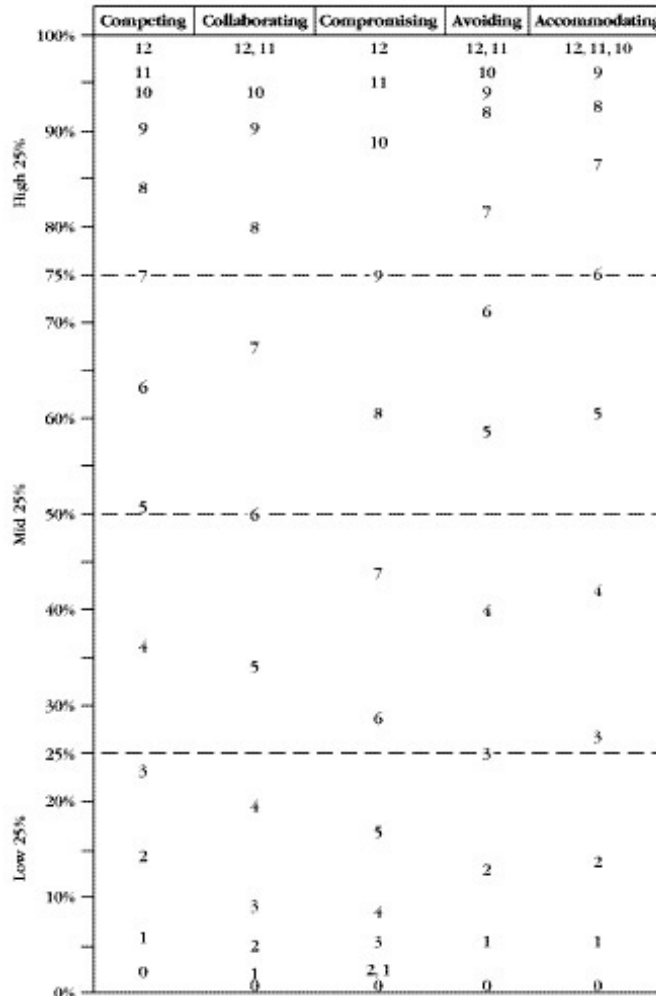


Fig 2. Wharton Bargaining Styles Grid (Shell 2001)

The accuracy for each curve distribution is given in the last column and compares the actual TK values of the sample data with the proposed curve distribution. Therefore, high values in compromising dictates a concave distribution curve, high values in competing and compromising results in a convex distribution and high values in accommodating results in a linear distribution.

TABLE III  
TK MEASURES AND CURVE DISTRIBUTION

TK1	TK3	TK5	Curve	Accuracy
	1		Concave	67%
1	1		Convex	71%
		1	Linear	65%

#### 4.4 Concession Modeling

The results of Table II and III allows the modeling of the concession graph for the user behaviour according to their TK conflict styles. The concession is measured with utility (or value) function. The

equation for the concession graph can be constructed as follows, assuming the shape of the concession curve to be exponential:

$$v = \delta_i \cdot v_1 + \delta_j \cdot v_2 + \delta_k \cdot v_3 \quad (1)$$

where:

$$v_1 = \alpha \cdot e^x \quad (1a)$$

represents the concave distribution of the concession curve,

$$v_2 = \beta \cdot x \quad (1b)$$

represents the linear distribution of the concession curve,

$$v_3 = -\gamma \cdot e^{-x} \quad (1c)$$

represents the convex distribution of the concession curve,

$$\delta_i = \begin{cases} 1 & \text{for } i = 1 \\ 0 & \text{for } i = 0 \end{cases} \quad (1d)$$

represents the factor for the concave part,

$$\delta_j = \begin{cases} 1 & \text{for } j = 1 \\ 0 & \text{for } j = 0 \end{cases} \quad (1e)$$

represents the factor for the linear part,

$$\delta_k = \begin{cases} 1 & \text{for } k = 1 \\ 0 & \text{for } k = 0 \end{cases} \quad (1f)$$

represents the factor for the convex part.

Factor  $x$  represents the time step normalized by an interval  $T$ . The three different distributions are shown in Fig. 3 where the relative concession is shown versus the time steps during a negotiation.

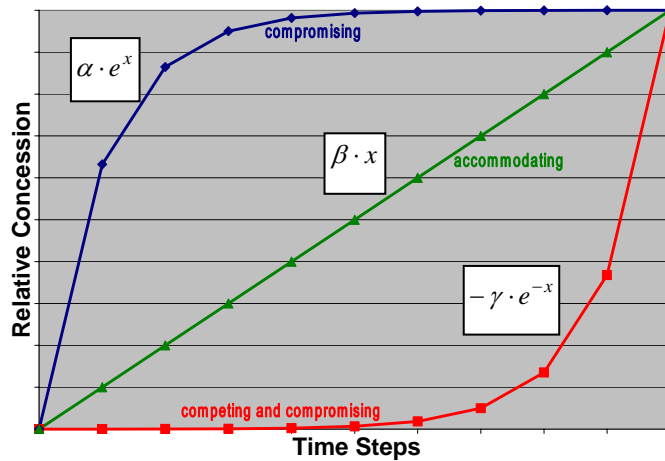


Fig. 3. Relative Concession Graph

## 4.5 Concession Algorithm

The following algorithm (see Fig. 4) is derived from the previous equations.

*Input variables:*

TKmeasures[]: Vector of TK values before Wharton Grid  
 TK[]: Vector of TK measure after Wharton Grid  
 deltas[]: Delta value for concave, linear and convex distribution  
 factors[]: concave, linear, convex

```

Output variable:
formula:      Equation of concession graph
Initialization:
deltas[] ← 0
TKmeasures[] ← calculateTKMeasuresFromQuestionnaire()
TK[] ← applyWhartonGridHigh25%(TKmeasures)
factors[] ← calculateFactorValues(TKmeasures)
Computation:
if TK1=0 and TK3=1 and TK5=0 then
    deltas[] ← setDeltaConcave()
end if
if TK1=0 and TK3=0 and TK5=1 then
    deltas[] ← setDeltaLinear()
end if
if TK1=1 and TK3=1 and TK5=0 then
    deltas[] ← setDeltaConvex()
end if
formula ← generateEq(factors[],deltas[])
return formula

```

Fig. 4. Concession Calculation Algorithm

First, the TK measures are calculated from the questionnaire which results in values in the range of 0 and 12 for all conflict styles. After that, the Wharton Grid is applied considering only the high 25% score values. Depending on the TK values, the delta values are defined according to equation (1d)-(1f) and at last, the formula is constructed and returned (according equation (1)). Then, the factor values for the concave, linear and convex distribution are calculated according equation (1a)-(1c). Note that the algorithm only considers people with conflict styles which fall into one of the three categories.

## 4.6 Agent-based Assistant

The agent-based assistant is supporting the user during the negotiation; more specifically, the assistant suggests the offers which were constructed with the use of the model. The model contains the three different curve distributions, however to construct an offer for a bilateral multi-attribute negotiation, the use of the bilateral negotiation model is necessary and is defined as follows:

Let  $i$  ( $i \in \{a, b\}$ ) represent the negotiating agents and  $j$ , ( $j \in \{1, \dots, n\}$ ) the issues to negotiate about. The set of issues in real world negotiations is always finite.

Let  $x_j \in [\min_j^i, \max_j^i]$  be a value for issue  $j$  acceptable by agent  $i$ . Each agent has a scoring function:  
 $S_j^i : [\min_j^i, \max_j^i] \rightarrow [0, 1]$ ,

which gives the score agent  $i$  assigned to a value for issue  $j$  in the range of its acceptable values, whereby the scores are kept in the interval  $[0, 1]$ .

The specification of weight values to calculate the relative importance that an agent assigns to each issue under negotiation is done as follows.  $w_j^i$  is the importance of issue  $j$  for agent  $i$ . Assumed is here that the weighted sum of both agents are normalized, i.e.

$$\sum_{1 \leq j \leq n} w_j^i S_j^i(x_j) = 1, \text{ for all } i \text{ in } \{a, b\}.$$

With these elements in place, it is now possible to define an agent's scoring function for a negotiation – that is, for a value  $x = (x_1, \dots, x_n)$  in the multi-dimensional space defined by the issues' value ranges:

$$S^i(x) = \sum_{1 \leq j \leq n} w_j^i S_j^i(x_j).$$

This calculation is used by the agent to construct the offer. However, for the agent to be able to compute the offer, the user is requested to enter weighted values and the minimum and maximum values for each issue. The agent-based assistant will use the concession graph and will suggest and construct an offer to the user. The user can then decide whether to take the offer and send it to the counterpart or whether an amendment should be done.

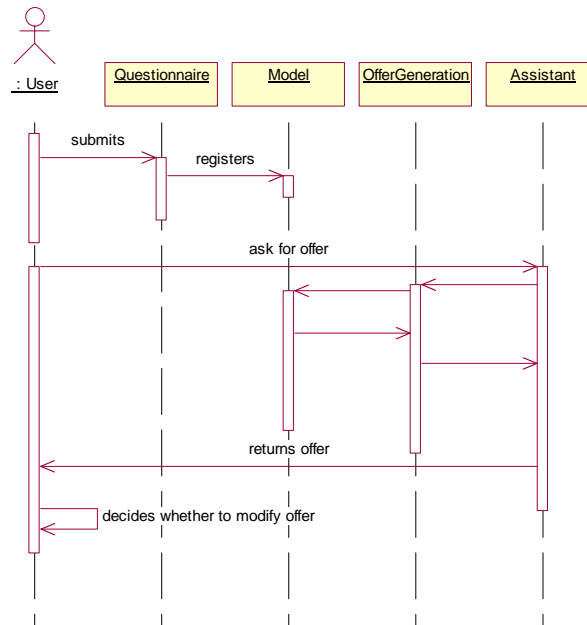


Fig. 5. Interaction diagram of concession modeling and offer construction

Fig. 5 shows the interaction diagram of the user and the assistant agent. The user is requested to fill in the TK questionnaire, which in turn is used to construct the model. When a user wants to make the first offer, a message is sent to the assistant. The assistant will then compute and construct the offer using the model and will send the offer back to the user. The user will then decide whether to accept the offer or to modify it before sending it to the counterpart.

## 5. Conclusion

Our approach assists users in developing a strategy for electronic negotiations, whereby they are only required to fill in the Thomas-Kilmann questionnaire, which is designed to measure the conflict mode. The assisting software agent uses an implemented model, which uses the data of the Thomas-Kilmann questionnaire to construct the user's concession graph and suggests the concession for each offer and attributes (e.g. in a multi-attribute negotiation).

Results showed that people who had high compromising values had a concave 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 concession graph. Using the Thomas-Kilmann questionnaire is clearly a good step forward to model behaviour for concession modeling in electronic negotiations.

However, one of the drawbacks is that the assistant can only deal with negotiators which fall 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 drawback of this approach is that for the modeling process a large sample size is necessary. The sample size of 46, available for this investigation, was too small for accurate results as evident from the accuracy values shown in Table I and III. It is intended to expand this work as soon more data from the negotiation experiments, which are currently underway, becomes available.

One consideration has been left out throughout this paper which is the opponent's negotiation style. The reaction of an offer from the opponent is definitely an important influential factor for the counter offer of a negotiator and also needs to be investigated.

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