Applications of Trust Management in E-commerce

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Abstract. Trust is an important compound for human interaction. It allows people to interact each other and helps to increase prosperity in economical operations. Managing of trust is necessary for e-commerce environments especially prior to new transactions with an unknown peer. So, the trust evaluation is critical, which relies on the transaction history data in network components. Trust may also play a significant role for the efficient operation of more general multi-agent systems. This paper seeks to provide an overview of models for trust evaluation in transactions which computes trust values. Some other features of these models in e-commerce are also discussed that explained in details in side of this paper. The finding shows such defects and deficiency in these models; for example none of the existing trust models consider load balancing among service providers.

Keywords: e-commerce, trust, model, trust management, reputation systems.

1 Introduction

Trust has been studied in many disciplines, such as psychology, economics, marketing, and organizational behavior, in addition to the information systems discipline. As a result, the definition of trust varies depending on the discipline and the context. Therefore, there has been a great deal of confusion on the topic of trust. Many researchers agree trust is a psychological state comprising the intention to accept vulnerability based on positive expectations of the intentions or behavior of another has been found to offer numerous benefits for individuals, groups, and organizations. Other researchers recognize trust as an essential element in security solutions for distributed systems. However, it is still not clear what trust is and how exactly trust can benefit network security [F. Latifi, & N. Momen-Kashani, 2010; Y. Wang, D. S Wong, K. J. Lin, & V. Varadharajan, 2007; Y. Sun, Z. Han, & K. J. Ray Liu, 2008].

Trust can be divided into trust in one's, trust in group, and trust in organization. The three categories of trust have a close relationship with each other. Our trust in organization can be formed from our trust in one's or ones' working in the organization. Trust is the greatest asset that any organization have, and this incomparable asset gradually obtained with the sincere efforts of members, and of course, support of regulatory bodies and public relations activities over time and hardly [A. Yazdanian-Verjani, 2011; Y. L. Sun, Z. Hany, W. Yuy, & K. J. Ray Liuy, 2006; Y. Sun, Z. Han, & K. J. Ray Liu, 2008] .

The success of e-commerce depends on many factors; the most important one is trust. This study has shown that lack of trust is a major obstacle to the success of e-retailers and the most important deterrents to participation in e-commerce consumers. Hence, building trust for consumers is considered as one of the most challenging issues for experts in the field of e-commerce [F. Latifi, & N. Momen-Kashani, 2010;].

Evaluation of the trustworthiness of participating entities is an effective method to stimulate collaboration and improve network security in distributed networks. Recent observations suggest that individuals can exhibit surprisingly high levels of trust even without a history of interaction. These researchers explain that this high initial trust can arise for a variety of reasons, including an individual's disposition to trust; feelings of dependence; a belief that impersonal structures such as regulations and laws support one's likelihood of success in a given situation; and rapid, cognitive cues arising from group membership, reputations, and stereotypes [F. Verdinejad, 2013; Y. L. Sun, Z. Hany, W. Yuy, & K. J. Ray Liuy, 2006].

Trust modeling is also used as a basis for a decentralized reputation system. It is suitable for dynamic multi-agent environments. Lack of the trust by consumer in e-commerce merchants, e-commerce technology, and the social, financial and legal infrastructures of the e-commerce environment, poses a major challenge to the large-scale uptake of business to consumer e-commerce. Most traditional cues for assessing trust in the physical world are not available online [M. Elisabeth-Gaup-Moe, 2011; F. Latifi, & N. Momen-Kashani, 2010; A. Yazdanian-Verjani, 2011].

The objective of this study was to explain briefly positive and negative aspects of such models to evaluate trust in transaction. So, in the first section of this paper, information sources are introduced; second section explains some models to calculate trust in e-commerce. In the following section, the quality of these models has been discussed. In addition, some of the models proposed by other researchers are CRM, CTR, the SinAlpha Aggregation Engine, EBay reputation model, SPORAS, Jurca and Faltings, TRAVOS and Secured Trust, which presented in this paper.

2. Trust Information

2.1 Source of trust information

In order to calculate the trust value of a target agent, there needs to collect relevant ratings about that agent's past behavior. A common way to estimate that value is to calculate it as the calculation mean of all the rating values in the set [P. H. Kim, K.T. Dirks, & C. D. Cooper, 2008; Y. Wang, D. S Wong, K. J. Lin, & V. Varadharajan, 2007, D. Gefen, 2000].

As it can be seen in our environments, trust can come from a number of information sources, such as: direct experience, witness information, rules or policies. However, due to the openness of MAS (Multi-Agent-System), the level of an agent's knowledge about its environment and its peers may vary greatly during its life cycle. Therefore, at any given time, some information sources may not be available, or adequate, for comprehending of the trust [A. Yazdanian-Verjani, 2011; T. D. Huynh, N. R. Jennings, & N. R. Shadbolt, 2006; A. Das, & M. M. Islam, 2012].

Direct trust: direct trust is established through observations on whether the previous interactions between the subject and the agent are successful. Recommendation trust is a special type of direct trust. It is for trust relationship {subject: agent, making correct recommendations} [Y. L. Sun, Z. Hany, W. Yuy, & K. J. Ray Liuy, 2006; Y. Sun, Z. Han, & K. J. Ray Liu, 2008].

Indirect trust: Trust can transit through third parties. For example, if A has established a recommendation trust relationship with B, and B has established a trust relationship with Y, A can trust Y to a certain degree if B tells A its trust opinion of Y. Two key factors determine indirect trust. The first is when and from whom the subject can collect recommendations. The second is to determine how to calculate indirect trust values based on recommendations [Y. Sun, Z. Han, & K. J. Ray Liu, 2008; H. Nahid-Titkanloo, M. Fathian, & S. Noori, 2007].

The third parties in the web environment are engaged in various roles, including roles of search and data collection, transaction-related services and the role of confirming, audit, and controller in order to promote and facilitate transactions. The role of building trust in the third parties is of particular importance in the context of e-commerce due to its complex and risky nature [T. D. Huynh, N. R. Jennings, & N. R. Shadbolt, 2006; A. Das, & M. M. Islam, 2012; H. Nahid-Titkanloo, M. Fathian, & S. Noori, 2007].

2.2 Trust policy management

One of the ways to achieve trust is using endorsements. In this respect, Maximilien and Singh introduce the concept of endorsements. Certificates endorsing that a service (provider) is trusted and preferred by their issuers. However, such endorsements can only let an agent know that the service may be trusted because it is preferred by other agents. This information is typically somewhat imprecise and does not reveal the expected or achievable performance of that service [T. D. Huynh, N. R. Jennings, & N. R. Shadbolt, 2006].

Moreover, a service provider may serve different consumers differently. Certified reputation provides more useful information for estimating an agent's performance than endorsements. The idea of certified reputation is also similar to the RCertPX protocol in storing ratings at the rate. Certificates are also used by Mass and Shehory for trust establishment in open MAS. In their system, an agent presents certificates about itself given by third-parties to gain the trust of another agent. Reputation systems have also emerged as a method for fostering trust amongst strangers in e-commerce environments. A reputation system gathers, distributes, and aggregates feedback about participants' behavior [Y. Sun, Z. Han, & K. J. Ray Liu, 2008; T. D. Huynh, N. R. Jennings, & N. R. Shadbolt, 2006].

Reputation mechanisms have been widely used in online electronic commerce systems (e.g. eBay, Amazon) which typically manage the reputation of all its users in a centralized manner. Following we survey the reputation model of EBay and SPORAS, which are the most popular in this approach [Y. Wang, D. S Wong, K. J. Lin, & V. Varadharajan, 2007, T. D. Huynh, N. R. Jennings, & N. R. Shadbolt, 2006].

2.3 Trust formula

As researchers have discussed, the trust value given lets an agent know the expected performance of the target agent. However, the trust value alone is not enough. For example, a trust value of +1 calculated from only 1 rating or from 10 ratings may have different effects on an agent's decision. Therefore, an agent usually also needs to know how likely it is that the target agent will perform at that expected performance. **In other words, apart from the trust value, its reliability should also be provided by a trust model.** Here, we define a reliability measure that reflects the confidence of the trust model in producing each trust value given the data it took into account. This is given in the form of a reliability value that ranges in [0, 1], where 0 is for complete uncertainty and 1 for total confidence. The reliability value is given based on the two following measures [T. D. Huynh, N. R. Jennings, & N. R. Shadbolt, 2006; A. Das, & M. M. Islam, 2012; J. S. Chang, & H. J. Wong, 2011; B. Khosravifar, J. Bentahar, M. Gomrokchi, & R. Alam, 2012]:

- **Rating reliability**: Gradually increases from 0 (the lowest reliability) to 1 (the highest reliability) when the sum of rating weights increases from 0 to $+\infty$.
- **Deviation reliability:** The greater of the variability in the rating values, the more unstable the other agent is likely to be in fulfilling its agreements. Therefore, the deviation in the ratings' values is also a metric that reflects a trust value's reliability: the calculated abnormality is then normalized to [0, 1]. Naturally, when there is no abnormality in the rating's value (i.e. the target agent performs consistently), the abnormality reliability is 1 (i.e. the most reliable); and it decreases proportionally to 0 (i.e. the least reliable) when the deviation increases.

2.4 Trust metrics

Trust has been evaluated by very different metrics. For example, trust is measured by linguistic descriptions, discrete integers, continuous value in [0, 1], a 2-tuple in $[0, 1]^2$, and a triplet in $[0, 1]^3$. The probability value to describe the level of trustworthiness is adopted. Here, the probability that the agent will perform the action in the subject's point of view, denoted by Pfsubject; agent; actiong is used to measure trust. This metric mainly is adopted because it has a clear physical meaning. One can estimate this value based on observations [Y. Wang, D. S Wong, K. J. Lin, & V. Varadharajan, 2007; J. Riegelsberger, 2005; D. Gefen, 2000; M. A. Patton, & A. Jøsang, 2002].

2.5 Interaction trust

Interaction trust is built from the direct experience of an agent. It models the trust that results from the direct interactions between two agents. Here it's simply exploited the direct trust component of Regret since this meets all our requirements for dealing with direct experiences. In more details, each agent rates its partner's performance after every transaction and stores its ratings in a local rating database. When calculating the IT value for agent b with respect to term 'c', agent 'a' has to query its database for all the ratings that have the form (a, b, c, _, _), where the "_" symbol can be replaced by any value. Researchers call the set of those ratings RI (a, b, c). Since older ratings may become out-of-date quickly, they use the recency of the ratings as a rating weight function to give recent and likely more updated, ratings more weights than older ratings in IT evaluation. Regret's method of calculating rating recency has several unfavorable aspects. Therefore, it is developed a new rating recency function based on the time difference between current time and the rating time as this metrics reflects precisely how old (i.e. how recent) a rating is [T. D. Huynh, N. R. Jennings, & N. R. Shadbolt, 2006; J. S. Chang, & H. J. Wong, 2011; B. Khosravifar, J. Bentahar, M. Gomrokchi, & R. Alam, 2012].

3 Trust Models

The aim of trust models is to collect reliable information leading to an accurate trust assessment process. Since agents might be selfish, receiving fake information by particular agent(s) is always possible. This problem does exist even when a certified reputation is provided by the agent to be evaluated. In this case, the final trust rate would be affected by non-reliable information and eventually the agents' perception of their surrounding environment will not be accurate [Y. Wang, D. S Wong, K. J. Lin, & V. Varadharajan, 2007; T. D. Huynh, N. R. Jennings, & N. R. Shadbolt, 2006; M. A. Patton, & A. Jøsang, 2002].

A trust model needs to possess the following properties (in open MAS):

- It should take into account a variety of sources of trust information in order to have a more robust trust measure and to cope with the situation that some of the sources may not be available.
- Each agent should be able to evaluate trust for itself. Given the "no central authority" nature of open MAS, agents will typically be unwilling to rely solely on a single centralized reputation service.
- It should be robust against possible lying from agents.
- Because of different ownership, the agents are likely to be self-interested and may be unreliable;
- No agent can know everything about its environment because in such environments it is impossible or too costly to obtain such a global perspective [J. Riegelsberger, 2005;

T. D. Huynh, N. R. Jennings, & N. R. Shadbolt, 2006; A. Das, & M. M. Islam, 2012; W. T. L. Teacy, J. Patel, N. R. Jennings, & M. Luck, 2006];

After that, researchers have developed a modular model that integrates four different types of trust and reputation:

- Interaction trust resulting from past experience of direct interactions
- Role-based trust defined by various role-based relationships between the agents
- Witness reputation built from reports of witnesses about an agent's behavior
- And certified reputation built from third-party references provided by the agent itself [Y. Sun, Z. Han, & K. J. Ray Liu, 2008; T. D. Huynh, N. R. Jennings, & N. R. Shadbolt, 2006; B. Khosravifar, J. Bentahar, M. Gomrokchi, & R. Alam, 2012; H. Le, 2004]

The most recent research proposals in trust models for MASs are as follows: (a) interaction trust, based on the direct interactions of two parties; (b) trust based on the type of prior interactions; (c) witness reputation based on certified references obtained by the agent to be evaluated after interacting with other agents. These references are then made public to any other agent who wants to interact with this agent; and (d) referenced reputation, based on references from other agents detailing a particular agent's behavior [T. D. Huynh, N. R. Jennings, & N. R. Shadbolt, 2006; A. Das, & M. M. Islam, 2012; J. S. Chang, & H. J. Wong, 2011; B. Khosravifar, J. Bentahar, M. Gomrokchi, & R. Alam, 2012].

3.1 CRM (Comprehensive Reputation Model)

The framework proposed here, is built upon a model in which a set of trust meta-data was introduced to define the trust level of contributing agents. Efficiency of the proposed framework is related to some performance of the CRM: accuracy, scalability and applicability.

In this framework, agents interact and rate each other based on previous interactions. The obtained ratings are collected to assess the trustworthiness of a particular agent. To be self-contained, it is also considered how agents communicate to exchange ratings. Inter-agent communication is regulated by protocols and determined by strategies. Using this framework, agents are capable of evaluating the trust level of other agents that are not known by collecting some relative information, either from their interaction history or from consulting other agents that can provide their suggestions in the form of ratings.

This model is a new probabilistic-based model to secure multi-agent systems in which agents communicate with each other using dialogue games. The trust assessment procedure is composed of on-line and off-line evaluation processes. Objectively, this allows enhancing the accuracy for agents to make use of the information communicated to them by other agents. Our model has the advantage of being comprehensive and taking into account five important factors: (1) the trust (from the viewpoint of the trustor agents) of consulting agents; (2) the trust value assigned to trustee agents according to the point of view of consulting agents; (3) the number of interactions between consulting and trustee agents; (4) the timely relevance of provided information; and (5) the confidence of consulting agents on the provided data [D. Gefen, 2000; T. D. Huynh, N. R. Jennings, & N. R. Shadbolt, 2006; B. Khosravifar, J. Bentahar, M. Gomrokchi, & R. Alam, 2012; M. A. Patton, & A. Jøsang, 2002; W. T. L. Teacy, J. Patel, N. R. Jennings, & M. Luck, 2006].

3.2 CTR (Computational Trust and Reputation)

CTR systems are platforms capable of collecting trust information about candidate partners and of computing confidence scores for each one of these partners. These systems start to be viewed as vital elements in environments of electronic institutions, as they support fundamental decision making processes, such as the selection of business partners and the automatic and adaptive creation of contractual terms and associated enforcement methodologies. CTR systems can be centralized, as adequate to electronic institutions and virtual organizations (VO), or decentralized, as adequate to extremely open environments where agents can enter and leave the society at any time (e.g. in e-commerce sites of eBay.com, Amazon.com, and Epinions.com [J.Urbano, A. P. Rocha, & E. Oliveira, 2010].

The evolution of trust over time was initiated by Elofson in 1997 as the dynamics of trust, and was addressed one year later by Castelfranchi and Falcone. An interesting formalization of the dynamics of trust is presented by Jonker and Treur in 1999 that defend the need for a continuous verification and validation in the trust building process, and define six different types of trust dynamics:

- **Blindly positive:** the agent is unconditionally trusted or after a certain number or sequence of positive trust experiences (i.e. evaluated events) the agent reaches the state of unconditional trust and stays there for good;
- **Blindly negative:** the agent is unconditionally distrusted or after a certain number or sequence of negative trust experiences the agent reaches the state of unconditional distrust and stays there for good;
- **Slow positive, fast negative:** it takes a lot of trust-positive experiences to gain trust and it takes only a few trust-negative experiences to lose trust;
- **Balanced slow:** trust moves in slow dynamics in both positive and negative sense;
- **Balanced fast:** trust moves in fast dynamics in both positive and negative sense;
- **Slow negative, fast positive:** it takes a lot of trust-negative experiences to lose trust and it takes only a few trust-positive experiences to gain trust.

Computational trust and reputation models seek to quantify trust as a value derived from previous direct experiences and/or second-hand information, such as recommendations, and suggest mathematical and logical expressions for how to combine several opinions about trustworthiness into reputation values. Such models are clearly needed in the virtual world where non-human agents are making trust-based decisions. Also when a human end-user is making the decisions, such calculated trust values can be very useful as decision support [M. Elisabeth-Gaup-Moe, 2011; T. D. Huynh, N. R. Jennings, & N. R. Shadbolt, 2006; B. Khosravifar, J. Bentahar, M. Gomrokchi, & R. Alam, 2012; J.Urbano, A. P. Rocha, & E. Oliveira, 2010;].

3.3 The SinAlpha aggregation engine

For simplicity, we assume that the available information about a candidate partner is given by a central trust authority, and that it takes the form of binary values, either representing past successful (1) or violated (0) contracts by the partner. The constructing of trust for this partner using the sigmoid curve implies a slow growth upon positive results when the partner is not yet trustable, it accelerates when it is acquiring confidence, and finally slows down when the partner is considered trustable. The decrease movement upon negative results follows the same logic. However, we intuitively feel by graphically analyzing the curve that it permits a probably too soft penalization of partners that proved to be trustable but that failed the last n contracts. Therefore, we lightly soften the slope of the sigmoid shape at the top and bottom thirds of the curve, by using instead the trigonometric formula and depicted, with the name of SinAlpha. This way, in each one of the three stages of trust construction, trust grows slower and decreases faster [B. Khosravifar, J. Bentahar, M. Gomrokchi, & R. Alam, 2012; J.Urbano, A. P. Rocha, & E. Oliveira, 2010].

3.4 E-Bay reputation model

Since traditional security mechanisms cannot protect an agent from unreliable service providers, novel models have been developed to model service provision trust. The main building block of these models is information about an agent's past behaviors. This information is used to comprehend the trustworthiness of that agent in terms of its competency and reliability. Online reputation mechanisms are probably the most widely used such models. They are implemented as a centralized rating system so that their users can report about the behavior of one another in past transactions via rating and leaving textual comments. In so doing, users in their communities can learn about the past behavior of a given user to decide whether it is trustworthy to do business with. For example, an eBay user, after an interaction, can rate its partner on the scale of −1, 0, or +1, which means positive, neutral and negative rating respectively. Reputation in these models is a global single value representing a user's overall trustworthiness. However, this is too simple for applications in MAS since they only consider the trustworthiness of an agent as one dimension. In summary, the reputation values in these systems contain very little information, and users of these systems need to look for textual comments providing more information. Therefore, such mechanisms are not well suited to computational agents, which must usually make decisions autonomously. In addition, since there is no central authority that can control all the agents in an open MAS, an agent may well question the credibility of those centralized reputation models and decide not to use them [Y. Wang, D. S Wong, K. J. Lin, & V. Varadharajan, 2007; T. D. Huynh, N. R. Jennings, & N. R. Shadbolt, 2006; M. A. Patton, & A. Jøsang, 2002].

3.5 Sporas

SPORAS extends the online reputation models mentioned above by introducing a new method for rating aggregation. Specifically, instead of storing all the ratings, each time a rating is received it updates the reputation of the involved party using an algorithm that satisfies the following principles:

- New users start with a minimum reputation value and they build up reputation during their activity on the system.
- The reputation value of a user never falls below the reputation of a new user.
- After each transaction, the reputation values of the involved users are updated according to the feedback provided by other parties, which reflect their trustworthiness in the latest transaction.
- Users with very high reputation values experience much smaller rating changes after each update.
- Ratings must be discounted over time so that the most recent ratings have more weight in the evaluation of a user's reputation.

In summary, SPORAS provides a trust measure that has more desirable features than that of similar online models such as eBay's, or Amazon's. However, its centralized design is not suitable for applications in open MAS. Moreover, SPORAS is very susceptible to rating noise resulted from agents' subjective views that are commonplace in open MAS [T. D. Huynh, N. R. Jennings, & N. R. Shadbolt, 2006; B. Khosravifar, J. Bentahar, M. Gomrokchi, & R. Alam, 2012].

3.6 Jurca and faltings

Jurca and Faltings introduce a reputation mechanism where agents are incentivized to report truthfully about their interactions' results. They define a set of broker agents (called R-agents) whose tasks are buying and aggregating reports from other agents and selling back reputation information to them when they need it. Regret is a reputation model in which the trust evaluation process is completely decentralized. Employing Regret, each agent is able to evaluate the reputation of others by itself. Like SPORAS, Regret also provides a reliability value for each trust value to represent its predictive power. The reliability value is calculated from two reliability measures: the number of ratings taken into account in producing the trust values and the deviation of these ratings. All reports about an agent are simply aggregated using the averaging method to produce the reputation value for that agent. Although the R-agents are distributed in the system, each of them collects and aggregates reputation reports centrally. In order to incentivize agents to share their reports truthfully, Jurca and Faltings propose a payment scheme for reputation reports. This scheme guarantees that agents who report incorrectly will gradually lose money, while honest agents will not. Therefore, this mechanism makes it rational for an agent to report its observations honestly and this is the main contribution of their work. However, reputation reports are limited to the values 0 and 1 (0 for cheating agents and 1 for cooperating agents in an iterated Prisoner's Dilemma environment), and the rational property may not hold if an application requires reports represented by more than these particular values [T. D. Huynh, N. R. Jennings, & N. R. Shadbolt, 2006; 23].

3.7 Referral system

In building a reputation system based on witness information, Yu and Singh develop a mechanism to locate information sources (i.e. witnesses) based on individual agents' knowledge and help without relying on a centralized service. The testbed (The code is open source) environment for evaluating FIRE is a MAS consisting of agents providing services (called providers) and agents using those services (called consumers). The consumer agent will then select one provider from the list to use its service. The selection process relies on the agent's trust model to decide which provider is likely to be the most reliable. It is assumed that all agents exchange their information honestly in this testbed. This means an agent (as a witness or as a referee) provides its true ratings as they are without any modification. In our testbed the only difference in each situation is the performance of the provider agents. We consider four types of provider agents: good, ordinary, bad, and intermittent. Since agents can freely join and leave open MAS, the agent population can be very dynamic. Moreover, since agents are owned and controlled by various stakeholders, the performance of an agent may not be consistent over time. Therefore, in order to simulate such dynamism, we introduce the following factors in our testbed [T. D. Huynh, N. R. Jennings, & N. R. Shadbolt, 2006; B. Khosravifar, J. Bentahar, M. Gomrokchi, & R. Alam, 2012; W. T. L. Teacy, J. Patel, N. R. Jennings, & M. Luck, 2006]:

- *The population of agents*
- *The locations of agents*
- *The behavior of the providers*

3.8 Travos

Trust is often built up over time by accumulating personal experience with others; we use this experience to judge how agents will perform in an as yet unobserved situation. However, when assessing trust in an individual with whom we have no direct personal experience, we often ask others about their experiences with that individual. This collective opinion of others regarding an individual is known as the individual's reputation, which we use to assess its trustworthiness, if we have no personal experience of it. TRAVOS is a trust model that is built upon probability theory and based on observations of past interaction between agents. In this model, the outcome of an interaction is simplified into a binary rating (i.e. 1 for a successful interaction, 0 for an unsuccessful one). Using binary ratings allows TRAVOS to make use of the beta family of Probability Density Functions (PDF) to model the probability of having a successful interaction with a particular given agent. This probability is then used as that agent's trust value. In addition, using PDFs, TRAVOS also calculates the confidence of its trust values given an acceptable level of error. If the confidence level of a trust value is below a predetermined minimum level, TRAVOS will seek witness information about the target agent's past performance. The evaluator calculates the probability that the witness's information supports the true behavior of the target agent within a reasonable margin of error, and uses this probability to weight the impact of the witness' opinions on future decisions made, is the evaluator. However, TRAVOS's simplified representation of interaction ratings is rather limited and not suitable for a wide range of applications in open MAS. Given the importance of trust and reputation in open systems and their use as a form of social control, several computational models of trust and reputation have been developed, each tailored to the domain to which they apply. In our case, the requirements can be summarized as follows [T. D. Huynh, N. R. Jennings, & N. R. Shadbolt, 2006; B. Khosravifar, J. Bentahar, M. Gomrokchi, & R. Alam, 2012; W. T. L. Teacy, J. Patel, N. R. Jennings, & M. Luck, 2006].

- First, the model must provide a trust metric that represents a level of trust in an agent.
- Second, the model must reflect an individual's confidence in its level of trust for another agent.
- Third, an agent must not assume that the opinions of others are accurate or based on actual experience.

3.9 Securedtrust: a dynamic trust computation model for secured communication in mass

A reputation based trust model collects, distributes, and aggregates feedback about participants' past behavior. These models help agents decide who to trust, encourage trustworthy behavior, and discourage participation by agents who are dishonest. Reputation based trust models are basically divided into two category based on the way information is aggregated from an evaluator's perspective. They are ”Direct/Local experience model” and ”Indirect/Global reputation model” where direct experience is derived from direct encounters or observations and indirect reputation is derived from inferences based on information gathered indirectly. Most of the existing global reputation models can successfully isolate malicious agents when the agents behave in a predictable way. However, these models suffer greatly when agents start to show dynamic personality. This model is a novel trust computation model called SecuredTrust for evaluating agents in multi-agent environments. SecuredTrust can ensure secured communication among agents by effectively detecting strategic behaviors of malicious agents. This model has given a comprehensive mathematical definition of the different factors related to computing trust. We also provide a model for combining all these factors to evaluate trust and, then propose a heuristic load balancing algorithm for distributing workload among service providers. Simulation results indicate, compared to other existing trust models SecuredTrust is more robust and effective against attacks from opportunistic malicious agents while being capable of balancing load among service providers [A. Das, & M. M. Islam, 2012; W. T. L. Teacy, J. Patel, N. R. Jennings, & M. Luck, 2006; H. Le, 2004].

4 Conclusion

These models also fail to adapt to the unexpected change in agents' behavior and as a result suffer when agents alter their activities strategically. None of the existing trust models consider load balancing among service providers.

However, such a simple management mechanism is not dependable enough to provide an accurate measure of trustworthiness for several reasons. First, the credibility of a member who gives feedback is not considered in the binary reputation system. Second, the amount of money changing hands during the trade is not taken into account when feedback is given. Finally, a binary reputation value does not take into consideration the factor of time decay.

In addition to the above reasons, it is also worth noting that feedback scores received through trading commodities in different categories are weighted equally in the binary reputation system. This may not be a problem in estimating the overall trustworthiness of a member; however, if the quality of service for a target item is considered, such as ''item as described" or ''packing", positive feedback obtained from the same category of the target item of the buyer would be more valuable than other different category. In fact, the necessity of category similarity is analogous to that of expertise matching in a MAS.

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