Reputation Model with Forgiveness Factor for Semi-Competitive E-Business Agent Societies

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Abstract. In this paper we introduce a new reputation model for agents engaged in e-business transactions. Our model enhances classic reputation models by adding forgiveness factor and new sources of reputation information based on agents groups. The model was implemented using JADE multi-agent platform and initially evaluated for e-business scenarios comprising societies of buyer and seller agents.

1 Introduction

Reputation is one of important concepts that helps selection of partners in e-business transactions. Participants to a global electronic market, usually buyers and sellers, are represented using software agents. Similarly to human society, an agent will agree to engage in a new business relation governed by a set of contractual terms and conditions, only with reputable business partners. This means that, if an agent has a good reputation in a society of agents, other agents will decide to select him for engaging together in future business transactions.

Closely related to reputation is concept of trust. Although there is no full agreement on their definitions, usually *trust* is understood as a subjective measure of an agent's belief in another agent's capabilities, honesty and reliability based on its own direct experiences (one-to-one relationship), while by *reputation* is understood an objective measure of an agent's belief in another agent's capabilities, honesty and reliability based on recommendations received from other agents (one-to-many relationship) [1].

So, in order to clarify the terminology, given two agents a and b, we shall talk about reputation of agent a for agent b as the measure of the degree of b's belief in the capability, honesty and reliability of agent a. We shall denote this value with $R_{b,a}$. In this paper we only consider reputation, as we believe that this concept is more appropriate to e-business domain. Note that according to this view of reputation a and b can be either singleton agents or groups of agents.

Traditionally, reputation is evaluated by collecting feedback during history of previous interactions between business partners [1], [2]. There are many approaches for modeling and evaluation of reputation in agent systems, ranging from simple rating methods to more complex mathematical models based on graphs or sophisticated uncertainty or logic models ([3], [4], [5]).

In our proposal we model e-business as a semi-competitive environment where agents will have to decide if to engage or not in e-business transactions with a given

partner [4]. Their decision is taken based on reputation of the potential partners, i.e. the higher partner's reputation, the higher is considered agent's utility by engaging with that partner.

In our model we consider that agents are grouped into "societies". We consider two societies: buyer society and seller society. With respect to these two societies, following an initial proposal from [4], depending on the sources of information that we use for computing reputation, we define four types of reputation: (i) direct reputation of a given seller for a given buyer; (ii) direct reputation of a given buyer for a given seller; (iii) reputation of given seller for buyers' society; (iv) reputation of sellers' society for given buyer. Direct reputations (i.e. first two types) are then augmented with forgiveness factor model [6] that basically proposes the application of "philosophy of reconciliation". This means that, as time is passing, each agent should forget the mistakes made by his or her partner in former e-business transactions. Additionally, our forgiveness factor model introduces an optimistic view of the reality. This means that an agent should always give credit to his partner, i.e. initially or equivalently after a sufficiently large time passed without any interaction, reputation of the partner should have or increase to the highest possible value.

The paper is structured as follows. We start in section 2 by introducing our model with forgiveness factor. We continue in section 3 with an outline of the multi-agent system that we used in our simulation. In section 4 we present some experimental results, while in section 5 we conclude and point to future works.

2 Reputation model with forgiveness

Reputation types. E-business transactions are modeled as "signed contracts". A contract is signed between a buyer and a seller following a negotiation process. The buyer sends a call for proposals to each member of the seller society. Some sellers are able to satisfy the terms and conditions of the call and decide to cooperate by submitting a proposal. The buyer will select a preferred seller (that maximizes his own utility) and this selection will define a "signed contract" between the buyer and selected seller.

A contract between two agents specifies terms of the service that provider agent agrees to offer to requester agent. For example, if the provider is a seller and the requester is a buyer, the contract will specify the terms of the sell, including things like: on time delivery, delivery of the right product, etc. If $\mathcal{S}$ is the set of terms and each term k has a given weight w_k that measures the importance of the term for the requester then the requester can evaluate the contract as: $C = \sum_{k \in \mathcal{S}} w_k t_k$ where $t_k = 1$ if requester agent is happy with term k of delivered service, otherwise $t_k = 0$. Note that, as weights of service terms satisfy $w_k \geq 0$ and $\sum_{k \in \mathcal{S}} w_k = 1$, it easily follows that $0 \leq C \leq 1$.

In our model we consider two agent societies: buyer society $\mathcal{B} = \{b_1, b_2, \ldots, b_m\}$ and seller society $\mathcal{S} = \{s_1, s_2, \ldots, s_n\}$. Buyer agents are looking for engagement in e-business transactions with seller agents. A transaction involves signing and carrying out a contract between two agents. Based on societies and following proposal of [4], we define four types of reputation measures.

Direct reputation is defined between a buyer agent and a seller agent based on results of past contracts made between them. If $\mathcal{B} = m$ and $\mathcal{S} = n$ then we can

define $2mn$ reputations between b_i and s_j (note that reputation relation is not symmetric). Value of direct reputation is updated after each contract with formula $R' = \lambda C + (1 - \lambda)R$ where R' and R are new and previous values of direct reputation, while C is the value of last contract carried out between the agents. Parameter $0 < \lambda < 1$ controls the relative importance of the value of the current contract in the updated value of direct reputation.

Note that we have both *direct reputation of a given seller for a given buyer*, as well as *direct reputation of a given buyer for a given seller*. This is not difficult to understand as one can easily note that a contract signed between a buyer and a seller defines a set of commitments for seller, as well as a set of commitments for buyer. For example, the seller commits to deliver a product with a given set of features, at a given price and before a given deadline, while the buyer commits to accept and pay for a delivered product with the given set of features that was received on time.

Reputation of given seller for buyers' society is defined between buyer society and each member of the seller society and defines the image of the seller for the entire buyer society. This reputation is influenced by the direct reputation of given seller for each buyer. If $\mathcal{S} = n$ then we can define n reputations between $\mathcal{B}$ and s_j. Reputation of given seller for buyers' society is computed as average of direct reputations of given seller j for each member i of buyer society i.e. $R_{\mathcal{B},j} = (\sum_{i \in \mathcal{B}} R_{i,j})/m$, where $R_{i,j}$ is direct reputation of seller j for buyer i.

Reputation of sellers' society for given buyer is defined between each member of buyer society and seller society. This reputation is influenced by the direct reputation of each seller for given buyer. If $\mathcal{B} = m$ then then we can define m reputations between and b_i and $\mathcal{S}$. Reputation of sellers' society for given buyer is computed as average of each seller j for given buyer i, i.e. $R_{i,\mathcal{S}} = (\sum_{j \in \mathcal{S}} R_{i,j})/n$, where $R_{i,j}$ is direct reputation of seller j for buyer i.

Forgiveness factor. Reputation is cumulative and dynamic, so it depends on time. As time is passing reputation will be updated in the following two ways: (i) whenever a new contract is signed and carried out between a seller agent and a buyer agent, reputation is updated to reflect the status of contract results; (ii) whenever a sufficiently large quiescence time Δt without any signed contracts has passed, reputation is updated by being slightly increased.

Forgiveness factor acts by triggering the update of direct reputation according to the following equation: $R(t + \Delta t) = \min\{(1 + \alpha)R(t), 1\}$. Here Δt and $\alpha > 0$ are parameters of forgiveness factor model. Parameter α controls the proportion by which reputation is increased, while Δt controls the speed at which reputation is increased. Note that according to this equation, reputation value will also be almost 1. If no contracts are signed for a long time then the value of reputation will converge to 1, thus reflecting our optimistic view of the reality.

3 Design and implementation

We designed and implemented an agent-based simulation system of our reputation model using JADE multi-agent platform [7]. According to our model, in the system we can find two agent groups: *Sellers* group and *Buyers* group.

Note that in our simulation model we have experimentally evaluated only three types of reputations, as follows: (i) direct reputation of a given seller for a given buyer, (ii) reputation of given seller for buyers' society, and (iii) reputation of sellers' society for given buyer. Basically this means that in our simulation model we have only recorded how buyers evaluate sellers based on contracts signed between them.

Buyers group contains the following types of software agents: (i) *Buyer* agent is basically the agent that acts as buyer in an e-business application. More than one agent of this type may be started in the simulation, and each of them represents a different buyer that can select sellers to interact with. At least one *Buyer* is required for running a simulation; (ii) *BuyerManager* agent acts as manager of the buyer society. Only one agent of this type is allowed in a simulation; (iii) *Interpreter* agent acts as interpreter of the information that is captured during a simulation. Its main purpose is to analyze and interpret this information in order to dynamically generate an HTML form that displays simulation results regarding seller society.

Sellers group contains *Seller* agents. A *Seller* agent is basically the agent that acts as seller in an e-business application. More than one agent of this type may be started in the simulation, and each of them represents a different seller that the buyers may select to interact with. At least one *Seller* is required for running a simulation. Note that as in our simulation we only let buyers evaluate contracts signed with sellers, interpreter and manager agents for *Sellers* group were not needed.

During a simulation, each buyer b_i has a specific number of contracts c_i to sign before it goes offline. There is a time unit θ between two consecutive signings of contracts for each buyer, so the buyer and the chosen seller can communicate properly. This interval models the time required for carrying out a given contract. It follows that the simulation time of each buyer agent i is equal to $c_i\theta$. If each buyer b_i starts its activity at time T_i then the total simulation time will be $\max_{1\leq i\leq m}\{T_i + c_i\theta\} - \min_{1\leq i\leq m}\{T_i\}$, where m is the total numbers of buyers that participate in the simulation.

First step of our simulation is creation of *Seller* agents. When a *Seller* agent goes online, it first registers to JADE's *Directory Facilitator – DF* agent [7], and then it initializes the types of items it is able to sell. During the simulation, each *Seller* agent handles requests for items from *Buyer* agents.

The simulation is driven by *Buyer* agents, that continuously contact *Seller* agents in order to sign new contracts. When a new *Buyer* agent goes online it first gets the list of *Seller* agents that are currently available in system by querying *DF* agent. In the next step it sends the list of available *Seller* agents to the *BuyerManager* agent and then informs the *BuyerManager* agent that it starts the simulation – i.e. the process of contacting *Seller* agents for signing new contracts.

BuyerManager agent is used for centralizing all the information acquired during a simulation by storing it into a database. In order to achieve its purpose, this agent is continuously updated by *Buyer* agents, whenever new information is generated during simulation, until the end of simulation is reached.

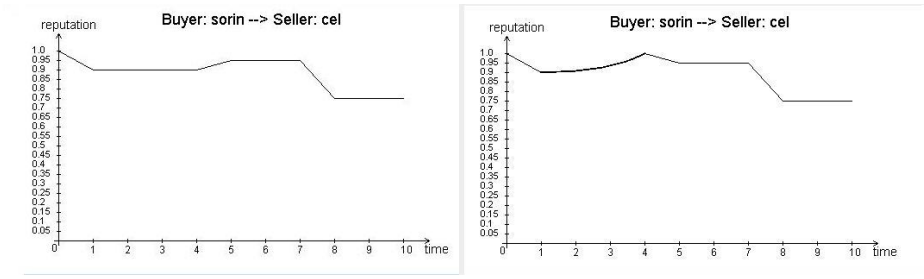
Interpreter agent is used for analyzing information acquired during a simulation. This agent gets notifications from each *Buyer* agent when they reached their maximum number of contracts, then starts the analysis of acquired information and finally displays results.

4 Experimental results

We have performed a series of experiments with our multi-agent simulation system of reputation with forgiveness factor. In this section we discuss results obtained with a simple scenario consisting of 2 buyers named *sorin* and *radu* and 2 sellers named *cel* and *emag*. In this scenario a buyer evaluates results of a contract according to 4 criteria: delivery problems, quality of item bought problems, pricing problems, and other problems. Weights of these criteria were set as follows: $w_1 = 0.2$, $w_2 = 0.4$, $w_3 = 0.3$, and $w_4 = 0.1$. Parameter that controls importance of the current contract in updating direct reputation was set to $\lambda = 0.5$. Number of contracts signed by each buyer was set to $c_i = 10$.

Parameters of forgiveness factor model were chosen as follows: (i) quiescence time for increasing reputation was set $\Delta t = 3\theta$, where θ is the unit time of the simulation; unit time was set to 1 second in our experiments; (ii) proportion by which reputation is increased was set to $\alpha = 0.1$.

Figure 1 shows a comparison of direct reputation without forgiveness factor (figure 1a) with direct reputation with forgiveness factor (figure 1b) of seller *cel* for buyer *radu*. On figure 1b, note that for 3 time units (contracts with numbers 2, 3, and 4) buyer *radu* does not sign any contract with seller *cel*. Therefore, according to the rule of forgiveness factor, reputation is increased with 10 %. On the other hand, on figure 1a note that reputation remains constant while no new contracts are signed.



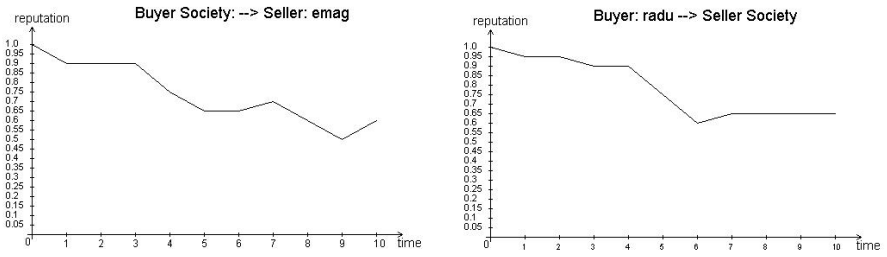
a.Direct reputation without forgiveness factor. b.Direct reputation with forgiveness factor.

Fig. 1. Comparison of direct reputations of *cel* seller for *sorin* buyer without (left) and with (right) forgiveness factor.

Figure 2 shows evolution of reputations involving buyer and seller societies. Figure 2a displays reputation of *emag* seller agent for buyer society. Note that this value of reputation was obtained by averaging direct reputations of *emag* seller for each of *radu* and *sorin* buyer agents. Figure 2b displays reputation of seller society for *radu* buyer agent. Note that this value of reputation was obtained by averaging direct reputations of each of *emag* and *cel* seller agents for *radu* buyer agent.

5 Conclusions

In this paper we proposed a simple reputation model for agent societies encountered in e-business applications. The model is enhanced with addition of forgiveness factor



a.Reputation of *emag* seller agent for buyer society.

b.Reputation of seller society for *radu* buyer agent.

Fig. 2. Reputations involving buyer and seller societies.

parameters, according to the philosophy of reconciliation and considering an optimistic view of reality. The model was experimentally implemented and initially evaluated with the help of JADE multi-agent platform in a scenario involving two agent societies: buyer society and seller society. We plan to extend our simulation system to be able to model other forms of reputations (for example to capture how sellers evaluate buyers). Moreover, we plan to perform more experiments with a significantly larger number of buyer and seller agents.

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