INCREASING PROFIT IN AGENT BUSINESS MODEL WITH TRUST

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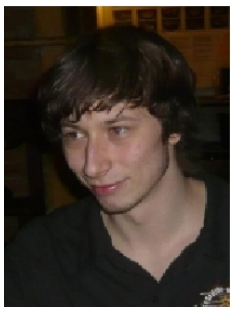
Abstract

Development of new technology also brings new areas where it would be appropriate to automatize or simulate human activity. One way to achieve this is to use agent systems. In these cases the agent as a software component represents the human decision-making process and acting on his behalf. To achieve its goals often needs to cooperate with other agents. Trustworthiness of these agents may play a key role in efforts to achieve these goals. In real life in these cases is decisions made based on the experience with that partner. How to handle with these experiences and how they determine the risk of cooperation is one of the topics of artificial intelligence. A possible solution is to use the principles of trust and reputation. There are many studies in different objectives. This article aims to propose a model of trust and reputation based on the standard human decision-making, with application mainly in the field of e-commerce.

Keywords: Trust and reputation, Multi-agent systems, Simulation model.

Presenting Author's Biography

Ondřej Malačka graduated in 2009 at the Faculty of Information Technology, Brno University of Technology. Later that year he started his Ph.D at the same faculty in Brno. His research interests are in simulation of multi-agent systems and artificial intelligence.



1 Introduction

One of the main goals of intelligent systems and especially agent systems is to replace the human in acting and decision-making. This brings many problems to solve. The situation is even more difficult in the presence of other agents in the environment, representing the interests of someone else. In this case the interaction is often desirable or even necessary. However, such interactions may involve some risk associated with the reliability of the other parts. There are many approaches to eliminate this risk. One of many of them is to use trust and reputation principles.

Today, these principles are used in a wide range of applications. One of the most common areas is e-commerce. Often it is impossible to know all the entities involved in trade, especially in the anonymous Internet. It is desirable to have a safety mechanism to eliminate possible misbehaviour in this case. Especially when considering that there are significant financial flows. An example of such a system is an Internet auction house eBay [1]. Seller reputation is calculated based on buyers rating and vice versa. The buyer in this case is not able to determine how this reputation is calculated due to the central calculation. The advantage is that the whole reputation mechanism is directed by the provider, in this case by eBay servers. Reputation is calculated as the average of all ratings in six months. This approach has the disadvantage on the other hand: the high demands on the performance of the provider and the overall evaluation is not subjective. Therefore, a large number of models of trust and reputation was proposed, such as [2, 3, 4, 5]. A brief description of these and some other models can be found in [6] and [7]. We are primarily interested in models for distributed systems, especially with use in e-commerce. In this paper are described basis of our trust and reputation model, possible application scenario, experiments with trust and reputation model in system of this scenario and future expansion of our trust and reputation model.

2 Trust and reputation model

The main aim of our trust and reputation model is to reflect the human decision-making in selecting a vendor to purchase. In the real world, we can simplify this decision in this process:

- If I have enough personal experience with the seller, the decision is made on the basis of these experiences.
- If I do not have enough direct experiences, I try to ask other trusted people for their views on the seller.
- Trustworthy people do not have direct experience, but can provide information about other persons who are credible and the information may have.
- In case of lack of information or even no information there is an important risk associated with trade. Usually, the main risk is the product price.

These conditions therefore define the basic requirements for the model. Another requirement is that recent information had greater influence on the overall calculation. First, this paper describes a model for assessing trust based on direct experiences, and then the model will be expanded on the principles of reputation.

Input values for calculation of confidence are positive numbers corresponding with interactions with the entity whose confidence is evaluated. It is on the application, how those values will be determined. The calculated value of trust will also be in the range of this numbers. Requirement is to evaluate fully correct behaviour with number 0. Values indicate how much the agent behaviour differs from the fully correct behaviour. Also how to convert the product price to a similar value is determined by specific application. For the calculation of confidence it is necessary to create two lists. The first list (denoted by *o*) is composed of the values described above. At the front of the list there is the value of the actual transaction price (denoted *c*) and other values in the list are the values of evaluation of interactions sorted form the oldest to the newest (denoted by *h* with using time index). Thus we defined it as a list of interactions:

$$o = (o_0, o_1, ..., o_{n-1}) = (c, h_{t0}, ..., h_{t(n-2)}) \quad (1)$$

The second list is a list of weights (denoted by v). Each value in the first list corresponds with exactly one value in the list of weights:

$$v = (v_0, v_1, ..., v_{n-1}) \quad (2)$$

The weights are calculated as follows:

$$v_i = \frac{\frac{2i}{n(n-1)} + \frac{p}{n}}{p+1} \quad (3)$$

In this formula, the variable n corresponds to the total number of values in the list of weights/interactions. The variable p is arbitrarily adjustable positive number. Increasing p-value causes smaller spacing between weight values. Sum of all weights in the list will always be equal to one, which will be beneficial for the final calculation. More recent information could be favoured by a variable p.

The weights thus reflect the time only as a sequence of interactions. In our case, it allows us to deal with the risk associated with the price of the product so that their influences decrease with the amount of information. Now we are familiar with all the elements for calculating the reliability of any entity on the basis of direct experiences. At the end there are two lists **v** and **o** considered as vectors and there is calculated their inner product:

$$N = \sum_{i=1}^{n-1} v_i o_i \quad (4)$$

The resulting value *N* is the size of no-confidence in the seller. There are more ways to determine whether

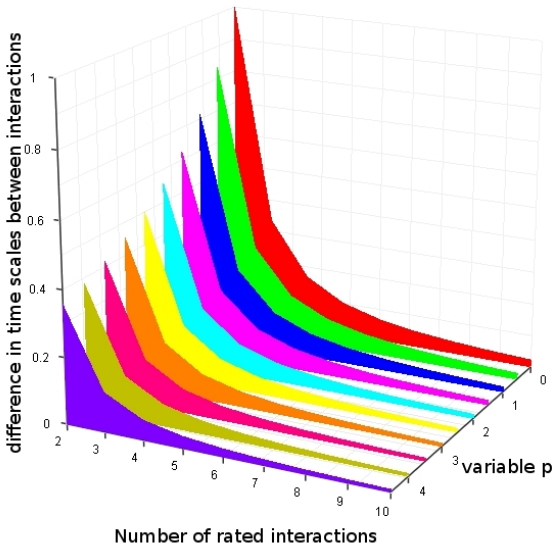


Fig. 1 the impact of variable p

to initiate a trade with the seller or not. Often decisions are based on the selected threshold *t*. In our case, if the *N* is above then threshold *t*, then business may be risky. However, often could be better to use the computed value as only one of several factors, when deciding if to purchase the product. For example, we consider whether it is profitable for us to buy a product which price may be overestimated in proportion to the calculated value. Thus the calculated value is also seen in our experiments.

In the case of using this trust model in distributed systems, we find out that the number of interactions among the various entities will often be small. The model is therefore necessary to extend about the principles of reputation. Comprehensive model of reputation will be the subject of future research. In this paper, we will focus only to a simple model. We will not combine direct experiences with indirect experiences. Interrogation other agents for information about seller is done only when it is impossible to calculate the value of trust from own experiences. Asked agents are only those agents whose are trusted in this context. From a rational point of view we can expect that the trusted agents will be interested in the dissemination of such information. In the other hand, it is expected that an agent who is lying in the trade, is likely to lie in the provision of such information. Context of agent trust as a seller and as a witness are together in some way related.

Interrogation about target agent (agentC) is then implemented recursively. There are three answers from queried agents (agentB) based on their knowledge as shown in Fig. 2:

- If they have any experiences with a target agent, they provide information about these experiences.
- They don't have with the target agent experiences but they know other trustworthy agents. They provide a list of these trustworthy agents.
- They don't have any experiences and don't know any other agents which might this experiences have.

Queried agents provide only information to trusted agents. There are two contexts. One is credibility in the provision of specific services, second is provision of information about the trust of other agents. These contexts are closely related. When an agent gets enough of the necessary information or there is no agent to ask, the interrogation is over. Decision how to combine this information is on concrete application. In our experiments the information are used in a similar way as in the case of direct trust. The value is calculated separately for the information obtained from various sources and by averaging the final value is calculated. Another possible approach could for example be based on combining the information from various sources on the basis of their credibility, especially in the context of the referral.

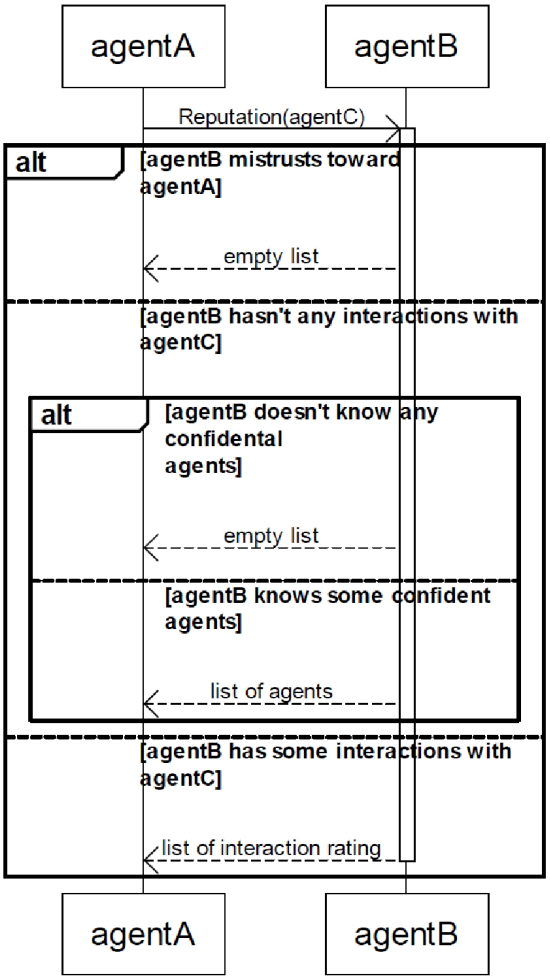


Fig. 2 Query diagram

3 Model of the system

Our effort was to create a business model to simulate situations in which people have objectives in conflict, but to achieve these objectives they have to cooperate in some way. Consider a closed system with number of acting managers. Their goal is to maximize their profit. Profit is generated on the basis of ownership of a limited number of certain commodities, their quality and also comparison with competitors. The dynamics of the environment is determined by random generation of new commodities in the system and by the aging of these commodities with the dependence on the quality and the life cycle of the commodity. All this should contribute to an adequate system complexity. The proposed model is composed of fully autonomously acting agents representing managers and also the environment in which they act. The greatest emphasis in the design of the agent, was placed on decision-making mechanisms. Agents are able to completely independently evaluate the current situation and find out whether it would be desirable to buy/sell any of the commodities. Purchases and sales play a key role in achieving the intentions (maximum profit) of these agents (managers). Agents do trying to achieve any given fixed targets. Like in the real world they are constantly trying to improve their situation. Buying and selling are distributed. All agents are able to produce English type auction Fig. 3. The price of commodities is not fixed and depends

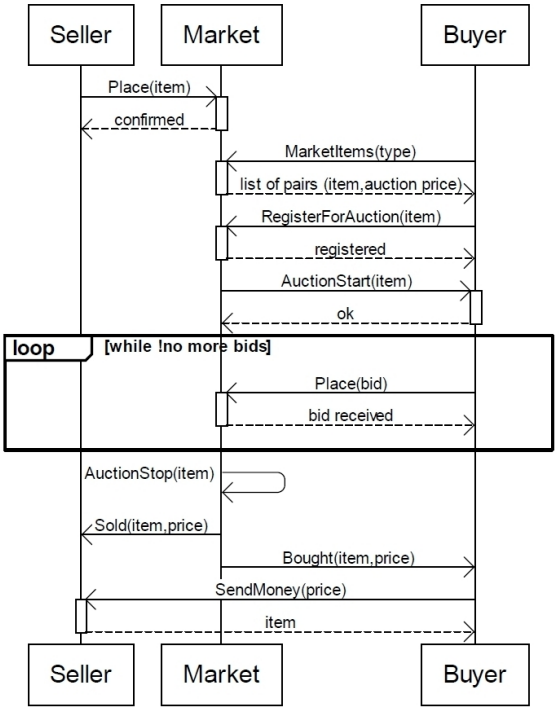


Fig. 3 Auction protocol

mainly on demand. It may for example happen that in the system will be lack of some type of commodity and thus will be increased the price due to demand and the principle of auction (the highest bid wins). All agents have the same financial capital at the beginning of simulation (10M$) and each receives a commodity with similar quality, which enables their basic functioning. Parameters of products, especially quality, determine their basic price (influenced by demand). Important role in purchasing decisions and calculating how beneficial to the manager is correct knowledge of the product parameters. Parameters of the products are fully known only to their owners. Other agents have only partial knowledge about these parameters. Parameters, which are unknown to non-owner agents, have sufficiently large impact on quality of product. Their seller decides whether they provide true or false information about them. Confidence plays a key role in decision making. Our goal is to monitor how much beneficial it could be improper behaviour and how to defend against him and especially to prevent it. Proposed model of trust and reputation is then used as a safety mechanism. Experiments with such a simulation model are described in the following chapter.

4 Performed experiments

On this basis, a simulation model in Jason [8] with using AgentSpeak and JAVA was created. On this simulation model have been performed several experiments. Variable p which has influence on the computation of trust and on favouritism newer informations was set up to 1. It means that newest interaction has 3 times higher bias on final trust value than oldest one (as you can see in equation 1). All experiments were executed with 16 agents/managers. All agents had almost the same decision logic. The difference was only in reliability of this agents (*honesty* parameter of agents) and in using trust and reputation model. The *honesty* parameter was set randomly. Reliability of the agents was not only dependent on their honesty, but partly also on their financial situation (if the agent has financial problems, there is a slightly greater chance that he will behave incorrectly).

The first experiments were aimed to verify whether the developed model behaves as is expected from it. Half of the agents were chosen to provide sometime false information about the products. It was assumed that if some agents overvalue their product, they must achieve greater profits than correctly behaving agents. The rate of incorrect behaviour was directly proportional to the financial problems of the agent and the agent's honesty parameter. In this experiment, agents do not use any protection against incorrect behaviour. The purpose of these experiments was only to validate simulation model and to detect advantages which result from incorrect behaviour. Further experiments were aimed at verifying the benefits of using the principle of trust in these experiments. The situation was reversed and trustworthy agents achieve higher profits than untrustworthy agents. This happened mainly because of the gradual isolation of untrustworthy agents during the experiments. But, as expected, each agent has to obtain their own experience with each other and every other agent can at least once fool him. For large distributed systems applications of the principles of trust has brought only small improvements (more agents = more unknown managers at the start of simulation).

Another series of experiments was therefore also with using the reputation mechanism. Trusted agents gained better profit than the untrustworthy agents much earlier than in previous experiments. Summary of these experiments is in table 1. This table shows the total profits of the agents, but also profits which are related only with the sale of overvalued products, mainly due to providing false informations.

Tab. 1 Experiments, trusted × untrusted agents 1:1

	Trusted agents		**Untrusted agents**	
	øprofit [M$]	øprofit from lying [M$]	øprofit [M$]	øprofit from lying [M$]
no trust and reputation	-13,52	-10,38	17,22	10,38
Only trust	12,83	-3,36	-3,56	3,36
Trust and reputation	17,76	-1,16	-9,34	1,16

The importance of reputation principles would continue to grow with the increasing number of agents in the system. In this experiment, there was a very rapid spread of information about the behaviour of agents. Its time complexity due to the number of agents in the system was only logarithmic. Possibilities of such a model are thus much better than when using only a direct experience. But it would be appropriate to extend the model so as to be able deal with more sophisticated attacks. This will be the subject of our future research. Recent experiments have focused on comparing the difference between profit trustworthy and untrustworthy agents, with varying proportions of these agents. Also, the principles of trust and reputation were only used by a number of agents. Results are showed in table 2 and figure 4.

Tab. 2 Comparison of profit agent using trust and reputation model with untrustworthy agents (difference in M$)

		Number of untrusted agents in system						
		2	**4**	**6**	**8**	**10**	**12**	**14**
Number of agents using trust	**2**	-16,04	-12,72	10,11	20,48	23,43	9,04	34,97
	4	-4,05	-5,28	9,86	15,29	24,72	30,04	30,12
	6	-5,83	-9,15	9,18	23,05	32,55	25,56	29,46
	8	2,12	3,43	18,19	25,04	44,24	22,62	35,43
	10	-5,87	5,3	20,31	39,77	22,3	36,83	51,24
	12	29,46	11,02	25,85	31,38	41,56	33,45	46,48
	14	36,93	32,6	38,77	43,65	47,81	48,22	59,4

As you can see in the chart, with the increasing number of agents using trust and reputation model decreases the profit of agents who behave improperly at the expense of agents behaving correctly. As you can see in the chart, with the increasing number of agents using trust and reputation model decreases the profit of agents who behave improperly at the expense of agents behaving correctly. You can also see that with an increasing proportion of agents in the system, who are treated unfairly, their declining profits, since it reduces the scope for misleading agents behaved correctly.

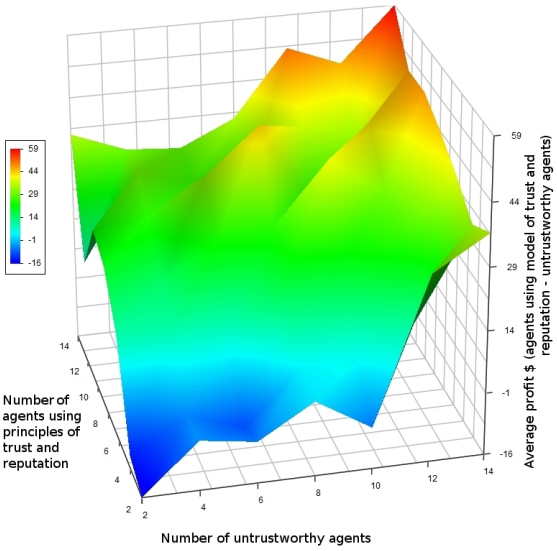


Fig. 4 Graph showing results of the experiments

5 Conclusion and future work

In this paper was presented simple trust and reputation model. The main aim of this model is on direct experiences and time context of them. Basic function of this model was try-out by several experiments. The resulting value of this model was not only used as some threshold, for decision about making same interaction. Benefits from the interaction were considered. If the profit with taking into account risks arising from the trustworthiness of the partner is positive, the interaction is made.

Our future research will be aimed on more complex models which will be applicable in distributed systems with taking into account surveys of other trust and reputation authors like [9]. General purpose of trust and reputation models is to prevent risks. Multi-contextual principles enabling lots of this risk prevents. One of most important things is an accurate management of the reliability of the entities in the system, not only as service providers, but also as recommendation providers. This is one way to improve our model in future, concretely by adding extension to Hierarchical Model of Trust in Context [10].

Acknowledgement

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