Peyman Faratin
David C. Parkes
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Agent-Mediated Electronic Commerce V

Designing Mechanisms and Systems

AAMAS 2003 Workshop, AMEC 2003
Melbourne, Australia, July 2003
Revised Selected Papers

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Lecture Notes in Artificial Intelligence 3048

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Preface

The design of intelligent trading agents, mechanisms, and systems has received growing attention in the agents and multiagent systems communities in an effort to address the increasing costs of search, transaction, and coordination which follows from the increasing number of Internet-enabled distributed electronic markets. Furthermore, new technologies and supporting business models are resulting in a growing volume of open and horizontally integrated markets for trading of an increasingly diverse set of goods and services. However, growth of technologies for such markets requires innovative solutions to a diverse set of existing and novel technical problems which we are only beginning to understand. Specifically, distributed markets present not only traditional economic problems but also introduce novel and challenging computational issues that are not represented in the classic economic solution concepts. Novel to agent-mediated electronic commerce are considerations involving the computation substrates of the agents and the electronic institutions that supports, and trading, and also the human-agent interface (involving issues of preference elicitation, representation, reasoning and trust). In sum, agent-mediated electronic trade requires principled design (from economics and game theory) and incorporates novel combinations of theories from different disciplines such as computer science, operations research, artificial intelligence and distributed systems.

The collection of above-mentioned issues and challenges has crystallized into a new, consolidated agent research field that has become a focus of attention in recent years: *agent-mediated electronic commerce.*

The papers in this volume originate from the 5th Workshop on Agent-Mediated Electronic Commerce (AMEC V), held in conjunction with the 2nd International Joint Conference on Autonomous Agents and Multiagent Systems (AAMAS) in July 2003. The AMEC V workshop continued with the tradition, and built upon the success of the previous AMEC workshops.

The workshop was intended to explore research in the principled design of economic agents, mechanisms, and systems. Along this direction, areas of particular interest included:

- mechanisms, negotiation protocols, and auctions (especially advanced designs such as multi-attribute auctions)
- bidding and negotiation strategies
- integration of negotiation with broader decision making
- economic-based theory and design methodologies
- market-based problem solving
- trading and pricing
- eliciting human preferences and requirements and ensuring that they are represented in automated agent behavior
- significant new problem domains

- systems that support bidding and negotiation
- simulation and evaluation of properties of novel and complex mechanisms

The workshop received a total of 22 submissions, from which 9 were selected for full presentation during the workshop. After the workshop, the authors were asked to submit their revised versions for publication in this volume. The result is that this volume contains 9 high-quality papers that can be regarded as representative of the field.

We have arranged the papers in the book around three major topics:

- *automated negotiation*;
- *mechanism design*; and
- *multi-agent markets.*

The first section contains four papers dealing with a variety of issues on automated negotiation. Somefun et al. elaborate on bargaining strategies aimed at the trading of bundles of information goods. Similarly, Feng et al. examine automated strategies for trading agents, but in a rather different negotiation scenario: stock trading. Complementarily to these works, Luo et al. turn their attention to a central HCI problem of automated negotiation: how to capture a user's preferences so that his agent can adequately represent him. This section ends with the contribution by Hoen et al., who analyze the convenience for trading agents to decommit after a negotiated contract has been settled.

The second section compiles papers focusing on computational mechanism design. Firstly, Sandholm et al. introduce a new allocation mechanism (take-it-or-leave-it auction) that generates close-to-optimal expected utility for the seller while allowing buyers to hide much of their private valuation. Elaborating further on auction design, Likhodedov et al. design a dominant-strategy auction mechanism aimed at maximizing expected social welfare. A rather different approach is taken by Walsh et al., who offer methods designed to sample the strategy profile that is expected to provide the most value of information, measured in terms of beliefs about the effect that one more sample might have on the current decision about the equilibrium of the system. These methods are said to be relevant to *experimental mechanism design*, in which computational methods are used in a closed loop to evaluate alternative designs for electronic markets.

Finally, the third section contains two papers dealing with upcoming issues in digital markets. Firstly, the work by Brooks et al. develops a model of an information goods duopoly to empirically support the hypothesis that a producer using some knowledge of a problem's structure can outperform a producer employing knowledge-free forms of learning. Secondly, Klein et al. address the problem of emergent dysfunctions in open markets where consumers select providers among competing providers. The authors offer a method for coping with such dysfunctions based on selective stochastic resource request rejection.

We would like to conclude by thanking the members of the program committee. They were able to produce a large number of high-quality reviews in a very short time span. Furthermore, we would also like to thank the authors for submitting their papers to our workshop, as well as the attendees and panelists

for their valuable insights and discussions. Needless to say that these helped authors to improve the revised papers published in this book.

May 2004

Peyman Faratin
David C. Parkes
Juan A. Rodríguez-Aguilar
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Table of Contents

Automated Negotiation and Bundling of Information Goods

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Abstract. In this paper, we present a novel system for selling bundles of news items. Through the system, customers bargain with the seller over the price and quality of the delivered goods. The advantage of the developed system is that it allows for a high degree of flexibility in the price, quality, and content of the offered bundles. The price, quality, and content of the delivered goods may, for example, differ based on daily dynamics and personal interests of customers. Autonomous "software agents" execute the negotiation on behalf of the users of the system. To perform the actual negotiation these agents make use of bargaining strategies. We decompose bargaining strategies into concession strategies and Pareto efficient search strategies. Additionally, we introduce the orthogonal and orthogonal-DF strategy: two Pareto search strategies. We show through computer experiments that the use of these Pareto search strategies will result in very efficient bargaining outcomes. Moreover, the system is set up such that it is actually in the best interest of the customer to have their agent adhere to this approach of disentangling the bargaining strategy.

1 Introduction

Personalization of information goods becomes more and more a key component of a successful electronic business strategy [1]. The challenge is to develop systems that can deliver a high level of personalization combined with, whenever possible, a high adaptability to changing circumstances. In this paper we develop a system which can attain these properties through the manner in which it sells information goods.

We consider the novel approach of selling bundles of news items through a system that allows for bargaining over the price and quality of the delivered goods. Bundling of information goods has many potential benefits including complementarities among the bundle components, and sorting consumers according to their valuation (cf. [2] and the references therein). The advantage of the developed system is that it allows for a high degree of flexibility in the price, quality, and content of the offered bundles. The price, quality, and content of the

P. Faratin et al. (Eds.): AMEC 2003, LNAI 3048, pp. 1–17, 2004.

delivered goods may, for example, differ based on daily dynamics and personal interest of customers.

The system as developed is capable of taking into account business related constraints. More specifically, it tries to ensure that customers perceive the bargaining outcomes as being "fair" by having customers end up with equivalent offers whenever that seems fair. Partly because of this fairness constraint the actual bargaining process is not really one-to-one bargaining between seller and customer but instead is one-to-many (i.e., between seller and customers).

To accelerate the negotiation process, customers can initiate concurrent negotiation threads for the same bundle with differences in the quality of the delivered bundles. The thread in which the agreement is reached first determines the final bargaining outcome.

In the developed system, autonomous "software agents" perform (part of) the negotiation on behalf of the users of the system. These software agents bargain over a multi-issue price (the price is actually a tariff with a fixed and variable component).

To enable efficient multi-issue bargaining outcomes, we decompose the bargaining strategies into concession strategies and Pareto search strategies. Additionally, we introduce the orthogonal and orthogonal-DF strategy: two Pareto search strategies. We show through computer experiments that the respective use of these two Pareto search strategies by the two bargainers will result in very efficient bargaining outcomes (i.e., these outcomes closely approximate Pareto-efficient bargaining solutions).

In the system the seller agent uses a Pareto search strategy (i.e., the orthogonal-DF) combined with a concession strategy. Although the customer is free to choose other bargaining strategies, the system is set up such that it is actually in the best interest of the customer to have their agent also use a Pareto search strategy (i.e, the orthogonal strategy) combined with a concession strategy.

In Section 2 we discuss the developed system at a more conceptual level. In Section 3 we discuss the customer and seller agent in greater detail. Furthermore, we discuss the type of bargaining strategies these agents use. In Section 4 we study in greater detail the Pareto search aspects of bargaining. Through computer experiments we investigate the efficiency of the introduced bargaining approach. (Note that for this purpose it is not necessary to simulate the entire system as developed, it suffices to consider one-to-one bargaining only.) In Section 5 we discuss the results of the paper and relate the paper to the relevant literature. Conclusions follow in Section 6.

2 A System for Selling Information Goods

2.1 Problem Statement

The goal is to develop a system for the sales of bundles of news items where customers bargain over the price and quality of the delivered goods. The negotiated contract applies to a fixed time interval, which is typically a short period

of time, e.g., a single day. There are roughly three possibilities for implementing the starting time of the negotiation process: customers can negotiate a contract before the news arises, after the news arises, or while the news arises. The system is set up in such a way that all three possibilities can be implemented.

The value customers attach to news items may fluctuate heavily due to daily dynamics. Moreover, there may be wide differences in personal interests of customers. The advantage of the developed system is that it allows for a high degree of flexibility in the price, quality, and content of the offered bundles. The price, quality, and content of the delivered goods may, for example, differ based on daily dynamics and personal interest of customers.

2.2 Bundles of Information Goods

The system sells bundles of news items which become available during a predefined and fixed time interval (e.g., a day). Within the system, prices vary based on the content and "quality of service" of the bundle. A *bundle content* defines which types of news categories the bundle contains. The system distinguishes between k categories. Within a category the system distinguishes between two quality of service levels: i.e., a customer pays a fixed price for either receiving headlines or complete news articles. In the former case we speak of a category with low quality of service, whereas in the latter case we speak of a category with high quality of service. Moreover, with the quality of service (or just quality) of a bundle we actually mean the quality of service specified per category.

A customer bargains with the seller over the bundle tariff. The negotiated tariff is a two-part tariff with a fixed and variable price. The fixed price (p_f) is the price a customer pays for receiving the bundle content with the specified quality of service. Moreover, the variable price (p_v) is the price the customer pays for reading a full article whenever the quality of service only specifies delivery of the article headline.

Consider, for example, the bundle content religion, culture, and politics, where the category religion has a high quality of service and the other two have a low quality of service. Then the customer pays a fixed price for receiving all the full articles in the category religion and only the headlines of all the articles which do not belong to the category religion but do belong to the other two categories. Moreover, the variable price is the price the customer pays whenever she wants to read the full article of a news item that belongs to the categories culture or politics (and does not belong to the category religion).

2.3 Bargaining with Software Agents

We employ the paradigm of "software agents," where pieces of autonomous software perform (part of) the negotiating on behalf of the users of the system. Customers and seller instruct their agent through a user interface (UI). The agents conduct the actual negotiation. Figure 1 depicts, at a high abstraction level, the bargaining process between a customer and the seller.

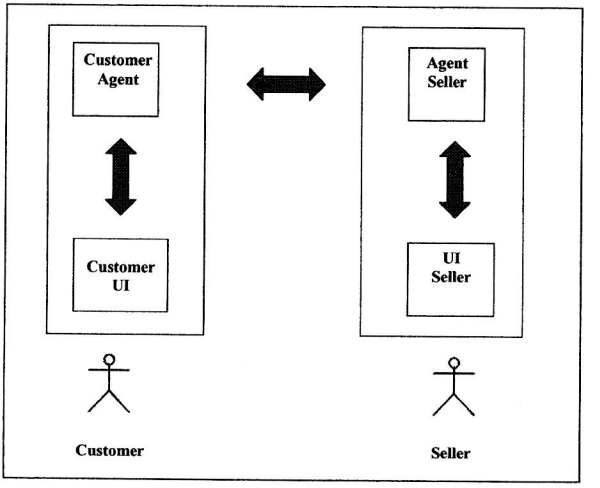

Fig. 1. The one-to-one bargaining process

2.4 Bargaining Process

Bargaining occurs in an alternating exchange of offers and counter offers, typically initiated by the customer. An offer specifies the fixed price, the variable price (uniform for all low quality of service categories), the bundle content, and also the desired quality of service of the information for each category separately. The bargaining process continues until an agreement is reached or one of the bargainers terminates the process. Based on this bargaining process, figure 2 draws the bargaining protocol the customer agents and seller agent use to do the actual bargaining.

To accelerate the negotiation process, we allow concurrent negotiation threads for the same bundle content with different quality of service. The customer can therefore submit several offers at the same time. In order to discern between threads, each thread must have a different quality configuration for the categories where a quality configuration specifies the quality of service for all the bundle categories. The seller can only respond by varying the fixed and variable price. The thread in which the agreement is reached first determines the tariff and quality configuration for the desired categories.

2.5 Fairness & One-to-Many Bargaining

A possible drawback of bargaining is that two customers may end up paying a substantially different price for very similar bundles. Customers may perceive this as unfair. This is an important concern for the seller, since customers may become dissatisfied or stop using the system altogether.

In the system a notion of fairness is incorporated into the bargaining strategy the seller agent uses. More specifically, within a limited timeframe the seller agent

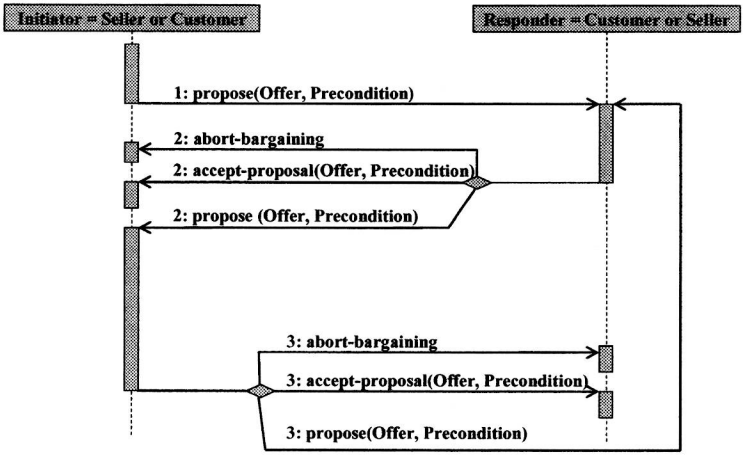

Fig. 2. The agents bargaining protocol

makes equivalent offers to customers who are interested in identical bundles. For offers that specify identical bundles, the actual tariff may still differ from customer to customer. Fairness, however, ensures that the expected revenue of these tariffs is identical for all (counter) offers submitted by the seller agent; the expected revenue (R) of a tariff (p_f, p_v) for a particular bundle is defined as follows:

$$R = p_f + p_v \cdot \rho, \tag{1}$$

where ρ denotes the expected number of articles read in the low quality of service categories (for the average customer). The expected revenue can, however, vary through time. The offer equivalence therefore only holds within a limited time frame. Note that beside "fairness" also other business side-constraints may be implemented. The actual way in which side-constraints, such as fairness, are implemented may be important because it can alter the strategic behavior of customers. It is however beyond the scope of the paper to discuss these issues.

The actual bargaining process between seller and customers is not really one-to-one bargaining between seller and customer but instead is one-to-many. On the one hand, the seller can use his experience in other ongoing bargaining processes between customers to adjust his bargaining strategy; under true one-to-one bargaining the bargaining strategy only depends on the moves of the direct opponent. On the other hand, fairness and/or other side-constraints limit the bargaining options of the seller. These limitations do not apply under true one-to-one bargaining. Figure 3 depicts the one-to-many bargaining process and the possibility of parallel negotiation threads between a customer and the seller.

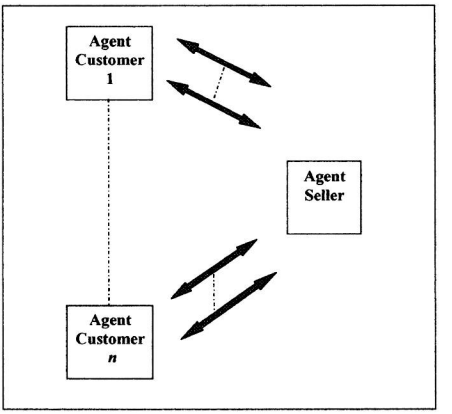

Fig. 3. The one-to-many bargaining with parallel threads

3 Agents & Bargaining

3.1 Agents

Seller Agent Bargaining with a customer is done based on the seller agent's desired aspiration level expressed in expected utils. We define the expected utility u of the seller agent as the expected revenue from selling a bundle given p_f and p_v (see also equation 1), i.e., $u(p_f, p_v) = p_f + p_v \cdot \rho$. We assume that all costs are sunk, i.e., there are no transaction costs. Recall from section 2.5 that ρ denotes the number of expected articles read in the low quality of service categories. The agent can assess the expected number of articles read based on, for example, aggregate past sales data.

Due to the fairness constraint, the seller agent cannot charge different prices to different individuals for identical bundles (within the same time frame). The seller agent can indirectly discriminate between different customers, however, based on differences in the preferred bundle content and/or quality of service. In the system, the seller can discriminate by varying for example the desired expected utility for different combinations of quality of service and bundle content.

Customer Agent The customer agent acts on behalf of the customer. The customer can indicate her preferences by specifying, for each information category she is interested in, the amount of articles she expects to read. The customer can furthermore select between several negotiation strategies to be used by the agent and specify a maximum budget b_{max}. The budget provides the agent with a mandate for the negotiation; the total expected costs should not exceed b_{max}.

Given a tariff (p_f, p_v) for a particular bundle, the customer's expected utility is defined as $u(p_f, p_v) = b_{max} - (p_f + p_v \cdot \rho)$. The second part of the equation is identical to seller's expected revenue (see equation (1)). However, ρ, the number