On a Collaborative Reputation Mechanism enhancing intelligent agent negotiation frameworks in the E-marketplace

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Abstract. E-commerce is expected to achieve high market penetration if coupled with the appropriate technologies. Mobile Agent Technology (*MAT*) may enhance the intelligence and improve the efficiency of systems in the e-marketplace. In this highly dynamic and competitive market, the users (Buyers) should be assisted in finding the service provider (Seller) best fitting their needs. In this paper, the Buyers' decision on the "*best*" Seller is based on a weighted combination of the evaluation of the quality of the Sellers' offer (*performance related factor*) and of their reputation rating (*reliability related factor*). Automated negotiation frameworks are enhanced with a Sellers' collaborative reputation mechanism, which helps estimating their trustworthiness and predicting their future behaviour, taking into account the Sellers' past performance in satisfying the Buyers' expectations. In essence, Sellers are rated with respect to whether they honoured or not the agreements they have established with the Buyers, thus introducing the concept of trust among the negotiators. The reputation mechanism considers both first-hand information (acquired from the Buyer's past experiences with the Sellers) and second-hand information (disseminated from other Buyers' based on their own past experiences with the Sellers), while spurious reputation ratings are taken into account.

Keywords. Intelligent Agents, Automated Negotiation, Reputation Mechanism.

1. INTRODUCTION

E-Commerce is foreseen to develop to a field dominating transactions in the near future. Harnessing its full potential and achieving the degree of automation required necessitates the design of automated negotiation mechanisms, which seem to play a leading role to these issues [1]. This paper aims to propose enhancements to the sophistication of the negotiation functionality that can be offered by e-commerce systems in open competitive communications environments. It is based upon the notion of interacting intelligent agents [2], which participate in trading activities on behalf of their owners, while exhibiting properties such as autonomy, reactivation, and pro-activation, in order to achieve particular objectives and accomplish their goals.

Automated negotiation is a very broad and encompassing field. Thus, it is vital to understand the dimensions and range of options available. When building autonomous agents capable of sophisticated and flexible negotiation, three broad areas need to be considered [3]: (i) what negotiation protocol and model will be adopted, (ii) what are the issues over which negotiation will take place, and (iii) what negotiation strategies will the agents employ. The negotiation protocol defines the "rules of encounter" between the agents [4]. Then, depending on the goals set for the agents and the negotiation protocol, the negotiation strategies are determined [5].

In the highly competitive and dynamic e-marketplace users (Buyers) should be provided with mechanisms that enable them to find the most appropriate service providers (Sellers), i.e., those

offering the desirable quality of service at a certain time period in a cost efficient manner. As a first step, a negotiation protocol to be employed in an automatic *multi-lateral*, *multi-issue* negotiation model has been designed and evaluated [6] by the authors and efficient negotiation strategies for *Business-to-Consumer* e-commerce have been implemented [7][8][9]. A multi-round negotiation framework has been exploited, which demonstrates computational and communication advantages over single step mechanisms in complex environments [10]. The framework considered covers multi-issue contracts and multi-party situations, while being a highly dynamic one, in the sense that its variables, attributes and objectives may change over time. The designed negotiation strategies, address the case where the negotiators face strict deadlines, and assist agents to reach to a satisfactory agreement within the specified time-limits.

E-marketplace is commonly perceived as an environment offering both opportunities and threats. Buyers' or Sellers' misbehaviour due to selfish or malicious reasons can significantly degrade the performance of the e-market. To cope with misbehaviour the negotiators should be able to automatically adapt their strategies to different levels of cooperation and trust. *Reputation Mechanisms* provide means of obtaining a reliability rating of participants in e-marketplace environments and serve as an incentive for good behaviour to avoid the negative consequences of a bad reputation spreading in the market. Such systems in essence exploit learning from experience concepts. Learning refers to a component's ability to use information previously obtained from the environment in order to adjust its decisions and behaviour.

In this paper, the designed negotiation framework [6][7][8][9] is enhanced by a Sellers' collaborative reputation mechanism, which takes into account the Sellers' past performance in consistently satisfying Buyers' expectations. Thus, the reputation mechanism rates the Sellers with respect to whether they honoured or not the agreements established with the Buyers, thus introducing the concept of trust among the negotiating parties. The rest of the paper is structured as follows. In Section 2, the designed collaborative reputation mechanism is presented that aims to offer an efficient way of building the necessary level of trust in the e-market. Finally, in Section 3, conclusions are drawn and directions for future plans are presented.

2. COLLABORATIVE REPUTATION MECHANISM

The establishment of trust is of outmost importance in the highly dynamic e-marketplace, where small players emerge and vanish, anyone can choose to be anonymous, while users may participate in only a few transactions that may be of relatively low value and potential contracts may cross jurisdictional boundaries, raising the difficulty of legal contract enforcement.

Traditional models aiming to avoid strategic misbehaviour involve *Trusted Third Parties* (*TTPs*) or intermediaries [11] that monitor every transaction, while in most cases, a reputation based mechanism is used in order to automatically isolate a misbehaving party [12][13], providing a "softer" notion of security, considered to be sufficient for many multi-agent applications. In this paper, Sellers that are deemed misbehaving are not directly ostracised, but instead the Buyers' decision on the most appropriate Seller is based on a weighted combination of the evaluation of the Sellers' offer quality (*performance related factor*) and of their reputation rating (*reliability related factor*). The agents may only use first-hand information, based on their own experiences or they may additionally exploit second-hand information disseminated from other parties, which enables them to identify misbehaving participants early enough.

In Section 2.1 the fundamental concepts of our proposed collaborative reputation mechanism are given, while Section 2.2 provides the mathematical description of the reputation ratings and of the Buyers' decision.

2.1. Reputation Rating and Buyer Decision Fundamentals

Assuming the presence of multiple *Seller Agents* (*SAs*) negotiating with a *Buyer Agent* (*BA*) for

the terms and conditions of the provision of a product / service, the *BA* can decide on the most appropriate *SA* based on the evaluation of the *SA's* offer quality combined with an estimation of the *SA's* expected behaviour. In our approach this estimation comprises the reliability related factor, which is introduced in order to reflect whether the Seller finally provides to the Buyers the product / service that corresponds to the established contract terms or not. The *SA's* reliability is reduced whenever the *SA* does not honour the agreement contract terms reached via the negotiation process. The *SAs'* performance evaluation factor is based on the fact that there may be different levels of satisfaction with respect to the various *SAs'* offers. In this respect, there may be *SAs* that, in principle, do not satisfy the *BA* with their offer.

The proposed reputation mechanism is collaborative in the sense that it considers both first-hand information (acquired from the Buyer's past experiences with the Sellers) and second-hand information (disseminated from other Buyers). To be more specific, each *BA* keeps a record of the reputation ratings of the *SAs* it has negotiated with. Additionally, a centralised component called *Reputation Manager* (*RM*), maintains a collective record of the *SAs'* reputation ratings based on the feedback given by the *BAs* on their experiences in the e-market.

True feedback can not be automatically assumed. Second-hand information can be spurious (e.g., parties may choose to misreport their experience due to jealousy or in order to discredit trustworthy Sellers). In general, a mechanism for eliciting true feedback in the absence of *TTPs* is necessitated. In the proposed scheme, in order to account for possible inaccuracies to the feedback provided to the *RM* by the *BAs* (both intentional and unintentional), the *BA* mostly relies on its own experiences rather on the *SAs'* reputation ratings provided by the *RM*, which in our approach, is attributed with a relatively low significance factor.

The *BA* uses the reputation mechanism to decide on the most appropriate *SA*, especially in cases where the *BA* doubts the accuracy of the information provided by the *SA*. A learning period is required in order for the *RM* and the *BA* to obtain fundamental information for the *SAs*. In case reputation specific information is not available to the *BA* (both through its own experiences and through the *RM*) the reliability related factor is not considered for the Seller selection. At this point it should be noted that the reputation mechanism comes at the cost of keeping reputation ratings related information and updating it after service provision has taken place.

2.2. Mathematical description of the Sellers Reputation Rating System

Each Seller *S* may be rated in accordance with the following formula:

$$RR_{post}(S) = RR_{pre}(S) + k_r \cdot l(R) \cdot (rr(S) - E[rr(S)]) \quad (1)$$

Where RR_{post} and RR_{pre} are the Seller's *S* reliability based rating after and before the updating procedure. It has been assumed that RR_{post} and RR_{pre} lie within the $[0,1]$ range, where a value close to *0* indicates a misbehaving Seller. $rr(S)$ is a (reward) function reflecting whether the service quality is compliant with the picture established during the negotiation phase and $E[rr(S)]$ is the mean (expected) value of the $rr(S)$ variable. In general the larger the $rr(S)$ value, the better the Seller behaves with respect to the agreed terms and conditions of the established contract, and therefore the more positive the influence on the rating of the Seller. Factor k_r ($k_r \in (0,1]$) determines the relative significance of the new outcome with respect to the old one. In essence, this value determines the memory of the system. Small k_r values mean that the memory of the system is large. However, good behaviour will gradually improve the Seller's *S* reputation ratings. $l(R)$ is a function of the Seller's reputation rating RR_{pre} and is introduced in order to keep the Seller's rating within the range $[0,1]$. In the current version of

this study, $l(R) = \frac{1}{1-e} \cdot [1 - \exp(1-R)]$, for which it stands $\underset{R \to 0}{l(R)} \to 1$ and $\underset{R \to 1}{l(R)} \to 0$.

It should be noted that Seller's misbehaviour (or at least deterioration of its previous behaviour) leads to a decreased post rating value, since the $(rr(S) - E[rr(S)])$ quantity is negative. The $rr(S)$ function may be implemented in several ways. In this paper, it was assumed without loss of generality that the $rr(S)$ values vary from 0.1 to 1.

The reliability rating value of the Seller *S* is updated after the user finally accesses the service. This rating requires in some cases (e.g., when consumption of network or computational resources are entailed in the service provision process) a mechanism for evaluating whether the service quality was compliant with the picture promised during the negotiation phase.

The Seller's *S* reputation rating may be calculated by the following formula:

$$RR(S) = w_{BA} \cdot RR_{BA}(S) + w_{RM} \cdot RR_{RM}(S) \quad (2)$$

Where RR_{BA} and RR_{RM} are the Seller's *S* reputation information concerning *BA* experiences and its collective rating stored by the *RM*, respectively. Both RR_{BA} and RR_{RM} are calculated based on equation (1). Weights w_{BA} and w_{RM} provide the relative value of the reputation rating of the Seller *S* as experienced by *BA* and the reputation rating of the Seller *S* as maintained in the *RM* component. It has been assumed that weights w_{BA} and w_{RM} are normalized to add up to 1 (i.e., $w_{BA} + w_{RM} = 1$), while a relatively low w_{RM} aims to avoid erroneous decisions based on potential fake and misleading feedbacks provided by various *BA*s to the *RM*.

Finally, the *BA* decides on the most appropriate Seller *S* (i.e., the Seller best serving its current service / product request) and selects the one that maximizes the value of the following formula:

$$A_{PR} = w_p \cdot U^B(C_{final}) + w_r \cdot RR(S) \quad (3)$$

As you may observe, A_{pr} is an objective function that models the performance and the reliability of the Seller *S*. Among the terms of this function there can be the overall anticipated user satisfaction stemming from the final contract reached within the negotiation phase, which is expressed by the function $U^B(C_{final})$ with respect to the contract proposed to the *BA* and the reputation rating of the Seller *S*. Of course, one of the two factors (anticipated user satisfaction or reputation rating of the Seller *S*) can be omitted in certain variants of the general problem version considered in this paper. Weights w_p and w_r provide the relative value of the anticipated user satisfaction and the reputation related part. It is assumed that weights w_p and w_r are normalized to add up to 1 (i.e., $w_p + w_r = 1$).

3. CONCLUSIONS

In this paper, the automated negotiation framework designed and evaluated by the authors is enhanced with a Sellers' collaborative reputation mechanism, which helps estimating their trustworthiness and predicting their future behaviour, taking into account the Sellers' past performance in consistently satisfying Buyers' expectations. The reputation mechanism considers both first- and second-hand information, while spurious reputation ratings are taken into account. Initial experiments indicate that the designed strategies enhanced with the proposed Sellers' collaborative reputation mechanism achieve higher social welfare levels with regards to reputation independent frameworks, in case there are Sellers prone to misbehaving. Future plans involve its extensive empirical evaluation against existent negotiation and reputation models and strategies and against the optimal solution that maximizes the social welfare in multi-party e-marketplace environments.

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