Balancing Conflict and Cost in the Selection of Negotiation Opponents

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ABSTRACT

Within the context of bi-lateral negotiation, a problem that has received little attention is that of identifying negotiation opponents in situations in which the consequences of conflict and the ability to access resources vary dynamically. Such dynamism poses a number of problems that make it difficult to automate the identification of appropriate negotiation opponents. To that end, this paper describes an opponent selection mechanism used by a buyer-agent to evaluate and select between an already identified set of seller-agents.

Categories and Subject Descriptors

I.2 [**Artificial Intelligence**]: Distributed Artificial Intelligence—*Multiagent systems*

General Terms

Design, Algorithms

Keywords

Negotiation Opponent Selection

1. INTRODUCTION

Negotiation is a particularly important form of interaction as it allows conflicts to be resolved in situations of competing interests. Many existing frameworks for negotiation (e.g., [2]), focus on the problems inherent *within* the negotiation episode, such as which negotiation strategies and tactics offer the best results, and how best to employ them. Though the steps taken within a negotiation are typically the responsibility of an agent to determine, decisions made prior to negotiation are usually taken by the agent's user. But in persistent, multi-agent systems where agents perform their tasks away from human direction, it is often not possible. In such circumstances it is left to the agent itself to determine acceptable levels of risk given the worth of the goal and, similarly, to determine how much resource to commit to negotiation. Consequently, agents must reason about the level of conflict arising with

different negotiation opponents, and trade it off against concerns over cost. The problems inherent in doing this successfully are important to address if negotiation is to be effectively employed in dynamic domains.

1.1 Opponent Selection for Negotiation

Opponent selection has been investigated by a number of researchers from a variety of perspectives (e.g. [1]). The aim of such research is to examine the ways in which agents can increase the effectiveness of their interactions and avoid entering into cooperations, negotiations, etc, that end in failure. Most, however, fail to examine the trade-offs to be made when an agent tries to balance conflict and cost concerns in opponent selection.

A common source of negotiation failure is the existence of irreconcilable interests between the negotiation participants. Thus, for example, a buyer may require a service delivered by a given date that the seller is not willing or able to meet, and so agreement is not possible. The choice about which opponent to negotiate with should, therefore, be made relative to the probability of conflict and the consequences of any subsequent failure, which depends upon the worth of the goal; agents should be less willing to risk conflict in negotiations over goals with high worth than goals with less worth. Often, however, decreasing conflict comes at a price. Sellers may be willing to be more cooperative for some negotiation issues, but may try to balance this by being more demanding on other issues, such as price for example. This means that negotiations with less conflict can cost more, and the difficulty is to balance the need for lower conflict against the need to minimise cost. This paper addresses these issues by defining a number of decision mechanisms that enable agents to balance their needs for minimising conflict with a varying need to manage resources.

2. THE OPPONENT SELECTION MODEL

In our model, the buyer dynamically assesses the worth of its resources by calculating how much it currently has access to, and changes its evaluation of them accordingly. This enables it to determine its *reservation price* for negotiation *on the fly*. In order to reason about conflict, buyers build up information based on past negotiations about the probable issue choices of sellers, enabling predictions to be made regarding future issue choices of sellers and thus enabling the buyer to estimate the the level of conflict for any seller. This is achieved by examining the probable issue choices of the seller, and comparing this with the buyer's own choice of issues. The more issues that *both* agents select, the higher the chance of conflict. However, if only one agent selects an issue, it is dropped from the negotiation since, by not selecting it, the other agent has no preferences regarding issue settlement.

To decrease the risk that conflict will arise, the buyer agent's

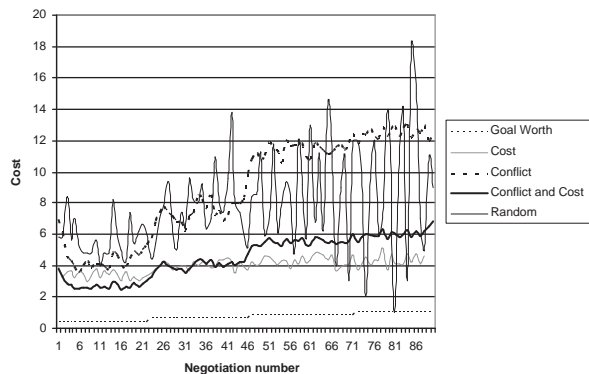**Figure 1: Average cost of negotiations using different selection criteria**

Figure 2: Success rate for negotiations using different selection criteria

task, therefore, is to select those sellers whose choice of issues is *divergent* from its own. Sellers that select fewer issues represent more cooperative sellers, though increases in cooperation are more likely to involve an increase in price. Thus, more cooperative negotiations are generally more expensive.

In addition to information about issue selection, the buyer also has access to information about the initial ask prices and past deal prices of sellers that it has obtained from previous negotiations. The distance between an initial ask price and the deal price represents the level of *concession-making behaviour* that a seller expresses. Taking averages of the concessions made by sellers in previous negotiations and, given a current ask price, this allows the buyer to predict the deal price in future negotiations. Selecting sellers on price simply involves looking at the expected deal price of a seller and seeing if it is below the current reservation price of the buyer.

For goals with high value, the buyer tries to select sellers that offer small amounts of conflict, though cost will be high. Alternatively, when resources are low the buyer tries to select cheaper sellers, though the risk of conflict may be high. The buyer is also able to balance cost and conflict concerns by weighting the scores obtained for seller agents on both of these criteria using the worth of the goal, and the current value placed on resources, respectively.

3. EMPIRICAL EVALUATION

Figure 1 shows the results of opponent selection using different selection strategies in terms of the cost of negotiation. In the figure, the x-axis shows the number of negotiations, while the y-axis shows the cost of the negotiation. All values shown are for successful negotiations. The bottom of the graph shows the worth of the goal under negotiation (the small dotted line), which increases over time. The line labelled *cost* indicates the selection of opponents by a buyer whose sole concern is to minimise cost, the line labelled *conflict* indicates a buyer whose sole concern is to minimise conflict, and the line labelled *conflict and cost* indicates a buyer who attempts to minimise both cost and conflict. The graph shows that the *cost* focused buyer succeeds in minimising cost even when the worth of the goal increases, showing an average cost over all negotiations of 3.9. The *conflict* focused buyer, however, does not manage this and, as the goal increases in worth, selects more costly negotiation opponents, showing an average cost over all negotiations of 8.8. The *cost* and *conflict* focused buyer manages keep costs lower than the *conflict* focused agent, but not the *cost* focused
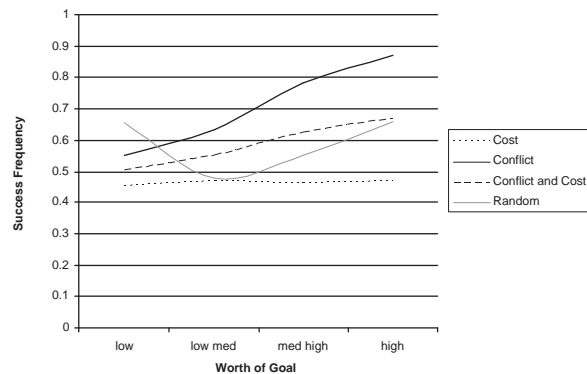
agent, and shows an average cost of 4.5. The buyer using the random strategy displays wild behaviour, jumping from high to low cost negotiations without a pattern, and giving an average overall negotiation cost of 7.7. Figure 3 shows the same buyers' performances when considering the frequency of successfully completed negotiations. It is apparent that, although the *cost* focused buyer keeps costs down, as shown in Figure 1, the frequency of successful negotiations is low, displaying an average of 46% success rate over all negotiations conducted. The *conflict* focused buyer, however, performs much better, with the frequency of successful negotiation increasing steadily as more information about sellers is obtained, to almost a 90% success rate for high worth goals, and an average success rate of 71%, though the cost of these negotiations also increases. The *conflict* and *cost* focused buyer again manages to make a compromise; keeping costs low and producing a success rate average of 58%. The buyer selecting randomly performs the same as the *conflict* and *cost* focused agent, successfully concluding 58% of negotiations. However, if we compare these agents on both success rate and cost we see that the *conflict* and *cost* focused buyer easily outperforms the random.

4. CONCLUSION AND FUTURE WORK

By explicitly reasoning about the potential for conflict in negotiation and enabling agents to dynamically evaluate the constraints placed on the use of their resources, we have shown how opponent selection in dynamic domains can be effectively conducted. Initial empirical results show that agents can be made to dynamically change the focus of their selections depending on the changing needs for conflict minimisation or cost minimisation. Future work will involve looking at how the amount of dynamism in the environment can be used to help the buyer make decisions on the degree to which it constraints its negotiation goals.

5. REFERENCES

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