REPUTATION BASED 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. Such a highly competitive and extremely dynamic market should encompass mechanisms for enabling users (Buyers) to find the most appropriate service providers (Sellers), i.e., those offering adequate quality services at a certain time period in a cost efficient manner. In this study, 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*). Efficient 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.

1 INTRODUCTION

In the liberalised and deregulated e-marketplace some key factors for service providers' success are the following. First, the efficiency with which services will be developed. Second, the quality level, in relation with the corresponding cost, of new services. Third, the efficiency with which the services will be operated (controlled, maintained, administered, etc.). The aim of this paper is, in accordance with efficient service operation objectives, to propose enhancements to the sophistication of the negotiation functionality that can be offered by e-commerce systems in open competitive communications environments. This study is based upon the notion of interacting intelligent agents which participate in trading activities on behalf of their owners, while exhibiting properties such as autonomy, reactiveness, and proactiveness, in order to achieve particular objectives and accomplish their goals (He, 2003).

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 (Faratin, 1998): (i) what negotiation protocol and model will be adopted, (ii) what are the issues over which negotiation will take place, and

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(iii) what negotiation strategies will the agents employ. The negotiation protocol defines the “rules of encounter” between the agents (Rosenschein, 1994). Then, depending on the goals set for the agents and the negotiation protocol, the negotiation strategies are determined (Roussaki, 2003).

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. In this study we present such mechanisms. As a first step, a negotiation protocol to be employed in an automatic *multi-lateral*, *multi-issue* negotiation model is proposed and efficient negotiation strategies for *Business-to-Consumer* e-commerce are presented. In this framework, the roles of the negotiating agents may be classified into two main categories that, in principle, are in conflict. These two categories are: the Buyer Agents (*BAs*) and the Seller Agents (*SAs*) that are both considered to be rational and self-interested, while aiming to maximise their owners' profit.

A multi-round negotiation framework is exploited, which demonstrates inherent computational and communication advantages over single step mechanisms in such complex frameworks (Conitzer, 2003). In essence, the agents hold private information, which may be revealed incrementally, only on an as-needed basis. 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 assume 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 exploiting learning from experience concept and serve as an incentive for good behaviour to avoid the negative consequences of a bad reputation spreading in the market.

In the context of this study, as a second step, the proposed framework is enhanced by a Sellers' collaborative reputation mechanism, which takes into account the Sellers' past performance in consistently satisfying Buyers' expectations. To be more specific, 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. Most reputation based systems in related research literature aim to enable parties to make decisions on which parties to negotiate/cooperate with or exclude, after they have been informed about the reputation ratings of the parties of interest. The authors in this study do not directly exclude / isolate the Sellers that are deemed misbehaving, but instead base the Buyers' decision on the most appropriate Seller 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*). The reputation mechanism considers both first-hand information (acquired from the *BA's* past experiences with the *SAs*) and second-hand information (disseminated from other *BAs*), while spurious reputation ratings are taken into account.

The rest of the paper is structured as follows. Section 2, presents the negotiation framework adopted in detail. Different contract ranking mechanisms are employed instead of the usual alternating sequential offers pattern, while the concept of decision issues is introduced. In Section 3, a collaborative reputation mechanism is presented aiming to offer an efficient way of building the necessary level of trust in the e-market. Finally, in Section 4, conclusions are drawn and directions for future plans are presented.

2 THE PROPOSED NEGOTIATION FRAMEWORK

In order to create a successful negotiation framework, the design of an appropriate protocol that will govern the interactions between the negotiation participants is necessary. Depending on the specific negotiation problem that needs to be solved, a protocol is the set of rules that correspondingly constrain the proposals that the negotiation parties are able to make. In this section, we initially describe the adopted negotiation protocol that is based on a ranking mechanism on the Buyer's side. Subsequently, an efficient dynamic negotiation model is presented, based on the multi-issue value scoring system introduced by Raiffa (Raiffa, 1982), in the context of bilateral negotiations. Based on the designed negotiation protocol, the proposed multi-party, multi-issue, dynamic model is exploited by the *SA* in its contract generation process, and by the *BA* during the contract evaluation phase. Our focus is laid on the rationale of the *SA*, while simplifying assumptions are made regarding the *BA's* logic. We consider that a negotiation is successful, if a mutually acceptable contract is reached within reasonable time. Since an exhaustive exploration of the possible contract space may form a computationally intensive task, the *SAs* are provided with a mechanism enabling them to find good (near optimal) solutions in reasonable time, by means of computationally efficient algorithms. The rest of this section is structured as follows. In subsection 2.1, the designed negotiation protocol and model are presented, while in subsection 2.2 the basic elements of the negotiation problem and the designed negotiation strategies are provided.

2.1 Designed Negotiation Protocol & Model

In the negotiation research literature, the interactions among the parties follow mostly the rules of an alternating sequential protocol in which the agents take turns to make offers and counter offers (Rubinstein, 1982). This model however necessitates an advanced reasoning component on behalf of the *BA* as well as the *SA*. In this study, we initially tackle a simpler case where *BA* does not give a counter offer to the *SA*, but ranks the *SA's* offers instead. This ranking is then provided to the *SA*, which generates a new offer hopefully closer to a mutually acceptable contract. This process continues until an agreement is reached, or one of the parties withdraws. This protocol is very efficient in case the *BA* is not able to express the user requirements/preferences in a completely quantified way, while being capable of selecting, classifying or rating the contract(s) proposed.

The protocol adopted can be described as follows. Once the agents have determined the set of issues over which they will negotiate, the negotiation process consists of an alternate succession of contract proposals on behalf of the *SA* and subsequent ranking of them by the *BA* according to its preferences and current conditions. Thus, at each round, the *SA* sends to the *BA* N contracts (i.e., N packets consisting on n-plets of values of the n contract issues), which are subsequently evaluated by the *BA* and a rank vector is returned to the *SA*. This process continues until a contract proposed by the *SA* is accepted by the *BA* or one of the agents terminates the negotiation (e.g., if the time deadline is reached without an agreement being in place). Even though negotiation can be initiated by *SAs* or *BAs*, only the *SAs* propose concrete contracts, as there is no counter offer generation mechanism for the *BAs*. We hereafter consider the case where the negotiation process is initiated by the *BA* who sends to the *SA* an initial *Request for Proposal* (*RFP*) specifying the types and nature of the contract issues and the values of all non negotiable parameters. The main issue is assumed to be the price of the good/service under negotiation, while various other issues may be considered as well.

Subsequently, we propose a dynamic model for agent negotiation that can be exploited by strategies in order to construct contracts acceptable to the opponent parties but which, nevertheless, maximise the agent's own utility function. The notation used by this negotiation model is as follows. The agents that represent *Sellers* are denoted by $S=\{S_1,S_2,...\}$ and the ones that represent potential *Buyers* are denoted by $B=\{B_1,B_2,...\}$. We introduce the notion of *decision issues* (*DIs*), issues that even though their values are not under negotiation and they are not included in the contract parameters, they affect the evaluation of the values of the contract issues. Without being exhaustive, such issues may consist of: the number of competitor companies, the number of substitute or complementary products/services, the quantity of product in stock, the number of current potential buyers, the time until the negotiation deadline expires, the resources availability and restrictions, etc. The values of the *DIs* may change overtime, depending on the e-marketplace conditions and on the Seller's and Buyer's state. The values of the *DIs* are denoted by d_j, $j=1,...,f$. We may now introduce the utility function of the proposed framework as follows. Let $U_i^a:[m_i^a,M_i^a]\to[0,1]$ denote the utility that agent $a\in S\cup B$ assigns to a value of contract issue i in the range of its acceptable values. In order for the utility function of any contract issue i for any negotiator to lie within the range $[0,1]$, the value of issue i must lie within the range of its acceptable values. To ensure this, we introduce the notion of *value constraints*, that is expressed as follows: $m_i^a\le c_i\le M_i^a$. In case the *value constraints* hold for all contract issues, the utility function can be used to measure the satisfaction of a negotiator as far as the proposed contract is concerned. Nevertheless, often, the value constraints are not met for some contract issues, thus constituting the contract completely unacceptable, regardless of the utility level. In this case, there is not much value in using the above specified utility function to measure the satisfaction degree of this negotiator, as the contract is completely unacceptable. Thus, we may introduce a *value constraint validity vector*: $VCV^a=[VCV_i^a]$,

$i = 1,...,n$, where $VCV_i^a \in \{0,1\}$, depending on whether the value constraint for negotiating party a is met for contract issue i (i.e., $VCV_i^a = 1$) or not (i.e., $VCV_i^a = 0$). The requirement of mere presence or absence of a particular feature can be reduced to value constraints and thus will not be further analysed.

Let w_i^a be the importance of issue i for agent a, where $\sum_{i=1}^{n} w_i^a = 1$. Using the above notation, the agent's a utility function for a contract $C_k = \{c_{k1},...,c_{kn}\}$ can be expressed by the following equation: $U^a(C_k) = \sum_{i=1}^{n} w_i^a U_i^a(c_{ki}, d_j^{t=t_k})$, where $d_j^{t=t_k}$, $j = 1,...,m$ is the value of decision issue d_j at the time t_k, when contract C_k is proposed. It should be mentioned that the utility function $U_i^a(c_{ki}, d_j^{t=t_k})$ may be of any form (e.g., linear, polynomial, exponential, quasilinear, etc.), as nonlinear formulations of the overall utility function do not affect the basic ideas of the model.

As already mentioned, the *BA* ranks the contracts proposed by the *SA*. For the simplest ranking function, the ranks that may be assigned to any contract proposed are boolean variables, i.e., one instance of the set $\{accept, reject\}$. A second ranking scheme may entail the identification of the contract best suiting the Buyer's needs without any further classification of the contracts proposed, while in a more sophisticated approach, the ranks lie within a range $[m_r, M_r]$, where any contract rated with less than M_r is not acceptable by the *BA*, while, when a contract is rated with M_r, then the proposed by the *SA* contract is accepted by the *BA*. In order to signal the case where at least one value constraint is not met for the BA for a certain contract, we introduce another parameter called *contract value constraints validity* that will be denoted by $CVCV_k^a$ for contract C_k and is given by the following equation: $CVCV_k^a = \prod_{i=1}^{n} VCV_{ki}^a$. Based on the previous analysis, in case all *value constraints* are met for contract C_k, it stands that $CVCV_k^a = 1$. On the other hand, in case at least one *value constraint* is not valid for contract C_k, it stands that $CVCV_k^a = 0$, and then the particular contract is definitely rejected.

Furthermore, the vector of the $N \geq 1$ contracts proposed by the Seller agent S to the Buyer agent B at time t is denoted by $P^t = \{C_1^t,...,C_N^t\}$, the vector of the n contract issues values proposed by S to B at time t for the k-contract of this proposal ($k = 1,...,N$) is represented by $C_k^t = \{c_{k1}^t,...,c_{kn}^t\}$, while the value of issue i proposed by S to B at time t for the k-contract of this proposal is denoted by c_{ki}^t ($i = 1,...,n$). Let now $R^t = \{r_1^t,...,r_N^t\}$ be the vector of ranking values that B assigns at time t to the previous contracts proposal made by S, and r_k^t ($k = 1,...,N$) be the rank that B assigns at time t to the k-contract of this proposal. The range of values acceptable to agent $a \in \{S, B\}$ for issue i is represented by the interval $[m_i^a, M_i^a]$.

A contract package proposal is accepted by B when at least one contract is rated with M_r, while the negotiation terminates in case the agent(s) deadline is reached or when a boolean variable expressing the wish of the agents to quit the negotiation is set to true. If an agreement is reached, then we call the negotiation successful, while in case one of the negotiators quits it is called unsuccessful. In any other case, we say that the negotiation thread is active. A detailed presentation of the negotiation protocol and model adopted can be found in (Roussaki, 2004a).

2.2 Negotiation Problem and the Designed Strategies

The objective of the negotiation problem on the Seller's side is to find a contract $C_{final} = \{c_{1final}, c_{2final},...,c_{nfinal}\}$ that maximises his/her overall utility function $U^S(C_{final})$, i.e., the satisfaction stemming from the proposed contract, within the negotiation deadlines for both the *BA* and the *SA*. Nevertheless, there are constraints on the acceptable value ranges that should apply for both negotiating parties, while their individual utilities should be above a minimum acceptable threshold (i.e., $U^S(C_{final}) \geq U^S_{\min Acc}$ and $U^B(C_{final}) \geq U^B_{\min Acc}$). Based on the selected protocol and the proposed model, designing a negotiation strategy can be reduced to a decision problem on finding the contract package proposal $P^{t_{l+1}} = \{C_1^{t_{l+1}},...,C_N^{t_{l+1}}\}$ of the N contracts $C_k^{t_{l+1}} = \{c_{k1}^{t_{l+1}},...,c_{kn}^{t_{l+1}}\}$ ($k = 1,...,N$) that should be proposed by the *SA* to the *BA* in the next round $l+1$, given the vector $P^{t_l} = \{C_1^{t_l},...,C_N^{t_l}\}$ proposed by the *SA* to the *BA* during the previous round l, the vector $R^{t_l} = \{r_1^{t_l},...,r_N^{t_l}\}$ of the ranking values $r_k^{t_l}$ ($k = 1,...,N$) that the *BA* assigns to the previously made by the *SA* contract proposal at the negotiation round l and the value constraint validity vector $VCV_k^B = \{VCV_{ki}^B\}$ ($i = 1,...,n$) for at least one of the contracts proposed subject to the *SA's* related constraints and to the existent resource and computational limitations.

The complexity of the negotiation problem is increased with regards to the number of the contract issues involved and the range of their acceptable values. In this respect, the design of computationally efficient algorithms that may provide good (near-optimal) solutions in reasonable time is required.

A detailed presentation of the proposed negotiation strategies can be found in (Louta, 2004a), (Louta, 2004b), (Roussaki, 2004b). The general idea is that all contracts $C_k^{t_l}$ ($k=1,\dots,n$) of a negotiation round l are generated by the same "source" contract that will be hereafter denoted as $C_0^{t_l}$. All contracts of the same round are generated so that they correspond to equal utilities for the Seller. Specifically, N contracts are proposed at each negotiation round l, which yield the same utility concession quantity Θ^{t_0} with respect to the source contract $C_0^{t_l}$. Thus, the utility of the contracts proposed is equal to $U^S\left(C_k^{t_l},\underline{d}^{t_0}\right)=U^S\left(C_0^{t_l},\underline{d}^{t_0}\right)-\Theta^{t_0}$, while $U^S\left(C_k^{t_{l-1}},\underline{d}^{t_0}\right)=U^S\left(C_0^{t_l},\underline{d}^{t_0}\right)$, $\forall k=1,\dots,n$. Utility concession quantity Θ^{t_0} has been considered to be constant and equal to $(U_{\max}^{S,t_0}-U_{\min Acc}^{S})/L$ for each negotiation round, where L is the number of negotiation rounds that could take place before the *SA's* negotiation deadline is reached. It has been assumed that the values of all decision issues are invariable for the entire negotiation procedure. It is noted that in case an agreement between *BA* and *SA* is feasible (that is there exist at least one contract $C_k^{t_l}$ for which it stands: $U^S\left(C_k^{t_l}\right)\geq U_{\min Acc}^{S}$ and $U^B\left(C_k^{t_l}\right)\geq U_{\min Acc}^{B}$), our approach will succeed in identifying a mutually acceptable contract due to the fact that as its deadline approaches, the *SA* concedes up to its reservation value $U_{\min Acc}^{S}$.

Based on the *RFP* sent by the *BA*, the *SA* proposes an initial contract $C^{t_0}=\{c_1^{t_0},\dots,c_n^{t_0}\}$ to the *BA* at $t=t_0$, setting all contract issues at the values that maximise the Seller's utility (i.e., if $\partial\left[U^S\left(C_k,\underline{d}^{t_0}\right)\right]/\partial c_i>0$, then the *SA* sets $c_i^{t_0}=M_i^S$, while in case $\partial\left[U^S\left(C_k,\underline{d}^{t_0}\right)\right]/\partial c_i<0$, then the *SA* sets $c_i^{t_0}=m_i^S$). The utility of the initial contract C^{t_0} for the *SA* is denoted by: $U^S\left(C^{t_0},\underline{d}^{t_0}\right)=U_{\max}^{S,t_0}$, as $U_{\max}^{S,t_0}$ is the maximum utility that can be achieved for the Seller, given the values of the decision issues $\underline{d}^{t_0}=\{d_j^{t_0}\}$ at time $t=t_0$. With respect to this initial contract C^{t_0} two distinct cases may be identified. First, no *value constraint violation* exists and the Seller aims to find a contract satisfying the Buyer's utility constraint. Second, *value constraint violation* occurs, in which case the *BA* also provides its *value constraint validity vector* VCV_0^B, while the *SA*, initially tries to generate a contract that satisfies the *BA's* value constraints. Until a non value constraint violating contract C^{t_l} is acquired, at each negotiation round $l>1$ the source contract $C_0^{t_l}$ is generated based on the contract $C_0^{t_{l-1}}$ by distributing the utility concession Θ^{t_0} amongst the contract issues, whose values are not acceptable to the *BA*. This process continues until a non value constraint violating contract C^{t_l} is produced, in which case the *SA's* strategy is modified in order to generate a mutually acceptable contract within reasonable time.

3 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 (Atif, 2002) that monitor every transaction, which is very costly and sometimes impossible to apply due to the complexity and the heterogeneity of the environment. Misbehaviour means deviation from regular functionality. In the most general case, it may be unintentional (due to faults) or intentional in order for selfish parties to take advantage of certain situations. Reputation mechanisms are claimed to provide a "*softer*" notion of security considered to be sufficient for many multi-agent applications (Zacharia, 2000). In essence, they discourage the parties involved from misbehaving, since the gains expected by future potential contracts establishment due to a higher reputation rating can offset the loss incurred by honouring the transaction terms. Dissemination of reputation related information to a large number of negotiating participants may multiply the expected future gains of honest negotiation parties.

Our study is related to previous pertinent work in the literature, since reputation based mechanisms is a quite popular research field, attracting researchers working in various different areas (Buchegger, 2005). In most cases, a reputation based mechanism is used in order to automatically isolate a misbehaving party. Thus, the goal of a reputation system is to enable parties to make decisions on which parties to negotiate / cooperate with or exclude, after they have been informed about the reputation ratings of the parties of interest. Feedback received from negotiating participants related to an agent's past behaviour may be formulated as a reputation measure exploiting learning from experience concepts. The reputation related information obtained may be used by the parties in order to adjust their decisions and behaviour. In this study, 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 3.1 the fundamental concepts of our proposed collaborative reputation mechanism are given, while Section 3.2 provides the mathematical description of the reputation ratings and of the Buyers' decision.

3.1 Reputation Rating and Buyer Decision Fundamentals

Assuming the presence of *M SAs* negotiating with a *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 cannot 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. According to the simplest possible approach that may be adopted in order to account for possible inaccuracies to the feedback provided to the *RM* by the *BAs* (both intentional and unintentional), the *BA* can mostly rely on its own experiences rather on the *SAs'* reputation ratings provided by the *RM*. To this respect, *SAs'* reputation ratings provided by the *RM* may be attributed with a relatively low significance factor. In the context of this study, we consider that each *BA* is associated with a predetermined trust level, which reflects whether the *BA* reports to the *RM* its experiences with the *SAs* truthfully. To be more specific, an honesty probability is attributed to each *BA*, i.e., a measure of the likelihood that a *BA* gives feedback compliant to the real picture concerning service provisioning. Second-hand information obtained from trustworthy *BAs* (associated with a high honesty probability), are given a higher significance factor, whereas reports (positive or negative) coming from untrustworthy sources have a small impact on the formation of the *SAs'* reputation ratings kept by the *RM*.

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.

3.2 Formulation 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 the context of this study, 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. RR_{BA} is calculated based on equation (1), while RR_{RM} is obtained through the following formula:

$$RR_{post}(S) = RR_{pre}(S) + k_r \cdot l(R) \cdot T(B) \cdot (rr(S) - E[rr(S)]) \quad (3),$$

where $T(B)$ is the trust level attributed to the *BA*. It stands $T(B) \in [0,1]$ with level *1* denoting a fully trusted *BA*.

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 $w_{RM} < w_{BA}$ giving thus a higher significance value to the BA's own experiences.

According to the presented approach, the value of w_{RM} could be close to the value of w_{BA} since potential erroneous decisions (based on fake and misleading feedbacks) are avoided by incorporating to the formation of the RR_{RM} values the trustworthiness of each *BA*. This way, the limitations of the simplified approach (e.g., underestimation of all *BAs'* reports, even those reflecting the real picture) are overcome. At this point it should be noted that we have assumed that the trustworthiness of each *BA* is known and is not modified in the course of time.

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

$$A_{PR} = w_p \cdot U^B(C_{final}) + w_r \cdot RR(S) \quad (4)$$

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., $w_p + w_r = 1$).

4 CONCLUSIONS

This paper initially presented a dynamic multi-lateral negotiation model and efficient negotiation strategies based on a ranking mechanism that replaces the counter offer complicated scheme. The proposed framework 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 agents hold private information which may be revealed incrementally, only on an as-needed basis. The designed strategies assume that the negotiators face strict deadlines, which mostly is considered to be private information. Since e-marketplace is commonly perceived as an environment offering both opportunities and threats, in order to cope with negotiating parties' misbehaviour, as a second step, the proposed framework 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-hand information (acquired from the Buyer's past experiences with the Sellers) and second-hand information (disseminated from other Buyers' past experiences with the Sellers), while spurious reputation ratings are taken into account.

The negotiation framework designed has been adopted by self-interested autonomous agents and has performed well, always converging to a mutually acceptable contract, if any, due to the fact that the Seller concedes to his reservation value as his deadline approaches. Initial results 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 the incorporation to our model of adaptive trust ratings for the Buyers without predetermined values and 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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