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Sellers in e-marketplaces: A Fuzzy Logic based decision support system

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ABSTRACT

Web business models typically rely on environments where entities, not known in advance, try to negotiate and agree on the purchase of products. Such environments are termed Electronic Markets (EMs). In EMs there are two main groups of entities: the buyers and the sellers. Intelligent agents can play the role of buyers and sellers as delegates of them. Agents, acting autonomously, can guarantee the efficiency in the discovery of items of interest to the buyer. The interaction between buyers and sellers can be modeled as a zero knowledge negotiation. In this paper, we discuss basic characteristics of the negotiation and define a decision support mechanism for sellers. We focus on bilateral single issue negotiations between a buyer and a seller. The proposed decision making mechanism is based on Fuzzy Logic (FL) in order to handle uncertainty in the negotiation process. The seller, at every negotiation round, receives the buyer's offer and decides her course of actions. In this setting, we consider that no knowledge on the strategies that entities follow is available. The seller uses fuzzy inference rules in order to decide if she is going to accept or reject the offer of the buyer at every round. Compared with other relevant schemes, our approach demonstrates increased efficiency by raising the utility that the seller obtains through negotiations.

1. Introduction

1.1. Motivation

The current form of the Web integrates a huge number of resources and services that are available to end users. Users have the opportunity to navigate and search in millions of web pages in order to find resources that best match their needs. However, this becomes a tedious task, possibly incompatible with human capability. Users cannot browse and process numerous resources in order to find the needed service or product. On the other side, providers should interact with a large number of potential buyers and decide when a purchase proposal is profitable for them. Their decision making mechanism tries to determine the most appropriate action for every buyer and every product. In order to handle the aforementioned issues, the use of intelligent techniques is considered imperative. A possible solution could be the adoption of the *Intelligent Agent* (*IA*) technology in *Electronic Marketplaces* (*EMs*).

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An IA is a software component capable of acting autonomously in order to accomplish the tasks delegated by its user [44]. An IA has artificial intelligence capabilities, i.e., it is capable of learning the preferences of its owner in order to increase efficiency. An IA can undertake the responsibility of finding products in the Web. We define EMs as places where a set of entities try to agree upon the purchase of goods. There are types of market members such as: the *buyers*, the *sellers*, and *intermediaries* i.e., members that are in the middle between buyers and sellers helping in accomplishing their tasks. The main problem in EMs is the evaluation of the proposed models (for solving important problems in EMs) in real life conditions [61]. Problems arise when researchers try to provide solutions in dynamic environments (common case in real scenarios) or when agents face heterogeneous entities trying to act in parallel on-line markets. Facing heterogeneous entities requires a more complex behavior and increased computational capabilities. Additionally, the interaction problem between unknown entities is another challenging research issue [26].

In this paper, we study the adoption of the IA in EM environments and elaborate on an interaction model between buyers and sellers. This model involves a negotiation between them. Negotiation is defined as the process where two entities attempt to agree upon the exchange of a product or service [49]. A lot of research has been undertaken in this area, however, there are still certain open issues [16,50,51]. In an open environment, like EMs, IAs have selfish behavior and are not cooperative [56].

The foundations of negotiation theory are theories such as decision analysis, behavioral decision making, game theory, and negotiation analysis [38–40,47,49]. Negotiation theory mainly involves game-theoretic and behavioral approaches. The game theoretic approach is based on concepts like strategies, payoffs, information structure and equilibrium. The behavioral approach, on the other hand, is connected with the bargaining problem. Two models can be used for solving this problem: the axiomatic and the strategic. The axiomatic approach [38–40] defines a number of axioms implying a unique solution, where players are allowed to make binding agreements. The strategic approach [47] focuses on players' strategies in a non-cooperative interaction, modeling a time-dependent bargaining process. Research efforts that combine these two approaches are discussed in [25,28].

In the majority of the pertinent research proposals, the authors handle negotiations through the use of game theory [24]. Many of the proposed interaction models are simplistic. They consider knowledge on all, or a number of the entities' characteristics (e.g., deadlines, reservation prices). The reason is that game theoretic models try to provide means for the profit maximization through a number of restricted actions. Additionally, solving a model with absolutely no knowledge on the entities' characteristics is a very demanding task. In general, game theoretic models assume that players are perfectly rational and this rationality is common knowledge [19]. However, when playing a game, the most effective strategy of a player is to find the best reply to the opponent's strategy instead of following the equilibrium path. For instance, Rubinstein in [50,51] studied a bargaining game and defined the equilibrium path. The proposed model is related to a two round, two player negotiation (like the game analyzed in [20] by Fudenberg and Tirole) which is not common in real life situations.

In such interactions, players' deadlines are very important as they define an upper time limit for their participation in negotiations. One can find research efforts assuming finite [54] or infinite horizon settings [8,12]. The entities participating in negotiations have specific deadlines as their owners should experience finite delay. Deadlines are defined by the users or can be calculated based on specific characteristics. In [54], the authors consider a negotiation under incomplete knowledge, however, they present a theoretical study on the effect that deadlines have on players.

Another important issue in negotiations is that players should reason at every round and take the appropriate decision pertinent to their actions. It is common that such actions involve the acceptance or the rejection of the opponent's offer. Game theory and the corresponding equilibrium analysis provide such a reasoning mechanism. Another methodology example is presented in [15,17] where the authors present decision functions for deriving decisions at every negotiation round. More intelligent techniques involve Optimal Stopping Theory (OST) [33] and Swarm Intelligence (SI) [34]. OST models try to identify the right time to stop the negotiation and the take the final decision. The actions taken, at every negotiation round, aim to utility maximization. SI models try to benefit from the collective behavior of a group of agents and they are typically used in concurrent negotiations (one entity negotiates with multiple opponents).

All the aforementioned models cannot be efficiently implemented in open environments where the information is sparse and full of uncertainty [59]. Entities need a decision making mechanism that handles uncertainty. Hence, many researchers have adopted other techniques like *Fuzzy Logic* (*FL*) [64]. FL is the appropriate tool for handling uncertainty in open and very dynamic environments. FL has been used in many research efforts related to negotiations. In short, some of the FL uses in negotiations are:

- In [7], the authors adopt fuzzy sets and fuzzy labels for defining the attributes of each offer. The objective is to persuade the seller to provide a better offer in the upcoming rounds. In this model, the FL is used in the buyer side while the seller proposes crisp values.
- In [10], the authors utilize FL for evaluating the difference of issue values (multiple characteristics of products) between successive rounds of the negotiation. Based on this difference, supplier tactics are defined.
- The model in [17] is combined with a fuzzy model discussed in [48]. The authors utilize fuzzy values to represent offers on both sides (i.e., buyer and seller). However, the decision mechanism is similar to that presented in [17] using specific thresholds for accepting offers.