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Trust Aware Negotiation Dissolution

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Abstract. In this paper we propose a recommender system that suggests the best moment to end a negotiation. The recommendation is made from a trust evaluation of every agent in the negotiation based on their past negotiation experiences. For this, we introduce the Trust Aware Negotiation Dissolution algorithm.

1 INTRODUCTION

Negotiation and cooperation are critical issues in multi-agent environments [3], such as in Multi Agents Systems and research on Distributed Artificial Intelligence. In distributed systems, high costs and time delays are associated with operators that make high demands on the communication bandwidth [1].

Considering that agents are aware of their own preferences, which help their decision making during the negotiation process, the negotiation can go through several steps depending on their values as each agent does not know the others' preferences. This can lead to an increase of communication bandwith costs affecting the general performance, and might put agents in undesirable negotiation situations (such as a negotiation that probably will not end with an acceptable agreement).

Termination of the negotiation process or a negotiation dissolution action should be considered when the negotiation is in a situation where the expected result of the following steps cannot be better than the current result. This will not only help to determine when to end a negotiation process, but also to help decide wether to end it with or without an agreement.

2 TRUST AWARE DISSOLUTION

The Trust Aware Negotiation Dissolution algorithm (TAND from now on) takes into account direct interactions from similar situations in the past (Situational Trust [4]). The basic formula used to calculate this type of trust is:

$$T_a(y, \alpha) = U_a(\alpha) \times T_a\widehat{(y, P_\alpha)} \tag{1}$$

Where:

- a is the evaluator agent.
- y is the target agent.
- α is the situation.
- $U_a(\alpha)$ represents the utility that a gains from a situation α, calculated by its utility function.
- P_α is a set of past situations similar to α.
- $T_a\widehat{(y, P_\alpha)}$ is an estimated general trust for the current situation. We will calculate this value considering two possible results for each situation in the set of past interactions P_α, that are similar to α: a successful result or an unsuccessful one (whether or not an agreement was reached). This leads to the calculation of the probability that the current situation could end in an agreement based on past interactions (based on the work in [6]). This is calculated by:

$$T_a\widehat{(y, P_\alpha)} = \frac{e}{n} \tag{2}$$

Where e is the number of times that an agreement has been made with the agent y on the each situation from P_α, and n is the total number of observed cases in P_α with the agent y. $n = |P_\alpha|$.

A function g based on agent a's decision process returns the set S of j possible negotiation situations (the offers the agent is willing to make) σ based on the current situation α the agent is in:

$$g : \alpha \longrightarrow S \tag{3}$$

$$S = \{\sigma_1, \sigma_2, ..., \sigma_j\} \tag{4}$$

From the possible situations, we obtain the *best expected situational trust* $E_a(y, S)$; which obtains the trust for the best expected case from among the possible situations in which the agents can find themselves in the future, given the current negotiation:

$$E_a(y, S) = \max_{\sigma \in S} T_a(y, \sigma) \tag{5}$$

We know the trust in the current situation $T_a(y, \alpha)$. We also have the best expected situational trust $E_a(y, S)$. With these two values, we can calculate a rate that will help the agent decide whether or not they should continue the negotiation. The situational trust at the present time, divided by the potential situational trust gives us the Dissolution Rate R, which in conjunction with a minimum acceptable trust value M, will help to decide whether or not to dissolve the negotiation process.

$$R = \frac{T_a(y, \alpha)}{E_a(y, S)} \tag{6}$$

The dissolution decision depends on the value of R:

$$\begin{aligned} &R \geq 1 \Rightarrow \text{Dissolve} \\ &(R < 1) \vee (E_a(y, S) < M) \Rightarrow \text{Dissolve} \\ &(R < 1) \vee (E_a(y, S) \geq M) \Rightarrow \text{Continue Negotiating} \end{aligned} \tag{7}$$

In other words, if, based on future steps, the expected situation does not have a better trust value than the current one, the best thing to do is to end the negotiation now. Otherwise, it is better to continue negotiating.

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3 EXPERIMENT AND RESULTS

For testing the TAND algorithm, we implemented a negotiation environment where two agents negotiate to reach an agreement from a limited number of options; agents consecutively offer their next best option at each step until the offer is no better than the received one. The scenario consists of different agents that each represent a person who wants to go to a movie with a partner, so they negotiate between them from different available movie genres to choose which movie to go to together. The environment was developed in RePast [2].

In order to avoid affecting the system performance, agents will only save the trust of a limited number of potential partners in their knowledge base; that is, they will maintain a limited contact list instead of recording the experience of every partner they have negotiated with.

There will be a fixed number of available movie genres (for example, drama, comedy, horror, etc.) during the whole simulation.

Each agent will have a randomly generated personal preference value (from a uniform distribution) for each genre between 0 and 1, where 0 is a genre it does not like at all, and 1 is its preferred movie genre. One of these genres, randomly chosen for each agent, will have a preference value of 1, so each agent will have always a favorite genre.

We assume that there is always a movie in the theaters available for each genre. Each movie genre will be used to identify the situation α the negotiation is in, for the calculation of the trust from equation 1.

The result of the utility function $U_a(\alpha)$ will be the preference for each movie genre randomly assigned for each agent.

Partners, involved in the negotiation will be randomly chosen.

An agent can participate only in one negotiation at one time.

The experiment will run through three different cases, each one with 100 agents and 10 different movie genres:

- Case 1: Contact list of 20 most trusted partners.
- Case 2: Unlimited contact list size.
- Case 3: No TAND, simple negotiation.

Every experiment will run through 2000 steps. At each step, 1/4 of the total population (25 agents for the cases described above) will invite another partner to a negotiation for a movie.

For evaluating the performance, we will use three values:

- Average steps used for all agreements made: AS (lower is better).
- Average preference (the final preference value during the agreement for each successful negotiation): AP (higher is better).
- Average distance from the perfect pitch: AD (lower is better).

We define the perfect pitch P as the highest value for the product of each agent a in the A set of participating agents' preference (result of the utility function $U_a(\alpha)$ for each movie genre) from every possible agreement d:

$$P = \max_{d \in D}(\prod_{a \in A} f_a) \tag{8}$$

The distance from the perfect pitch is the difference from the negotiation preference K with the perfect pitch P.

$$AD = P - K \tag{9}$$

After 20 experiments for each case, in every case at each experiment we averaged the results obtained, seen in table 1.

[2] http://repast.sourceforge.net

Table 1. Average Final Steps.

		Case 1	Case 2	Case 3
AS	Avg	5,2894	4,6683	5,6993
	Std Dev	0,0283	0,0249	0,0282
AP	Avg	0,8001	0,8168	0,7892
	Std Dev	0,0073	0,0064	0,0080
AD	Avg	0,1370	0,1125	0,1548
	Std Dev	0,0034	0,0030	0,0048

The results improve in cases 1 and 2, in terms of average steps AS needed for closing a negotiation with an agreement, compared to case 3, where TAND is not used. However, the average preference AP has a higher value, and the distance from the perfect pitch AD is reduced more than 35% from case 3 to case 2. The contact list size is a critical issue, as we can see from comparing results between cases 1 and 2, that the improvement is higher when there are no limits in the contact list's size.

4 CONCLUSIONS AND FUTURE WORK

We have presented TAND and its preliminary results, where we can see that it improves the negotiation process in terms of agents' preferences and number of steps to achieve an agreement. Taking into account possible agents' performance issues, a limited contact list should be considered, but its size limitation could negatively affect the TAND results as we can see in table 1, so that work finding the optimal contact list size should be done. As far as now, the contact list filling criteria are simple, in the trusted contact list, agents with higher trust replace the agents with lower values and when the contact list is full, improved results are expected using other criteria for dealing with the contact list, for example using different levels of priorities, or a relation with the partner selection criteria (in the experiments the selection is made randomly).

TAND has been tested on a simple bilateral negotiation process, but can also be used on other types of temporary coalitions such as dynamic electronic institutions [5] for supporting their dissolution phase. Future work will focus on this, expanding its scope to generic types of coalitions. In addition, work on implementing other ways to calculate trust should be done, and other methods to manage the dissolution (such as Case Based Reasoning [2]) in order to compare results. The topic of dissolution of coalitions is not a new one, but it is not a topic that has been studied in depth [2], so this research topic provides a wide open field that needs to be explored.

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