Effects of Negotiation Tactics and Task Complexity in Software Agent – Human Negotiations

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ABSTRACT
Electronic commerce allows for design of flexible and effective mechanisms of exchange between economic parties. Electronic negotiations let the geographically and temporally separated participants to engage in offer exchange in search for acceptable agreements. The digital medium enables the designers to build software agents that can take over the time and effort consuming negotiation tasks. The current work assesses the prospects of utilizing software agents in negotiations with the human counterparts. It describes an experiment in B2C settings where human subjects acted as buyers shopping for a mobile phone service. The experimental treatments included various agent concession-making strategies, as well as the complexity of the task.

CCS Concepts
• Computing methodologies→Intelligent agents

Keywords
Electronic negotiations; software agents; experimental studies

1. INTRODUCTION
Electronic negotiations may involve use of electronic negotiation systems, which allow parties exchange offers over the internet [1]. Compared with generic communication tools, such as e-mail, these systems typically impose a certain structure on the process of exchange, as well as the format of the exchanged offers. Additionally, they can provide analytical support for negotiators in the process of conducting negotiations. Typically, this support helps users capture and model their objectives, preferences, reservation levels, and other important aspects. While providing such support greatly simplifies the analysis of offers and the process of offer exchange, the negotiator is still responsible for repetitive decision-making, as she has to assess incoming offer and construct counter-offers, which may include multiple issues (dimensions).

Autonomous software agents have been proliferating into the various aspects of e-commerce [2]. Electronic commerce negotiations have long been targeted by the software agents researchers [3]. The distinguishing feature of employing agents in negotiations is that the outcome cannot be predicted from the start. While for many tasks objectives can either achieved, or not, in negotiations the final agreement depends on the other party’s behavior. Thus, fully automating negotiations is a tricky task, as the resulting commitment may not be desirable to the principal businesses or individuals.

On the other hand, agent negotiation behavior promises to be more consistent than that of the human negotiators. This is due to the fact that agents can be configured to act according to pre-specified plans. When an agent is given the issues, the preference structure, the reservation levels, and the concession-making strategy, it will make decisions precisely in accordance with these specifications. For example, it will never make an offer below the given reservation level.

Additional benefits of using agents include: agents can alleviating negotiation-related efforts; helping people with limited negotiation skills [4]; time saving with lower opportunity costs; fewer negative effects, and more efficient settlements [5]. The work on design and study of agent negotiations has been substantial. However, the experimental studies of how agents perform when paired with human negotiators have been somewhat limited.

This work investigates the performance of agent vs. human negotiations in experimental settings. The effects of agent negotiation style and task complexity were used as the basis for experimental treatments. The purpose of the work is to assess the prospects of employing software negotiation agents in real business transactions. The work uses an electronic negotiation system incorporating software agents has been built. The system enables creation of negotiation cases, pairing agent and human participants in negotiation dyads, setting up multiple negotiation issues and preference structures, defining negotiation tactics for agents, and other functions. It was used in experiments involving a large pool of human subjects. The key measurements included the achieved outcomes and the agreement rate.

2. BACKGROUND
Early experiments involving agents in e-negotiations involved Kasbah marketplace [6, 7]. In these experiments users created simple agents that were dispatched to meet and negotiate with each other on price only for items. The agents incorporated three types...
of negotiation tactics. One influential work on defining agent tactics has been by Faratin et al. [8]. Tactics are used to decide what kind of offer to make at a given point in the negotiation process. They also defined negotiation strategies as the choice of tactics based on history, context, and other variables. Therefore, a strategy can employ multiple tactics.

Three categories of tactics have been identified: behavior-dependent, time-dependent, and resource-dependent. The behavior-dependent tactics make their choice of offer based on the moves made by the parties. An example includes tit-for-tat tactics that advocates that the concession to be made by a party should be proportional, or symmetrical to the one made by the counterpart. The second family of tactics model concession-making as a function of time elapsed between the beginning of negotiation and the estimated ending point. Curves showing small concessions in the beginning corresponded to tougher competitive behavior, while those making large concessions and quickly approaching the vicinity of reservation levels related to conceding behavior. Resource-dependent tactics adjusted concession levels based on the scarcity of the resources involved.

Regarding agent involvement in electronic negotiations three categories can be mentioned: (1) human-to-human negotiations with agent support; (2) agent-to-agent negotiations featuring full automation on both sides of a table, and (3) human-to-agent negotiations, where a software agent is paired up with a human counterpart [5]. First category includes use of agents as advisors for helping human negotiators cope with the complexity of negotiations involving multiple issues, and staying in line with their defined preference structures and concession-making plans. Work on Aspire agent [9] and eAgora marketplace [10] are examples of such work. For instance, experiments with agent-supported negotiations revealed that human negotiators using agents as advisors performed better in complex (multi-issues) tasks than unassisted human negotiators [11]. Work in second category has been extensive. The current work falls in the third category of agent-involved negotiations.

The idea of designing agents that could proficiently negotiate with human counter-parts was advanced [4]. Major challenges of designing such agents include bounded rationality and incomplete information. The following guidelines for agent designers have been proposed: randomization (to prevent manipulation of an agent by an opponent), having concession strategy, and maintaining a database of past interactions (for modeling the opponents). Regarding agent tactics in negotiations with humans, several suggestions have been made in [5], including: making a tough initial offer; making simultaneous equivalent (to an agent) offers; making monotonously decreasing concessions (as suggested by Raiffa to signal “approaching the limit” [12]); making large concession in the final offer; and using strategic delays.

Few experimental studies involving human and agents in exchange settings focusing on objective as well as subjective aspects of negotiations have been reported. An early experimental study matching humans with agent counterparts involved AutONA agents [13]. The agents negotiated on price and volume while following the so-called alpha-beta tactics. The agents did not significantly outperform humans. An agent representing a salesperson that employed persuasion and negotiation techniques while interacting with a customer is described in [14]. Persuasion involved customer – agent dialogue with the use of pre-defined arguments organized into a tree. Price was the single negotiated issue. The findings suggested that persuasion increased buyers’ product valuation and willingness to pay, and negotiation increased the seller’s surplus. In [15] a study was conducted examining the effects of agents’ expression of emotions on the negotiator’s concession behavior. In this study human subjects were paired up with agents that expressed anger, neutrality, or happiness during negotiations using both with verbal and non-verbal expression mode. The subjects were aware they were negotiating with machines. As expected “angry” agents were able to gain more concessions from the human opponents, than the “happy” ones.

In [16] the authors have investigated effects of using various agent negotiation tactics in experiments with human subjects. In these bilateral negotiation experiments involving sale of a computer five different concession-making styles were used: competitive, linear, conceding, competitive-then-conceding, and tit-for-tat. Agents were on the seller side, while humans were on the buyer side. A control group was included on the seller side including human subjects. The results revealed that most agent types outperformed human “colleagues” in terms of utility of the achieved agreement, and the agreement rate. Competitive agents achieved the highest utility levels, while conceding agents had the highest number of agreements.

In [17] agents were employed in multi-bilateral negotiation settings. Here, the case featured a procurement scenario with a single buyer and three sellers. Buyer would award a single contract to one of the sellers based on simultaneous negotiations with all three counterparts. While most of the participants were human subjects, agents were present in some of the seller groups. The results showed that conceding agents achieved higher agreement rates than humans, while competitive ones failed to win any contract.

In the current work we set out to investigate the performance of agents not only based on the agent tactics, but also on the complexity of the negotiation task. The complexity is manipulated by varying the number of issues involved in the negotiation process.

3. NEGOTIATION SETUP

The subjects were recruited from university students enrolled in an online case. The case was chosen so that the subject had a good level of familiarity with it. The case featured a sale of a mobile phone plan. Most students are well aware of the issues involved in such plans. Two types of cases were included: a simple and a complex one.

Simple case involved the following issues: price, regular air time, extra air time, text messaging, and data. The buyers and sellers were given different weights for these issues, indicating their importance levels. Figure 1 shows the screenshot for the setup of a simple case.
In order to calculate the total utility of the offer the issues were assigned different weights. These were then used in an additive utility function to estimate the level of attractiveness of an offer. Agents used this information in order to decide on the acceptability of the received offers and generate offers. The complex case, additionally included call display, voicemail, call waiting, conference call, and call forwarding as extra issues.

All agents acted on the seller side, and they were not aware of the buyers’ preference structures. As mentioned weights were somewhat different for sellers vs. buyers to facilitate tradeoffs, which have been considered one of the key integrative negotiation characteristics. Although the system allows users to specify their own preference structures, these were fixed to be the same for all human users in order to control variation in the experiments. This is not an issue for the current experiments as we will be comparing the sellers’ performance.

We have chose used four different time-depending tactics. These included: competitive, conceding, competitive-then-conceding, and conceding-then-competitive. Figures 2 to 5 shows the concession schedules for those tactics.
Competitive agents tend to make smaller concessions in terms of utility of generated offers in the beginning of the negotiation period. However, as they approach the end of the period, they start making larger concessions in search of an agreement. These agents are expected to have the highest utility of agreement levels, perhaps at the expense of the number of agreements.

Conceding agents tend to make large concessions in the very beginning of the negotiation period in search of a quick agreement. This represents the case where an agent is anxious to sell the plan. Conceding agents are not expected to have high utility value deals, although they are more likely to make an agreement.

Two remaining tactics represent the mix of the above two schedules. Part of the guidelines for agent tactics design given in [5], mentioned in the background section suggested: making a tough initial offer; making monotonously decreasing concessions; making large concession in the final offer. The conceding-competitive schedule mimics this sort of behavior. It starts with the tough offer, then makes quick concessions. These become smaller with time to make an opponent think that the agent is reaching its reservation level. If the deal is still not made towards the agent makes again quick concessions to grab the deal.

The competitive-conceding strategy starts out tough in the hopes of grabbing high-value deals. However, if agreement is not made in the initial phases, the agent switches to conceding mode. In this way, the agent could combine the benefits of both competitive and conceding tactics. The tactics for the agents are modeled using Bezier curves.

The subjects in the study included university students enrolled in the introductory course on information technology. The treatments included randomly pairing up the subjects with various types of agents in a simple or complex case as described above. The experiment was conducted on the web, whereby subjects could perform their tasks from any location in an asynchronous mode during a two-day period. The subjects were invited to join the negotiations via email containing the link to the system. Human subjects were free to terminate the negotiation at any time without reaching an agreement.

4. RESULTS

A total of 754 subjects have participated in the experiment and have completed the experimental task. For the analysis of the results we have selected only those subjects who made more than one offer to filter out the cases where subjects did not take the experimental case seriously. After filtering the number of subjects dropped to 368. Based on these retained observations, 262 negotiations (71%) ended up in an agreement, while 106 (29%) dyads did not make an agreement.

The agreement rate for the simple case setting was 75.5%, while for the complex case it was 65.4%. Thus, in simple case, including fewer issues, the agreements were more frequent. On one hand, a larger number of issues should give negotiators more space for “maneuvering” in negotiations, thus higher likelihood of making an agreement. On the other hand, the complexity of the case taxes cognitive capabilities of the humans and requires more cognitive effort. In our setup, one case included five issues, while the other featured ten. This seems to be the reason why fewer agreements were made in the complex case. Table 1 displays the agreement rates for the four tactics overall, and for simple vs. complex cases separately.

<table>
<thead>
<tr>
<th>Tactic</th>
<th>Simple case</th>
<th>Complex case</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td>Competitive</td>
<td>57.1%</td>
<td>48.9%</td>
<td>53.6%</td>
</tr>
<tr>
<td>Conceding</td>
<td>87.7%</td>
<td>85.3%</td>
<td>87.0%</td>
</tr>
<tr>
<td>Conceding - Competitive</td>
<td>83.8%</td>
<td>70.0%</td>
<td>75.9%</td>
</tr>
<tr>
<td>Competitive - Conceding</td>
<td>71.0%</td>
<td>60.0%</td>
<td>66.1%</td>
</tr>
</tbody>
</table>

As one can see from the table, the highest agreement rates were achieved by the conceding agents, and the lowest one by the competitive agents. This is not surprising given their concession schedules the other two agent types are in between the extremes. However, conceding-competitive agents seem to have been able to make more agreements than the competitive-conceding ones. Thus, apparently the guidelines for agent design seem to be having a positive impact in terms of the likelihood of an agreement.

Case complexity does not seem to have a large effect on the agreement rate for the conceding agents. This makes sense, as the agent concedes so quickly that agreements are reached early regardless the complexity of the case. It does seem to have a larger impact when an agent is competitive. The implication here is that competitive agents are more likely to make an agreement in simpler cases. Interestingly, the biggest difference in terms of agreement rate is for the conceding-competitive agents. For simple cases their agreement rate approaches the rates for the conceding agent.

Next, we analyze the agent performance in terms of the seller utility of the achieved agreements. For this analysis only the instances where the agreement was achieved were included to enable calculation of the utilities. A general linear model was built incorporating agent types and the complexity level for predicting the obtained utilities. Number of offers was included as a co-variate as it represented effort and time spent in the negotiation instances.

Multivariate tests showed that the case complexity, agent type, and number of offers were all significant at 0.05 level. Furthermore, the interaction of case complexity and agent type was also significant. Table 2 shows the results of utility calculations for different agent types.

Overall, in simple case settings the sellers achieved higher final utility (61.5) than in complex settings (52.4). Conversely, buyers achieved higher utility in more complex cases. Also, all types of agents received higher utilities than human buyers. Overall, competitive agents achieved highest utility agreements, followed by the conceding-competitive, competitive-conceding, and lastly, conceding agents. Complexity of the case has the largest impact for competitive agents, medium impact for the conceding-competitive and competitive-conceding agents, and virtually no impact for the conceding agents.
5. CONCLUSIONS

The purpose of this work was to investigate the effects of agent negotiation style and negotiation task complexity on agent performance in electronic negotiations. As suspected, the agent negotiation tactic does have a significant interaction with the task complexity. This difference is especially prominent for the competitive agents, as they made significantly less agreements and significantly lower agreement utilities in complex cases. Overall, agents made more agreements in negotiations involving fewer issues.

One limitation of the current research is that experiment was done not in the lab settings, but online. This reduced the potential control over the subject behavior in the experiments. Furthermore, the time span allocated for the experiment (two days) may have affected the results. Future in-lab studies can be performed to overcome these limitations. Furthermore, future research could also be done with varying levels of complexity, for example, including one issue, three issues, five issues, and ten issues.

6. ACKNOWLEDGMENTS

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7. REFERENCES


