

# Automated Purchase Negotiations in a Dynamic Electronic Marketplace\*

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**Abstract.** Nowadays, there is a surge of B2C and B2B e-commerce operated on the Internet. However, many of these systems are often nothing more than electronic product or service catalogues. Against this background, it is argued that new generation systems based on automatic negotiation will emerge. This paper covers a particular kind of automatic negotiation systems, where a number of participants in a mobile dynamic electronic marketplace automatically negotiate the purchase of products or services, by means of multiple automated one-to-one bargainings. In a dynamic e-marketplace, the number of buyers and sellers and their preferences may change over time. By mobile we mean that buyers in a commercial area may initiate simultaneous negotiations with several sellers using portable devices like cell phones, laptops or personal digital assistants, so these negotiations do not require participants to be colocated in space. We will show how an expressive approach to fuzzy constraint based agent purchase negotiations in competitive trading environments, is ideally suited to work on these kind of e-marketplaces. An example of mobile e-marketplace, and a comparison between an expressive and an inexpressive approach will be presented to show the efficiency of the proposed solution.

## 1 Introduction

In the commercial and service surroundings of a city situations occur in which people need certain information or service. For example, a person who needs information on a certain product and is interested in looking for the best price. It requires to go to the commerce and to ask the price, having sometimes to wait for tails. Another example is when a tourist looks for a restaurant to have lunch in a zone in which a great number of restaurants is concentrated, so the tourist has to walk (sometimes for a long time) and observe the menus and the prices. The city councils and retailers of the cities can deploy a platform of services based on wireless technology, and with a low cost give a gratuitous service to the users, solving the described problems. A user who has a Personal Digital

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Assistant (PDA) with wireless technology, could use this services with no need to move physically, to know the menus and prices in a zone of cover, and even to reserve table.

The benefits that a user can obtain from this platform of services are to receive information and to make a decision on where and what product or service to acquire, in a time smaller than if the user had to be crossing diverse commerces and making tails in some cases. We can distinguish two levels in the raised examples, services in which the user simply asks for information according to a certain profile, and services in which the user must interact with the provider of the services, and to send and receive data to conduct one more complex operation, for example a purchase negotiation [1]. In this context visitors may be thought of as consumers which compete for obtaining services, while providers may be seen as sellers which also compete for selling their services.

The aim of this paper is to show how an expressive approach to fuzzy constraint based agent purchase negotiations [2] is ideally suited to work on a dynamic e-marketplace [3] where: mobile users have access to service providers by means of portable electronic devices; users have a need to purchase a service or a product which must satisfy a set of constraints in order to meet the user's preferences; service providers own hidden catalogues of products or services for sale; and both consumers and providers have preference profiles which may change over time, even during the course of negotiation.

The rest of the paper is organised as follows. In Section 2 we present a scenario where automated purchase negotiations may be useful, in the context of a mobile dynamic e-marketplace. Section 3 shows with an example the effectiveness of our approach. Finally, Section 4 draws some conclusions.

## 2 A Mobile E-Marketplace

E-marketplaces are trading platforms that offer e-commerce online trade between several buying and selling entities [4]. Nevertheless, today's e-marketplaces lack of fully automated business processes and still require a significant manual effort by human users. The agent technology [5] might take e-commerce trading to a next phase. Agents are intelligent, independent, and proactive electronic representatives of businesses, buyers, suppliers, customers, or even whole companies which can relieve marketplace participants from lots of routine works. The possibility of using altogether mobile devices such as personal digital assistants or cell phones and intelligent agents describes a new kind of e-marketplace which we call *mobile e-marketplace*. In order to show the usefulness of this type of e-marketplace we present the following scenario.

### 2.1 A Second Hand Vehicle E-marketplace

Several car showrooms located in a commercial area of a city offer second hand vehicles. This commercial area could be located in the same building, or the dependencies of the different sellers could be distributed by all the city. What

is needed is to have a network platform which is accessible for the users. A user accesses to the zone of cover of one or more sellers through a portable device which could be a PDA, a cell phone or a laptop. The user does not have why to locate itself at any of the dependencies of the providers.

A set of preferences for a particular kind of car (i.e. brand, consumption, price, and so on) are known by her personal agent which lives in her PDA. These preferences may have been defined several days ago. This way when a user accesses a zone of cover of one or more second hand vehicle sellers, the personal agent in the background negotiates with the software agents which represent the sellers. Each negotiation will conclude with: a pre-agreed solution and a measurement of associated utility, or a conflict solution (i.e. without agreement). This way, without moving of her site, the visitor, through her personal agent has a list with the negotiated solutions ordered by utility. Although we could think about a full automated purchase for the best pre-agreed solution, being realistic we think that at least for the raised example, this is more a vision than reality. Thus, we believe that a more realistic assumption is the one than would take the client to personally: confirm the transaction commitment, or negotiate the pre-agreed solution. If for some reason the seller refuses to sell, the buyer would have to personally negotiate the pre-agreed solution with the following seller. The main problem of this approach is when a provider generates false pre-agreed solutions in order to enforce the clients to visit the sellers' dependencies. Nevertheless, this weakness could be avoided if we consider that a mechanism measuring the sellers' reputation exists. This mechanism could be based on the number of pre-agreed solutions not satisfied by sellers when buyers ask to satisfy the commitments.

## 2.2 Analysis of the Mobile E-marketplace

From a computational point view, a mobile e-marketplace is similar to a static one, with the difference that participants (if not all, at least some of them) use portable devices in order to manage their interactions with the rest of participants<sup>1</sup>. So our second hand vehicle e-marketplace may be seen as a market where multiple buyers and sellers negotiate the purchase of products. First task in order to model the mobile e-market is to characterize the type of commercial relationship among participants. It is straightforward that it may be defined as a *multiple bilateral negotiation B2C e-market*. In [4] a classification of *controlled multi-agent e-marketplaces* is defined. This classification scheme is presented in Figure 1 by using the technique of morphologic boxes. Our scenario may be classified as a B2C, many-to-many(n:m), many issues<sup>2</sup>, and fuzzy constraints on both sides controlled e-marketplace. In the framework of a controlled e-marketplace the participants have to agree upon a set of rules regarding what can be bought and sold and how it can be done. In particular, the negotiation process requires regulation of three important questions [1, 6]:

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<sup>1</sup> In an extreme the sellers could also use portable devices to deploy an ad-hoc e-marketplace.

<sup>2</sup> The products are characterized by a set of attributes.

Criterion	Possible values		
Type of e-marketplace	B2B	B2C	C2C
Type of negotiation model	1:n (A)	m:1 (B)	n:m (C)
Negotiation issues	One issue		Many issues
Type of consumer's constraints	Crisp		Fuzzy
Type of merchant's constraints	Crisp		Fuzzy

**Fig. 1.** Classification of controlled multi-agent e-marketplaces

- **Negotiation protocols:** the set of rules which govern the interactions.
- **Negotiation objects:** the range of issues which an agreement must be reached.
- **Agents decision making models:** the decision making mechanisms which agents use in order to achieve their negotiation objectives.

In order to define a negotiation framework which regulates these questions we need to analyze the *dominant strategies* [7, 8] of the participants. First, we have to make the following assumptions: coalitions among participants are not possible, which means that there is no subgroup that can deviate by changing strategies jointly in a manner that increases the payoff of all of its members given that nonmembers do not deviate from the original solution [9]; offers in a bilateral negotiation are only visible to buyer and seller participants in the negotiation; participation in a negotiation is individually rational to an agent, so the agent's payoff in the negotiated solution is not less than the payoff that the agent would get by not participating in the negotiation [9]; and participants do not know anything about other negotiations in which they do not participate. If these conditions are satisfied we can reason about the strategies of the participants in the following way:

- A buyer will try to maximize her degree of satisfaction. So, she will concede as less as possible when negotiating. On the other hand, buyers will cooperate in order to speed up the course of negotiations. This is because buyers assume the worse negotiation scenario where other buyers may reach agreements on the same solutions, and there is a scarce of products. Under the previous assumption of a buyer agent which is a local utility maximizer, one of the alternatives to cooperate in the convergence of the negotiation is to argument the proposals by means of preferences [10].
- A seller will try to maximize her degree of satisfaction. So, she will concede as less as possible when negotiating, and will cooperate to speed up negotiations. Here the seller assumes the worse negotiation scenario where multiple sellers may be offering the same products. One of the alternatives to cooperate for the seller is to argument her proposals by means of preferences.

The conclusion is that both the buyer and seller agents should use strategies which attempt to accelerate the negotiation, so both agents should make proposals which include their preferences while minimizing the revelation of private information [11].

Attending to all these requirements, we propose the use of a fuzzy constraint based approach to negotiation. Fuzzy constraints have been used in several approaches to multi-attribute negotiation [12–14]. We proposed in [2] a general framework to fuzzy constraint based agent purchase negotiation, and in [15] we demonstrated the effectiveness of our approach. Now, we show with an example the effectiveness of our approach in the context of the e-market presented in Section 2.1.

### 3 Negotiations in a Second Hand Vehicle E-marketplace

In this section we present an example of negotiations in a mobile second hand vehicle e-marketplace. With this example we show how an expressive approach to fuzzy constraint based purchase negotiation may improve the outcomes of the negotiations. Firstly, in Figure 2 are represented the buyer’s preferences regard-

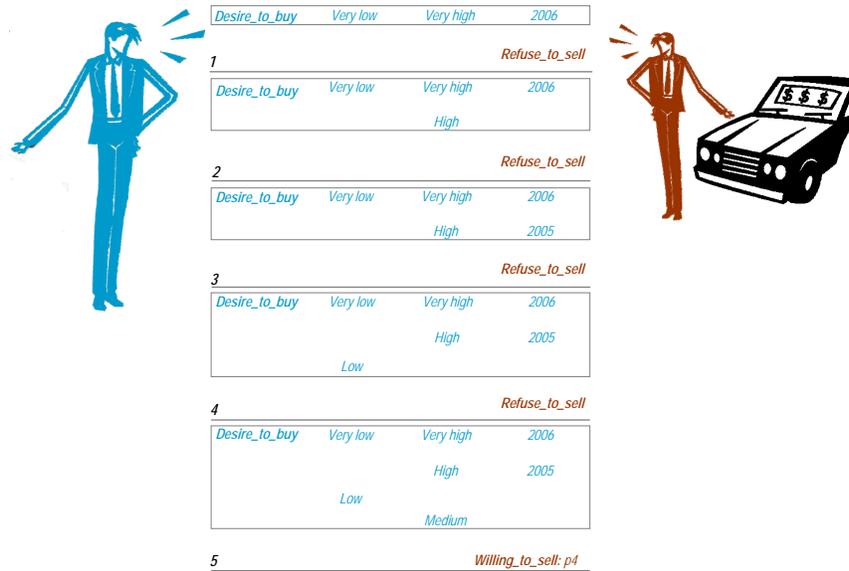


Fig. 2. Buyer’s Preferences

ing the attributes of a car, and Figure 3 shows the seller agent’s catalogue of cars. Buyer and seller agents negotiate the purchase of a car which is defined by a set of three attributes: price, quality, and year. The buyer’s preferences are expressed as a set of three fuzzy constraints (one per attribute). In this way, each column specifies different levels of satisfaction for different values of the corresponding attribute. As we argued, both the buyer and seller agents should make proposals which include their preferences. First, we show what would happen if none agent include preferences. This is what we call an *inexpressive dialogue*, and is shown in Figure 4 . Each buyer’s proposal is a `Desire_to_buy` locution which contains a set of hard constraints. For example, the fifth locution states: “*I desire to buy*

<i>Products</i>	<i>price</i>	<i>quality</i>	<i>year</i>	<i>profit</i>
<i>p1</i>	<i>Very low</i>	<i>Very low</i>	<i>2006</i>	<i>Very low</i>
<i>p2</i>	<i>Very high</i>	<i>Very high</i>	<i>2006</i>	<i>Very high</i>
<i>p3</i>	<i>Low</i>	<i>High</i>	<i>2004</i>	<i>Medium</i>
<i>p4</i>	<i>Low</i>	<i>Medium</i>	<i>2005</i>	<i>Very low</i>

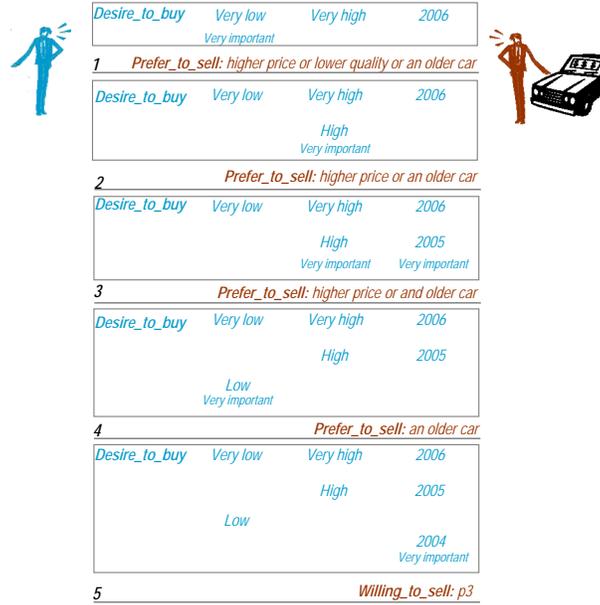
**Fig. 3.** Seller's Product Catalogue



**Fig. 4.** Inexpressive Dialogue

a car at a very low or low price, with medium, high or very high quality, and which is made in 2005 or 2006". Each seller's locution is a `Refuse_to_sell` or a `Willing_to_sell`, so her expressiveness is limited to refuse or accept proposals. The outcome of the negotiation is not satisfactory because the profit the seller agent gets is "very low".

Figure 5 represents an *expressive dialogue*. The buyer agent qualifies each



**Fig. 5.** Expressive Dialogue

submitted constraint and the seller agent explicitly suggests the relaxation of specific constraints. The dialogue works as follows:

1. The buyer states that she prefers: very low price, very high quality and a new car. Moreover, she qualifies the very low price constraint as very important. The seller agent has no cars satisfying these constraints, and these constraints are still far from the products in the catalogue. So, the seller agent informs buyer agent that she should relax any constraint to reach an agreement.
2. The buyer relaxes the quality constraint and she qualifies it as the most important. The seller agent analyses the proposal and selects p2 and p3 as good candidates for sale. p2 gives a high profit, and p3 is nearer from the buyer's requirements while giving a reasonable profit (medium). Finally, the seller agent says that the price or year constraints should be relaxed.
3. This stage is similar to the previous one.

4. The buyer relaxes the price constraint and she qualifies it as the most important. The seller believes that p3 is even nearer from the buyer's requirements, so it is selected as a potential sale offer. However, p2 is discarded because price is qualified as very important. In order to sell p3, the seller agent informs that the year constraint should be relaxed.
5. The buyer agent could relax the quality or the year constraints. Attending the seller's recommendation the buyer relaxes the year constraint. Finally, the outcome of the negotiation is p3, which is a better agreement.

We can see how buyer and seller agents may benefit from a partial revelation of preferences. A buyer agent may attend the seller's requirements in order to select the alternative from the set of trade-off proposals that is likely to benefit both agents. Constraints can be valued in order to help the seller agent to make a more effective search. The purpose of this search is to select the most convenient potential sale offers in order to generate a balanced relax requirement.

## 4 Conclusions

We have seen how by means of portable electronic devices buyers may engage in semi-automatic negotiations with one or more sellers. This mobile e-market may be useful in situations where manual negotiation is considered either too embarrassing or frustrating for ordinary consumers (even if it is in their best interest to do so) [12, 16]. We have also shown how an expressive approach to fuzzy constraint based agent purchase negotiation is ideally suited to work on mobile dynamic e-marketplaces where multiple buyers and sellers negotiate the purchase of products.

## References

1. Jennings, N.R., Faratin, P., Lomuscio, A.R., Parsons, S., Sierra, C., Wooldridge, M.: Automated negotiation: Prospects, methods and challenges. *Int Journal of Group Decision and Negotiation* **10**(2) (2001) 199–215
2. Lopez-Carmona, M.A., Velasco, J.R.: An expressive approach to fuzzy constraint based agent purchase negotiation. In: *AAMAS '06 Proceedings*, Hakodate, Japan (2006)
3. Minghua-He, Jennings, N.R., Ho-Fung-Leung: On agent-mediated electronic commerce. *IEEE Transactions on Knowledge and Data Engineering* **15**(4) (2003) 985–1003
4. Kurbel, K., Loutchko, I.: Towards multi-agent electronic marketplaces: What is there and what is missing? *The Knowledge Engineering Review* **18**(1) (2003) 33–46
5. Wooldridge, M.: *An Introduction to Multiagent Systems*. John Wiley & Sons (2002)
6. Jennings, N.R., Parsons, S., Sierra, C., Faratin, P.: Automated negotiation. In: *Proc. 5th Int. Conf. on the Practical Application of Intelligent Agents and Multi-Agent Systems (PAAM-2000)*. (2000) 23–30
7. Osborne, M.J., Rubinstein, A.: *A Course in Game Theory*. MIT Press, Cambridge, Massachusetts (1994)

8. Rosenschein, J.S., Zlotkin, G.: Rules of Encounter. MIT Press, Cambridge MA, USA (1994)
9. Weiss, G.: Multiagent Systems: A Modern Approach to Distributed Artificial Intelligence. MIT Press, Cambridge MA, USA (1999)
10. Jennings, N.R., Parsons, S., Noriega, P., Sierra, C.: On argumentation-based negotiation. In: Proc. Int. Workshop on Multi-Agent Systems. (1998)
11. Raiffa, H.: The Art and Science of Negotiation. Harvard University Press (1982)
12. Xudong-Luo, Jennings, N.R., Shadbolt, N., Ho-Fung-Leung, Lee, J.H.M.: A fuzzy constraint based model for bilateral, multi-issue negotiations in semi-competitive environments. *Artificial Intelligence* **148**(1-2) (2003) 53–102
13. Kowalczyk, R., Bui, V.A.: Fenax: a fuzzy e-negotiation agents system. In: Proceedings of the IEEE/IAFE/INFORMS 2000 Conference on Computational Intelligence for Financial Engineering CIFE<sub>r</sub> Cat. (2002)
14. Lai, K.R., Lin, M.W.: Modeling agent negotiation via fuzzy constraints in e-business. *Computational Intelligence* **20**(4) (2004) 624–642
15. Lopez-Carmona, M.A., Velasco, J.R.: A fuzzy constraint based model for automated purchase negotiations. In: TADA-AMEC VIII, AAMAS'06, Hakodate, Japan (2006)
16. Guttman, R.H., Moukas, A.G., Maes, P.: Agent-mediated electronic commerce: A survey. **13**(2) (1998) 147–159