A Computational Trust Model for E-Commerce Systems

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Abstract. Today, one of the most important factors of successful e-commerce is creating trust and security. Undoubtedly, in absence of trust as a key element of online business communications, e-commerce will face a lot of challenges. Assessing trust, especially in the beginning of a commercial relation and generally, formulizing the trust is a complex and difficult task. Trust may not be defined in a special framework even for customers and e-vendors. The reason is that for giving a definition for trust, different people, based on their cultural and familial background, believe in different features and dimensions in their mind. In the model proposed for computing trust in e-commerce, first of all based on past research three general fields are envisaged. Then, a computational model has been presented for evaluating trust. Finally a case study is presented to illustrate the proposed trust evaluation model. Future works are also discussed in addition.

Keywords: Trust model, trust evaluation, e-commerce, trust manager agent (TMA).

1 Introduction

Trust is very important in individual and social life. In absence of trust, many of social aims will be unachievable and inaccessible. E-commerce has not yet attained its full capacity mostly because of the absence of trust in relations of the agents of the transaction. Based on the research presented in [11], trust has several properties: - Trust is context dependent. -Trust describes the degree of belief in the trustworthiness of a partner. - Trust is based on previous experience. - Trust is not transitive. - Trust is subjective. Generally, if people get certain that electronic buying and selling will save the time and costs, their trust will promote. In this line, the models offered for assessing trust in e-commerce are very useful.

This paper will establish a trust evaluation model in e-commerce based on analyzing conception and component of trust in e-commerce. This trust evaluation model has two features: First, trust is evaluated dynamically and with a change in any of trust variables, the new value is calculated for trust. Second, it is optional. It means that it is capable to make partial study of trust on contexts presented in general dimensions of trust. The advantage of partial study of trust is that the trust parameters are mostly personal and each agent has his own beliefs which can serve as basis of trust

evaluation. The remainder of this paper is organized as follows. The envisaged dimension for trust is presented in Section 2. Main factors that influence the trust in e-commerce also are analyzed in this section. Computational Trust Model is introduced in Section 3. Definitions of the model and the components that are used in this model and also the trust management agent are presented in this section. In Section 4 a case study is given to illustrate the proposed trust evaluation model. Section 5 discusses conclusions, limitations and future works.

2   The Envisaged Dimensions

Based on past investigations the dimensions proposed in this study which will be a base for presenting the computational trust model have been presented as follows. As seen, three general backgrounds have been viewed for trust in e-commerce. They are:

- Institutional Trust
- Technology Trust
- Trading Party Trust

Institutional trust includes laws and regulations which facilitate commercial transactions. It consists of two groups, namely structural assurance and certificates of third parties. This category of trust mostly is focused on B2B transactions and structurally decreases distrust and uncertainty. It is like a state in which we do not trust the other party and use structures and control mechanisms as substitute of trust and apply a series of supervision mechanism. The testimonies of third parties which assesses an online trade in respect of security or organizational and procedural and then releases the results on web site for being visited by probable customers is an example of those mechanisms.

Nowadays, there are organizations which assess the commercial transactions in accordance with their special standards. The commercial companies coordinate their commercial processes with those standards and then receive approval certificate of those organizations. In [6], the infrastructural dimensions of an institutional trust have been examined. The structural guarantees include agreements and instructions dealing with organizational processes and the standards and procedures which lead to success of different services such as transportation, delivery, and processes.

Technology trust may be studied from two angles of view:

- Web site
- Security Infrastructure

Web site is the first thing the customer faces (especially for a person who visits an e-commerce site for first time) and can have desirable effect on purchase decision of the visitor. The particulars which may attract the attention of the consumer to the web site include appearance of the web site (such as beauty, convenience of using, accessibility, and speed) and the site's technical specifications (such as being up to date in respect of software and hardware) as well as transparency and standardization of the information. For instance, the complete specification of the product and company, the company's logo and trade name shall be given in the web site and the laws and contracts shall be observable. Off line attendance or contact (Tel No., Email address, fax No.) too is effective in winning the trust of the customer.

The security infrastructures which provide safe connective mechanisms deal with issues such as confidentiality and security of information related to persons and organizations. Generally, the mechanisms such as integrity, confidentiality, non-denial, access control, etc., are among the security mechanisms [2]. Because technical ability and security services of websites play important role in customer trust absorption and website is the first demonstrator of vendors' abilities, increase trading party trust.

As past investigations in [1], [2] indicate and especially in B2B transactions, three categories of trust, that is, competency, benevolence, and predictability of the trading party are considered.

In trading a product or a service one very critical matter is that satisfaction of the product may become the root of many later decisions. Since in doing a transaction is acquiring a special product or service so trust to the product is very critical and satisfaction of the product is one of the prerequisites of trading party trust. For evaluating the product trust a signature of one reliable reference may be used or the product trust index based on satisfied or unsatisfied customers may be given along with the specifications of the product.

3   A Computational Trust Model

Samples of models for evaluating trust in e-commerce have been presented in [3], [5], [10], [18], [19]. In this section, a solution for evaluating trust is proposed. The solution has two important features: 1) It studies trust in a dynamic way and by changing each of the variables of trust the new value of trust is calculated. 2) It is optional, that is, the consumer may measure the properties or features that he/she wishes to know their value. The importance of this aspect rests in the fact that since trust is a multidimensional issue, different individuals may concentrate on different dimensions of that and thus it is better for them to measure the features they attach importance to. The important point is that distrust is qualitatively different from trust. Lack of trust does not mean distrust because lack of trust may be originated from non-existence of trust-related information. In [15, 17], trust and distrust and their preliminaries and consequences in e-commerce have been studied. In the proposed model, an agent may be considered trusted in one context and may be distrusted in another context because of lack of needed information or bad history in past transactions.

Generally, there are two approaches to trust management. One is the centralized method in which for storing and searching the data some perfectly concentrated mechanisms are used. These mechanisms have one main central database for assessment and there is a central control. The second approach is the distribution methods. In this method, there is no central database and thus none of the agents have a general understanding of entire system. Assessment and management of trust are done locally by number of agents without using any central control.

In proposed model, for evaluating trust we assume a reliable reference which is trusted by both vendor and consumer. This reference is in fact the principal core of the evaluating system and may control the commercial processes too.

We call this trusted medium of the model "trust manager agent" or TMA and suppose that for specific subsets of network nodes there is a node with duty of trust management and the other nodes have assigned the duty of other subsets trust management. So, the trust management is distributed between trade agents.

It is possible that TMA enjoys the help of other references for completing its knowledge. In this case, the techniques of trust propagation shall be used. Samples of trust propagation models are in [13], [14], [16], [12]. In addition to that, since the intrinsic nature of trust is being temporary the agent at each intention of purchase will have opportunity to enjoy this TMA to complete its knowledge.

TMAs not only receive the information of transactions from the nodes of the set but also share information with other TMAs if requested. Neighboring TMAs know each other and confirm the validity of each other through cryptography.

In TMA database there is a table for maintaining the information of agents. The calculated value of trust in each context is allocated for each agent. The table is updated dynamically with implementation of transactions or propagation the information from other nodes. TMA saves the feedback of agents in its database too. The manner is such that the e-vendors send some information to TMA periodically about their transactions. Also the consumers reflect their assessment of their trading party. The reflections are kept by TMA.

We have following definitions:

1. Agent is an active entity who plays a role in trust model and fulfills different activities toward meeting the needs. Vendor, mediums, and trusted parties are examples of agents: $Agent = \{a_1, \ldots, a_n \,|\, Agent(a_i), i \in [1, m]\}$
2. Transaction is a unit of action which is entangled with two agents. The result may be failure or success. The result of a transaction can be a value in [0, 1] interval which points at the degree of success of the transaction.
3. The context of trust as was stated and considering the request of the agent, is defined as: $Context = \{I, T, Tp, Be, Co, Pr, G\}$

I: *Institutional Trust*, T: *Technology Trust*, Tp: *Trading Party Trust,* Be: *Benevolence*, Co: *Competence,* Pr: *Predictability*, G: *Goods*

In relation to trading party trust we have defined four context, namely, Be, Co, Pr and G. for future calculation, trading party trust itself and two other dimentions too have been included in the context.

One of the advantages for existing TMA is that an agent may need consultation only in one context. For instance, for a consumer, the trustworthiness of trading party is certain but trustworthiness of his technology is not perfect then consumer consults with TMA. We have $T(x)$ function whose ($x \in$ Context) makes clear that in which context TMA assesses the trustworthiness of a_j.

3.1   Trading Party Trust

3.1.1   The Supplier Trust
One of the definitions proposed for trust is following definition: Trust is the subjective probability by which person *A* expects person B to fulfill an activity assigned to him/her in direction of the welfare of person *A*. The important element existing in this definition is "activity". Activity is in contrast with information and we can trust a man through considering a specific activity by that person and also we can trust a man based on the information provided by him/her. In computation model both of activities and information are envisaged. We have relation (1) for trade party trust evaluation.

$$Ta(Tp) = \sum_{i=1}^{I(a)} \alpha * S(i)/I(a) + \sum_{i=1}^{I(a)} D(i)/I(a) + \sum_{i=1}^{I(a)} B(a,i)/I(a) + \sum_{i=1}^{I(a)} G(a,i)/I(a) \qquad (1)$$

Where $I(a)$ is total number of transactions of agent a and i indicates the transaction. The relation $\sum_{i=1}^{I(a)} \alpha S(i)/I(a)$ is based on the past transactions history of the agent. $S(i)$ are transactions completed successfully and with satisfaction of the customer. Any successful transaction is graded "1". Success in transactions may be determined by the feedback mechanisms of e-commerce sites. Since feedback mechanisms play a very important role in studying the history of commercial transactions we attach positive point to having feedback mechanism in commercial sites. α is a coefficient which is used in calculating the final value based on the importance degree of satisfaction and success. In formula (1), we have purposed the $\sum_{i=1}^{I(a)} D(i)/I(a)$ for information sharing factor that indicate benevolence of trading party. The relation shows the total number of files downloaded by e-consumers for the total number of transactions of agent a and $D(i)$ shows downloading in i^{th} transaction and is determined with due regard to transactions and according to the standard drawn up by TMA, for example we can envisage that each downloading receives "0.5" as grade. Maximum value of information sharing factor in integrated trust value is 0.5.

The $\sum_{i=1}^{I(a)} B(a,i)/I(a)$ relation shows the positive behaviors of the seller agent. Positive behavior is same as preference behavior such as giving prizes or prominence to some consumers or receiving the amount in installments that the seller may consider for some customers. $B(a, i)$ means the positive behavior of the vendor toward consumer in i^{th} transaction. Since this factor does not apply to all customers so it does not apply to all transactions and its value is between zero and one. Legal commitment or $G(a, i)$ are the guarantees given by the e-vendor to its trading party in i^{th} transaction and the $\sum_{i=1}^{I(a)} G(a,i)/I(a)$ relation calculates the number of commitment of the supplier in all completed transactions. The commitments are not usually fulfilled for low-value transactions and in limited time. In fact, they change with the conditions of transaction and type of the service. We envisage 0.5 as maximum value of this factor in integrated trust value.

The above mentioned points show the behavior of online merchant and study transactions history of e-vendor. The researchers have found out that trust has positive relation with disclosure of information and case studies made on interpersonal exchanges confirm that trust is a pre-requisite for self-disclosure because decreases the risk existing in disclosing the personal information [9]. A very important issue in the field is the truthfulness and correctness of the information given to TMA by the agents sincerely and without intention of deceit. This means risk in the transaction that shall be assessed based on the value of transaction and its expected revenue. For preventing fraud, the customers are asked to reflect their opinions related to above matters after each transaction. It needs to be pointed out that since in proposed model trust context is optional, the agent who sends request to TMA may send the request on

special field. He/she may request the assessment of benevolence alone. In this case, in relation 1 the formulas related to past history and legal commitment become inactive and the formula will change to:

$$Ta(Be) = (\sum_{i=1}^{I(a)} D(i) + \sum_{i=1}^{I(a)} B(a,i)) / I(a) \qquad (2)$$

When assessment of trading party competence is requested the formula will be

$$Ta(Co) = \sum_{i=1}^{I(a)} \alpha * S(i) / I(a) \qquad (3)$$

If the agent wants to assess the trading party predictability, TMA will calculate the Formula (1) in the following manner:

$$Ta(\text{Pr}) = \sum_{i=1}^{I(a)} G(a,i) / I(a) \qquad (4)$$

3.1.2 Product Trust

In this study it has been supposed that trust to the product affects on trading party trust. When the consumer makes its first electronic purchase and is not familiar with the products offered by the e-vendor, for investigating product trust he/she sends to TMA a product trust request.

TMA is capable to evaluate product if it has been signed by a trusted party or if the product has satisfaction index. Organizations which prove their skill in producing high-quality goods and services achieve high rank in trustworthiness scale. If the total number of goods and services offered for sale by agent a is showed by $G(a)$, the grade of product trust will have following form. In this relation, $S_g(a, g)$ is signed goods and g is the products. Any signed good is graded "1". Therefore maximum value for product trust will be "1"

$$Ta(G) = \sum_{g=1}^{G(a)} Sg(a,g) / G(a) \qquad (5)$$

The above relation can be added to general relation of $T_a(Tp)$. TMA is able to verify the genuineness of the product signature.

3.2 Technology Trust Evaluation

Web site is the entrance gate of e-commerce. The appearance of web site may have considerable effects on continuation of purchase because beauty and efficiency of website are features which non-professional users too can realize. For evaluation the website, TMA makes a questionnaire accessible to the consumer and when the questionnaire is filled in TMA gives points based on its own policy and makes the points of the product accessible to the agent. For different agents, the points of the web site may differ because based on personal factors, tastes, and social and contractual status of persons and or organizations the points may differ. Therefore, the points are determined based on the completed questionnaire.

The questionnaire has two sections: website and information. Let's suppose that the points considered by TMA are as follows: The points of website section are 0.4 and the points of information section are 0.6. If all points are won, TMA points 1 for technology trust. The security infrastructure of website cannot be checked in this way and for evaluating it, received certificates should be examined. This examination has been made in section 3.3 accompanied by examination of other certificates.

3.3 Institutional Trust Evaluation

Traditional commercial communication relies on legal commitments in primary communication making phases which are used for management on uncertainties. Because of non-transparent legal environment of internet, this does not work well in online environments [6]. To decrease uncertainties of online environments, a great number of third parties are active for helping the transactions of the organization and special structures, guarantees, and laws are used. Institutional trust is like a belief the trustor has on the security of a situation because of the guarantees, safe networks and other efficient structures. In studying institutional trust we assume two general components: 1) Institution-based third party trust 2) structural guarantees and processes.

In first form, the mediums define the organizational supplies but in second situation, the supplies are directed in two-way relation and are not arranged by the medium (such as legal agreements between commercial agents and the standards like commercial messages, product information, infrastructure of information technology, etc.). The structural guarantees may be provided as they are ordered for meeting common needs of the agent. Reference [6] names bilateral institutionalized trust substituting the structural guarantees and divides it into three groups. These three groups are structural guarantees, facilitating conditions and situational normality. The states predicted in the contract between trading agents shall be prepared in accordance to a procedure or standard which TMA is able to evaluate. The relevant contracts shall be signed by parties and shall bear signature of TMA and time stamp. TMA keeps these signed documents in its database. If the consumer wants to know about institutional certificate of e-vendor, TMA make evaluation in accordance to relation 6.

$$T_a(I) = I(C)*\alpha \tag{6}$$

Where C stands for certificates, $I(C)$ is the number of received certificates. The security certificates too are evaluated by this relation. Generally speaking, the point of the set of the certificates received by online company is determined based on the importance of the certificate which has been pre-defined for TMA. The degree of importance is determined by α. The maximum point we have chosen for that is 3.

4 A Case Study

For making the trust calculations we take an Internet service providers company in Iran, which offers services for finding access to local and world networks. We refer to this company as ANET. Since, it is not possible to have access to the information of this site concerning the sales (for becoming aware of the number and items of transactions and services of ANET company) we resort to knowledge of persons who have

had interactions with this website. We call these persons A, B, and C. A is a person who had commercial relations with company as a customer for about three years. A uses the Internet services of this company in framework of an ADSL contract which is extended often monthly. B has used the services of the company for six months in form of hourly subscription to dial up Service, and C has used ADSL ANET services for one year. First we consider trust to trade partner whose calculation has been presented in relation 1. In recent two years, totally, A has had 24 interactions with this online store and has been pleased with all these transactions except one. So, the result of the relation $Ta(Co) = \sum_{i=1}^{I(a)} S(i)/I(a)$ is 0.96. This value for B and C is 1 and 0.92, respectively. Concerning information sharing factor, the information related to access contracts and other services are available in a complete way. These information has been uploaded in forms and are accessible to the customers. Considering the activities of this company and the needs of customers, full point may be given to information sharing factor. Points that may be given for positive behavior factor is for two services: "little more" service (permits the users to have access to ANET services during a 5-day period after expiry of the contract period without paying additional fee) and giving rewards to any customer who introduces new customer to the company. A, in his 24 interactions with this website, has used "little more" service of ADSL for 23 times and had one reward for introducing new customer. Therefore, the positive behavior point of the company with customer A is 1, with B is 0.83 and with customer C is 0.92.

The obligations of ANET Company have been enumerated in the contracts for ADSL and Dial up services. One obligation relates to installation and commissioning the connection to Internet at "entrance" of modem for the subscriber. The second obligation relates to granting access right in each extension of the contract and rendering support services to the subscribers through telephone. It may be said that considering the need of the customer in respect of having access to the services of the company, the Company will receive entire points of legal obligations or $G(a, i)$.

Concerning product trust, generally speaking, ANET Company offers seven services. Though, according to the solution proposed in computational model, many of the customers are fully satisfied with this service but the services of the company do not bear signature of any special reference and no product satisfaction index has been registered for them and therefore, no point can be scored for product trust.

What pointed out above is all related to appraisal of the trust to trade partner. For appraising trust to technology, a questionnaire was send to persons. Based on opinion of A, totally 0.95 point was scored to the technology of the company. B and C gave points 0.9 and 0.85 respectively to online company for this aspect of trust. Concerning organizational trust, there is no certificate of special reference for this company and so no point can be allocated to the Company for this type trust.

Since the competence of the company is an important element appraised with due regarded to satisfaction of the customer, high importance is attached to that when points are given to trust. Therefore, in calculating the general scores of trust we have applied coefficient 2. Considering above points and as presented in calculative model, we will have following table for trust to ANET Internet virtual store. Results indicate that evaluating of A, B, C is almost similar and is in near range.

Table 1. Contexts of trust and their values

Trust dimensions	Trust context	A	B	C	Max
Trade party trust	competence	1.92	2	1.84	2
	Benevolence	1.5	1.33	1.42	1.5
	Predictability	0.5	0.5	0.5	0.5
	Products	0	0	0	1
Technology trust		0.95	0.9	0.85	1
Institutional trust		0	0	0	3
Total		4.87	4.73	4.61	9

5   Conclusions

In this paper, first of all three general dimensions for trust in e-commerce have been presented which is the base of later calculations of trust. The manner is such that some trusted parties (TMA) have been envisaged distributed in the network. TMAs have duty to evaluate, maintain and propagate trust for agents. The presented computational model has the ability of evaluating all contexts of the trust.

We present a case study to display efficiency and rationality of the proposed computational formula of trust. We didn't have access to e-suppliers sales and transaction information because of security problems. This limitation and the experiment condition lead us to do our case study with three consumers who purchase from a common e-vendor. In future, we intend to do a case study with different supplier and different shopping with more experiment and sufficient data to demonstrate the advantages of the proposed model. We also intend to implement a prototype of the model in a sample e-commerce system. Analyzing the detail of institutional trust especially in structural guarantee and process and presenting a solution for evaluating it in our computational trust model is another work we will try to do in future. Also we intend to design and assess a model for dimensions we discussed in this study and specify relations between dimensions.

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