Adopting Agent-Based Situated Decision Support Framework for Managing One-to-Many Negotiations with Multiple Potential Agreements

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Introduction

The rise of the Internet and electronic business presents new opportunities to develop flexible and effective exchange mechanisms. The information and communication technologies allow the individuals and the organizations engage in potentially fruitful interactions and joint solution search regardless of their location and time. Rise of interest in electronic negotiation systems (ENS) is a logical consequence of the today's business and technological trends [1].

Electronic Negotiation Systems allow, as a minimum, the participants to communicate with each other exchanging offers and messages. In addition to these basic capabilities, they can also incorporate some analytical capabilities, e.g. user's preference elicitation. The more sophisticated systems incorporate so-called software agents (active software components) that can automate various negotiation related tasks, from information search to full automation of the negotiation process.

Much effort has been spent in the design and evaluation of agent solutions to automate one-to-one negotiations. Recently, researchers have been expanding the agent-based models to address bi-lateral negotiations as well. In this work our interest is in one-to-many negotiations involving multiple potential agreements. This may involve selling products or services to customers through deal-making. The work aims at applying the framework for situated decision support developed recently to this problem. The major components of situated decision support system include sensors, effectors, manager, and active user interface. We illustrate the approach through simulations for the case used previously in our agent-assisted negotiation experiments.

Background

Autonomous software agents have been employed in the past studies for conducting one-to-one negotiations. While the past work is extensive, we will mention only few examples here. An early work on Kasbah marketplace involves agents in a C2C artificial marketplace negotiating deals on behalf of their opponents [2]. Agents in Kasbah negotiated only on a single issue, which is price, based on one of the standard negotiation strategies specified by their users. In Tête-à-Tête, an improved system, agents were able to negotiate on multiple issues. Faratin et al. have proposed a "smart" strategy for autonomous negotiating agents [3]. Agents following this strategy will try to make trade-offs in a manner that the newly generated offer is similar to the opponent's last offer,

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before trying a concession. Another work in this direction seeks to map business policies and contexts to negotiation goals, strategies, plans, and decision-action rules [4].

While fully automated negotiations may not always be a feasible choice, agents could also act as intelligent assistants, helping the users by providing advice, critiquing user's own candidate offers as well as the offers by an opponent, and generating candidate offers for a user to consider [5, 6]. One such system, eAgora has been demonstrated to lead to improved outcomes in experimental settings [7].

The above work has focused on supporting or automating one-to-one negotiations. Multi-bilateral negotiations present a greater challenge to researchers, as one has to provide means of managing multiple negotiations with one possible agreement at the same time. There has been some work in this area that sought application of agents to conduct one-to-many negotiations. A fuzzy set-theoretic approach to analysis of alternatives in multi-bilateral negotiations has been proposed in [8]. A setup where multiple agents negotiate autonomously and one agnet is designated as a coordinator has been proposed in [9] and [10].

While these contributions are important, there has been limited work in the past that looks to integrate agent technologies in support of one-to-many negotiations with multiple potential agreements.

Situated decision support framework for managing one-to-many negotiations

The purpose of this work is to propose a framework for managing multiple negotiations with many potential agreements. Handling multiple negotiations simultaneously is a cognitively challenging task. Unaided human decision makers may compromise the quality of the outcomes and make suboptimal decisions due to their limited cognitive capacities. Therefore, there is a need to delegate some tasks to software components, i.e. agents. On the other hand, there is a danger that with multiple automated negotiations the final results may be unpredictable. The situation is worsened by the fact that often the course of negotiations depends on other factors, lying outside the domain of the expertise or sensory capabilities of the agents. For example, real estate negotiations may be heavily affected by the latest important economic news or major decisions by the municipalities. Thus, an attractive setup for a system would rely on some degree of automation, but allowing the control by the user of the overall process.

One such, model introduced in the field of decision support is known as "situated decision support system" (SDSS), or "decision station" [11]. SDSS looks to combine the benefits of agent technologies and those of decision support systems. An SDSS is made up from different agent components in addition to the traditional "toolbox" of data, models, and knowledge. The components include: sensors (for information search and retrieval), effectors (for affecting current state of affairs), manager (for deciding how to handle a particular situation), and active user interfaces (for intelligent interaction with the user).

The adapted model for supporting multiple negotiations is shown on figure 1. The effectors in the model are the agents that conduct (or assist human intermediaries conducing) multiple negotiations. They encapsulate the provided preference structure, reservation levels, and negotiation strategies, and may also adapt to the opponent's profile. The manager agent monitors performance of effectors and compares the outcomes with goals and resources for a given period. The manager also makes adjustments to reservation levels and issue preferences subject to constraints, and sends alerts and makes recommendations to decision maker if goals deemed unachievable. The task of the sensors is delivery of relevant information, e.g. economic and market indicators, and news filtering. Active user interface facilitates effective interaction with the user, while learning user preferences. The user utilizes models to set goals and limits for the autonomous negotiations throughout the process, and exercises judgment based on knowledge of the market, possible external effects, company policies, and risk attitude.

Essentially, the model allows for autonomous negotiations while managing is done at a higher level by the manager or the user. In this fashion the user would be in control of the overall process and performance, while avoiding the effort of being involved in every single negotiation session.

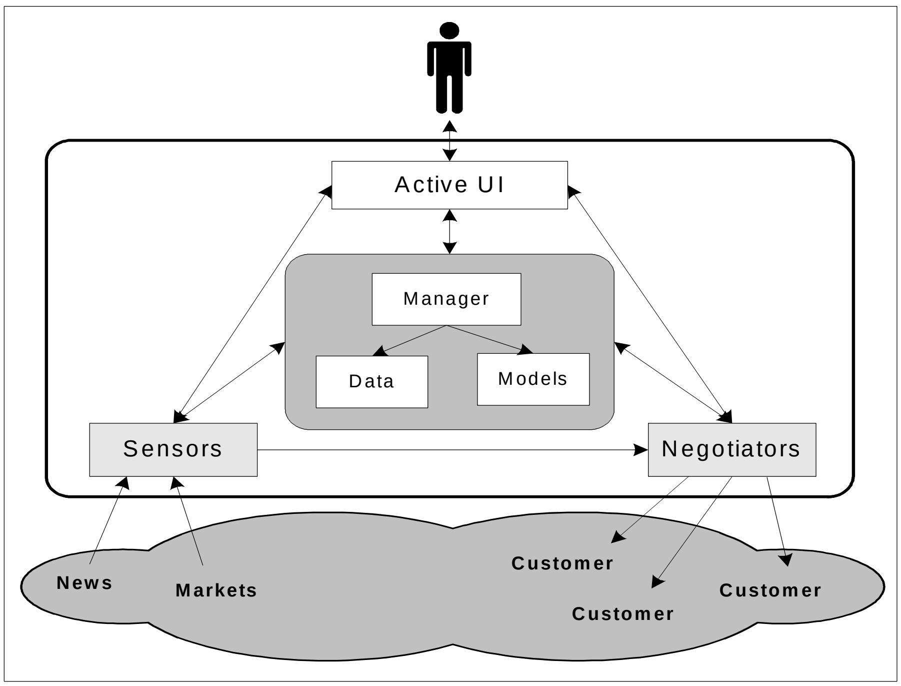

Figure 1. Situated decision support model for managing one-to-many negotiations

Simulation Results

We have conducted preliminary experiments based on the simulations of the SDSS. The case have been adapted from the earlier experimental study and involved negotiations about rental of a condominium. In this case the only two issues involved were the price and the availability of parking spot. In our scenario a seller owned a number of units to be rented and had a 30-day horizon to rent them out through negotiations. Simplifying assumptions were made, e.g. the negotiation ended the same day as it began; and if agreement was possible it was a Nash solution. Buyers' preferences were simulated using normal distribution and were tied to the average market price for such units.

Figure 2 shows an example of average agreed-upon price dynamics and how it is affected by the adjustments made by the manager agents. For example, if a manager senses that there haven't been many agreements made, it may decide to relax some of the reservation levels, or change preferences, which could result in an improvement.

Figure 3 compares profits achieved by the fixed pricing policy vs. negotiation based policies. The latter divide into two: the one where manager's actions are restricted (Dynamic1), and the one where there are no restrictions (Dynamic2). The latter case promises highest profits, though also least control that might jeopardize higher-level policies. We have also tested the case where the market price changes, and the system is able to adapt to that change autonomously. In case of a sudden change, the system may take more time to adapt, and thus lose profits. In this case, timely correct judgment made by the human decision maker (who has access to other sorts of information, e.g. news) has been shown to lead to greater benefits. Thus, the right combination of autonomous action and human judgment is critical for the successful operation.

Conclusions

In this work we have briefly outlined a framework for managing one-to-many negotiations with multiple potential agreements. The framework is based on the model for situated decision support that effectively combines human judgment and autonomous decision making and action by agent components. We have demonstrated the value of the approach through simulation experiments. Future work should be directed towards implementing a user-friendly prototype for a given problem domain and empirical testing involving human subjects.

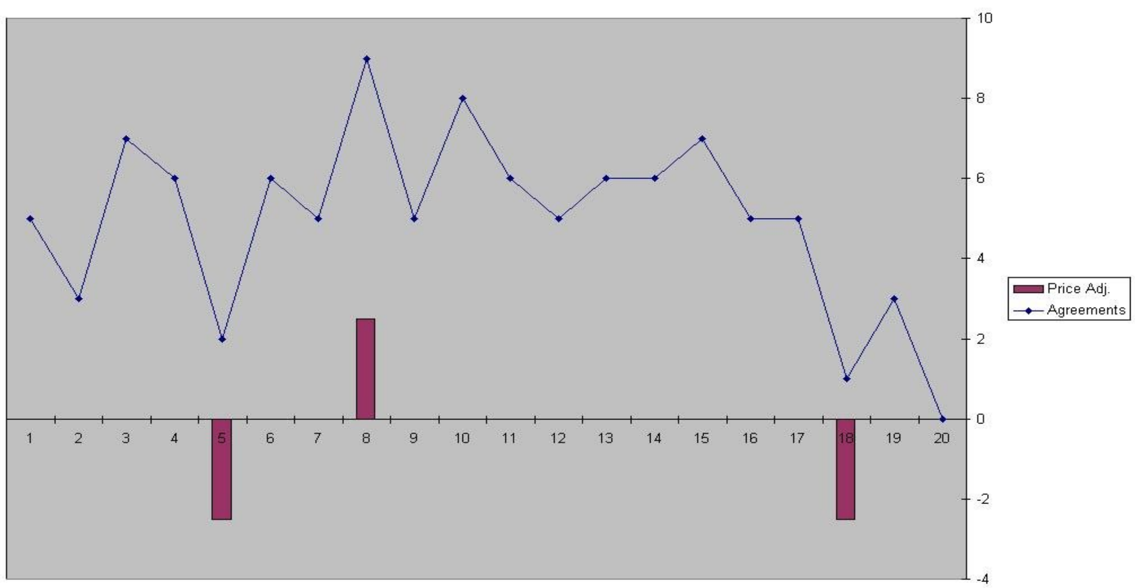

Figure 2. Price dynamics and adjustments

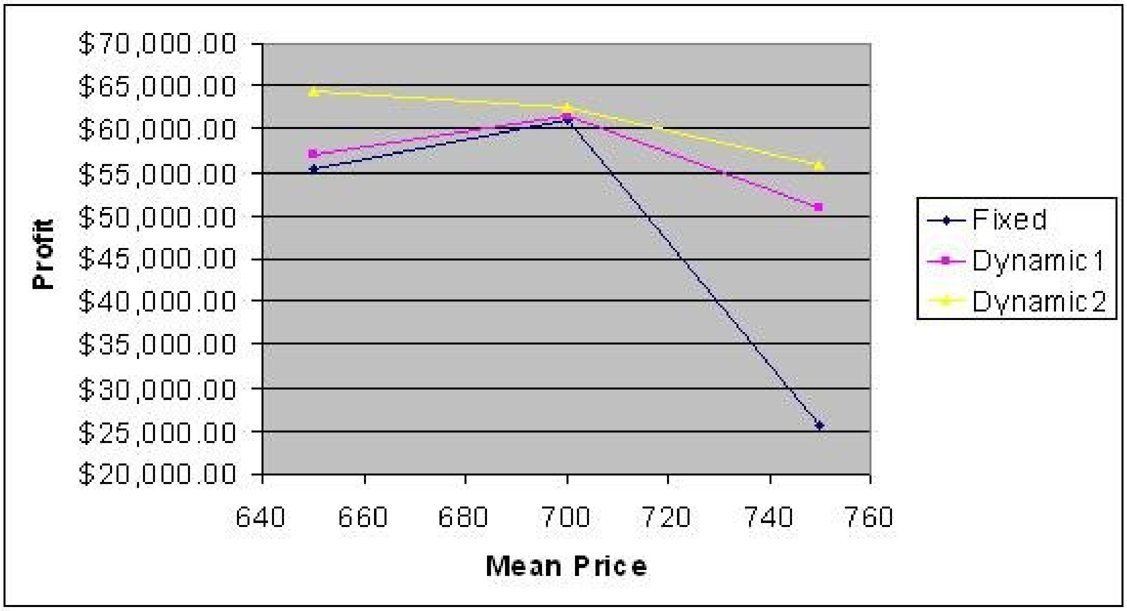

Figure 3. Profits made by applying different policies ($700 is market price).

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