ONLINE AUCTION TRUST MODELS

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ABSTRACT

The communication proceeds within Internet auction systems as a rule under the situation, when users are not in physical contact nor they do not know anything of each other. They have therefore to rely on mechanisms implemented within these online systems. Most of such mechanisms is based on creation trustworthy environment by the help of additional attributes associated to users and their roles (see for example system of evaluation on mentioned electronic auctions) on the basis of previous transactions or recommendations (positive or negative commentaries and messages of those who got into touch with this person within some their previous activities). The creation of trusts in online auction environment (to system itself and among users of this virtual world) is the basic element for functionality of these environments. Some specificities and models of trusts in online auction will be described in our paper. We discuss also the trust model in commercial online auctions and their mechanism for trust building.

KEYWORDS

Online auction, trust models, reputation system, Internet

INTRODUCTION

At present a great numbers of users is taking part in activities on Internet infrastructure. These activities are for example electronic auctions (aukro.cz, ikup.cz, odklepnuto.cz and next), systems for opinions sharing, recommendations and activities sharing (epinions.com, avaaz.org), various social networks (friendster.com, facebook.com), network sharing entertainment and further applications over P2P networks. Within mentioned online systems the communication proceeds as a rule under the situation, when we are not in physical contact with other person nor we do not know anything of him. We have therefore to rely on the mechanisms implemented within these online systems. Most of such mechanisms are based on the creation of a trustworthy environment by the help of additional attributes associated to users and their roles on the basis of previous transactions or recommendations (positive or negative commentaries and messages of those who got into touch with respective person within some of their previous activities). Actually there are some studies about trust in online environment (e-commerce) in general, but they do not specifically discuss the trust in online auctions. Authors of [1] in their research on eBay found that good or positive reputation will have impact on price, while negative feedback will lead to price reduction. Reputation building is hence important to increase business on seller perspective [2]. Some principles and models of trust in online auction will be described in next chapters. We discuss also trust models in realistic commercial Internet online auctions.

MODELS OF TRUSTS AND REPUTATION

This part describes different principles for the calculation of reputation and trust in online systems formed by certain community of people. We can divide these methods in principle into three groups. The first group can be called algebraic methods where we can typically place simple ratings summation or averaging and others. The second group is formed by the methods based on expression of uncertainty by means of the probability, Bayesian networks, fuzzy approach, belief functions and other concepts. The third group contains methods based on network analysis or graph methods and also social network analysis methods are used within methods of this group.

Some mechanisms from mentioned principles are used in commercial applications, especially the simplest models – simple summation or discrete trust models are mostly used in practical Internet auctions. Most models still exist only like suggestions of researchers; see [3] for other detail information.

ALGEBRAIC MODELS

Ratings summation or calculation of average rating

The simplest form of calculation of reputation of certain entity is to keep separately the number of positive evaluations and negative evaluations and then to calculate the total reputation score like summation of the number of positive evaluations minus the number of negative evaluations. This principle is used for example in Aukro.cz for calculation of reputation of auction users. The advantage of this method of reputation calculation is the possibility of understanding for users of online systems (auctions). Users can easy understand how the calculation is performed. The disadvantage is excessive simplicity namely, that the mechanism do not provide sufficient picture about participants of auctions. Therefore this mechanism (simple summation) is at real systems supplemented by possibility of addition of evaluative commentaries. These commentaries can support the picture of the reputation of participants.

This method of reputation score calculation can be completed by other operations, for example [4] calculation of reputation score like average of all evaluations (this principle is exploited on reputation mechanisms in e.g. Epinions, Amazon). Eventually the principle of weighted average of all evaluation is used. Weight of single evaluations can be determined by factors such as trustfulness (reputation) of evaluative party or discrepancy between respective evaluation and current value of reputation and so on.

We can describe this model formally. Let P denotes the set of N members of electronic community and let u,v $\in$ P are the members of community P. Let's notice that the number of active members (connected into the online system) varies with the time and it is not possible to determine in advance their number. Let S(u,v) denote the number of satisfied responses of a member u concerning certain transaction t that he had with an other member v of community P. Similarly N(u,v) denote the number of unsatisfied responses of a member u concerning certain transaction t that he had with an other member v of community P. Let T(u,t) is a total evaluation of reputation (trust) that the respective member obtains from the others members of community P on the basis of transaction t. T(u,t) in such system can be defined as a function S and N subsequently:

$$T(u,t) = \sum_{v \in P, v \neq u} (S(u,v,t) + N(u,v,t))$$

Models of discrete trust

People are often better able to evaluate a performance in the form of ordinal variables (discrete verbal statements) than in form of numerical value, because meaning expressed like "as a rule trustful" is easy to understand for them, while formulation in form of stochastic value requires deeper understanding for correct interpretation. Various authors e.g. [4, 5, 6, 7] suggested discrete models of trust that use mentioned ordinal variables for the evaluation of levels of trusts. For example in model [4] the measure trustfulness of certain entities can be represented like "Very trustful", "Trustful", "Untrustworthy" and "Very untrustworthy". The entity can also at decision-making about trustfulness of a second party x use its personal perception of trustfulness of other referring entity before taking recommendation of this entity into consideration. Look-up tables with entries for referred trust and for entities giving recommendation and their adjustment (downgrade or upgrade of value of recommendation according to the personal perception of trustfulness of a other referring entity) are used for the determination of trust to x. If an entity has personal experience with x (party x which trustfulness evaluate before transaction), it can apply this experience for the determination of trustfulness of referral entity (any entity which gives recommendation concerning party x). It is possible to suppose that the personal experience reflexes the real trustfulness and the recommendation about x, that differs from personal experience, will indicate whether referral entity underestimates or overestimates the party x. Recommendation from respective referral entity will be corrected (evaluation that seems overvalued will be lowered, respectively).

Disadvantage of discrete measure is that such measures are not convenient for computational calculations. Therefore some heuristic methods are used within described model.

Encryption software PGP (PKI system) uses also discrete measure for the formulation and for the analysis of trust to public keys. PGP implements very pragmatic approach to complex problem of derivation of trust from trust network.

MODELS BASED ON VARIOUS EXPRESSION OF UNCERTAINTY

Bayesian models

The calculation of reputation (trust) based on Bayesian concept uses binary evaluation like input (it means positive or negative evaluation) it is based on calculation of reputation by statistical updating of beta probability density function. A posteriori (updated) value of reputation is computed by combination of a priory (previous) value of reputation with new evaluation [8, 9, 10]. A reputation value can be represented in practice by parameters of beta probability density function (a and b), where (where a and b represent the quantity of appropriate positive and negative evaluations) or in form of probability the expected values of beta distribution (probability density function), eventually characteristics of variance or reliability. Advantage of Bayesian systems is that they provide theoretically reliable basis for computation of reputation values. Only disadvantage is that they can be too complex for understanding.

The beta distribution belongs in probability theory and statistics to the set of random continuous probability distribution functions defined on interval [0, 1]. Distribution is determined by two parameters $a > 0$ and $b > 0$. It is used in Bayesian statistics like posteriori distribution of parameter p of binomial distribution for a -1 observations of independent occurrence with probability p and $b - 1$ with probability $1 - p$ provided that the last distribution of p was uniform (if we have no prior information about the probability of p then we choose for p a uniform density distribution function on interval $<0,1>$).

We can express the beta distribution function by the help of the beta function by the relation:

$$f(p \mid a,b) = \frac{1}{B(a,b)} p^{a-1}(1-p)^{b-1}$$ where a>0, b> 0 and $x \in (0,1)$

Eventually by the help of the gamma Γ function:

$$f(p \mid a,b) = \frac{\Gamma(a+b)}{\Gamma(a)\Gamma(b)} p^{(a-1)}(1-p)^{(b-1)}$$

with limitation, that the probability of variable $p \neq 0$ if $a < 1$ and $p \neq 1$ if $b < 1$.

Bayesian estimation of finding of the probability p is by the help of a posteriori mean value the estimation:

$$E(p) = \frac{a}{a+b} \tag{1}$$

If we do not know the input values then a prior distribution is the uniform beta distribution with a = 1 and b = 1 demonstrated on the figure 1. After the observation of r positive and s negative results of the respective random variable the a posteriori distribution will be the beta probability distribution function with a = r+1 and b = s+1. Demonstration of the beta distribution after observation of 7 positive and 1 negative result is illustrated on the figure 1b.

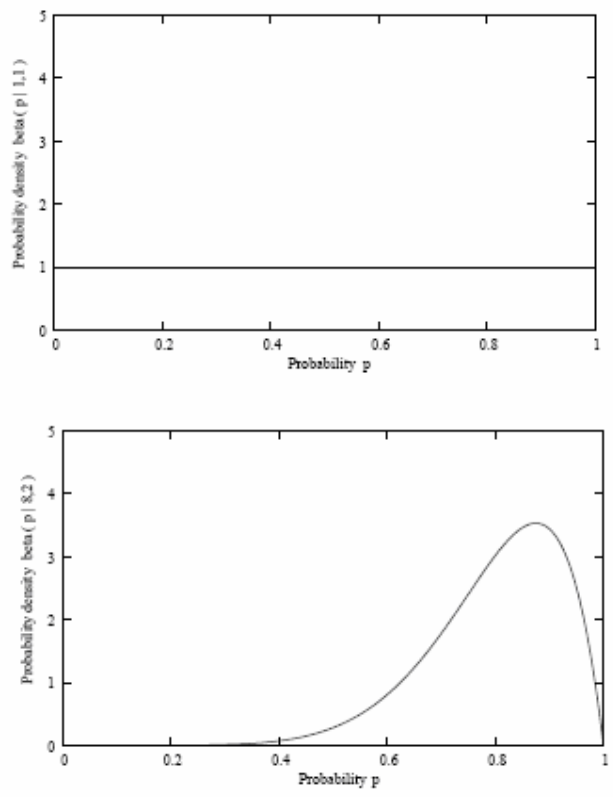

Fig. 1a, 1b Demonstration of beta distribution [3]

Distributions of this type express uncertain probability that the future interaction will be positive. Most often the value of reputation is defined as a function of expected value. Mean value (expected value) of a posteriori distribution according to the figure 1b according to the equation (1) is E(p) = 0,8. We can interpret this result as a statement that the relative

frequency of positive results in the future is somewhat uncertain and its likeliest value will be 0.8.

In previous paragraph the Bayesian approach based on dichotomous input (positive or negative evaluation) was analyzed. The expansion of described Bayesian approach is given in [11]. Here suggested models compute reputation when input values for trust formulation is expressed by ordinal or numerical variable, for example measure like positive evaluation, rather positive, neutral, rather negative and negative evaluation.

Model based on belief functions

One example how to treat uncertainty is the belief theory. Belief theory is related to probability theory but here the sum of probability over all possible results doesn't need to gives sum of 1 (can be less than 1) and the remaining probability (value up to the 1) is then interpreted as uncertainty (uncertainty about trust or ignorance).

In [12,13] it is suggested the metric of trust that is called opinion and is denoted by $\omega_x^A = (b, d, u, a)$. This metric means confidence of trusting party concerning the truth of statement x. Here b, d and u represent belief, unbelief and uncertainty, where b, d a u $\in$ [0; 1] and it is valid that the b + d + u = 1. Parameter a $\in$ [0; 1], this parameter is called relative atomist, represents basic size of probability in the absence of evidence (that would upheld belief concerning statement x) and it is used to computation of probability of expected value of certain opinion. This means that the parameter a determines what uncertainty contributes to $E(\omega_x^A)$. If the statements x for example says "David is honest and reliable", then this opinion can be interpreted as a trusts in David. For example let's suppose that the Alice needs to repair her car and therefore she asks Bob to recommend her a good car mechanic. Bob advises David, but Alice would like to get a second opinion, so she asks Clare on her opinion about David. This situation is illustrated on the fig. 2 below.

If trust and trust referrals are expressed as opinion, every transitive trust path Alice → Bob → David a Alice → Clare → David can be quantified by the help of discounting operator, where idea is that the recommendation from Bob and Clare are discounted as a function of Alice's trust in Bob and Clare. In the end using of consensus operator can combine both paths. These two operators form the part of Subjective Logic [12] and beside it is necessary to take into account semantic constrains, so that transitive trust derivation is meaningful [13]. Opinions can be uniquely mapped on beta probability distribution function and the sense of consensus operator is equivalent to the Bayesian updating described in previous chapter. This model is then based how on belief and on Bayesian approach.

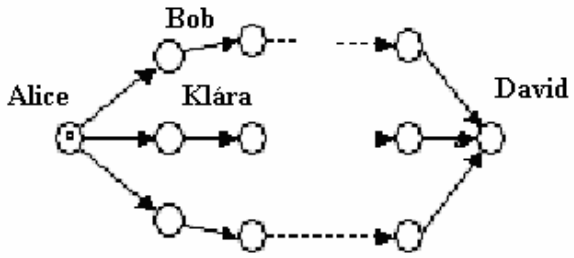

Fig. 2. Deriving trust from parallel transitive chains

Authors of [14] proposed to use belief theory for calculation of reputation value. In their proposal they assume two possible results, that the entity A is trustworthy (T_A) or not

trustworthy ($\neg T_A$), and separate beliefs are being kept about whether is A trustworthy or not, denoted $m(T_A)$ and $m(\neg T_A)$. Reputation score Γ of entity A is then defined like belief function:

$\Gamma(A) = m(T_A) - (\neg T_A)$, where $m(T_A), m(\neg T_A) < [0,1]$ a $\Gamma(A) < [-1,1]$ (3)

Evaluation performed by single entities are belief measures determined as a function of past transaction of entity A with single entities which were evaluated as untrustworthy or untrustworthy (prior defined threshold values for determination of what presents trustworthy or untrustworthy behaviour are used). These belief measures concerning trust are then computed using Dempster's rule (Dempster's rule is classical operator for combination of evidences from different sources) and resulting beliefs are then placed into equation (3) to compute the reputation score.

Dempster's rule has a following form

$$m_3(C) = \frac{\sum_{A,B \subseteq X, A \cap B = C} m_1(A).m_2(B)}{1 - \sum_{A,B \subseteq X, A \cap B = \phi} m_1(A).m_2(B)}$$

It is defined for environment that formed by entire system of mutually disjoint basic hypothesis X = {h1, h2, …, hn}. Value of m(A) presents a measure of trust, that it pays just hypothesis A, whereas it does not predicate nothing of measure of trusts in components of set A. Then it doesn't need to pay $m(B) \leq m(A)$ pro $B \subset A$..

Evaluations are regarded as valid, if they are derived from transitive chains of trust of length smaller or straight of prior defined limit.

MODEL BASED ON GRAPH APPROACH

Graph models

Graph model are based on the notion that entities and trust relation among them can be represented by network where entities are vertices and trust relations edges. Network analysis (or graph computational methods) are then used to compute trust or reputation

Some graph models suppose constant weight of trusts/reputation for whole community and this weight can be divided among members of community. Participants can only increase their trusts /reputation at the expense of others. Algorithm Page Rank, Appleseed and Advogato [15] come under this category. Reputation of participant generally increases as a function of incoming flow and decrease as a function of outgoing flow. In the event of Google, hyperlinks to a given to web page contributes to increase of Page Rank value, while hyperlinks aiming from web site contribute to decrease of Page Rank value of given web site.

Graph models do not require sum of reputation/trusts to be state. Such instance is model EigenTrust [16], which computes trust values of entities in P2P networks through repeated and iterative multiplication and aggregation of trust transitive chains until the value of trust for all entities (members of P2P community) converge to stable values.

The usage of social network analysis methods for calculation of trust in various communities and trust networks are described for example in [17, 18].

REPUTATION SYSTEMS IN ONLINE AUCTIONS

Online auction are online systems build on Internet infrastructure, in which user can sell items that he owns and can buy offered items. In these systems buyer as a rule doesn't know seller respectively. Performed transactions are characterized by asynchronous (sequential) actions of two anonymous parties that function as a rule in geographically distant localities. It is important in this context that both parties could consider trustfulness of business partner. Both parties must decide whether they will trust each other. Decision about certain business transaction includes namely default risk of nonpayment of price or no sending of a product. Online auction as for example Aukro (http://aukro.cz) or eBay (http://eBay.com) are successful thanks to the way whereby they are able to mediate this trust between members of online auction community.

Most widely used models for conclusion of an agreement about sale and purchase are: fixed price and auction. While sale with fixed price is a model with we know very good, auctions can have several variants depending on variables as bid publication, lifetime, whether an initial offer is specified and next. Within the auction buyers competes and if somebody from them during given time puts the best bid, then he win the sale and gains goods offered in auction. We describe problems of trusts between the two roles that the users play in this environment e-auction: i.e. buyers and sellers.

Main complication at conclusion of an agreement on virtual market is that generally buyer and seller do not know each other. Both know only information that given web site of online auction eventually displays about the other user. It is obvious that if we do business transactions with somebody whom we do not know, then the risk is connected with this transaction. It isn't yet common, that we give money in the street to foreigner who promises that he send us certain product later within some days.

We can bring for instance a typical case for Internet auction. Alice was found a user, whose nickname was Baron and which sold music instruments. Alice is interesting in purchase of cymbals. Bid price is for Alice acceptable. But how but Alice can be certain, that after she sends money to Baron, Baron will send cymbals? How Alice can be certain that the picture on Web sites is truly a picture of cymbals that Baron sells and that he does not send her other perhaps older cymbals? If Alice does not find some verification that would bring her answerback on her questions, she probably refuses to realize the given business by reason of high risk. Contribution and success of Internet auctions is however based on that, that they are able to bring certain information and evidence about the behaviour of parties that are interested in taking part in transactions on Internet auction. It can be the information that Baron already sold 23 cymbals and all buyers were satisfied with what Baron sent them. Or on the contrary it can be information that the most buyers are notifying on the web pages of Internet auction, that Baron delivered them though cymbals, but these were worse type than they had ordered. This information can decrease the risk of intended transaction and so contribute to its realization. Just such information about sellers is possible to find on web pages of Internet auctions and this is the reason why these e-auction function.

Metrics of trust and reputation systems provide solution and help to entities to remove or at least reduce asymmetry of information. Possibility, that the user can express his/her measure of trust to other users, makes possible, that the future interactions are influenced possible past “bad” behaviour or “good” behaviour of the other party.

Example of e-auction model is in our county Aukro (http://www.aukro.cz/). Its model in principle results from successful model of other Internet auction eBay (http://www.ebay.com).

eBay is at the present time the best known and the most successful example of Internet auction.

Aukro users have possibility to rate other users after each transaction (and write a commentary about user – seller) and therefore to express the measure of his/her trust to a respective seller. Commentary can be positive, neutral or negative (in value 1,0, – 1), i.e. user states type of comment and further he/she can bring in written statement about the course of transaction. Users can comment rate of delivery, how the description of offered thing matches with reality and so on. Seller obtains one point for positive commentary, loses one point for negative and neutral commentary will not change the number of points of respective seller. Certain symbol is assigned to everyone user according to the number of positive points other users to be able to identify with how trustworthy user (in context of Internet auction Aukro) they eventually come into the contact.

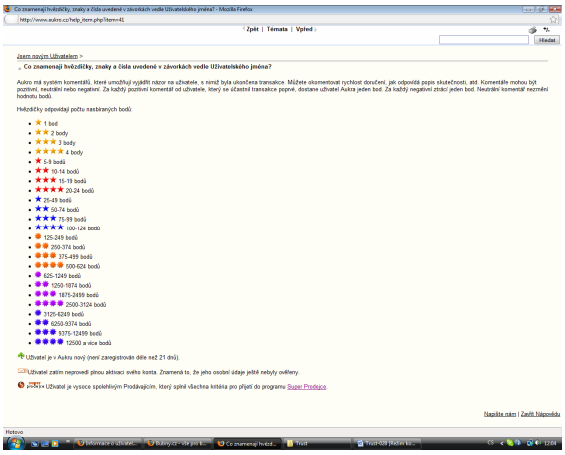

Fig. 3. Symbols of evaluation of trustfulness of Internet action Aukro users (www.aukro.cz)

In addition information about seller shows also total positive, negative and neutral evaluations for different time period: over the past 30 days or during more than 30 days. The aim is to shown the development of respective seller behaviour in time and especially his/her behaviour at the present time. The reputation of each user is created in this way and information about this reputation is public available. Such reputation is as a matter of fact the total evaluation performed by all users that have had in former times with respective user some business transaction. Evaluation represents opinion of all community about certain user and matches the model of simple summation described in previous chapter. Thanks this information every user is able to create quickly his/her opinion about any other user and make decision whether the risk of business transaction with this user is to him/her acceptable or not. Advantage of used digital technology is obvious. This advantage is the possibility of obtaining a large number of data concerning interactions and users behaviour. These data then can be stored in electronic form and can be further analyzed.

Model of trust evaluation on Aukro online auction is very simple and consist of whole number. The higher number the user has the more trustworthy he/she is. Measure of trusts is also bold on Web sites by means of colored stars (marks) beside name of given user. The color matches to certain range of trust value. Algorithm of trust updating that designates evaluation (rating) of trust subtracts the number of negative evaluation from the number of positive evaluation. In this algorithm it is taking into consideration only one evaluation from one evaluative. So that if the user A evaluates the user B at 6 occasions the value of trust of

user B will increase or decrease at most about 1. Because evaluations could differ the value of trust will increase about 1 if the number of positive evaluations among 6 evaluations is higher than the number of negative evaluations. Value of trust will reduce about 1 if number of negative evaluations is higher than a number of positive evaluations. Otherwise the value of trust of user B does not change on the basis of responses of user A.

Several studies proved that these valuation systems contribute notably to success of Internet online auction. It is described in [19] that sellers with high reputation has advantage and authors of this study state on the basis of their experiments that the buyers were willing to pay extra price which was about 8.1% higher if the seller was user with high reputation than they were willing to pay to seller with low reputation (seller who is in system for short time and hence he/she can not obtain higher reputation).

Study how system of user evaluation as a feedback influences market is presented in [19]. Study is related to Internet auction eBay. Very interesting data are connected with distribution of values of evaluation "from all valuations performed by buyers were only 0.6% commentaries negative, 0.3% neutral and 99.1% were positive". This disproportion between positive and negative feedback can indicate certain weak point of reputation system. I.e. that the reputation system considers response (commentary) from each user with the same weight, which can be misappropriated. Because very little of negative evaluations within the reputation system exist the user that has just a few negative evaluations appears to be highly suspicious. It is then very probable, that no user will risk and do with him business transactions. By this reason some users may threaten with negative evaluation (thereby decreasing of reputation of seller) with the aim to reach reduction in price on his/her purchase. This activity has a name on eBay "racket by evaluation" (EBay Help: Feedback extortion, n.d.). This problem is on online auction Aukro solved so, that the user is able to attain removing of negative comments, if he/she will evidence, that the commentary was written with the aim of causing of damage to him/her.

The further example of usage of centralized reputation mechanism is online market Amazon. Amazon makes it possible to users to write reviews for products offered on Amazon web pages. Like second step the users that read reviews might give to system a feedback whether specific review helped them or no. These responses are stored in Amazon system and they are used for determination of "the best" or "the most trustworthy" critic that are ranked like "500 top critics", "100 top critics" and so on. Trust is represented as a whole number like at eBay. Discrete scale of evaluation for "the best x" ("top x") is created on the basis of respective score. Analogous to eBay the algorithm of trust updating is taking into consideration positive responses and subtracts negative responses. Amazon also offers direct evaluation of buyers and sellers within C2C market that also functions on Amazon Web pages (sale of used literature). Amazon makes it possible to both buyer and seller to write evaluation (commentary) at each other mutually, but the calculation of trusts takes in account only responses that the seller writes on buyer. Evaluation consists of 1 till 5 stars that it is also used at representation of trust in model of trust.

Update algorithm counts here the arithmetic average from all received evaluation.

CONCLUSION

The basic characteristic of functioning of online Internet auction is trustworthy environment. Most of these systems have very simple measure of trust and they can be relatively vulnerable. Nevertheless it seems that they function in practice very well. One reasons is their simplicity. Every user may easily understand how given online auction works and hence he

gains confidence to this auction. If the mechanisms and trust measures were more complicated it would be more difficult to understand them and user would likely lose confidence to respective system that he would not understand.

In light of system functioning the perception of system by users is the crucial point. If they perceive the system like functional, able to give certain warranty and to deal with malicious users, then system is able to function successfully, even if statistics of reliability will not be quite favorable. After all the aim of Internet auction systems is to enable administration of great amount of transactions and it seems, that the positive feelings and perception by users may create successful and active community more efficient than the implementation of complicated measures of trust or reputation systems.

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