Negotiation Over Decommitment Penalty (Extended Abstract)

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ABSTRACT

We consider the role of negotiation in deciding decommitment penalties. In our model, agents simultaneously negotiate over both the contract price and decommitment penalty in the contracting game and then decide whether to decommit from contracts in the decommitment game. Experimental results show that setting penalties through negotiation achieved higher social welfare than other exogenous penalty setting mechanisms.

Categories and Subject Descriptors

I.2.11 [**Distributed Artificial Intelligence**]: Multiagent Systems

General Terms

Economics, Experimentation

Keywords

Negotiation agents, leveled-commitment, penalty

1. INTRODUCTION

In leveled-commitment contracting, both contract parties strategically choose their level of commitment based on the contract price and decommitment penalty which are determined prior to the start of the decommiting game. The efficiency of leveled-commitment contracting depends on how the contract price and decommitment penalty are set. In Sandholm *et al.*'s model of leveled-commitment contracts [4, 3], both the contract prices and decommitment penalties are assumed to be known to the contract parties before the decommiting game. This paper discusses how to set the contract price and decommitment penalty through negotiation. In our model, agents negotiate over both the contract and the amount of decommitment penalty in the contracting game and then decide whether to decommit from contracts in the decommitment game. Experimental results show that when decommitment penalties are decided through negotiation, agents achieved higher social welfare than other approaches of setting decommitment penalties, which corresponds to the observations in another study [1].

2. NEGOTIATING OVER PENALTY

We consider a contracting setting with agents: contractor **b** who pays to get a task done, and contractee **s** who gets paid for handling the task. In our model, **b** and **s** negotiate over contract price and decommitment penalty before additional offers (outside offers) from other agents become available. Then they strategically choose to decommit or not when their outside offers are available. The contractor's best (lowest) outside offer v is characterized by a probability density function $f(v)$. The contractee's best (highest) outside offer w is characterized by a probability density function $g(w)$.

An agent's options are either to make a contract or to wait for future option. The two agents could make a full commitment contract at some price. Alternatively, they can make a leveled-commitment contract which is specified by a contract price, ρ, and a decommitment penalty q. If one agent decommits from the agreement, it needs to pay the penalty q to the other agent. The leveled-commitment contracting consists of two stages. In the *contracting game*, the agents make agreements on both a contract price and a decommiting penalty. Formally, agent $\mathbf{a} \in \{\mathbf{b}, \mathbf{s}\}$ makes an offer $[\rho, q]$ where ρ is contract price and q is decommitment penalty. The other agent $\hat{\mathbf{a}}$ can choose to 1) $\mathbf{accept}$ or 2) $\mathbf{reject}$. If $\hat{\mathbf{a}}$ accepts the offer , the bargaining outcome is $[\rho, q]$. Otherwise, the bargaining fails. In the *decommiting game*, the contractee decides on whether to decommit first and contractor moves next.

Based on this analysis about agents' strategic behavior by Sandholm *et al*, we can compute agents' optimal contracts. The contract $c^*_{\mathbf{b}}(f, g)$ ($c^*_{\mathbf{s}}(f, g)$) which maximizes the contractor's (contractee's) expected utility is the contractor's (contractee's) optimal contract.

We experimentally compared the efficiency of negotiating over penalty in the two-player game [4, 3] with fixed penalties $\{0, 10, 20, 40\}$ and penalties is a percentage ($\{0.1, 0.3, 0.5\}$) of a contract price. We found that the negotiating over penalty achieved higher social welfare than other penalty setting approaches. Fig. 1 shows the performance of different mechanisms as well as the maximum social welfare when $f(v)$ and $g(w)$ are uniform distributions. $f(v)$ is defined by $[v_{min}, v_{max}]$ and $g(w)$ is defined by $[w_{min}, w_{max}]$ where 1) $0 < v_{min}, v_{max}, w_{min}, w_{max} \leq 100$ and 2) $v_{max} \geq w_{min}$. We can see that negotiating over penalty achieved much higher utility than other exogenous penalty setting mechanisms. Even when the offering agent always chooses the price and penalty to maximize its utility, the social welfare is close to the maximum social welfare.

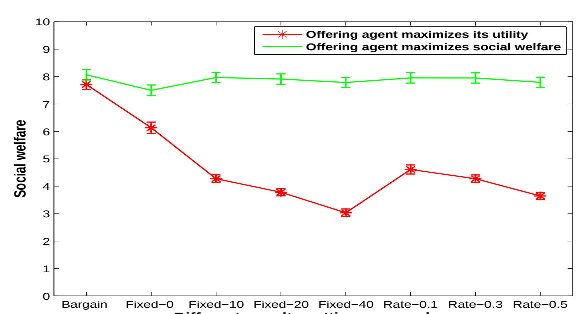
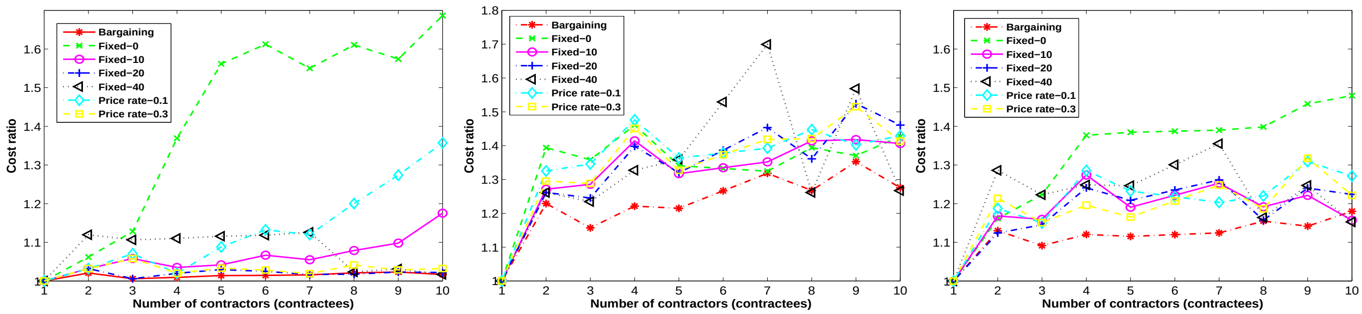


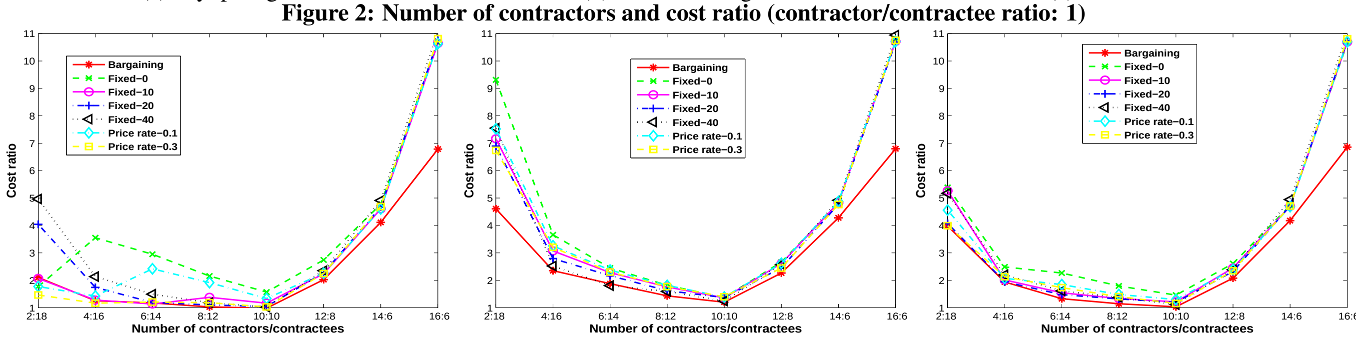
Figure 1: Efficiency comparison in two-player game.

Cite as: Negotiation Over Decommitment Penalty (Extended Abstract), Bo An and Victor Lesser, *Proc. of 10th Int. Conf. on Autonomous Agents and Multiagent Systems (AAMAS 2011)*, Tumer, Yolum, Sonenberg and Stone (eds.), May, 2–6, 2011, Taipei, Taiwan, pp. XXX-XXX.



(a) Myopic agents (b) Lookahead agents (c) Random match

Figure 2: Number of contractors and cost ratio (contractor/contractee ratio: 1)



(a) Myopic agents (b) Lookahead agents (c) Random match

Figure 3: contractor/contractee ratio and cost ratio

3. EFFICIENCY IN MULTI-PLAYER GAMES

Now we consider more realistic bargaining scenarios where there are multiple agents which have incomplete information about others. Each contractor has one task to finish and has a cost associated with the task. Each contractee has no task initially and also has a cost to handle a task. A contractor can either complete its task by itself or contract out its task to a contractee. As in [2], we use a sequential protocol in which only one contractor and one contractee negotiate in each round and the contractor makes the proposal.

For each type of agents, we developed two kinds of agents: myopic and partially lookahead. A myopic contractee accepts an offer if and only if it can gain some immediate payoff by accepting the offer. A myopic contractor $\mathbf{b}$ gradually increases its offering price when it fails to make a contract. $\mathbf{b}$ decides the penalty considering the offering price: the lower price, the higher the penalty. A lookahead bargaining strategy based on 1) the competition between contractors and contractees, and 2) agents' multiple opportunities to make a contract. $\mathbf{b}$ will search all possible values of ρ and q to find out the best offer.

Table 1: Average cost ratios

Strategy	All Myopic	All Lookahead	Random match
Bargaining	2.161	3.109	2.775
Fixed penalty-0	3.837	3.844	3.778
Fixed penalty-10	2.618	3.573	3.252
Fixed penalty-20	2.529	3.573	3.262
Fixed penalty-40	2.653	3.627	3.357
Price rate-0.1	3.355	3.573	3.518
Price rate-0.3	2.541	3.547	3.174

After each experiment, we measure the ratio of the social welfare of the solution obtained through negotiation to the optimal social welfare. The average cost ratio for all instances is calculated for each setting. The lower cost ratio, the better.

Observation 1: Table 1 summarizes the average cost ratios in all settings when the contractor/contractee ratio is within the range $[1/3, 3]$. We found that on average, negotiating over penalty achieved lower cost ratio as compared with exogenous methods for setting penalties, no matter which strategies were used by agents. Furthermore, when the decommitment penalty is 0, the cost ratio is higher than any other exogenous methods for setting penalties.

The cost ratio when all agents use a myopic strategy is lower than the cost ratio when agents use a lookahead strategy or randomly determine choose a lookahead strategy or a myopic strategy (*random match*). Furthermore, agents with random strategies achieved lower cost ratio than agents with lookahead strategies.

Observation 2: Fig. 2 shows the cost ratio with different number of contractors when the number of contractors are equal to the number of contractees. In all the settings, negotiating over penalty achieved lower cost ratio as compared with exogenous methods for setting penalties. It's observed that the cost ratio increases with the increase of number of agents.

Observation 3: It can be observed from Fig. 3 that with different contractor/contractee ratios, negotiating over penalty achieved lower cost ratio as compared with exogenous methods for setting penalties. The cost ratio decreases with the increase of contractor/contractee ratio when the contractor/contractee ratio is low. However, the cost ratio increases with the increase of contractor/contractee ratio when the contractor/contractee ratio is higher than 1.

4. REFERENCES

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