Using Two Main Arguments in Agent Negotiation

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Abstract. During agent negotiation, argumentation-based negotiation of agent has been widely studied for it can make agent who received the argument change its goals or preferences accordingly. Being the two main arguments, threat and reward can even make the negotiators reduce their behavior space to find a well compromise quickly in the end, which can make them accomplish their cooperation on the base of getting the most profit of each of them. This paper presents a type of formal models of threat and reward first, and then present a new way of how to calculate the negotiation strengths of them through simulated calculations based on the models to make the negotiators threatened or rewarded make a right choice and accomplish their cooperation well.

Keywords: Threat, Reward, Agent, Negotiation.

1 Introduction

Argumentation-based negotiation of agent [1, 2, 3] can make the negotiators exchange additional information that has not been expressed in the proposal, so it has been widely studied. Being the two main arguments, threat and reward can even make negotiators reduce their behavior space to find a well compromise quickly in the end, which can make them accomplish their cooperation on the base of getting the most profit of each of them. And it can also make their final decision-making [4] well.

In this area, [5] is classical, which has integrated four main parameters that can represent the mental state of agent as belief、desire、intention and goal with the definition of threat and reward, and then advanced a kind of logical model of them. But at first, the model hasn't dealt with the evaluation of the importance of its opponent such as knowledge; secondly, the parameters in this model just limited to mental and time, and it hasn't dealt with the evaluation of the negotiation content such as threat and reward itself; finally, the parameters are so many and complex that make the model difficult to be understood.

After that, many studies about the generation [6]、evaluation [7]、selection [8] of threat and reward has more thought much of its calculation only in simple calculation of mathematics, which has made the function of agent in negotiation limited to simple exchanges of proposals and counter-proposals.

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Now in [9], Amgoud has advanced a kind of formal model of threat and reward based on [5]. In their models, they has mainly made level with the information of agent about its context, then evaluated it by the maximum and minimum of corresponding weight after it has been put forward, which remedied some shortages of [5] to a certain extent. But the level has been made so simplest and it couldn't achieve the goal of quantification of threat and reward, which has little effect on evaluating them; on the other side, they hasn't set up relative models of their evaluation and analyze their negotiation strength.

Besides this, [10, 11, 12] has studied threat and reward solely. [10] is only about passive threat, which is an aspect of threat. [11, 12] has presented a way of evaluation about reward based on the learning of agent, whether their models can suit other forms of threat or reward has not been verified yet.

Based on this background, this paper aims at providing a type of formal models of threat and reward and present a new way of how to calculate the negotiation strengths of them. After that, some examples are proposed to explain the former, and some simulated calculation and analysis are proposed to verify the validity of the latter.

This paper is organized as follows: Section 2 presents a type of formal models of threat and reward after definite and classify them, then gives some examples to explain them; Section 3 presents a new way of how to calculate the negotiation strengths of threat and reward based on the models, then makes some simulated calculations and analysis to verify their validity; Section 4 is the conclusions.

2 Models of Threat and Reward

2.1 Definitions and Classifications

During the course of negotiation, when it is being brought into a stalemate for one's items of negotiation are conflicted with the goal or intention of another one, this agent may use it as a force (or an incitement) to persuade its opponent to do (or not to do) the business with it, which goal is to accomplish the cooperation between them, and at the same time get the most profit of both of them.

Usually a threat (reward) can be classified as two main kinds as follows [5]:

1. You should do this otherwise I will do that, which is bad (good) for you;
2. You should not do this otherwise I will do that, which is bad (good) for you.

2.2 Models

For the negotiation side of threatening (or rewarding) A, $Threat(A \Rightarrow B)$ $(\mathrm{Re}\, ward(A \Rightarrow B))$ can be formally modeled as a tuple $\langle A, B, K, G, G' \rangle$, and that:

1. A is the negotiation side of threatening (rewarding), B is the other negotiation side of threatened (rewarded);
2. K is the knowledge relative to this threat (reward) of A, $K \in K_A$;
3. G is the goal A want to achieve by proposing this threat (reward), $G \in G_A$;

4. G' is the goal A think B want to achieve after B has accepted this threat (reward), $G' \in G'_A$;
5. During the course of negotiation, for the threat, there is always $K \wedge \neg G \bullet \neg G'$; for the reward, there is always $K \wedge G \bullet G'$. $K \wedge G$ is consistent.

For the other negotiation side of threatened (rewarded) B, $Threat(A \Rightarrow B)$ $(\mathrm{Re}ward(A \Rightarrow B))$ can also be formally modeled with the same rule, but $K \in K_B$、 $G \in G_B$、 $G' \in G'_B$.

2.3 Examples

Example 1 (Threat). During the course of agent negotiation, the order has been given by a buyer agent A is quite different with expectation of a seller agent B, the former request the latter accept it $(AcptOrd)$. But for its most profit, B may reject it, which may bring the negotiation into a stalemate. In this status, to guarantee the most profit of both of them and the negotiation to be continued successfully, A may propose some threats such as stopping every deal $(StopDeal)$ with B to threaten B to accept, and finally accomplish the business to achieve the cooperation between them.

So for A, this threat can be formally modeled as:

$$Threat(A \Rightarrow B) = \langle A, B, \{\neg AcptOrd \rightarrow StopDeal\}, AcptOrd, \neg StopDeal \rangle$$

1. $K = \langle \neg AcptOrd \rightarrow StopDeal \rangle, K \in K_A$;
2. $G = \langle AcptOrd \rangle, G \in G_A$;
3. $G' = \langle \neg SopDeal \rangle, G' \in G'_A$.

For B, the model of this threat can be set up in the same way.

Example 2 (Reward). In the stalemate of negotiation in example1, A may propose some rewards such as buy some other products $(BuyOth)$ from B to incite B to accept, and finally accomplish the business to achieve the cooperation between them.

So for A, this reward can be formally modeled as:

$$\mathrm{Re}ward(A \Rightarrow B) = \langle A, B, \{AcptOrd \rightarrow BuyOth\}, AcptOrd, BuyOth \rangle$$

1. $K = \langle AcptOrd \rightarrow BuyOth \rangle, K \in K_A$;
2. $G = \langle AcptOrd \rangle, G \in G_A$;
3. $G' = \langle BuyOth \rangle, G' \in G'_A$.

For B, the model of this reward can be set up in the same way.

3 Calculation of Negotiation Strengths of Threat and Reward

The formal models of threat (reward) upwards include just two negotiators, and the negotiation side of threatened (rewarded) is usually willing to accept it to accomplish the cooperation of them and get the most profit of both of them. But during the course of negotiation, the numbers of negotiators and threats (rewards) can all be many and many. At this time, also to guarantee the most profit of both of them and the negotiation to be continued successfully, the negotiator which has been encountered with several threats (rewards) should make quantification with each threat (reward) according to its relative knowledge, and then calculate its value to compare the negotiation strengths of each threat (reward).

3.1 Calculation of Negotiation Strengths of Threat (Reward)

Let Σ be a collection of all the threats (rewards) that X have been encountered from A、B、C、D at the same time, such that:

$$Threat(A \Rightarrow X) \in \Sigma、\ Threat(B \Rightarrow X) \in \Sigma、$$
$$\mathrm{Re}ward(C \Rightarrow X) \in \Sigma、\mathrm{Re}ward(D \Rightarrow X) \in \Sigma$$

The calculations of negotiation strengths of threat from A and reward from C are:

$$VlStrTh(A \Rightarrow X) = \omega_{\Phi} \times E(\Phi_A) + \omega_G \times E(G_A) + \omega_{G'} \times E(G'_A) \quad (1)$$
$$VlStrRw(C \Rightarrow X) = \omega_{\Phi} \times E(\Phi_C) + \omega_G \times E(G_C) + \omega_{G'} \times E(G'_C) \quad (2)$$

1. $\Phi_A(\Phi_C)$ is the negotiation side of threatening (rewarding);
2. $G_A(G_C)$ is the goal the negotiation side of threatening (rewarding) wants;
3. $G'_A(G'_C)$ is the goal the negotiation side of threatened (rewarded) thinks itself wants after it has accepted this threat (reward);
4. $E(\Phi_A)$、$E(G_A)$、$E(G'_A)$ are evaluation values of Φ_A、G_A、G'_A calculated by X, and so do $E(\Phi_C)$、$E(G_C)$、$E(G'_C)$;
5. ω_{Φ}、ω_G、$\omega_{G'}$ are weight values of $E(\Phi_A)$、$E(G_A)$、$E(G'_A)$ of X according to its relative knowledge, and so does C.

The calculations of negotiation strengths of $Threat(B \Rightarrow X)$、$\mathrm{Re}ward(D \Rightarrow X)$ can also be calculated in the same way.

3.2 Simulated Calculation and Analysis

The evaluation of $E(\Phi_A)$、$E(\Phi_B)$、$E(\Phi_C)$、$E(\Phi_D)$ can be decomposed just as credit degree、the number of successful deals、satisfaction degrees; The evaluation of $E(G_A)$、$E(G_B)$、$E(G_C)$、$E(G_D)$ can be decomposed just as price quantity

delivery they are negotiating, and so does $E(G'_A)$、$E(G'_B)$、$E(G'_C)$、$E(G'_D)$. Corresponding data and weight values can be given as table 1、2、3, and the negotiation strength of every threat (reward) can be calculated as table 4.

Table 1. Corresponding data and weight values of $E(\Phi_A)$、$E(\Phi_B)$、$E(\Phi_C)$、$E(\Phi_D)$

	AgentA	*AgentB*	*AgentC*	*AgentD*	Weight
Credit	8	6	5	9	0.5
Deals	8	7	8	6	0.3
Satisfaction	6	10	7	5	0.2

Table 2. Corresponding data and weight values of $E(G_A)$、$E(G_B)$、$E(G_C)$、$E(G_D)$

	AgentA	*AgentB*	*AgentC*	*AgentD*	Weight
Price	5	6	4	10	0.4
Quantity	8	5	8	5	0.4
Delivery	7	9	7	6	0.2

Table 3. Corresponding data and weight values of $E(G'_A)$、$E(G'_B)$、$E(G'_C)$、$E(G'_D)$

	AgentA	*AgentB*	*AgentC*	*AgentD*	Weight
Price	9	10	7	8	0.4
Quantity	8	5	6	9	0.3
Delivery	6	8	5	5	0.3

Table 4. Calculations of negotiation strength of every threat (reward)

	Evaluation values			Weight values			Negotiation strength
	$E(\Phi)$	$E(G)$	$E(G')$	ω_Φ	ω_G	$\omega_{G'}$	
AgentA	7.6	6.6	7.8	0.3	0.5	0.2	7.14
AgentB	7.1	6.2	7.9				6.81
AgentC	6.3	6.2	6.1				6.21
AgentD	7.3	7.2	7.4				7.27

So for X, the negotiation strength of every threat (reward) can be ordered as:

$$VlStr\,\mathrm{Re}(D \Rightarrow X) \succ VlStrTh(A \Rightarrow X) \succ VlStrTh(B \Rightarrow X) \succ VlStrRw(C \Rightarrow X) \quad (3)$$

Finally with this result, X should deal with D first, and then deal with other agents by the order of A、B、C. And at the same time it can also guarantee the most profit of them and accomplish their cooperation.

4 Conclusions

Compared with traditional ways of agent negotiation such as proposal and counter-proposal, threat and reward in argumentation-based negotiation of agent can also make negotiators exchange additional knowledge that can simulate human beings besides such simple knowledge, which can reduce their behavior space of negotiation and make the result willingly accepted by each one of them, and finally accomplish their cooperation on the base of getting the most profit of them. How to effectively model and evaluate with some other kinds of argumentations in agent negotiation such as appeal, rebut, undercut, and etc., can be perspective extensions.

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