CONAN: a heuristic strategy for COncurrent Negotiating AgeNts

(Extended Abstract)

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ABSTRACT

We develop CONAN, a heuristic agent for concurrent bilateral negotiations in electronic markets that are open, dynamic and complex. Existing strategies often omit the factors determining when a market environment is open or how an agent evaluates progress in bilateral negotiations. Such omissions in turn damage the offer-making ability of an agent and consequently the number of successful negotiations that this agent can achieve. Negotiation experiments indicate that CONAN outperforms other agents that rely on the current state-of-the-art by a significant amount in terms of the utility gained during a negotiation.

Categories and Subject Descriptors

I.2.11 [**Distributed Artificial Intelligence**]: Intelligent agents, Multiagent systems

General Terms

Algorithms, Economics, Experimentation

Keywords

Concurrent negotiations; Heuristic strategies

1. INTRODUCTION

We study the problem of how a buyer agent engages in bilateral negotiations with a number of seller agents to purchase a resource. Existing work proposes agent strategies that compute offers using an opponent model only [4, 5], by ignoring the openness of the market and the individual factors that influence the progress in concurrent bilateral negotiations. Motivated by this observation, our study takes place in the context of single-issue negotiation using the well-known *alternating offers* protocol, as extended in [1]. This extension provides the agent with the opportunity to *commit* (hold) a preferred offer for a certain amount of time, unless it finds a better one, in which case it can *de-commit* (release) from committed offer(s) and pay a penalty. Such

penalty ensures fair play and discourages unnecessary de-commitments.

To address these issues, in CONAN we model explicitly the environment and the self (individual) factors of the agent. Environment factors include the number of sellers and competitors that are present in the market at a time, as well as the demand/supply ratio. Self factors include those that may affect individual negotiations (or threads), in particular how they are progressing and how they affect the global status of the negotiation such as the number of committed offers or the eagerness for buying a product.

The hypothesis that we wish to test is: a strategy that considers the market environment and the self factors produces more utility than strategies that do not. An initial set of experiments confirm this hypothesis and show that CONAN significantly improves over the-state-of-the-art [5] in terms of the utility gained during negotiations.

2. HEURISTICS FOR CONAN

We generate offers based on the following formula [3]:

$$\text{Offer}_{t,s_i} = IP + (RP - IP) * CR_{t,s_i}$$

where Offer_{t,s_i} is the offer for seller i at time t. An offer is generated between the initial price (IP) and the reservation price(RP). The concession rate CR_{t,s_i} for seller i at a specific time t is $\in [0, 1]$.

$$CR_{t,s_i} = \begin{cases} 0, & \text{if } t = T_{start} \\ 0.99, & \text{if } t = T_{end} - 1 \\ w_{Self_t} S_t + w_{Env_t} E_t, & \text{otherwise} \end{cases}$$

where T_{start} is start time of negotiation, T_{end} is the deadline of negotiation, E_t is the effect of environmental factors and S_t is the effect of self factors. The weights w_{self_t}, w_{env_t} are used to weigh the self and environment factors, respectively. Note that the weights are normalised so that: $w_{self_t}, w_{env_t} \in [0, 1]$ and $w_{self_t} + w_{env_t} = 1$.

Self Factors S_t : We compute self factors using the following formula:

$$S_t = 0.25 * (\frac{1}{CO} + NS + T_{end} + Eg)$$

a) Number of committed offers (CO): is the number of committed offers, and updated each time the buyer commits or de-commits an offer.

b) Negotiation status in each thread (NS): is a value that represent the progress status in each negotiation thread. It

is calculated using the following two criteria:

- C_1 is the opponent response time.

- C_2 is the opponent concession rate for the last ϕ offers. In our setting we used $\phi = 3$.

The values of C_1 and C_2 are mapped to the qualitative values: compatible, moderate-compatible and incompatible (stating how compatible/incompatible is an opponent's behaviour in relation to our expectations). From these two criteria, our goal is to derive one global status for each negotiation thread δ_i, where i is a seller identifier. To compute this, we have chosen the multi-criteria decision making process known as the Borda method [2]. This method gives a rank to every criteria based on its qualitative value, e.g., if C_1 is compatible, then it will be ranked 1. Accordingly, the evaluation for each thread δ_i is assigned to a value between 2 and 6.

$$ NS = \frac{x - (2 * k)}{(6 * k) - (2 * k)} \qquad x = \sum_{i=1}^{k} \delta_i $$

c) *Deadline (T_{end}):* is the deadline for all the concurrent negotiations and its given by the user.

d) *Eagerness (Eg):* is the agent eagerness to obtain a good. The user provides the eagerness value. In the same manner, the values of $1/CO$, NS, T and $Eg \in [0, 1]$ are normalised.

If the value of S_t is low (i.e., implies a low concession rate), it indicates that the agent is in a good situation. As a result, a high weight will be assigned to w_{self_t}. Similarly, if the value of S_t is medium/high then w_{self_t} will be medium/low.

Environmental Factors E_t : We compute environmental factors using the following formula:

$$ E_t = 0.33 * (\frac{1}{Se_t} + C_t + R_{ds}) $$

a) *Number of sellers (Se_t):* is the number of sellers that are actively negotiating with the buyer.

b) *Number of competitors (C_t):* is the number of active competitor agents. The competitors are other agents who are trying to obtain an agreement from the sellers that are negotiating with buyer for the same resource. We assume that this number is obtained from the e-market.

c) *Demand/supply ratio (R_{ds}):* is the ratio of number of buyers to the number of sellers. Since both numbers are known by the agent, the ratio can be calculated. Note that the values of R_{ds}, C_t and $1/Se_t$ are normalised between $[0, 1]$.

3. EXPERIMENTAL RESULTS

We conducted a series of experiments where opponents have been developed as an extended version of Faratin's strategies [3] to allow them to concurrently negotiate with different buyers. To evaluate agent performance we use the metric of *average utility* over all negotiation runs. We followed the agent architecture and protocol proposed in [1].

In our evaluation, we allow the demand/supply ratio and market density to change during negotiation to create more realistic settings. The current state-of-the-art strategy of Williams et al. [5] is used as a benchmark for comparing the performance of CONAN. Our agents and the benchmark agents run concurrently within the same simulation as competitors. We put three agents for each strategy and run the simulation 100 times for two different settings.
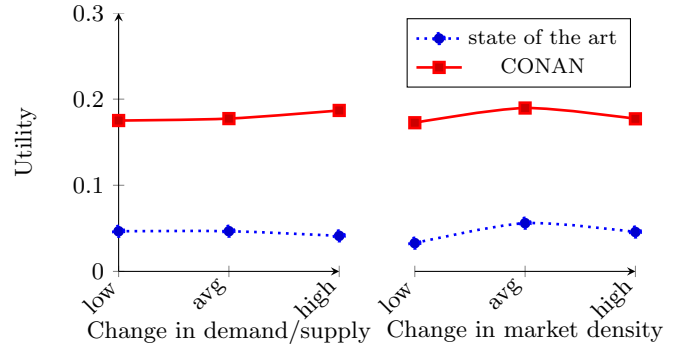

Figure 1: Average utility.

The results[1] (see Figure 1) show that CONAN outperforms the state-of-the-art.

4. CONCLUSIONS

We have presented CONAN, a heuristic negotiation agent for open, dynamic and complex e-market environments. We have evaluated the performance of CONAN in various settings, and showed that it performs significantly better than the state of the art [5]. Our plans for future work include: implementing ANAC agents as opponents, enhancing CONAN and extending it with an opponent model.

Acknowledgments

5. REFERENCES

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[1]The complete set of experiments are displayed in http://dice.cs.rhul.ac.uk/aamas2014_results/